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How Do Rising U.S. Interest Rates Affect Emerging and Developing Economies?

It Depends

Carlos Arteta
Steven Kamin
Franz Ulrich Ruch

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Abstract

This paper examines the implications of different types of interest rate shocks in the United States for emerging market and developing economies (EMDEs). It first classifies changes in U.S. interest rates into those caused by changes in inflation expectations ("inflation" shocks), changes in perceptions of the Federal Reserve's reaction function ("reaction" shocks), and changes in real activity ("real" shocks). The analysis attributes this year's sharp increases in U.S. interest rates almost exclusively to inflation and reaction shocks. These types of shocks are found to be associated with especially adverse effects: EMDE financial conditions tighten, consumption and investment fall, and governments cut spending to improve budget balances. By comparison, rising U.S. interest rates stemming from real shocks are not only associated with benign outcomes for EMDE financial conditions but also improvements in budget balances that reflect higher revenues as well as lower expenditures. Finally, this paper documents that rising U.S. interest rates driven by reaction shocks are especially likely to push EMDEs into financial crisis.

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Carlos Arteta, Steven Kamin, and Franz Ulrich Ruch[1]

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[1] Carlos Arteta: Prospects Group, World Bank. Email: carteta@worldbank.org
Steven Kamin: American Enterprise Institute. Email: steven.kamin@aei.org
Franz U Ruch: Prospects Group, World Bank. Email: fruch@worldbank.org

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1. Introduction

The rapid rise in interest rates both in the United States and throughout the world, which has been prompted by the global surge in inflation, poses a significant threat to the economic welfare of emerging market and developing economies (EMDEs). The sharp increases in U.S. interest rates, along with the associated rise in the foreign exchange value of the dollar, exert notable spillovers on EMDE borrowing costs. These spillovers are substantially exacerbating debt burdens, rendering it more difficult to finance debt repayments, and heightening the likelihood of debt distress and financial crises in some EMDEs. Anticipation of such developments, in turn, are disrupting EMDE financial markets, discouraging capital inflows, and leading to financial market strains.

These concerns are all the more salient, as the COVID-19 pandemic has given further impetus to a broad-based surge in debt levels in EMDEs, with government debt reaching record highs (Kose et al. 2021, World Bank 2022). These developments have already led to financial distress and even default in several countries. Furthermore, economic losses from the pandemic have weighed on growth, while soaring energy and food prices associated with Russia's invasion of Ukraine have exacerbated the headwinds faced by many EMDEs.

The effect of the current period of rising U.S. interest rates on EMDE financial conditions are likely to be particularly injurious because of their underlying cause. This paper distinguishes between the effects of three different types of shocks that can boost U.S. interest rates: (1) inflation shocks, which are prompted by rising expectations of U.S. inflation; (2) reaction shocks, which are prompted by investors' assessments that the Federal Reserve has shifted toward a more hawkish stance; and (3) real shocks, which are prompted by anticipation of strengthening economic activity. Increases in U.S. interest rates associated with inflation or reaction shocks should lead to more adverse spillovers, since rising interest rates would be coupled with weakening U.S. economic activity and dampened investor sentiment. Real shocks should have relatively benign effects on EMDEs, since the beneficial effects of strong U.S. import demand and buoyant investor confidence would somewhat offset the adverse effects of higher borrowing costs.

The sharp increase in U.S. inflation over the past year, along with the Fed's pivot toward a much more aggressive tightening stance, suggest that increases in U.S. interest rates will continue to be driven mostly by inflation and reaction shocks. To be sure, if inflation subsides more rapidly than many observers now anticipate, the Fed could pause or even reverse its tightening of monetary policy, which would be helpful for EMDEs. Nonetheless, there is considerable uncertainty, and most observers expect policy rates to remain elevated for some time. And even if a rapid disinflation materialized, it might be because of a U.S. recession, which would also weigh on prospects for EMDEs.[2]

[2] See Guenette, Kose, and Sugawara (2022) for a discussion of scenarios for the economic outlook, including a global recession.

Against the backdrop of the ongoing aggressive tightening of Fed policy, this paper explores the impact of rising U.S. interest rates on EMDE financial and economic conditions and fiscal outcomes. In particular, it aims to answer the following questions:

- What mix of inflation, reaction, and real shocks have driven changes in U.S. interest rates in recent years?
- How do the different types of shocks behind changes in U.S. interest rates affect EMDEs financial markets, capital flows, borrowing costs, and fiscal outcomes?
- How do the real, inflation, and reaction shocks behind changes in U.S. interest rates affect the likelihood of EMDE financial crises?

Because each of these questions requires the analysis of different sets of data available at different frequencies, and in order to keep the models used to examine those datasets as parsimonious as possible, the paper employs three distinct empirical methodologies. To identify the mix of real, inflation, and reaction shocks that have been driving U.S. interest rates, the analysis applies a *sign-restricted Bayesian VAR model* to monthly U.S. data on bond yields, stock prices, and inflation expectations. It then estimates *panel local projection models* to assess the impact on EMDE financial, macroeconomic, and fiscal variables at a quarterly frequency of the different types of U.S. interest rate shocks identified by the VAR model. Finally, a *logit model* is applied to annual data to determine how these different types of interest rate shocks affect the probability that an EMDE will experience a financial crisis.

The paper reports the following key findings. First, since the start of 2022, rising rates have been driven almost exclusively by continued increases in inflation expectations and a perceived hawkish shift in the Fed's reaction function as it pivoted toward an exclusive focus on reversing the surge in inflation. Most observers and market participants anticipate some further Fed tightening as inflation remains well above target and the Fed continues to reaffirm that price stability is its highest priority.

Second, the paper confirms the intuition described above that such increases in U.S. interest rates, driven by inflation expectations and changing perceptions of the Fed's reaction function, are especially detrimental to EMDEs. Inflation and reaction shocks boost local-currency bond yields, widen sovereign risk spreads, depress equity prices, depreciate currencies, and dampen capital flows. These tighter financing conditions lead EMDE governments to cut spending to improve primary budget balances and reduce government debt. Generally, these spillovers appear to be more pronounced for reaction shocks—that is, increases in U.S. interest rates associated with market perceptions that the Fed has become more hawkish—than for shocks to inflation expectations. Reaction shocks also decrease private consumption and fixed investment.

By contrast, real shocks to U.S. interest rates would have been much more benign: They lower dollar-denominated sovereign spreads, increase equity prices, appreciate the real exchange rate, boost real exports, and bolster capital flows. And while real shocks are also associated with an increase in the primary budget balance, this reflects improvements in revenue collection as well as declines in expenditures.

Finally, increases in U.S. interest rates raise the likelihood that EMDEs could face financial crises—including currency, banking, and sovereign debt crises. Reaction shocks in particular boost the probability that an EMDE will experience a crisis (especially a currency crisis); by comparison, rising U.S. interest rates driven by real and inflation shocks lead to only small changes in the likelihood of a crisis. Estimates suggest that an increase of 25 basis points in U.S. 2-year yields driven by a reaction shock almost doubles the probability of a financial crisis in a given EMDE (from 3.5 percent to 6.6 percent). Considering that reaction shocks have boosted 2-year yields by 114 basis points since the beginning of the year (to September), this translates to an increase of 36 percentage points in the probability of financial crisis among EMDEs, to almost 40 percent. This significant rise reflects the non-linearity in the probability of crisis from the logit model; that is, a doubling of the size of the interest rate shock leads to a more-than-doubling of the size of the increase in crisis probability.

To be sure, the exact magnitude of the rise in crisis probability is notably uncertain, since no comparable hikes in yields occurred during the estimation sample period. Nevertheless, the results suggest a substantial increase in the likelihood of financial distress in EMDEs. This should not be surprising, insofar as considerable evidence of financial strain is already materializing. Many EMDEs have experienced very sharp currency depreciations this year, and by far more than can be explained by the standard macroeconomic factors pushing up the dollar (interest rate differentials and flight-to-safety motives). Over the past year, seven EMDEs have experienced depreciation against the dollar of at least 30 percent, and 21 EMDEs have reached agreements with the IMF for additional financing.

This paper makes contributions to several areas of the literature on the determinants of U.S. interest rates and their spillovers to EMDEs (see appendix A1 for a comprehensive literature review). One branch shows that changes in interest rates in response to Fed announcements may reflect the market's interpretation of the motivation for such announcements—for example, changes in prospects for economic activity, prospects for inflation, or shifts in the Fed's reaction function. This paper extends the analysis and is the first to decompose the evolution of U.S. interest rates since the onset of the COVID-19 pandemic into the separate contributions of real, inflation, and reaction shocks.

A second branch of research has focused on spillovers of monetary policy shocks—mainly but not exclusively U.S. policy shocks—on foreign financial markets and economies.[3] However, only a few studies—Arteta et al. (2015); Hoek, Yoldas, and Kamin (2021, 2022); IMF (2021); Iacoviello and Navarro (2019)—have examined how the effect of changes in U.S. interest rates on EMDE financial markets differs, depending on whether they are in response to changes in economic growth, in inflation, or in perceptions of the Fed's reaction function. While most of these papers focus on spillovers to government bond yields, capital flows, and other financial assets of EMDEs,

[3] These studies include Rogers et al. (2014); Bauer and Neely (2014); Chen, Mancini-Griffoli, and Sahay (2014); Mishra et al. (2014) ; Takáts and Vela (2014) ; Eichengreen and Gupta (2015); Bowman et al. (2015); Glick and Leduc (2015); Neely (2015); Bruno and Shin (2015a,b); Aizenman et al. (2016); Ahmed et al. (2017); Chari, Stedman, and Lundblad (2017); Curcuru et al. (2018); Albagli et al. (2019); Kalemli-Özcan (2019); Gilchrist, Yue, and Zakrajšek (2016, 2019); Kearns et al. (2019); Brauning and Ivashina (2020); Hoek, Kamin, and Yoldas (2021, 2022); Ferrari, Kearns, and Schrimpf (2021); and Ha (2021).

this paper is the first to go beyond these variables and show how different types of U.S. shocks affect government balances, expenditures, revenues, and debt, as well as extend the sample of EMDEs studied.

Finally, an extensive literature looks at the determinants of financial crises, including Kraay and Nehru (2006), Manasse and Roubini (2009), and Kose et al (2021).[4] The latter two papers find that increases in U.S. interest rates increase the probability of a financial crisis in EMDEs in the following year. This study is the first to examine how different types of U.S. interest rate shocks—real, inflation, and reaction—affect the likelihood of EMDE financial crises.

2. Methodology

2.1 Differentiating between inflation, reaction, and real shocks.

A key factor behind the effects of rising U.S. interest rates is the differentiation between real, inflation, and reaction shocks. Real shocks are defined as changes in interest rates that are caused by changing prospects for U.S. economic activity; they are identified as those that raise U.S. yields as well as U.S. equity prices. Inflation shocks are defined as changes in interest rates that reflect changing prospects for inflation; they are identified as those that raise U.S. yields but reduce equity prices, and within that group, those that raise inflation expectations. Finally, reaction shocks are defined as changes in interest rates due to changing market perceptions of the Fed's reaction function. They are identified as those that, like inflation shocks, raise U.S. yields but reduce equity prices; however, unlike inflation shocks, reaction shocks are assumed to lower inflation expectations.

To decompose U.S. interest rate movements into different types of shocks, the analysis builds on the method developed in Matheson and Stavrev (2014) and employs a sign-restricted Bayesian VAR model with stochastic volatility (see appendix A2 for details). The data are monthly, from January 1982 to June 2022. The model includes four variables: 2-year and 10-year bond yields, the S&P 500 index, and inflation expectations (see table A1 for details). The inclusion of the 10-year yield in addition to the 2-year yield is used to capture the persistent part of expectations of inflation and future monetary policy decisions.

The model is specified as:

$$Y_t = \mathrm{B}X_t + M_t$$

where Y_t is an $\mathrm{N} \times 1$ vector of endogenous variables, X_t is an $\mathrm{N} \times \mathrm{p} + 1$ vector of lagged dependent variables and an intercept term, and where p is the lag length, B is a matrix of coefficients, and M_t is a $\mathrm{N} \times 1$ vector of residuals.

As part of the identification strategy, the following sign restrictions are imposed on a four-variable VAR model as:

[4] For an extensive review, see Kaminsky, Lizondo, and Reinhart (1998); Frankel and Saravelos (2012); and Chamon and Crowe (2012).

$$\begin{bmatrix} \mu_t^{TB2} \\ \mu_t^{TB10} \\ \mu_t^{SPX} \\ \mu_t^{E\pi} \end{bmatrix} = \begin{bmatrix} + & + & + & * \\ + & + & + & * \\ - & + & - & * \\ - & + & + & * \end{bmatrix} \begin{bmatrix} \varepsilon_t^{reaction} \\ \varepsilon_t^{real} \\ \varepsilon_t^{inflation} \\ \varepsilon_t^{*} \end{bmatrix}$$

where μ_t^{TB2} and μ_t^{TB10} represent reduced-form shocks to 2-year and 10-year U.S. Treasury bond yields, μ_t^{SPX} represents a shock to the S&P 500 index, and $\mu_t^{E\pi}$ represents a shock to inflation expectations. The real shock ε_t^{real} is identified as one that raises both 2-year and 10-year interest rates (TB), inflation expectations (Eπ) and equity prices (SPX). The inflation shock $\varepsilon_t^{inflation}$ raises interest rates and inflation expectations but lowers equity prices. The reaction shock $\varepsilon_t^{reaction}$ raises interest rates but lowers inflation expectations and equity prices. Sign restrictions on both the 2-year and 10-year yield ensure that the identified shocks reflect changes from both conventional and unconventional policy moves by the Fed.

2.2 Estimating the impact on EMDEs

Armed with the identification of U.S. interest rate shocks, the analysis then uses ***panel local projection models*** to assess the impact of the different shocks on EMDE borrowing costs and debt burdens. The approach assesses how these shocks affect measures of EMDE asset prices related to the cost of borrowing, as well as real and fiscal variables.

The panel local projection model is used to link the U.S. interest rate shocks identified in the previous section to EMDE variables. The model, following Jorda (2005), identifies impulse response functions through consecutive regression models at different horizons (h):

$$y_{i,t+h} = \alpha_{i,h} + x_{i,t}\delta_h + \text{shock}_{i,t}\beta_h + \mu_{i,t+h}$$

where $\alpha_{i,h}$ are cross-section fixed effects, $x_{i,t}$ are a vector of control variables, and $shock_{i,t}$ are the U.S. interest rate shocks. The models are estimated eight quarters ahead for between 17 and 38 EMDEs, depending on data availability. The dependent variables include 3-month and 10-year local-currency government bond yields, sovereign spreads, capital flows, gross public local-currency and foreign-currency debt to GDP, short-term debt, real GDP, consumer price inflation, and the real effective exchange rate (see table A2 for details).[5] The control variables differ slightly depending on the dependent variable, as shown in table A3, but generally include GDP, CPI, capital flows, government debt, the real exchange rate, and the policy interest rate (table A2 indicates the transformations of the control variables).

The model is also extended to account for possible differences in the responses depending on the sovereign creditworthiness of EMDEs, distinguishing between investment grade and noninvestment grade. The rating of investment and noninvestment EMDEs is based on Kose et al.

[5] The real effective exchange rate is used to better capture financial conditions in EMDEs and to account for situations of high inflation. In this paper, references to "capital flows" are defined as increases in net portfolio and other investment liabilities of EMDEs, excluding foreign direct investment liabilities.

(2017) and uses the average foreign-currency long-term sovereign debt rating by Fitch Ratings, Moody's, and Standard and Poor's. A dummy variable approach is used, where I_t is set equal to one if the average rating at time *t* is below investment grade and 0 otherwise. Consequently, the state-dependent impulse response function becomes a function of the dummy variable and the endogenous variables:

$$y_{i,t+h} = I_t\left[\alpha_{\mathrm{A,i,h}} + \mathrm{x_{i,t}}\delta_{\mathrm{A,h}} + \mathrm{shock_{i,t}}\beta_{\mathrm{A,h}}\right] +$$

$$(1 - I_t)\left[\alpha_{\mathrm{B,i,h}} + \mathrm{x_{B,i,t}}\delta_{\mathrm{h}} + \mathrm{shock_{i,t}}\beta_{\mathrm{B,h}}\right] + \mu_{i,t+h}$$

2.3 Modeling financial crisis probability

Finally, the analysis explores how different U.S. interest rate shocks shape the probability of financial crises in EMDEs. To that end, it uses a logit model as in Kose et al. (2021) to assess the impact of different underlying shocks on the probability of crisis in EMDEs over the past 50 years. This is estimated using annual data from 1985 to 2018. Crisis events are based on Laeven and Valencia (2020) codified to 2017, and extended in Kose et al. (2021), and encompass sovereign debt, banking, and currency crises.

The model is estimated as:

$$Y_{i,t} = \beta' X_{i,t-1} + \mu_i + \epsilon_{i,t}$$

where $y_{i,t}$ is a binary variable of banking, currency, or sovereign debt crises for country *i* in year *t* taking the value of 1 if a crisis occurred; $X_{i,t-1}$ is a vector of determinants of crisis including the real, inflation, and reaction shocks as well as other control variables; μ_i captures unobserved country heterogeneity; and $\epsilon_{i,t}$ are the residuals. The baseline specification is a panel logit model with random effects, as the Hausmann test suggests that the random effects model is appropriate for debt and banking crises. For robustness, the appendix presents results for a probit model with random effects (table A6) and logit model with fixed effects (table A7).

3. Data

3.1 Identification of U.S interest rate shocks

The data included in the VAR model used to decompose U.S. interest rate shocks are provided in table A1. The table indicates the transformation used in the model and the data source. The model includes four variables and is estimated on monthly data from February 1982 to September 2022. The variables include 2-year and 10-year yields on U.S. Treasury bonds at a constant maturity (figure 1A). Due to the secular decline in U.S. interest rates over the past four decades, the data are transformed to be stationary using first differences, as the focus is on shocks over the business cycle. Equity prices are measured by the S&P 500 composite index and transformed to percent changes using log first differences. The 5-year breakeven inflation rate is used from 2003 onwards.[6]

3.2 Impact on EMDEs

The data included in the panel local projection models are provided in table A2 and include financial, real and fiscal variables (for details, see appendix figures A1-A3). Seasonal adjusted data are used when available or adjusted using X13-ARIMA-SEATS (U.S. Census Bureau 2017). The data are mainly sourced from Haver Analytics, with all available data collected for as long a time period as possible at a quarterly frequency. Quarterly data is used since it is the highest available frequency for most fiscal-related variables—a key focus of this paper. The datasets used to measure the impacts of different U.S. interest rate shocks differ based on the dependent variable. The most restricted country sample size, in the short-term yields, includes 19 economies from 1997Q4 to 2019Q4—an unbalanced panel of 768 total observations (table A3).[7] The largest country sample used, for example with capital flows, includes 36 EMDEs over 1997Q2 to 2019Q4—an unbalanced panel of 1547 observations. The EMDEs included across all regressions are provided in table A4.

To transform the monthly monetary policy shocks identified earlier into a quarterly frequency and to reflect a one-percentage-point change in the 2-year U.S. yield, the shocks are adjusted in two ways. First, given that monthly shocks are in first differences, shifting to a quarterly change is done by adding monthly changes within each quarter. Second, to make interpretation across shocks comparable, the contribution of all shocks from the historical decomposition of the 2-year yield is used.[8]

3.3 Correlates of crises

The probability of crises is estimated using logit and probit models based on a panel dataset of 139 EMDEs on annual data from 1985-2018. The variables selected are based on empirical findings in the early warning indicators literature on crises (see Kaminsky, Lizondo, and Reinhart 1998; Frankel and Saravelos 2012; and Chamon and Crowe 2012 for an extensive review) and Kose et al. (2021). The panel includes data on debt (both public and private), the balance of payments, and the real, banking, and financial sectors (table A5).

4. Results

4.1 Decomposition of movements in U.S. interest rates

The sign-restricted Bayesian VAR model described above is used to decompose movements in U.S. bond yields into the contributions of their respective shocks. Evolving expectations about

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[6] The 5-year maturity is used based on data availability and as a compromise between capturing information in both the 2-year and 10-year yields. Prior to 2003, the inflation expectations series is based on model estimates by Haubrich, Pennacchi, and Ritchken (2012).

[7] The models exclude observations between 2008Q4-2009Q4 to account for the period of the global financial crisis.

[8] The historical decomposition divides the 2-year yield into the contribution of each of the shocks to its evolution over time.

growth, inflation, and the Federal Reserve's reaction function explain about two-thirds of the variation in 2-year bond yields (figure 1B); using 10-year yields produces very similar results. Real shocks are the largest contributor to the variation in 2-year U.S. interest rates, explaining 39 percent of their variation after 10-months. Shocks to inflation expectations are the next largest contributor, accounting for 14 percent of the variation in interest rates, while shocks to perceptions of the Fed's reaction function explain 13 percent.

To varying degrees, these shocks track changes in the 2-year yields well. Real shocks are prominent determinants (figure 2A). The identified real shocks also correlate well with actual movements in economic activity as reflected in the evolution of U.S. industrial production (figure 2B). Periods of slowing and negative growth in industrial production are accompanied by negative real shocks to interest rates, while periods of accelerating growth track well those of positive real shocks.

Shocks to inflation expectations have also been important determinants of bond yields, especially in the first part of the sample period, when inflation concerns were more prominent (figure 2C). The inflation shocks correlate well with movements in 5-year inflation expectations, with periods of falling inflation expectations aligning to negative inflation shocks and vice versa (figure 2D).

The market's perception of the Fed's reaction function show periods of dovish (negative reaction shocks) and hawkish (positive reaction shocks) responses to economic and financial developments (figure 2E).[9] There is no straightforward comparison of these shocks to other possible descriptions of the stance of the Fed. The reaction shocks broadly track other descriptions of the policy preferences of the Fed, including in Istrefi (2019) and Bordo and Istrefi (2021). The reaction shock shows a weak correlation to the expected slope of the federal funds futures curve to 2-years (figure 2F).

4.2 Shock decomposition during major episodes of sharp U.S. interest rates movements

This section further explores how different shocks drive changes in U.S. Treasury yields, as well as the impacts on EMDEs. It focuses on two recent episodes: i) the 2013 taper tantrum and ii) the period encompassing the COVID-19 pandemic and the war in Ukraine. (Appendix A3 explores additional episodes, including the bond market turmoil of 1994, the build-up to the global financial crisis in the 2000s, and the hiking cycle in the second half of the 2010s.) The discussion is informed by the decomposition of movements in Treasury yields into the respective contributions of real, inflation, and reaction shocks (figure 3). The exploration of these episodes highlights the adverse impact of inflation and reaction shocks on EMDE financial conditions. For instance, the 2013 taper tantrum—where reaction shocks were predominant—resulted in dislocating financial market

[9] Romer and Romer (2004) measure monetary policy shocks by capturing dates when the Federal Reserve "attempted to exert a contractionary influence on the economy in order to reduce inflation." As such, this approach is closest to this paper's inflation and reaction shocks; nonetheless, there is effectively no correlation between their shocks and this paper's inflation or reaction shocks. Aruoba and Drechsel (2022) refine the narrative approach by using natural language processing techniques. Again, this method has low correlations, at or below 0.2, with the reaction and real shocks identified in this paper.

developments across EMDEs. Most recently, inflation and, in particular, reaction shocks herald the rising likelihood of EMDE financial strains.

4.2.1 The taper tantrum. In May 2013, the Fed chairman unexpectedly signaled that the Fed would start tapering asset purchases, bringing an end to its QE III program of quantitative easing. In response, 10-year government bonds experienced a sharp selloff and the yield on those bonds rose significantly, by around 100 basis points—an event known as the taper tantrum. The 2-year bond yield rose little, likely reflecting that the Fed was not expected to raise short-term rates for some time. Nearly all the increase in 10-year yields was accounted for by reaction shocks (figure 3A).

These developments were quite disruptive for EMDE financial markets. Their currencies depreciated, sovereign spreads rose by 60 basis points between May and June, long term yields shot up, and equity prices fell. Reflecting heightened investor risk aversion, portfolio and banking flows to EMDEs dropped sharply, and the upward trajectory of foreign currency debt, as a share of GDP, was arrested for several quarters. Despite these effects, impacts on the domestic economic conditions in EMDEs were difficult to identify—GDP growth appeared to be little affected. And perhaps because structural vulnerabilities were less pronounced than in earlier decades, there was little incidence of financial crisis in EMDEs.

4.2.2 COVID-19, the war in Ukraine, rising inflation, and the Fed's responses. At the onset of COVID-19, economic activity collapsed, inflation declined, the Fed pushed the federal funds rate back to zero, and Treasury yields plummeted. Subsequently, short-term yields remained near zero while 10-year yields rose, driven by the recovery in economic activity and inflation. By September 2021, 2-year yields started to rise in response to rising inflation and associated anticipation of earlier-than-expected Fed tightening, which was ratified by the FOMC's announcements at its December and January meetings. Russia's invasion of Ukraine in late February 2022 triggered further increases in food and energy prices that added to inflationary pressures. Five-year breakeven inflation expectations breached 3 percent for the first time in the two-decade history of the series. The Fed raised the policy rate by 25 basis points in March 2022, 50 basis points in May, and 75 basis points in June, July, September, and November—the fastest pace of increase since the 1990s. Yields also rose precipitously, reflecting both rising inflation expectations as well as a reassessment of the Fed's reaction function as being more markedly hawkish than previously believed (figure 3B). For 2022 to date, reaction and inflation shocks accounted for three-quarters of the cumulative increase in yields.

In the initial pandemic-related turmoil of March 2020, all gauges of EMDE financial markets—currencies, bond valuations, and equities—collapsed and then, following accommodative actions by the Fed and other major central banks, steadily improved through early 2021. At that point, EMDE financial markets generally plateaued and then deteriorated to various degrees after September 2021, when anticipations of Fed tightening mounted and shorter Treasury yields started moving up sharply. At the same time, portfolio and banking flows to EMDEs, having rebounded strongly from their pandemic "sudden stop" in late 2020 and early 2021, fell off sharply by the end of the year. Bond issuance in the first quarter of 2022 across EMDEs was weaker than in any first quarter since 2016. The war in Ukraine in March 2022 saw equity and debt flows to EMDEs turn sharply negative, while EMDE financial conditions have reached their tightest level since the start of the pandemic. Investor risk appetite has been sapped by the war in Ukraine, pandemic-related mobility restrictions in China, a weaker growth outlook, and higher interest rates in advanced economies.

4.3 Impact of U.S. interest rate shocks on EMDEs

This section compares the effects on financial, real, and fiscal variables in EMDEs of the U.S. interest rates shocks identified by the VAR analysis. As discussed above, the estimates of these effects are based on panel local projection models. Figures 4-6 shows the impact of a 25-basis-point shock—real, inflation, or reaction—to U.S. 2-year bond yields on EMDE variables (for additional detail, see also appendix figures A4-A6 for impact up to eight quarters).[10] The size of the shock corresponds to roughly a one standard deviation move in the 2-year yield as measured since the 1980s.

4.3.1 Financial markets response. As shown in figure 4, increases in U.S. interest rates driven by reaction shocks are associated with adverse movements in EMDE financial markets, including significant increases in 10-year yields and sovereign spreads (EMBI+), declines in capital flows, and depreciations of the real exchange rate; in addition, short-term interest rates rise and equities decline, although those movements are not statistically significant. Inflation shocks are also followed by increases in 10-year yields, lower capital flows, a depreciated real exchange rate, and depressed equity prices; however, with the exception of the last of these, the movements are not statistically significant.

In contrast, real shocks to U.S. interest rates tend to be followed by benign short-term movements in EMDE financial markets, including significant declines in sovereign spreads, an increase in capital flows, an increase in equity prices, and an appreciation of the real exchange rate (figure 4). Ten-year government bond yields rise, but this is to be expected, since bond markets are integrated globally, and even the bond yields of advanced economies tend to move together closely.

4.3.2 Economic activity response. The impacts of U.S. interest rate shocks are not restricted to financial variables, as they also have statistically significant impacts on economic activity and consumer price inflation in EMDEs after one quarter, as shown in figure 5. (Appendix figure A5 extends the analysis up to 8 quarters). Reaction shocks are associated with a significant decline in real GDP components, particularly fixed investment and private consumption expenditure (figure 5A).[11] In contrast, real shocks lead to higher real exports and leave other spending components unchanged. This is consistent with positive spillovers of stronger U.S. real activity on EMDE trade. In addition, inflation shocks induce a large and statistically significant increase in domestic EMDE consumer price inflation, while real shocks reduce it (figure 5B).

[10] The terms "a 25-basis-point increase in interest rates driven by an inflation shock", a "25 basis point inflation shock", and an "inflation shock" are used interchangeably in this section. This is equally true of real and reaction shocks. U.S. interest rates reflect changes in 2-year bond yields.

[11] See Arbatli et al (2022) for firm-level evidence of the channels through which U.S. monetary policy affects investment outcomes in EMDEs.

4.3.3 Fiscal response. The fiscal responses in EMDEs differ between U.S. real, inflation, and reaction shocks, as shown in figure 6.[12] Inflation and especially reaction shocks to U.S. interest rates are followed by an improvement in the primary balance (smaller deficit or larger surplus; figure 6A). This comes despite some weakening of real GDP, in the case of reaction shocks, and comes about almost exclusively as a result of declines in government expenditure. Most likely, the tightening of the cost and availability of credit triggered by inflation and reaction shocks lead governments to cut spending. Real shocks are also associated with a significant increase in the primary balance, but this reflects a rise in government revenues in addition to a decrease in government expenditure. Finally, the tightening of fiscal policy in response to all three shocks leads to declines in government debt to GDP, although these are only statistically significant in the case of real shocks (figure 6B).

4.3.4 Composition of government debt. As with the other variables examined in this paper, the composition of EMDE government debt responds differently to different U.S. interest rate shocks (figures 6C-6E). In the face of inflation and reaction shocks, the composition of government debt shifts in ways that suggest a tightening of credit markets. Inflation and reaction shocks are associated with a statistically significant decrease in debt held by external creditors, as well as an eventual rise in short-term debt. Inflation shocks lead to little change in foreign-currency debt, but this type of debt rises considerably following reaction shocks. This latter development likely reflects the depreciation in the exchange rate, which boosts the local-currency value of foreign-currency debt.

Conversely, in response to a real shock, government debt held by external creditors as a share of total government debt rises significantly, consistent with a loosening of global credit markets. The share of foreign currency debt does not materially change for most of the estimation period, but the share of short-term government debt (with a maturity of one year or less) declines significantly. This may reflect active maturity extension by fiscal authorities to minimize rollover risk, and again suggests improved access to credit markets; it may also indicate the maturation, and non-replacement, of this debt.

4.4 Impacts on investment- and noninvestment-grade EMDEs. In principle, one might expect more vulnerable economies to exhibit a more adverse response to higher U.S. interest rates than economies with stronger fundamentals. That should be especially true in the case of those shocks which tighten global financing conditions—i.e., reaction shocks. To assess this hypothesis, the analysis compares the response of investment-grade and noninvestment-grade EMDEs to U.S. reaction shocks. Economies were categorized according to the average foreign-currency long-term sovereign debt rating of Fitch Ratings, Moody's, and Standard and Poor's.

By and large, there was little evidence of important differences in the estimated effects of U.S. interest rate shocks on financial, economic and fiscal variables between investment- and noninvestment-grade EMDEs (figure 7). To be sure, noninvestment-grade EMDEs showed greater increases in EMBI+ spreads, 3-month yields, and 10-year yields than did investment-grade EMDEs, as one would expect, and in the latter case the difference was even statistically significant.

[12] Unlike in the previous figures, we show responses over 8 quarters as it may take time for fiscal policies to adjust.

But otherwise, spillovers to the two groups of countries were quite similar and not statistically distinguishable from each other. This is inconsistent with Chen et al. (2014), Ahmed et al. (2017), and Bowman et al. (2015), who find that spillovers from U.S. monetary policy are smaller for countries with stronger fundamentals. However, other studies find a limited role for fundamentals, including Eichengreen and Gupta (2015) and Aizenman et al. (2016). Accordingly, this issue remains unresolved, and further research is needed.

4.5 Correlates of crises

As discussed above, shocks to U.S. interest rates have demonstrable impacts on EMDE financial markets, real activity, and fiscal choices. This section looks at whether those impacts increase the likelihood of banking, currency, and sovereign debt crises in EMDEs. The approach in Kose et al. (2020) is followed. Their paper shows that a 2-percentage-point increase in the U.S. real interest rate, which is about half the cumulative increase in a typical hiking cycle, increased the probability of a currency crisis by half: from 4.1 percent to 6 percent. This paper extends their analysis to assess whether real, inflation, and financial shocks to U.S. interest rates have different effects on the likelihood of crisis.

The frequency of financial crises in EMDEs has declined since the 1980s and 1990s, but episodes of banking, currency, and sovereign debt crises continue to materialize (figure 8A). Whereas the probability of crisis is related to several factors, they generally occur in periods of larger government debt buildups, weaker economic outcomes, and larger macroeconomic and financial vulnerabilities (Kose et al. 2021).

To assess the effect of different types of U.S. interest rates shocks on the likelihood of financial crisis, a standard logit model is estimated; the estimation results are shown in table 1. The model is estimated for three different types of financial crises as identified by Laeven and Valencia (2020): sovereign debt crises, banking crises, and currency crises.[13] The dependent variable is a dummy equal to one when there is a crisis and 0 otherwise. The control variables include those in table A5. The analysis estimates the impacts of three types of shocks on the three kinds of crises and then combines them into a single crisis measure that accounts for the occurrence of any of the three types of crises.

4.5.1 Marginal impact. The coefficients on the three shocks at the top of table 1 represent the marginal impact of 100-basis-point increases in U.S. interest rates driven by these shocks on the probability that an EMDE experiences a financial crisis. The results suggest that reaction shocks are by far the most important drivers of financial crises, inducing large and significant effects for the "currency crisis" and "any crisis" categories. By comparison, inflation shocks are associated with only small and insignificant effects. Real shocks reduce the likelihood of EMDE debt crises (consistent with the benign effects of real shocks on financial markets and other variables described

[13] Sovereign debt crises are defined as a default by the government to private creditors and/or restructuring of debt. Banking crises are defined as an event where there is significant distress in the banking system combined with significant banking policy intervention measures in response to significant losses. Currency crises are defined as a "sharp" nominal depreciation (at least 30 percent) vis-a-vis the U.S. dollar. For additional details, see Laeven and Valencia (2020).

above); while they raise the likelihood of currency crises, they do so by much less than reaction shocks.

4.5.2 Probability of crises. In this section, the analysis shifts from describing the marginal impact of U.S. interest rate shocks on the probability of crisis to their implications for overall crisis probabilities.

In the average EMDE, the probability of facing a crisis of any type (when the explanatory variables are at their sample mean) from 1985 to 2018 was 3.5 percent—a currency and banking crisis being the most likely and a sovereign debt crisis the least (figure 8B). If 2-year yields in the U.S. were to increase by 25 basis points driven by reaction shocks, then the estimated probability of crisis about doubles, to 6.6 percent.

In 2022, reaction shocks have accounted for a 114-basis-point increase in 2-year treasury yields, which indicates a substantial increase in the probability of a financial crisis in EMDEs. Based on the model estimates, the probability of a financial crisis in the average EMDE has increased 36 percentage points, to almost 40 percent, assuming all other variables remain at their sample averages. This may seem like a very large increase, considering that, as noted above, a 25 basis-point rise driven by reaction shocks would boost the probability of crisis by only 3 percentage points. It is explained by the non-linear relationship between the interest rate shock and the probability of crisis that is estimated by the logit model: a doubling of the interest rate shock leads to a more-than-doubling of the rise in the crisis probability.[14]

To be sure, a very large confidence interval must be placed around the estimate. No rise in yields as large and fast as what took place in 2022 occurred during the 1985-2018 estimation period, so it is uncertain how well the model will perform at the current juncture. However, there are few grounds for optimism, considering the increase in EMDE debt, the slowdown in global growth, and the depletion of foreign currency reserves that has taken place of late. Indeed, in 2022, seven EMDEs have experienced a currency crisis, based on the definition in Laeven and Valencia (2020), and 21 EMDEs reached agreements with the IMF for additional financing.

5. Robustness

Several robustness tests were conducted to check the sensitivity of results. The VAR-based decomposition of U.S. interest rates was calculated using weekly data, where available, instead of monthly data. In addition, instead of identifying three shocks, the analysis was simplified to identify two—real shocks and monetary shocks, where monetary shocks combine both inflation and reaction shocks. The model was also extended to include real GDP and PCE inflation with the identification of the shocks assuming no contemporaneous impact on both variables, to ensure that real, inflation, and reaction shocks are independent of current economic conditions. Finally, instead of using inflation expectations based on TIPS from 2003 onwards, a robustness test uses those calculated in Haubrich, Pennacchi, and Ritchken (2012). In all cases, the results were not materially different, and the narrative regarding the evolution of U.S. interest rates around notable

[14] This non-linearity flows from the use of the logistics function embedded in the model, but it is also a good description of reality. When borrowing costs are low, small increases are unlikely to lead to much distress, but when they are high, even small further increases may trigger widespread defaults.

tightening events remained broadly unchanged. Moreover, the results continued to suggest that the impacts of inflation and reaction shocks on EMDE financial and fiscal variables are more adverse than those of real shocks, although now the importance of inflation shocks appears somewhat greater compared to that of reaction shocks.

In regard to the panel local projection model, the results were broadly unchanged regardless of whether China was included in the country sample or not. In terms of crisis probabilities, a panel probit model with random effects and a logit model with fixed effects were estimated in addition to the panel logit model described above; while the marginal impacts differ, the overall results remained the same: real shocks decrease the probability of a debt crisis, and reaction and real shocks raise the probability of a currency crisis; and only reaction shocks lead to a statistically significant increase in the probability of a EMDE crisis event of any type.

6. Conclusions

EMDEs have been going through a challenging period. Global inflation is at levels not seen for decades and the U.S. Federal Reserve will likely need to continue to tighten policy, leading to much more adverse global financing conditions. All this is occurring in an environment of unprecedented high debt levels both in the public and private sector in many EMDEs, as well as pandemic-related scarring of their economies and elevated food and energy costs in part due to the invasion of Ukraine. This paper provides a perspective on the impact of rising U.S. interest rates on EMDEs.

The ultimate impact of rising U.S. interest rates depends on the types of shocks that drive them. This paper decomposes U.S. interest rate moves into those driven by inflation expectations (inflation shocks), changes in the central bank's policy stance (reaction shocks), and better economic activity (real shocks). The analysis finds that the rapidly increasing U.S. interest rates over the past year reflect both rising inflation expectations and, especially, a perceived shift in the Fed's reaction function toward a more hawkish stance. This is the first paper to decompose the evolution of U.S. interest rates over the course of the COVID-19 pandemic recession, the subsequent economic recovery, and the rebound in global inflation into the separate contributions of real, inflation, and reaction shocks.

With the ongoing rise in U.S. interest rates being driven principally by inflation and reaction shocks, the outlook for EMDEs is exceptionally worrisome. The findings in this paper indicate that inflation and reaction shocks are associated with tighter financial conditions and more adverse economic outcomes for EMDEs: a widening of sovereign spreads, declining capital flows, decreasing equity prices, a depreciation of the real exchange rate, and a drop in consumption and investment. Moreover, the tighter financing conditions lead EMDE governments to cut spending in order to improve primary budget balances and reduce government debt. These adverse effects contrast with the effects of real shocks to U.S. interest rates driven by better economic activity, which tend to have much more benign effects on financial conditions in EMDEs. While real shocks to U.S. interest rates are also associated with an increase in the primary budget balance, this reflects improvements in revenue collection as well as declines in expenditures.

Finally, this paper shows that U.S. interest rate changes also affect the likelihood that EMDEs could face financial crisis. In particular, reaction shocks significantly increase the probability of crisis—especially a currency crisis. Given a 25 basis-point increase in U.S. 2-year yields driven by a reaction shock, the probability of a financial crisis the following year in a given EMDE about doubles, to 6.6 percent. Considering that reaction shocks are estimated to have boosted 2-year yields by 114 basis points since the beginning of 2022, this translates to an increase of 36 percentage points in the probability of financial crisis. By comparison, rising U.S. interest rates driven by real and inflation shocks lead to only small changes in the likelihood of a financial crisis.

These results highlight the precarious situation many EMDEs are facing. Like the mid-1990s and 2013, adverse monetary policy shocks—most critically, reaction shocks—currently predominate, and they are set to continue to be the main driver behind rising U.S. interest rates. Such movements may lead to destabilizing EMDE financial market movements. They may also exacerbate procyclical reductions in EMDE fiscal spending. Ultimately, these shocks may result in financial crisis in some EMDEs.

References

Ahmed, S., B. Coulibaly, and A. Zlate. 2017. "International Financial Spillovers to Emerging Market Economies: How Important Are Economic Fundamentals?" *Journal of International Money and Finance* 76 (September): 133-152.

Aizenman, J., M. Binici, and M. M. Hutchison. 2016. "The Transmission of Federal Reserve Tapering News to Emerging Financial Markets." *International Journal of Central Banking* 12 (2): 317–356.

Albagli, E., L. Ceballos, S. Claro, and D. Romero. 2019. "Channels of US Monetary Policy Spillovers to International Bond Markets." *Journal of Financial Economics* 134 (2): 447-473.

Arbatli, E.C., M. Firat, D. Furceri, and J. Verrier. 2022. "U.S. Monetary Policy Shock Spillovers: Evidence from Firm-Level Data." IMF Working Paper 22/191, International Monetary Fund, Washington, DC.

Arteta, C., M. A. Kose, F. Ohnsorge, and M. Stocker. 2015. "The Coming U.S. Interest Rate Tightening Cycle: Smooth Sailing or Stormy Waters?" Policy Research Note 15/02, World Bank, Washington, DC.

Aruoba, B., and T. Drechsel. 2022. "Identifying Monetary Policy Shocks: A Natural Language Approach." CEPR Discussion Paper 17133, Centre for Economic Policy Research, London.

Bagliano, F.C. and C.A. Favero. 1999. "Information From Financial Markets and VAR Measures of Monetary Policy." *European Economic Review*: 43(4-6): pp.825-837.

Bauer, M., and C. J. Neely. 2014. "International Channels of the Fed's Unconventional Monetary Policy." *Journal of International Money Finance*: 44 (June): 24-46.

Bernanke, B.S. 1986. *Alternative Explanations of the Money-Income Correlation.* NBER Working Paper 1842, National Bureau of Economic Research, Cambridge, MA.

Bernanke, B.S. and A.S. Blinder. 1988. *Credit, Money, and Aggregate Demand.* NBER Working Paper 2534, National Bureau of Economic Research, Cambridge, MA.

Bordo, M. D., and K. Istrefi. 2021. "Perceived FOMC: The Making of Hawks, Doves and Swingers." NBER Working Paper 24650, National Bureau of Economic Research, Cambridge, MA.

Bowman, D., J. M. Londono, and H. Sapriza. 2015. "U.S. Unconventional Monetary Policy and Transmission to Emerging Market Economies." *Journal of International Money and Finance* 55 (July): 27–59.

Bräuning, F., and V. Ivashina. 2020. "US Monetary Policy and Emerging Market Credit Cycles." *Journal of Monetary Economics* 112 (June): 57-76.

Bruno, V., and H. S. Shin. 2015a. "Cross-Border Banking and Global Liquidity." *Review of Economic Studies* 82 (2): 535–564.

Bruno, V., and H. S. Shin. 2015b. "Capital Flows and the Risk-Taking Channel of Monetary Policy." *Journal of Monetary Economics* 71 (April): 119–132.

Bu, C., J. Rogers, and W. Wu. 2021. "A Unified Measure of Fed Monetary Policy Shocks." *Journal of Monetary Economics* 118 (March): 331–349.

Chamon M., and C. Crowe. 2012. "Predictive Indicators of Crises." In *Handbook in Financial Globalization: The Evidence and Impact of Financial Globalization*, edited by G. Caprio, 499–505. London: Elsevier.

Chari, A., K.D. Stedman, and C. Lundblad. 2017. *Taper Tantrums: QE, its Aftermath and Emerging Market Capital Flows*. NBER Working Paper 23474, National Bureau of Economic Research, Cambridge, MA.

Christiano, L.J., M. Eichenbaum, and C.L. Evans. 1996. *Identification and the Effects of Monetary Policy Shocks*. In Financial Factors in Economic Stabilization and Growth: 36.

Chen, J., T. Mancini-Griffoli, and R. Sahay. 2014. "Spillovers from United States Monetary Policy on Emerging Markets: Different This Time?" IMF Working Paper 14/240, International Monetary Fund, Washington, DC.

Cieslak, A., and A. Schrimpf. 2019. "Non-monetary News in Central Bank Communication." *Journal of International Economics* 118 (C): 293-315.

Curcuru, S. E., S. B. Kamin, C. Li, and M. Rodriguez. 2018. "International Spillovers of Monetary Policy: Conventional Policy vs. Quantitative Easing." International Finance Discussion Paper 1234, Board of Governors of the Federal Reserve System, Washington, DC.

Darvas, Z. 2021. "Timely Measurement of Real Effective Exchange Rates." Working Paper 2021/15, Bruegel, Brussels.

Eichengreen, B., and P. Gupta. 2015. "Tapering Talk: The Impact of Expectations of Reduced Federal Reserve Security Purchases on Emerging Markets." *Emerging Market Review* 25 (September): 1–15.

Ferrari, M., J. Kearns, and A. Schrimpf. 2021. "Monetary Policy's Rising FX Impact in the Era of Ultra-low Rates." *Journal of Banking & Finance*, 129, p.106142.

Frankel, J. A., and G. Saravelos. 2012. "Can Leading Indicators Assess Country Vulnerability? Evidence from the 2008-09 Global Financial Crisis." *Journal of International Economics* 87 (2): 216-231.

Furceri, D., and A. Zdzienicka. 2012. "How Costly Are Debt Crises?" *Journal of International Money and Finance* 31 (4): 726-42.

Gertler, M. and P. Karadi. 2015. “Monetary Policy Surprises, Credit Costs, and Economic Activity.” *American Economic Journal: Macroeconomics*, 7(1), pp.44-76.

Gilchrist, S., V. Yue, and E. Zakrajšek. 2016. “The Response of Sovereign Bonds Yields to U.S. Monetary Policy.” In *Monetary Policy through Asset Markets: Lessons from Unconventional Measures and Implications for an Integrated World*, edited by E. Albagli, D. Saravia, and M. Woodford, 257-283. Santiago, Chile: Central Bank of Chile.

Gilchrist, S., V. Yue, and E. Zakrajšek. 2019. “U.S. Monetary Policy and International Bond Markets.” *Journal of Money, Credit and Banking* 51 (S1):127-161.

Glick, R., and S. Leduc. 2015. “Unconventional Monetary Policy and the Dollar: Conventional Signs, Unconventional Magnitudes.” Working Paper 2015-18, Federal Reserve Bank of San Francisco.

Guenette, J. D., M. A. Kose, and N. Sugawara. 2022. “Is a Global Recession Imminent?” EFI Policy Note 4, World Bank, Washington, DC.

Ha, J. 2021. “Financial Market Spillovers of U.S. Monetary Policy Shocks.” *Review of International Economics* 29 (5): 1221-1274.

Haubrich, J., G. Pennacchi, and P. Ritchken. 2012. “Inflation Expectations, Real Rates, and Risk Premia: Evidence from Inflation Swaps.” *The Review of Financial Studies* 25 (5): 1588-1629.

Hoek, J., S. Kamin, and E. Yoldas. 2021. "Are Rising U.S. Interest Rates Destabilizing for Emerging Market Economies?" FEDS Notes, Board of Governors of the Federal Reserve System, Washington, DC.

Hoek, J., S. Kamin, and E. Yoldas. 2022. “Are Higher U.S. Interest Rates Always Bad News for Emerging Markets?” *Journal of International Economics* 137 (July): 103585.

Iacoviello, M., and G. Navarro. 2019. “Foreign Effects of Higher U.S. Interest Rates.” *Journal of International Money and Finance* 95 (July): 232-250.

IMF (International Monetary Fund). 2021. “Shifting Gears: Monetary Policy Spillovers During the Recovery from COVID-19.” In *World Economic Outlook*. April. Washington, DC: International Monetary Fund.

Istrefi, K. 2019. “In Fed Watchers’ Eyes: Hawks, Doves and Monetary Policy.” Working Paper 725, Banque de France, Paris.

Jacquier, E., N. Polson, and P. Rossi. 1994. “Bayesian Analysis of Stochastic Volatility Models.” *Journal of Business and Economic Statistics* 12 (4): 371–389.

Jarociński, M., and P. Karadi. 2020. “Deconstructing Monetary Policy Surprises: The Role of Information Shocks.” *American Economic Review: Macroeconomics* 12 (2): 1–43.

Kalemli-Özcan, S. 2019. “U.S. Monetary Policy and International Risk Spillovers.” Proceedings-Economic Policy Symposium-Jackson Hole, Federal Reserve Bank of Kansas City.

Kalemli-Özcan, S., and L. Varela. 2019. “Exchange Rate and Interest Rate Disconnect: The Role of Capital Flows and Risk Premia.” Conference Paper 127061, National Bureau of Economic Research.

Kaminsky, G. L., S. Lizondo, and C. M. Reinhart. 1998. “Leading Indicators of Currency Crises.” *IMF Staff Papers* 45 (1): 1-48.

Kearns, J., A. Schrimpf, and F. D. Xia. 2019. “Explaining Monetary Spillovers: The Matrix Reloaded.” Research Discussion Paper 2019–03, Reserve Bank of Australia, Sydney.

Kose, M. A., S. Kurlat, F. Ohnsorge, and N. Sugawara. 2017. “A Cross-Country Database of Fiscal Space.” Policy Research Working Paper 8157, World Bank, Washington, DC.

Kose, M. A., P. Nagle, F. Ohnsorge, and N. Sugawara. 2021. *Global Waves of Debt: Causes and Consequences.* Washington, DC: World Bank.

Kraay, A., and V. Nehru. 2006. “When Is External Debt Sustainable?” *The World Bank Economic Review* 20 (3): 341-365.

Kuttner, K.N., 2001. “Monetary Policy Surprises and Interest Rates: Evidence From the Fed Funds Futures Market. *Journal of Monetary Economics*: 47(3): pp.523-544.

Laeven, L., and F. Valencia. 2020. “Systemic Banking Crises Database: A Timely Update in COVID-19 Times.” CEPR Discussion Paper 14569, Center for Economic and Policy Research, Washington, DC.

Lenza, M. and Primiceri, G.E., 2022. “How to Estimate a Vector Autoregression After March 2020.” *Journal of Applied Econometrics.*

Manasse, P., and N. Roubini. 2009. “‘Rules of Thumb’ for Sovereign Debt Crises.” *Journal of International Economics* 782): 192-205.

Matheson, T. and Stavrev, E., 2014. “News and Monetary Shocks at a High Frequency: A Simple Approach.” *Economics Letters* 1252): 282-286.

Mishra, P., K. Moriyama, P. M. B. N'Diaye, and L. Nguyen. 2014. “Impact of Fed Tapering Announcements on Emerging Markets.” IMF Working Paper 14/109, International Monetary Fund, Washington, DC.

Nakamura, E., and J. Steinsson. 2018. “High Frequency Identification of Monetary Non-neutrality: The Information Effect.” *Quarterly Journal of Economics* 133 (3): 1283–1330.

Neely, C. J. 2015. “Unconventional Monetary Policy Had Large International Effects.” *Journal of Banking & Finance* 52 (March) 101–111.

Rogers, J. H., C. Scotti, and J. H. Wright. 2014. “Evaluating Asset-Market Effects of Unconventional Monetary Policy: A Multi-Country Review.” *Economic Policy* 29 (80): 749–799.

Romer, C.D. and D.H. Romer. 1989. “Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz.” *NBER Macroeconomics Annual*, 4, pp.121-170.

Romer, C. D., and D. H. Romer. 2004. “A New Measure of Monetary Shocks: Derivation and Implications.” *American Economic Review* 94 (4): 1055–84.

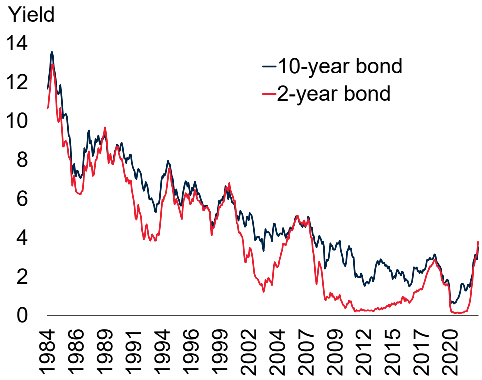
Takáts, E., and A. Vela. 2014. “International Monetary Policy Transmission,” BIS Working Paper 78, Bank for International Settlements, Basel, Switzerland.

U.S. Census Bureau. 2017. *X-13ARIMA-SEATS Reference Manual.* Washington DC: U.S. Census Bureau.

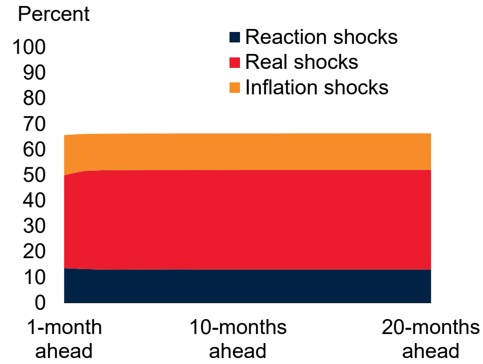
World Bank. 2022. *Global Economic Prospects*. January. Washington, DC: World Bank.

Figure 1: Interest rates in the United States

A. Government bond yields



B. Forecast error variance decomposition of 2-year bond yields, 1982-2022

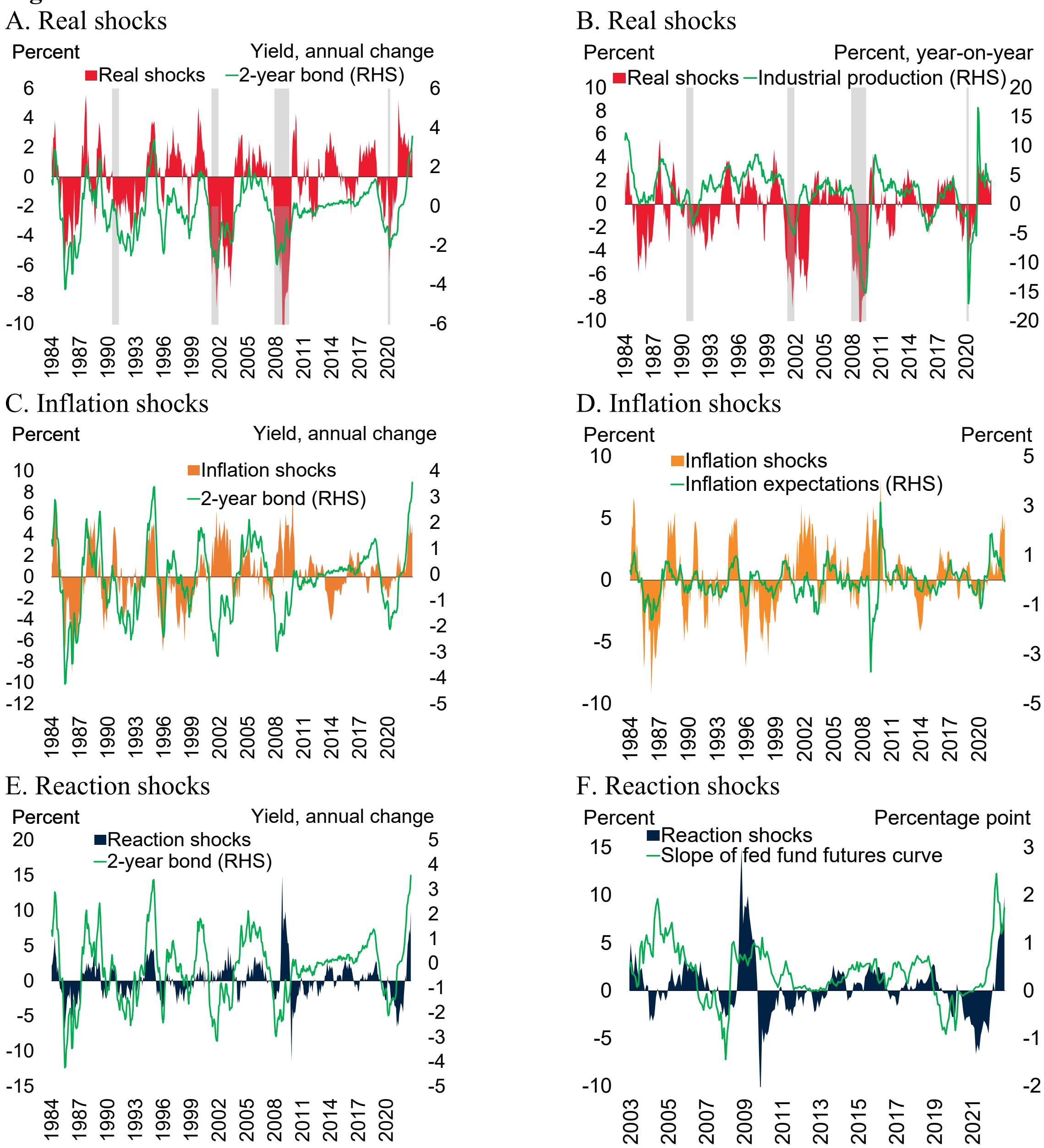


Sources: Federal Reserve Bank of St Louis; World Bank.

A. Last observation is September 2022.

B. Based on a sign-restricted Bayesian VAR model with stochastic volatility. The real shock is identified as one that raises both 2-year and 10-year interest rates, inflation expectations and equity prices. The inflation shock raises interest rates and inflation expectations but lowers equity prices. The reaction shock raises interest rates but lowers inflation expectations and equity prices. See section 2.1 for more details.

Figure 2: Interest rate shocks

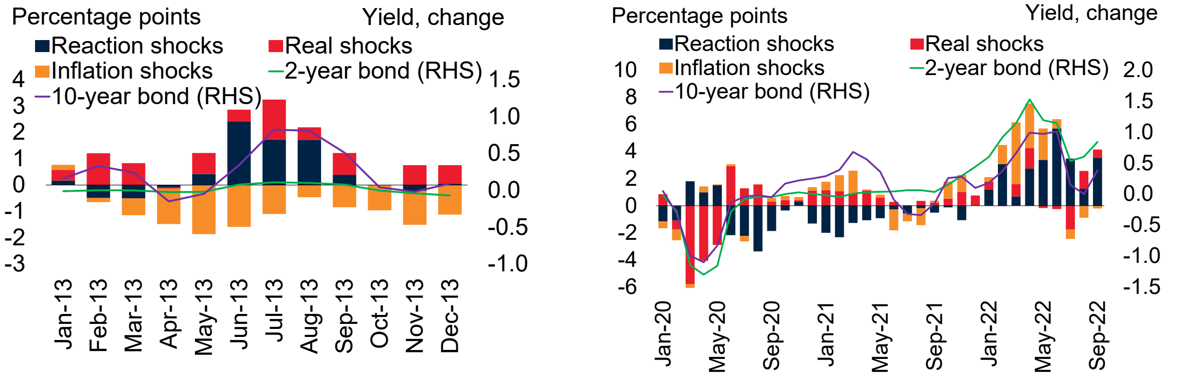


Sources: Bloomberg; Federal Reserve Bank of St Louis; Haubrich, Pennacchi, and Ritchken (2012); World Bank.
Notes: Figures reflect the year-on-year change in government bond yields. "Shocks" are 12-month moving averages of monthly shocks identified by the sign-restricted VAR model. Shaded area reflects NBER-dated recessions.
D. "Inflation expectations" reflect 5-year breakeven inflation rate from January 2003 and the 5-year inflation expectations measure of Haubrich, Pennacchi, and Ritchken (2012) prior.
F. "Slope of the federal funds futures curve" reflects the 2-year ahead USD overnight index swap less the current effective federal funds rate.

Figure 3: Shock decomposition during key episodes of sharp U.S. interest rates movements

A. Taper tantrum

B. COVID-19, war in Ukraine, and rising inflation



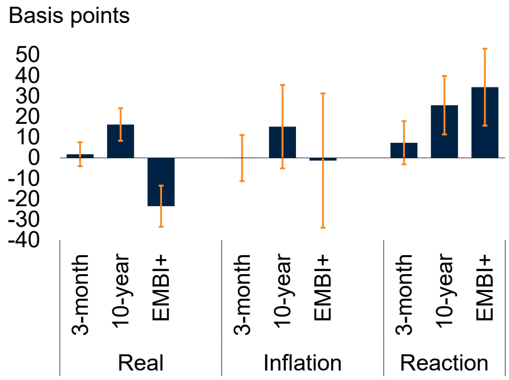
Sources: Federal Reserve Bank of St Louis; World Bank

Notes: Based on a sign-restricted Bayesian VAR model with stochastic volatility (see section 2.1 for more details). "Shocks" reflect 3-month moving sum of identified monthly shocks. Yields are 3-month-on-3-month changes.

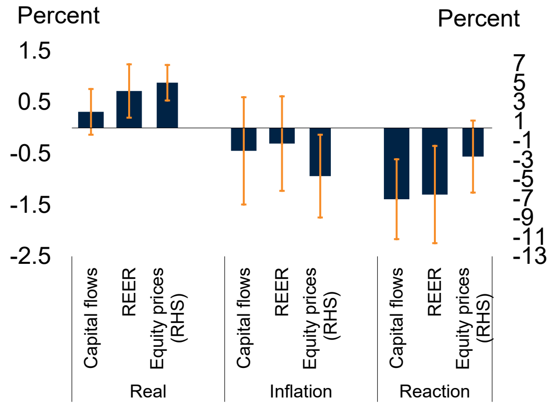
B. Last observation is September 2022.

Figure 4: Impact of U.S. interest rate shocks on EMDE financial markets

A. Impact of 25 basis point shock on EMDE interest rates after one quarter



B. Impact of 25 basis point shock on EMDE financial variables after one quarter



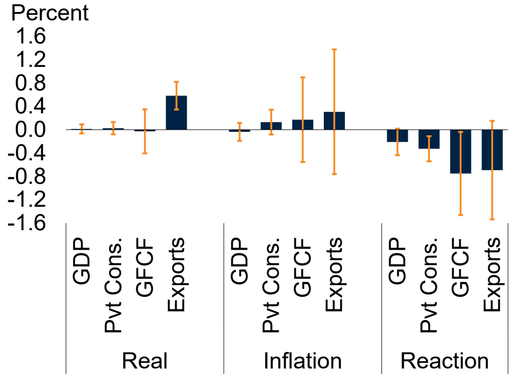
Source: World Bank

Notes: Panel local projection models with fixed effects and robust standard errors. See table A3 for details. Models estimated over periods as long as 1997Q2-2019Q4; they exclude observations during global financial crisis (2008Q4-2009Q4) and the COVID-19 pandemic. Bars reflect impact on first quarter (y_{t+1}). Orange whiskers reflect 90 percent confidence intervals. EMBI = emerging market bond index.

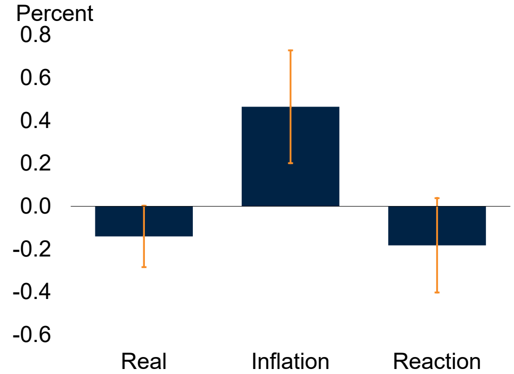
B. Positive "capital flows" values reflect an increase in net liabilities of portfolio and other investments as a percent of GDP for EMDEs. Positive "REER" values reflect an appreciation in the exchange rate. Figure excludes fixed exchange rate economies. REER = real effective exchange rate.

Figure 5: Impact of U.S. interest rate shocks on EMDE economic activity

A. Impact of 25 basis point shock on real GDP growth and components after one quarter



B. Impact of 25 basis point shock on consumer price inflation after one quarter.

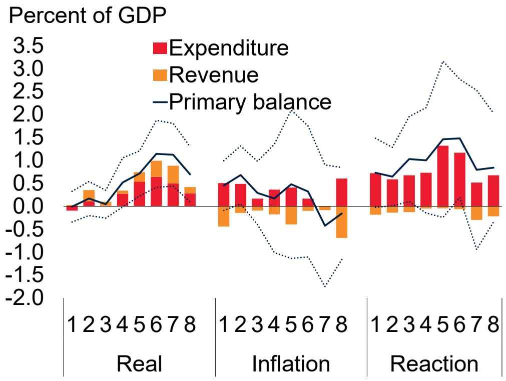


Source: World Bank

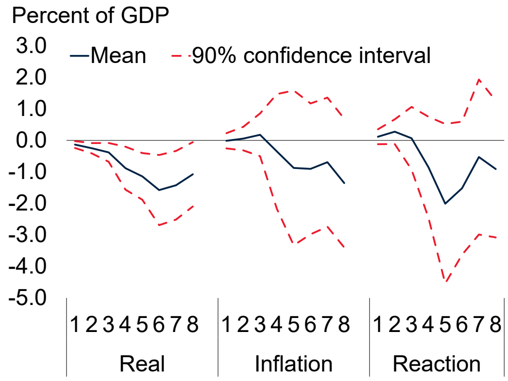
Notes: Panel local projection model with fixed effects and robust standard errors. See table A3 for details. Models estimated over periods as long as 1997Q2-2019Q4; they exclude observations during global financial crisis (2008Q4-2009Q4) and the COVID-19 pandemic. GDP = Gross domestic product; GFCF = Gross fixed capital formation; Pvt Cons = Private Consumption. Impact on first quarter (y_{t+1}). Orange whiskers reflect 90 percent confidence intervals.

Figure 6: Impact of U.S. interest rate shocks on EMDE fiscal variables

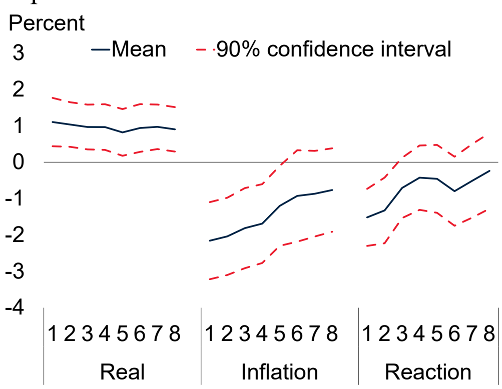
A. Impact of 25 basis point shock on primary balance over 8 quarters



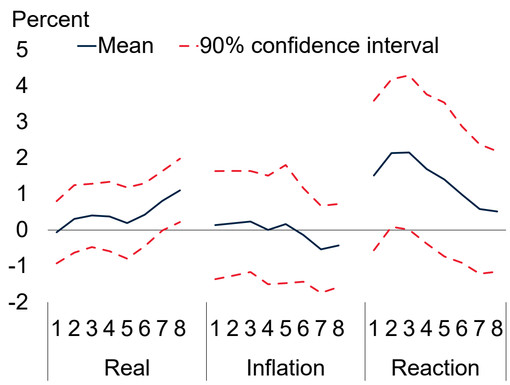
B. Impact of 25 basis point shock on gross government debt over 8 quarters



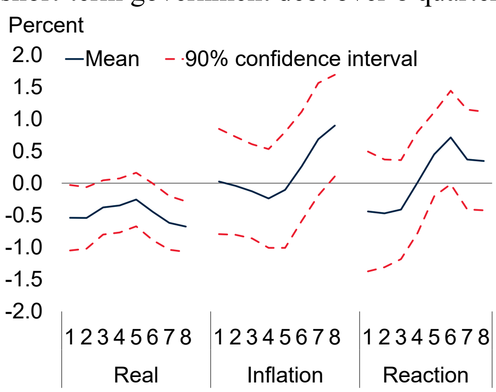
C. Impact of 25 basis point shock on the share of government debt held by external creditors over 8 quarters



D. Impact of 25 basis point shock on the share of foreign-currency government debt over 8 quarters



E. Impact of 25 basis point shock on the share of short-term government debt over 8 quarters



Source: World Bank

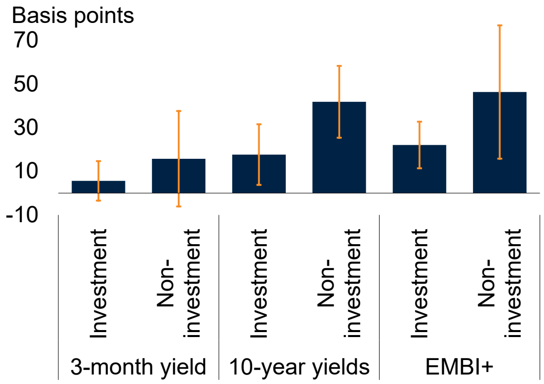
Notes: Panel local projection model with fixed effects and robust standard errors. See table A3 for details. Models estimated over periods as long as 1997Q2-2019Q4; they exclude observations during global financial crisis (2008Q4-2009Q4) and the COVID-19 pandemic.

A. "Expenditure" and "Revenue" reflect the mean response of each variable to the underlying shock. These responses come from separate models and may not add up to the change in the primary balance.

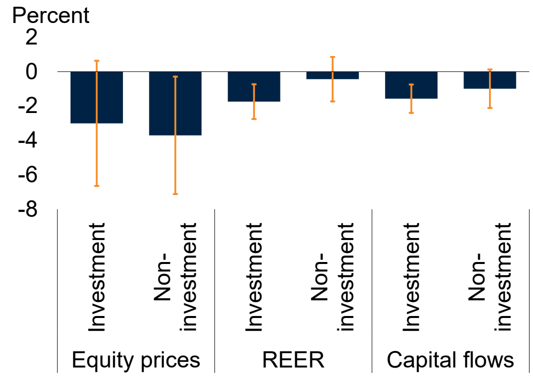
B. Reported as cumulative multiplier $(y_{t+h} - y_{t-1})$.

Figure 7: Impact of reaction shocks on EMDE financial and fiscal variables, by investment rate rating

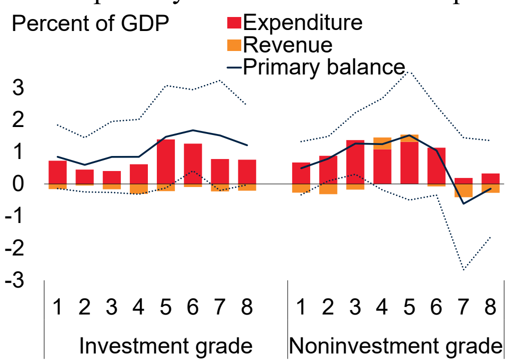
A. Impact of 25 basis point reaction shock on EMDE interest rates after one quarter



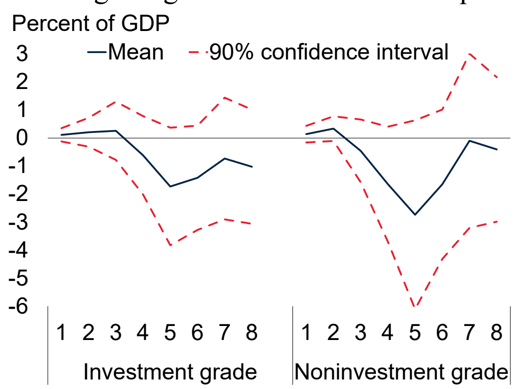
B. Impact of 1 percent reaction shock on EMDE short-term bond yields after one quarter



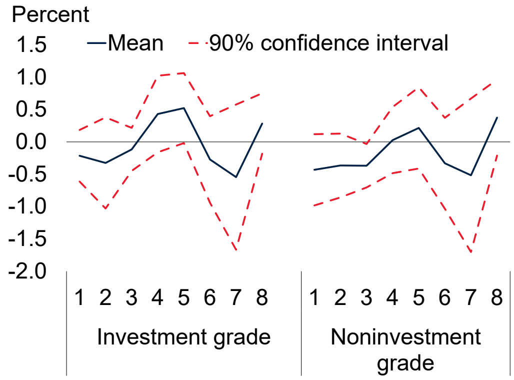
C. Impact of 25 basis point reaction shock on EMDE primary fiscal balance after 8 quarters



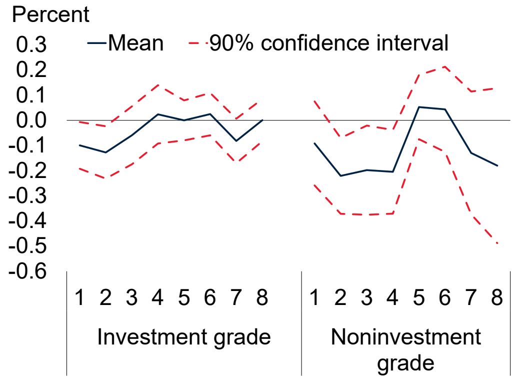
D. Impact of 25 basis point reaction shock on EMDE gross government debt after 8 quarters



E. Impact of 25 basis point reaction shock on EMDE real GDP after 8 quarters



F. Impact of 25 basis point reaction shock on EMDE consumer price inflation after 8 quarters



Source: World Bank

Notes: Panel non-linear local projection model with fixed effects and robust standard errors. Dotted lines reflect 90 percent confidence intervals. See table A3 for details. Models exclude observations during global financial crisis (2008Q4-2009Q4) and the COVID-19 pandemic. EMBI = emerging market bond index; REER = real effective exchange rate.

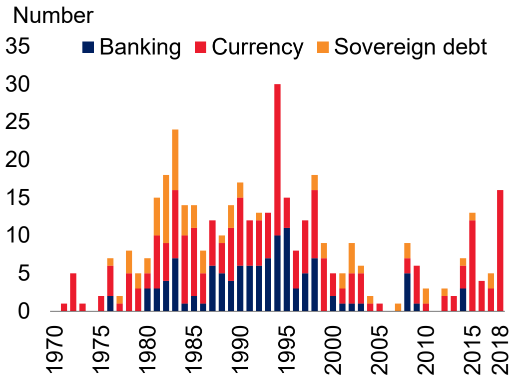
A.B. Impact on first quarter (y_{t+1}). Orange whiskers reflect 90 percent confidence intervals.

B. Positive values of capital flows reflect an increase in net liabilities of portfolio and other investments for EMDE. Positive values of the real exchange rate reflect an appreciation in the exchange rate.

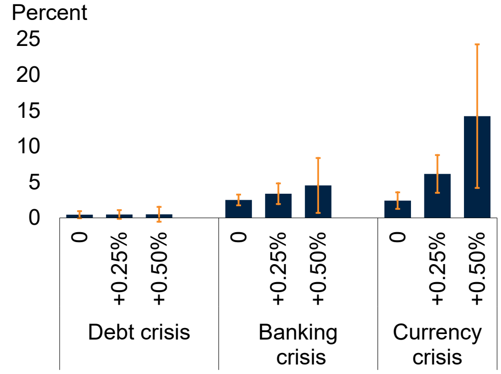
D. Reported as cumulative multiplier ($y_{t+h} - y_{t-1}$).

Figure 8: Crises in emerging market and developing economies

A. Frequency of crises



B. Likelihood of financial crises in response to reaction shock



Source: Laeven and Valencia (2020); World Bank.
Notes: Based on results from panel logit model with random effects.
B. "0" indicates the probability of a crisis in a given year when there is no change in the underlying shock and all other variables included in the regression are at their sample means. "+0.25%" and "+0.50%" indicate the crisis probabilities in the case of 25 and 50 basis point increase in the 2-year US treasury yield driven by the underlying shock. Orange whiskers reflect 95 percent confidence intervals.

Table 1: Crisis probability: Panel logit model with random effects

Explanatory variables	Debt crisis	Banking crisis	Currency crisis	Any crisis
Inflation shock	-0.012	-1.159	0.344	-0.327
	[2.502]	[0.780]	[1.131]	[0.984]
Reaction shock	0.301	1.245	4.528***	3.012***
	[2.813]	[1.030]	[1.309]	[1.113]
Real shock	-2.386**	-0.146	0.893**	-0.164
	[1.006]	[0.316]	[0.447]	[0.367]
GDP growth (t-1)	-0.214**	-0.041	-0.140***	-0.0545
	[0.093]	[0.032]	[0.047]	[0.0436]
Short-term debt (t-1)	-0.016	0.006	0.017	-0.016
	[0.048]	[0.014]	[0.019]	[0.018]
Debt service (t-1)	-0.004	0.016**	0.001	0.001
	[0.027]	[0.007]	[0.011]	[0.010]
Reserves cover (t-1)	-0.700**	-0.087*	-0.151*	-0.064
	[0.314]	[0.052]	[0.086]	[0.057]
Change in government debt (t-1)	0.007		0.042**	0.011
	[0.021]		[0.017]	[0.014]
Change in private debt (t-1)		0.063**	0.011	0.083**
		[0.030]	[0.047]	[0.036]
Change in government debt (t-1) x Change in private debt (t-1)			0.005* [0.003]	-0.001 [0.002]
Concessional debt (t-1)	-0.123**			-0.017*
	[0.061]			[0.009]
Funding ratio (t-1)		0.003**		0.002
		[0.001]		[0.002]
Currency overvaluation (t-1)			0.000	0.147***
			[0.001]	[0.026]
Currency mismatch (t-1)			-0.001	-0.000
			[0.001]	[0.001]
FDI (t-1)			0.001	-0.019
			[0.031]	[0.030]
Constant	-3.150**	-3.962***	-3.321***	-2.796***
	[1.532]	[0.362]	[0.643]	[0.625]
No. of observations	1,634	2,085	1,325	1,271
No. of countries	103	92	88	88

Estimated on annual data 1985-2018 excluding 2009. Standard errors in brackets. The coefficients on the real, inflation and reaction shocks reflect percent not percentage point. For example, a 25-basis-point increase in the 2-year U.S. bond yield driven by a reaction shock raises the probability of a currency crisis by over 100 percent, from 2.4 percent to 6.2 percent.
*** p<0.01, ** p<0.05, * p<0.1

Appendixes

A1. Literature review on U.S. monetary policy spillovers

There is a growing literature on how U.S. interest rates—and, in particular, U.S. monetary policy—spill over to EMDEs. This literature has attempted to understand both the types of shocks that drive changes in U.S. interest rates and the channels through which these occur as they affect EMDE conditions.

The literature identifying monetary policy shocks in the United States covers a variety of methods. It includes studies of financial market responses to central bank announcements, such as Bagliano and Favero (1999); Kuttner (2001); Gertler and Karadi (2015); Nakamura and Steinsson (2018; Cieslak and Schrimpf (2019); Jarociński and Karadi (2020); and Bu, Rogers, and Wu (2021). These papers examine high-frequency movements in data such as futures prices around FOMC announcements and other news events to identify monetary policy shocks. It also includes studies that use VAR models with various identification strategies, such as Bernanke (1986), Bernanke and Blinder (1988), and Christiano, Eichenbaum, and Evans (1996). These models rely on lower-frequency data and assumptions on the functioning of the economy to identify monetary policy shocks. Finally, the literature includes narrative methods such as Romer and Romer (1989, 2004) and Arouba and Drechsel (2022), which use official documents (and natural language processing thereof) to identify policy actions.

A substantial literature has also analyzed several channels of transmission (including financial, exchange rate, and risks channels) of monetary policy shocks—mainly but not exclusively U.S. policy shocks—on foreign financial markets and economies. Event studies that isolate FOMC surprises and estimate their impact on foreign markets through the financial channel include Rogers et al. (2014); Bauer and Neely (2014); Chen, Mancini-Griffoli, and Sahay (2014); Glick and Leduc (2015); Neely (2015); Chari, Stedman, and Lundblad (2017); Curcuru et al. (2018); Gilchrist, Yue, and Zakrajšek (2016, 2019); Hoek, Kamin, and Yoldas (2021, 2022); Ferrari, Kearns, and Schrimpf (2021); and Ha (2021). Kalemli-Özcan (2019), for example, focuses on the risk channel and finds that positive U.S. monetary policy shocks raise short-term government borrowing costs in EMDEs by affecting global investors' risk perceptions. In addition, Albagli et al. (2019) show that spillovers to long-term yields of EMDEs work mainly through risk premia. These results are corroborated in IMF (2021). Relatedly, Bruno and Shin (2015a,b), Brauning and Ivashina (2020), and others analyze monetary policy spillovers working through the bank lending channel.

Researchers have also examined how the vulnerability of EMDEs may affect their response to foreign monetary shocks. Chen et al. (2014), Mishra et al. (2014), Takáts and Vela (2014), Bowman et al. (2015), Ahmed et al. (2017), and Hoek, Yoldas, and Kamin (2021, 2022) all find that spillovers from U.S. monetary policy are smaller for countries with stronger fundamentals. Nonetheless, other studies find a limited role for fundamentals, including Eichengreen and Gupta (2015), Aizenman et al. (2016), and Kearns et al. (2019).

Most papers on spillovers to EMDEs of U.S. monetary policies have interpreted monetary "surprises"—that is, unexpected changes in U.S. interest rates—to be equivalent to monetary "shocks"—that is, changes in monetary policy that do not represent a response to changes in the U.S. macroeconomic environment. However, as noted by Nakamura and Steinsson (2018), Cieslak and Schrimpf (2019), and Jarociński and Karadi (2020), changes in interest rates in response to Fed announcements may reflect the market's interpretation of the motivation for those announcements, e.g., changes in prospects for economic activity, prospects for inflation, or shifts in the Fed's reaction function. Only a few papers have examined how differences in these types of shocks, as identified using financial market data, may lead to different spillovers to EMDEs.

Arteta et al. (2015) decompose daily movements in 10-year yields into two components: one reflecting real U.S. growth shocks and another reflecting U.S. monetary shocks (that is, both inflation and reaction shocks), based on a vector autoregressive (VAR) model with sign restrictions. The study then uses a panel VAR to show how these shocks impact EMDE indicators, finding that adverse U.S. monetary shocks lead to higher EMDE bond yields, lower equity prices, and weaker currencies, whereas positive U.S. real shocks raise EMDE equity prices and industrial production. Hoek, Yoldas, and Kamin (2021, 2022) categorize changes in U.S. Treasury yields around FOMC announcements as either real, inflation, or reaction shocks, based on the simultaneous movements in equity prices and inflation compensation in TIPS markets. They find that monetary surprises generated by rising inflation expectations have the greatest impact on EMDEs exchange rates, equity prices, bond yields, and CDS spreads, whereas real shocks are generally benign. IMF (2021) looks at the impact of U.S. employment and CPI releases on U.S. and EMDE financial conditions. Consistent with Arteta et al. (2015) and Hoek, Kamin, and Yoldas (2022), it finds that good employment releases that boost U.S. interest rates have benign effects on EMDEs, but unlike the previous studies, it finds little effect on EMDEs of inflation shocks.

Finally, rapidly rising borrowing costs amid elevated EMDEs debt levels, often in combination with other vulnerabilities, can result in financial crises. An extensive literature looks at the correlates of crises and finds that government debt—particularly, external debt—is an early warning indicator of financial crises (Kraay and Nehru 2006; Manasse and Roubini 2009). Kose et al (2020) find that rapid debt accumulation is often accompanied by financial crises. These crises can be very costly, with output 10 percent lower, on average, eight years after a debt crisis and the fiscal cost of resolving a banking crisis at 13 percent of GDP (Furceri and Zdzienicka 2012; Laeven and Valencia 2020).

In terms of the specific impact of rising interest rates on the probability of crisis, studies that link U.S. interest rates to crisis events include Kose et al. (2020) and Manasse and Roubini (2009). In Manasse and Roubini (2009), increases in the U.S. Treasury bill rate are usually observed in the years preceding a crisis. Kose et al. (2021) find that a 2-percentage-point increase in U.S. real interest rates increases the probability of entering a currency crisis the next year by almost 50 percent.

A2. VAR model estimation details

The VAR model used to decompose U.S. monetary policy shocks is a modified extension of that used in Matheson and Stavrev (2014) and Arteta et al (2015). The model is estimated using Bayesian techniques and the Minnesota prior with hyperparameters on the first lag coefficients at 0.8, on overall tightness at 0.1, on lag decay at 1.5, on the exogenous variable tightness at 100, and cross-variable weighting at 0.9. A total of 30,000 iterations are run, with the first 5000 discarded and only every 5th iteration kept. The model includes 12 lags. The prior autoregressive coefficient on the residual variance (i.e. stochastic volatility), is 0.85 and the prior's variance is 10000.

Since the period under review includes the COVID-19 crisis (whose unprecedented nature and size presents possible modeling challenges) and focuses on financial data (where heteroskedastic errors are common), the model includes stochastic volatility. Stochastic volatility in the error structure is modelled as in Jacquier, Polson, and Rossi (1994) and a generic version of what is suggested in Lenza and Primiceri (2022).

A3. Shock decomposition during other major episodes of U.S. interest rates movements

The main text reviews the evolution and spillovers from two major episodes of rising U.S. interest rates: the "taper tantrum" of 2013 and the most recent bout of monetary tightening this year. Below, several other such episodes are described.

A3.1. The "bond market turmoil" of 1994. In response to the 1990 recession and its aftermath, the Fed pushed the federal funds rate down to 3 percent by early 1993 (appendix figure A7). It stayed there for the next year, even as 2-year and 10-year bond yields moved somewhat lower on balance. By 1994, real GDP growth had strengthened but inflation remained quiescent and the unemployment rate, though moving down steadily, remained elevated at 6½ percent. Accordingly, the Fed's actions to hike the federal funds rate six times that year, taking it to 6 percent, caught markets by surprise and also triggered increases in inflation expectations. Treasury yields soared, which the structural VAR attributes mainly to inflation and reaction shocks. The U.S. corporate and municipal bond markets, reflecting structural weaknesses as well as the Fed's tightening, were thrown into turmoil, leading to the bankruptcy of Orange County.

The impact of these developments on EMDEs is well-known. Most prominently, higher interest rates and a flight from risk pushed Mexico, already weakened by political uncertainty and mounting macroeconomic imbalances, into devaluing the peso, triggering a severe financial crisis. In Argentina, as well, severe financial pressures put substantial pressure on the country's currency-board arrangement. More generally among EMDEs during later 1994 and 1995, currencies and equity prices declined, GDP growth fell, and inflation rose.

A3.2 The build-up to the global financial crisis. In the aftermath of the 2001 recession, the Fed had lowered the federal funds rate to only 1 percent by 2003, the lowest level since the 1950s. Subsequently, the Fed raised rates by 425 basis points between mid-2004 and mid-2006 as inflation picked up and the unemployment rate declined amid strengthening economic growth. Indeed, during 2004-06, real GDP expanded by an average of 3.4 percent, above estimates of potential growth. Treasury yields, and especially the 2-year yield, began rising before the Fed hikes and topped out around the same time, in 2006. The decomposition of changes in these yields indicates that all three types of shocks – real, inflation, and reaction—helped drive these increases, with none of them predominating for long.

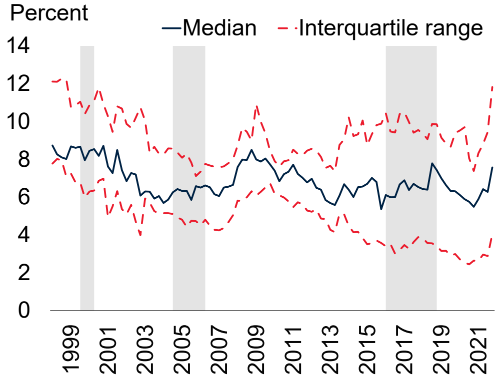
Impacts on EMDEs were generally benign. Focusing first on market impacts, domestic bond yields and EMBI spreads generally remained low or even declined, equity prices rose, and currencies appreciated. However, portfolio and banking flows to these economies slowed between mid-2005 and mid-2006 before surging in the leadup to the global financial crisis. The average share of total debt in GDP also flattened out and declined after early 2006, while the government primary balance moved higher into surplus. Although these trends seem suggestive of credit tightening in the wake of rising U.S. interest rates, they may reflect rising commodity prices and generally strong GDP growth in EMDEs during this period.

A3.3 The hiking cycle in the second half of the 2010s After many years of zero interest rates, the Fed started hiking policy rates in late 2015, and between November 2015 and January 2019 took them from zero to 2.5 percent. The tightening of monetary policy accompanied a recovery of inflation from very low rates in 2015 and early 2016, as well as continued declines in the unemployment rate. Accordingly, the decomposition analysis indicates that over this period, rising Treasury yields were predominantly driven by positive real and inflation shocks. However, positive reaction shocks were evident at two points in this cycle: in early 2016, when the Fed was perceived as being intent on raising rates despite volatility in global markets triggered by concerns about China's equity markets, and in later 2018, when the Fed continued to raise rates despite the economic slowing caused by U.S.-China trade tensions during the Trump administration.

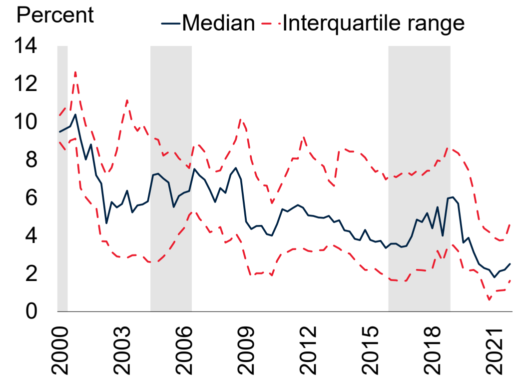
The impacts of these developments on EMDEs were in line with the shocks driving U.S. interest rates. As usual, these impacts were most evident in financial markets themselves. Both in early 2016 and later 2018, EMDE domestic yields rose, EMBI spreads widened, equities fell, and currencies depreciated. Capital flows were also relatively depressed in these periods (although they rebounded) in 2018Q4, as was GDP growth. Conversely, markets were more stable and capital flows larger during the intervening period, when real and inflation shocks predominated, and GDP growth was generally higher. It is more difficult to identify trends in debt or primary balances with debt gradually rising alongside small deficits on average among EMDEs. During this period, a number of major EMDEs suffered financial stress—this largely reflected domestic policy imbalances, even if rising interest rates probably contributed as well.

Figure A1: Financial data

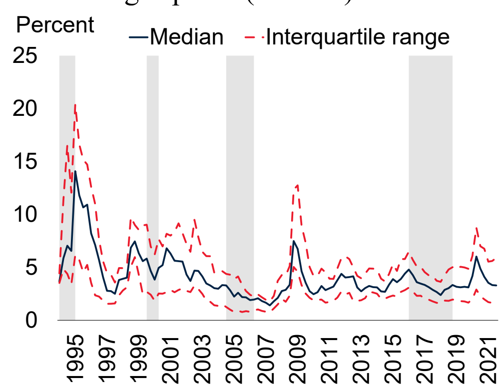
A. 10-year government bond yields



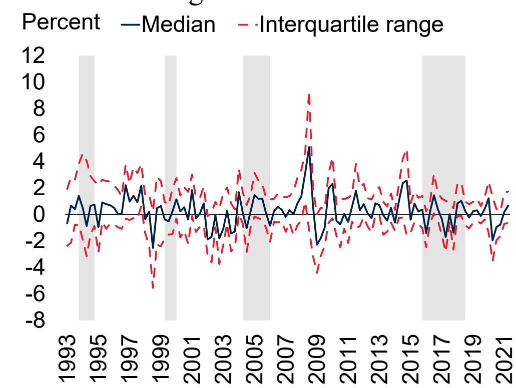
B. 3-month interest rates



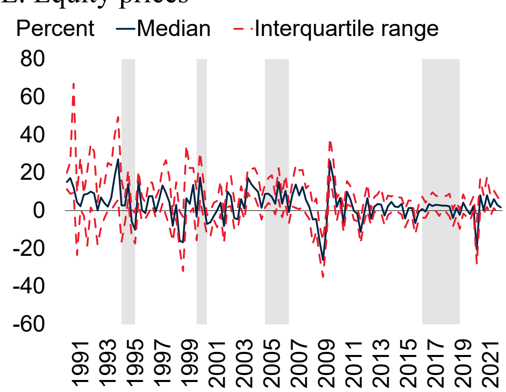
C. Sovereign spread (EMBI+)



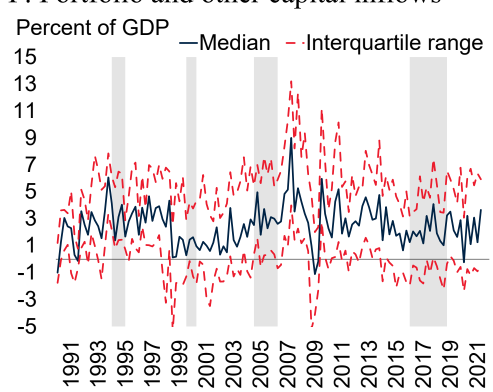
D. Real exchange rate



E. Equity prices



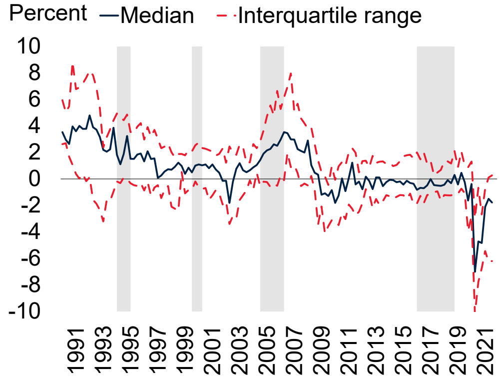
F. Portfolio and other capital inflows



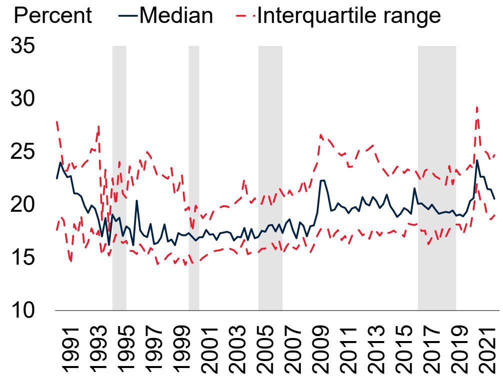
Source: Haver Analytics
Note: Shaded area reflects Federal Reserve hiking cycles.
A. Sample includes a maximum of 25 countries from 1995Q3 to 2021Q4.
B. Sample includes a maximum of 19 countries from 2000Q1 to 2021Q4.
C. Sample includes a maximum of 74 countries from 1994Q1 to 2021Q4. EMBI = emerging market bond index.
D. Year-on-year. Sample includes a maximum of 133 countries from 1993Q2 to 2021Q3.
E. Year-on-year. Sample includes a maximum of 55 countries from 1990Q1 to 2021Q4.
F. Sample includes a maximum of 103 countries from 1990Q1 to 2021Q2.

Figure A2: Fiscal data

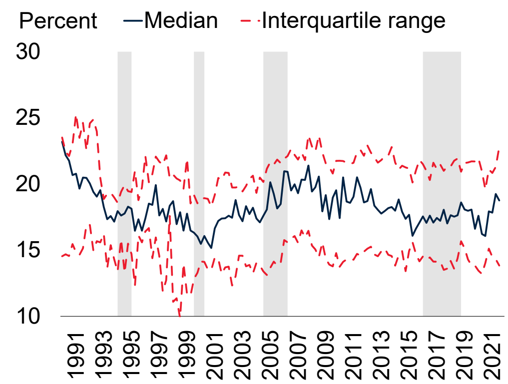
A. Primary balance to GDP



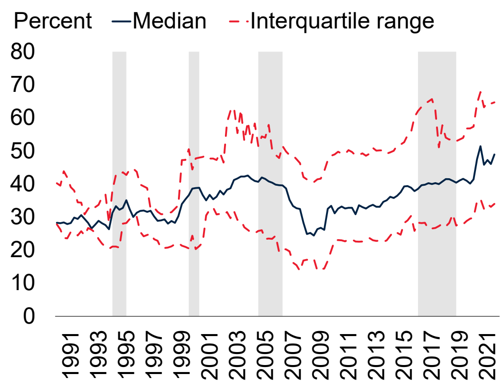
B. Expenditure to GDP



C. Revenue to GDP



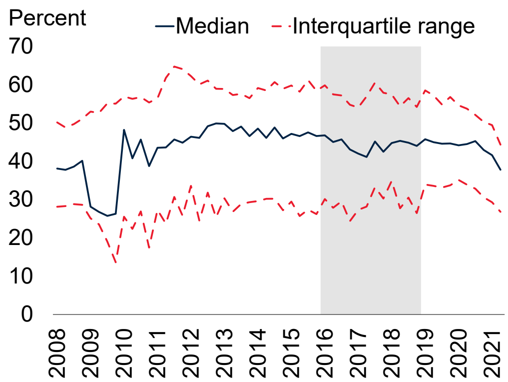
D. Gross debt to GDP



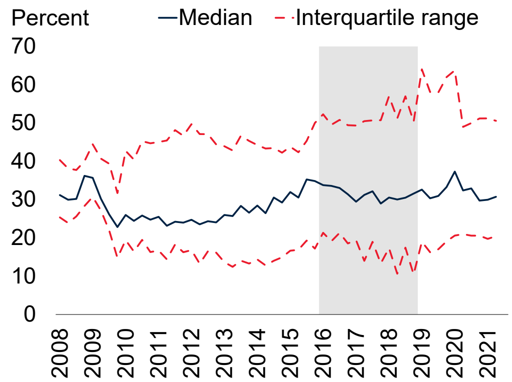
Source: Haver Analytics
Note: Shaded area reflects Federal Reserve hiking cycles.
A.B. Sample includes a maximum of 21 countries from 1990Q1 to 2021Q3.
C. Sample includes a maximum of 22 countries from 1990Q1 to 2021Q3.
D. Sample includes a maximum of 47 countries from 1990Q1 to 2021Q3.

Figure A3: Fiscal data

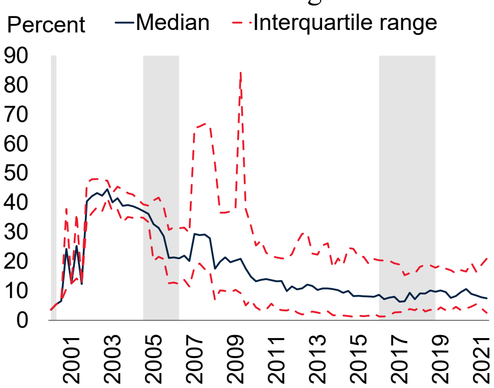
A. Government debt held by external creditors



B. Foreign-currency debt to total government debt



C. Short-term debt to total government debt



Source: Haver Analytics

Note: Shaded area reflects Federal Reserve hiking cycles.

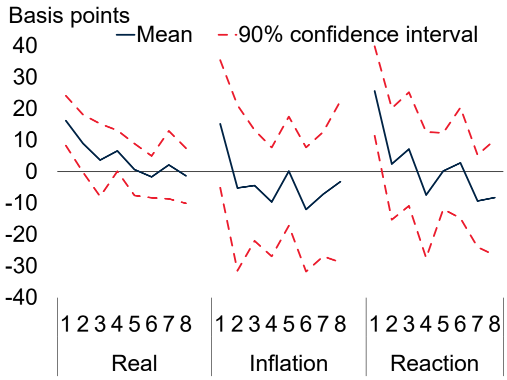
A. Sample includes a maximum of 25 countries from 2008Q1 to 2021Q2.

B. Sample includes a maximum of 20 countries from 2008Q1 to 2021Q2.

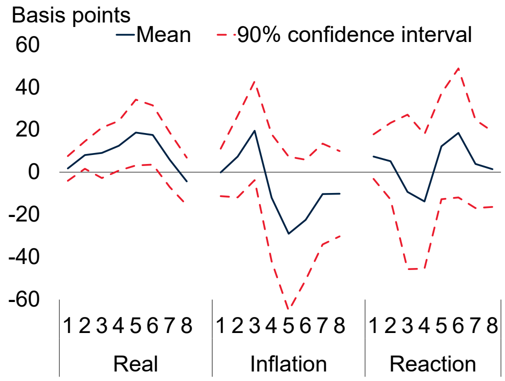
C. Sample includes a maximum of 43 countries from 2000Q1 to 2021Q2.

Figure A4: Impact of U.S. interest rate shocks on EMDE financial markets

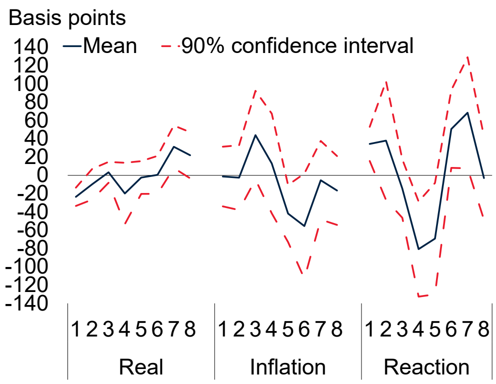
A. Impact of 25 basis point shock on 10-year bond yields



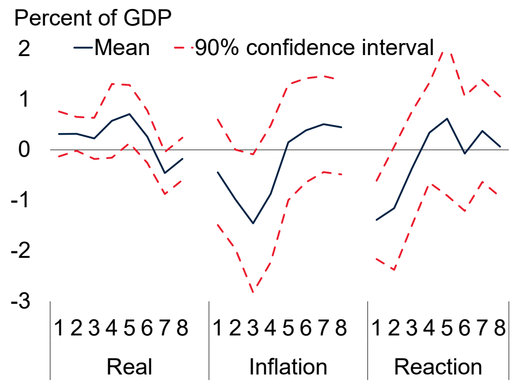
B. Impact of 25 basis point shock on 3-month bond yields



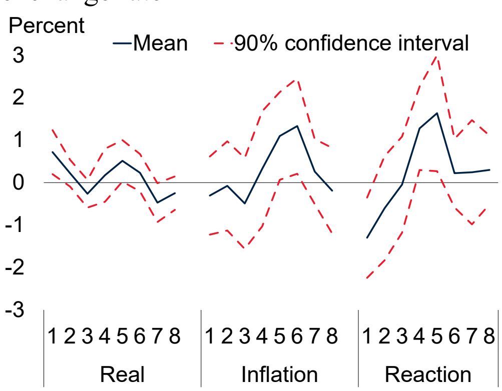
C. Impact of 25 basis point shock on sovereign risk spreads (EMBI+)



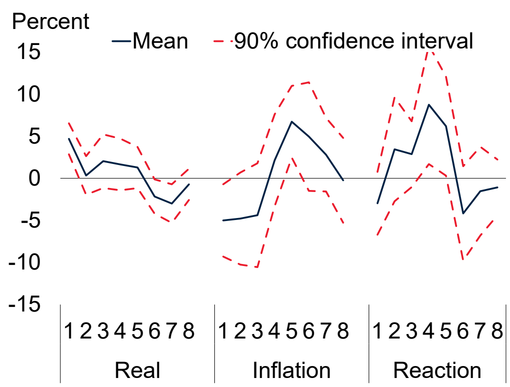
D. Impact of 25 basis point shock on capital inflows



E. Impact of 25 basis point shock on real exchange rate



F. Impact of 25 basis point shock on equity prices



Source: World Bank

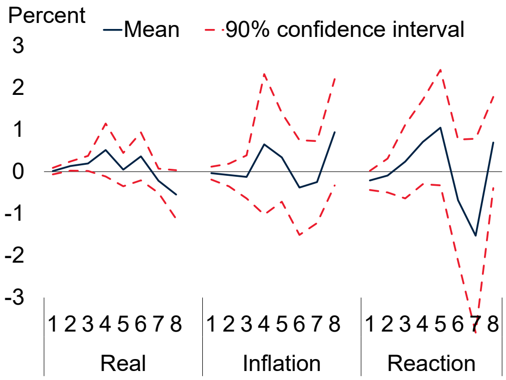
Notes: Panel local projection models with fixed effects and robust standard errors. See table A2 for details. Models estimated over periods as long as 1997Q2-2019Q4; they exclude observations during global financial crisis (2008Q4-2009Q4) and the COVID-19 pandemic. EMBI = emerging market bond index.

D. Positive values reflect an increase in net liabilities of portfolio and other investments for EMDE.

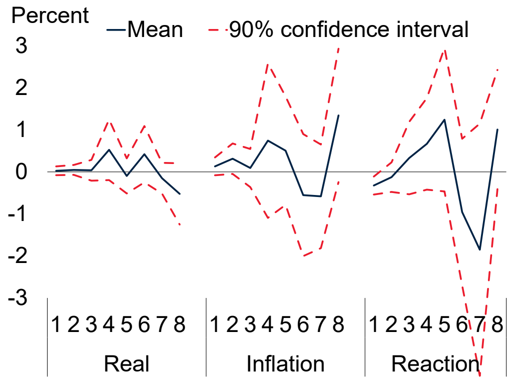
E. Positive values reflect an appreciation in the exchange rate. Figure excluded fixed exchange rate economies.

Figure A5: Impact of U.S. interest rate shocks on EMDE economic activity

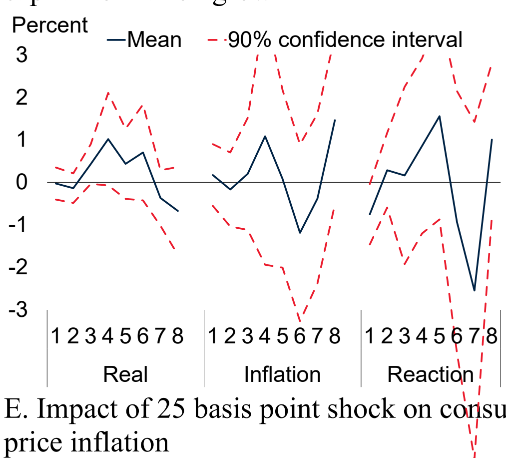
A. Impact of 25 basis point shock on real GDP growth



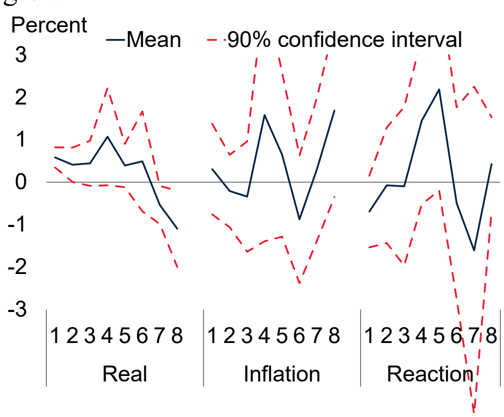
B. Impact of 25 basis point shock on private consumption expenditure growth



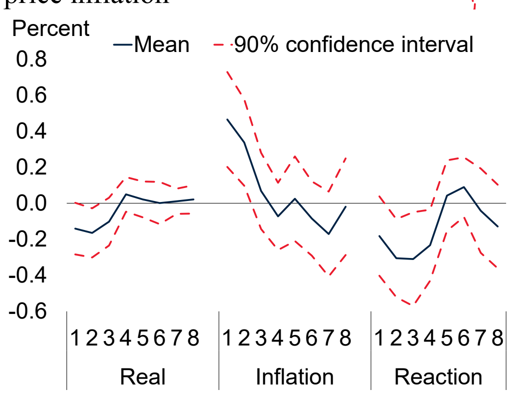
C. Impact of 25 basis point shock on gross fixed capital formation growth



D. Impact of 25 basis point shock on real export growth



E. Impact of 25 basis point shock on consumer price inflation

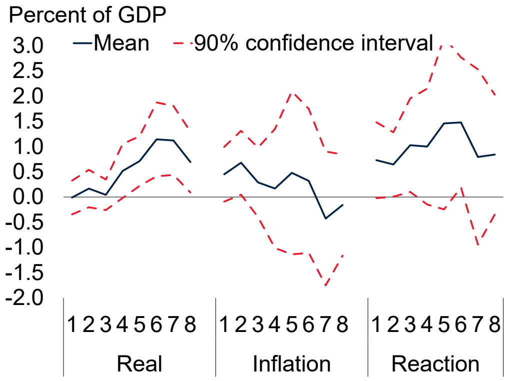


Source: World Bank

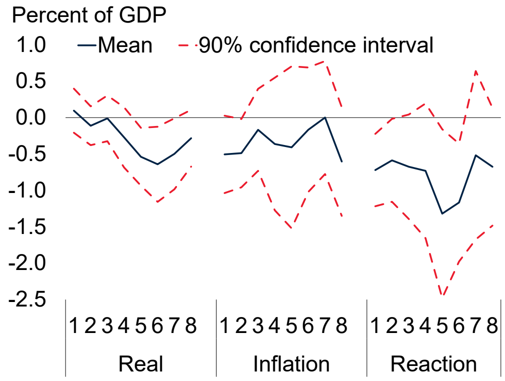
Notes: Panel local projection models with fixed effects and robust standard errors. See table A3 for details. Models estimated over periods as long as 1997Q2-2019Q4; they exclude observations during global financial crisis (2008Q4-2009Q4) and the COVID-19 pandemic.

Figure A6: Impact of U.S. interest rate shocks on EMDE fiscal variables

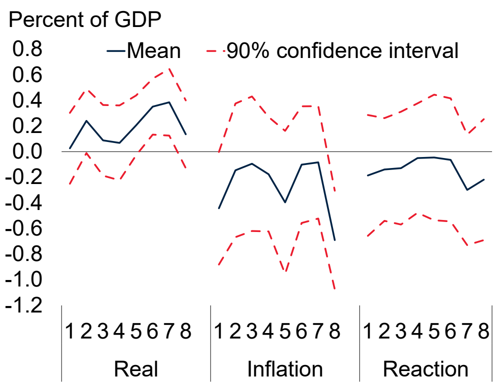
A. Impact of 25 basis point shock on primary balance



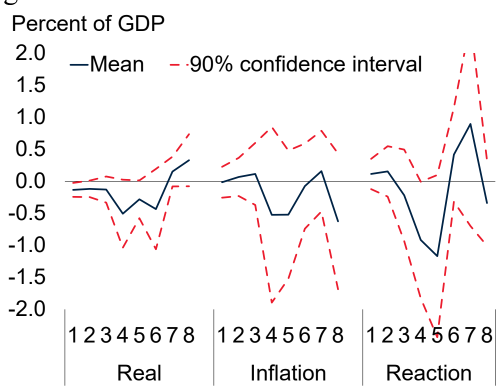
B. Impact of 25 basis point shock on government expenditure



C. Impact of 25 basis point shock on government revenue



D. Impact of 25 basis point shock on gross government debt

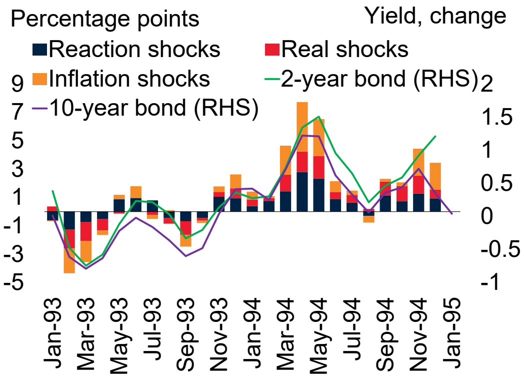


Source: World Bank

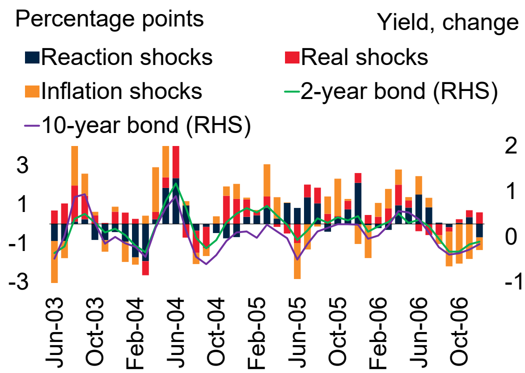
Notes: Panel local projection models with fixed effects and robust standard errors. See table A3 for details. Models estimated over periods as long as 1997Q2-2019Q4; they exclude observations during global financial crisis (2008Q4-2009Q4) and the COVID-19 pandemic.

Figure A7: Shock decomposition during key episodes of sharp U.S. interest rates movements

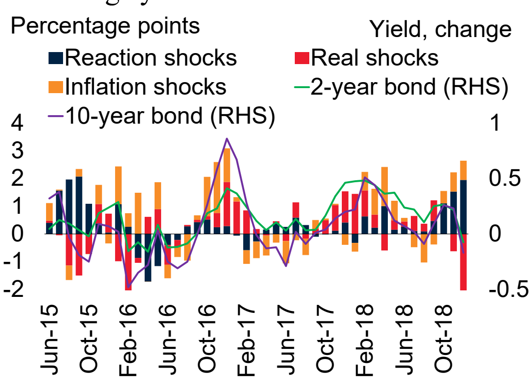
A. Bond market turmoil of 1994



B. Build-up to global financial crisis



D. Hiking cycle in second half of 2010s



Source: World Bank

Notes: Based on a sign-restricted Bayesian VAR model with stochastic volatility. "Shocks" reflect 3-month moving sum of identified monthly shocks. Yields are 3-month-on-3-month changes.

Table A1: Variables for sign-restricted VAR (monthly data)

Variable	Transformation	Source
2-Year treasury note yield at constant maturity	First difference	Haver Analytics
10-Year treasury bond yield at constant maturity	First difference	Haver Analytics
Standard & Poor's 500 Composite Index	Log first difference	Haver Analytics
5-Year inflation expectations (Jan 1982-Dec 2002)	First difference	Haubrich, Pennacchi, and Ritchken (2012)
5-Year breakeven inflation rate (5-year nominal Treasury yield less the 5-Year TIPS—inflation-protected—yield)	First difference	Federal Reserve Bank of St. Louis

Table A2: Variables for the panel local projection models (quarterly data)

Variable	Transformation	Source
Real GDP in local currency, seasonally adjusted	Log first difference	Haver Analytics
Real private consumption expenditure, seasonally adjusted	Log first difference	Haver Analytics
Real gross fixed capital formation, seasonally adjusted	Log first difference	Haver Analytics
Real exports, seasonally adjusted	Log first difference	Haver Analytics
Headline consumer price index, seasonally adjusted	Log first difference	Haver Analytics
Real effective exchange rate based on 120 trading partners deflated using consumer inflation, not seasonally adjusted	Log first difference	Darvas (2021); Haver Analytics
Portfolio (and other) investment liabilities to GDP	NA	International Monetary Fund
Stock market index	Log first difference	Haver Analytics
10-year local-currency government bond yield (or nearest maturity)	First difference	Haver Analytics
3-month interest rate (or nearest equivalent)	First difference	Haver Analytics
EMBI+ spread	First difference	J.P. Morgan
Primary balance (general government or central government) to GDP	NA	Haver Analytics
Revenue (general government or central government) to GDP	NA	Haver Analytics
Expenditure (general government or central government) to GDP	NA	Haver Analytics
Gross debt (general government or central government) to GDP	First difference	Haver Analytics; Quarterly Public Sector Debt Database, World Bank
Foreign-currency government debt as a ratio to total debt	NA	Quarterly Public Sector Debt Database, World Bank
Short-term (less than one year maturity) debt as a ratio to total debt	NA	Quarterly Public Sector Debt Database, World Bank
Debt held by external creditors as a ratio to total debt	NA	Quarterly Public Sector Debt Database, World Bank

Table A3: Samples by dependent variable in panel local projection model

Dependent variable	Total observations	Number of economies	Sample*	Control variables
Long-term yields	931	24	2000Q2-2019Q4	GDP, CPI, Portfolio inflows, Debt, REER, policy interest rate.
Short-term yields	768	19	1997Q4-2019Q4	GDP, CPI, Portfolio inflows, Debt, REER, policy interest rate.
EMBI+ spread	1257	32	1999Q4-2019Q4	GDP, CPI, Portfolio inflows, Debt, REER, policy interest rate.
Consumer price inflation	1538	36	1997Q2-2019Q4	GDP, Portfolio inflows, Debt, REER, policy interest rate
GDP	1542	36	1997Q2-2019Q4	CPI, Portfolio inflows, Debt, REER, policy interest rate
Real gross fixed capital formation	1165	24	1997Q2-2019Q4	CPI, Portfolio inflows, Debt, REER, policy interest rate
Real private consumption	1119	23	1997Q2-2019Q4	CPI, Portfolio inflows, Debt, REER, policy interest rate
Real Exports	975	22	1997Q2-2019Q4	CPI, Portfolio inflows, Debt, REER, policy interest rate
Capital flows	1547	36	1997Q2-2019Q4	GDP, CPI, Debt, REER, policy interest rate.
Real exchange rate	1200	21	1996Q3-2019Q4	GDP, CPI, Debt, Portfolio inflows, policy interest rate
Equity prices	1744	35	1994Q1-2019Q4	GDP, CPI, Debt, REER, Portfolio inflows, policy interest rate
Government debt	975	25	2000Q3-2019Q4	GDP, CPI, REER, Portfolio inflows, policy interest rate
Debt share held by external creditors	712	27	2001Q1-2019Q4	GDP, CPI, REER, Portfolio inflows, EMBI
Foreign-currency share to total debt	620	20	1999Q3-2019Q4	GDP, CPI, REER, Portfolio inflows, bond yield
Short-term share of total debt	609	20	1999Q3-2019Q4	GDP, CPI, REER, Portfolio inflows, bond yield
Primary balance	878	21	1999Q3-2019Q4	GDP, CPI, REER, Portfolio inflows, bond yield
Expenditure	959	22	1999Q2-2019Q4	GDP, CPI, REER, Portfolio inflows, bond yield
Revenue	959	23	1999Q3-2019Q4	GDP, CPI, REER, Portfolio inflows, bond yield

*Sample excludes 2008Q4-2009Q4. CPI = consumer price index; EMBI = emerging market bond index; REER = real effective exchange rate.

Table A4: Emerging market and developing economies included in panel local projection models

Albania*	Indonesia	Paraguay*
Argentina*	India	Qatar
Bahrain*	Jordan*	Romania
Belarus*	Kazakhstan	Russia
Brazil*	Sri Lanka*	Saudi Arabia
Chile	Morocco*	Serbia*
China	Mexico	South Africa*
Colombia	Macedonia*	Thailand
Dominican Republic*	Mongolia*	Türkiye *
Ecuador*	Malaysia	Uganda*
Egypt*	Nigeria*	Ukraine*
Georgia*	Peru	Vietnam*
Croatia*	Philippines	
Hungary	Poland	

* Indicates countries that are non-investment grade based on average ratings in 2019Q4.

Table A5: Variables for panel logit and probit models (annual data)

Variables	Definition	Source
Crisis dummy	Sovereign debt, banking, or currency crisis	Laeven and Valencia (2020)
GDP growth	Annual percentage growth rate of GDP at market prices based on constant local currency	WDI
Short-term debt	Share of short-term debt (with a maturity of 1 year or less) in external debt	WDI
Debt service	Ratio of debt service on external debt to exports	WDI
Reserve cover	International reserves in months of imports	IDS
Change in government debt	Percentage point change in public debt to GDP ratio	WEO
Change in private debt	Percentage point change in private debt to GDP ratio	GDD
Concessional debt	Share of concessional debt in external debt	IDS
Funding ratio	Ratio of credit provided to private sector to total deposits	GFDD
Currency overvaluation	Percentage deviation of real effective exchange rate from HP-filtered trend	Bruegel
Currency mismatch	Ratio of foreign liabilities to foreign assets	Lane and Milesi-Ferretti (2021)
FDI	Net inflows of foreign direct investment as a share of GNI	WDI

Table A6: Crisis probability: Panel probit model with random effects

Explanatory variables	Debt crisis	Banking crisis	Currency crisis	Any crisis
Inflation shock	0.052	-0.545	0.249	-0.252
	[1.181]	[0.351]	[0.537]	[0.472]
Reaction shock	0.355	0.568	2.095***	1.436***
	[1.377]	[0.459]	[0.612]	[0.534]
Real shock	-1.095**	-0.076	0.457**	-0.117
	[0.489]	[0.138]	[0.215]	[0.174]
GDP growth (t-1)	-0.104**	-0.020	-0.068***	-0.031
	[0.048]	[0.014]	[0.023]	[0.021]
Short-term debt (t-1)	-0.007	0.002	0.009	-0.008
	[0.023]	[0.006]	[0.009]	[0.009]
Debt service (t-1)	-0.002	0.007**	0.001	0.000
	[0.013]	[0.003]	[0.005]	[0.005]
Reserves cover (t-1)	-0.332**	-0.0358*	-0.076*	-0.033
	[0.150]	[0.021]	[0.039]	[0.026]
Change in government debt (t-1)	0.004		0.022**	0.005
	[0.011]		[0.009]	[0.007]
Change in private debt (t-1)		0.030**	0.009	0.041**
		[0.014]	[0.023]	[0.018]
Change in government debt (t-1) x Change in private debt (t-1)			0.003*	-0.000
			[0.002]	[0.001]
Concessional debt (t-1)	-0.055**			-0.008**
	[0.028]			[0.004]
Funding ratio (t-1)		0.002**		0.001
		[0.001]		[0.001]
Currency overvaluation (t-1)			0.000	0.075***
			[0.000]	[0.0119]
Currency mismatch (t-1)			-0.000	-0.000
			[0.000]	[0.000]
FDI (t-1)			-0.001	-0.013
			[0.016]	[0.016]
Constant	-1.710**	-2.119***	-1.764***	-1.503***
	[0.746]	[0.158]	[0.295]	[0.290]
No. of observations	1,634	2,085	1,325	1,271
No. of countries	103	92	88	88

Estimated on annual data 1985-2018 excluding 2009. Standard errors in brackets.
*** p<0.01, ** p<0.05, * p<0.1

Table A7: Crisis probability: Panel logit model with fixed effects

Explanatory variables	Debt crisis	Banking crisis	Currency crisis	Any crisis
Inflation shock	2.670	-1.094	1.054	-0.178
	[3.595]	[0.785]	[1.424]	[1.060]
Reaction shock	0.642	1.180	4.877***	3.197***
	[3.464]	[1.041]	[1.619]	[1.218]
Real shock	-2.879**	-0.104	1.296**	-0.233
	[1.299]	[0.318]	[0.571]	[0.387]
GDP growth (t-1)	-0.334**	-0.0260	-0.277***	-0.114**
	[0.167]	[0.033]	[0.082]	[0.055]
Short-term debt (t-1)	0.078	-0.007	0.055	-0.013
	[0.086]	[0.020]	[0.037]	[0.028]
Debt service (t-1)	-0.044	0.015	-0.033	-0.002
	[0.037]	[0.010]	[0.022]	[0.015]
Reserves cover (t-1)	-1.402*	-0.069	-0.213*	-0.123
	[0.754]	[0.077]	[0.130]	[0.096]
Change in government debt (t-1)	0.031		0.051	0.007
	[0.031]		[0.034]	[0.014]
Change in private debt (t-1)		0.059*	-0.003	0.111**
		[0.030]	[0.064]	[0.047]
Change in government debt (t-1) x Change in private debt (t-1)			0.008	-0.003
			[0.005]	[0.003]
Concessional debt (t-1)	0.054			-0.021
	[0.154]			[0.025]
Funding ratio (t-1)		0.003		0.015**
		[0.003]		[0.007]
Currency overvaluation (t-1)			0.133***	0.089***
			[0.031]	[0.022]
Currency mismatch (t-1)			-0.002	-0.000
			[0.001]	[0.001]
FDI (t-1)			-0.019	0.009
			[0.047]	[0.031]
No. of observations	123	1,229	490	555
No. of countries	8	49	30	37

Estimated on annual data 1985-2018 excluding 2009. Standard errors in brackets.
*** p<0.01, ** p<0.05, * p<0.1