CHAPTER 3

FINANCIAL SPILLOVERS OF RISING U.S. INTEREST RATES

The rapid rise in interest rates in the United States poses a significant challenge to emerging market and developing economies (EMDEs). As the Federal Reserve has pivoted toward a more hawkish stance to rein in inflation, a substantial part of the sharp increases in U.S. interest rates since early 2022 has been driven by shocks that capture changes in perceptions of the Fed's reaction function. These reaction shocks are associated with especially adverse financial market effects in EMDEs, including a higher likelihood of experiencing a financial crisis. Their effects also appear to be more pronounced in EMDEs with greater economic vulnerabilities. These findings suggest that major central banks can alleviate adverse spillovers through proper communication that clarifies their reaction functions. They also highlight that EMDEs need to adjust macroeconomic and financial policies to mitigate the negative impact of rising global and U.S. interest rates.

Introduction

The swift tightening of monetary policy in advanced economies, especially the United States, in response to high inflation poses grave challenges to emerging market and developing economies (EMDEs; figures 3.1.A and 3.1.B). Tight monetary policy by the Federal Reserve adversely affects EMDEs in several ways. It slows the U.S. economy, thereby diminishing imports from EMDEs and thus dampening their economic activity. The tightening of financial conditions in the United States and the associated increase in risk aversion spill over to EMDEs, leading to higher domestic interest rates and risk spreads as well as lower equity prices. Increases in U.S. interest rates also boost the cost of servicing dollar-denominated debt—both directly, by raising interest payments, and indirectly, by pushing up the foreign exchange value of the dollar, which increases the domestic-currency cost of repaying dollar debt. Currency depreciation may also exacerbate inflation, requiring additional monetary tightening by EMDE central banks.

These spillovers can heighten the likelihood of financial distress in EMDEs, especially in those with pre-existing vulnerabilities. Indeed, these developments have already contributed to financial strains and even default in several countries. EMDEs have become particularly exposed to rising global interest rates, as the COVID-19 pandemic gave 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).

Note: This chapter was prepared by Carlos Arteta, Steven Kamin, and Franz Ulrich Ruch. It is based and expands on Arteta, Kamin, and Ruch (2022).

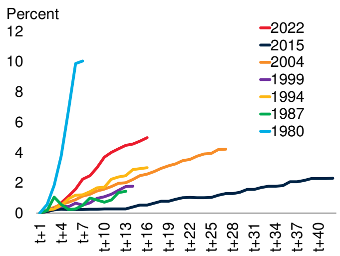
The effects of rising U.S. interest rates on EMDE financial conditions are likely to be particularly injurious because of their underlying cause. This chapter distinguishes between the effects of three different types of shocks that can boost U.S. interest rates: (1) inflation shocks, which are prompted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

Persistently high U.S. inflation, along with the Fed's pivot toward a more aggressive tightening stance, suggests that increases in U.S. interest rates over the past year and a half have been driven predominantly by inflation and reaction shocks. That said, the recent period of turmoil in the global banking sector has further complicated the path of U.S. monetary policy. If recent banking stresses were to intensify, the Fed could pause or even reverse its tightening of monetary policy. However, insofar as that reversal would reflect prospects of deteriorating economic conditions—essentially, a negative real shock to U.S. interest rates—it, too, would likely be associated with

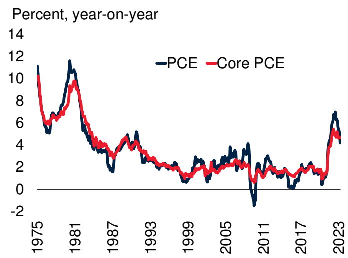
FIGURE 3.1 Recent financial developments in the United States and EMDEs

The Federal Reserve has embarked on its fastest and steepest hiking cycle to rein in high inflation since the early 1980s. This has resulted in adverse financial spillovers for emerging market and developing economies (EMDEs). These spillovers are particularly pronounced for countries with weaker credit ratings.

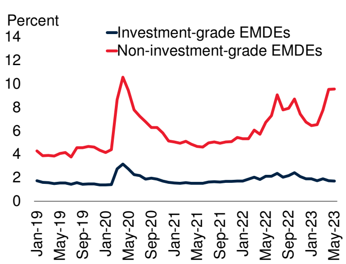
A. Federal Reserve hiking cycles, cumulative



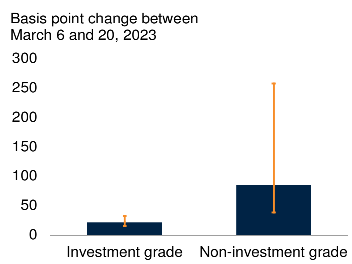
B. U.S. personal consumption expenditure inflation



C. Sovereign risk spreads



D. Change in EMDE CDS premia around advanced-economy bank failures



Sources: Bloomberg; Federal Reserve Bank of St. Louis; J.P. Morgan; Moody's Analytics; World Bank.

Note: EMDEs = emerging market and developing economies.

A. Based on the effective Federal Funds Rate. Monthly data. Last observation is May 2023.

B. PCE = personal consumption expenditure. Last observation is April 2023.

C. Sample includes 29 non-investment-grade and 15 investment-grade EMDEs based on Moody's long-term sovereign rating in foreign currency as of May 2023. Sample excludes Belarus, Ghana, Lebanon, the Russian Federation, Sri Lanka, Ukraine, and Zambia. Last observation is May 2023. Based on emerging market bond index global spreads.

D. Median change in 5-year U.S. dollar-denominated credit default swaps for 48 EMDEs, including 19 investment-grade and 29 non-investment-grade countries. Whiskers indicate interquartile range.

negative impacts on EMDEs. Although there is considerable uncertainty about future Fed policy action—with market participants assuming an earlier reversal of the tightening cycle than FOMC members do—most observers expect policy rates to remain elevated for some time. In particular, EMDEs with continued financial vulnerabilities and greater macroeconomic imbalances are likely to be more susceptible to the negative impacts of U.S. interest rate increases.

Against this backdrop, this chapter examines the effects of rising U.S. interest rates on financial conditions in EMDEs, including an analysis of the role of macroeconomic and financial vulnerabilities. The chapter also provides insights into the policy implications of these findings. In particular, it aims to answer the following questions:

- What mix of real, inflation, and reaction shocks have driven changes in U.S. interest rates in recent years?
- How do reaction shocks amid aggressive Fed policy affect EMDE financial conditions and the likelihood of financial crisis?
- Are EMDEs with lingering vulnerabilities and macroeconomic imbalances particularly prone to suffer the adverse effects of rising U.S. interest rates?
- What are the policy implications?

This chapter reports the following key findings. First, rising rates since the beginning of 2022 have been driven mainly by continued increases in inflation expectations and, especially, a perceived hawkish shift in the Fed's reaction function as it focuses on reining in inflation. These increases have been only slightly reversed since the onset of the banking stress amid prospects for weaker growth. Unless banking stresses were to intensify and become more widespread, Fed policy will most likely remain tight as inflation remains well above target and the Fed continues to reaffirm that returning inflation to target is its most urgent priority at present.

Second, this chapter 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 especially reaction shocks boost local-currency bond yields, widen sovereign risk spreads, depress equity prices, depreciate currencies, and dampen capital flows. Conversely, increases in U.S. interest rates driven by positive real shocks have relatively benign effects on EMDE financial markets.

Third, 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 shocks lead to only small changes in the likelihood of a crisis.

Fourth, more vulnerable EMDEs face more adverse impacts from reaction shocks. Economies with weaker credit ratings, higher sovereign risk spreads, and "twin" fiscal and current account deficits tend to experience greater financial market spillovers, including larger increases in local-currency long-term bond yields and sovereign risk premiums, as well as larger declines in equity prices. In fact, for any given increase in U.S. interest rates driven by reaction shocks, more vulnerable economies tend to experience local-currency yield increases that are almost twice as large. Financial crises are also more likely in economies with weaker credit ratings and macroeconomic imbalances.

Fifth, these findings, based on historical responses of EMDEs to changes in U.S. interest rates, are consistent with developments in EMDE financial markets in the past year and a half. Financial conditions in EMDEs with strong fundamentals and adept macroeconomic management have generally remained stable. Conversely, EMDEs with weaker fundamentals and less prudent fiscal and monetary policies, including so-called "frontier markets" and non-investment-grade countries, have experienced more pronounced financial downdrafts (figure 3.1.C).

Finally, the emergence of banking strains in the United States and Europe since March has led to some downshifting of the expected path of interest rates in these economies. In the case of the United States, this can be partly interpreted as a negative real shock to interest rates amid expectations of weaker U.S. growth. As noted above, positive real shocks pose generally benign effects on EMDEs; therefore, negative real shocks are likely to be adverse. As a result, the recent developments in the U.S. banking sector and associated declines in U.S. interest rates are unlikely to be helpful to EMDEs since the lower rates reflect diminished growth prospects and heightened risk aversion, and therefore could lead to reduced exports, dampened capital inflows, and disrupted financial markets for EMDEs. Indeed, when those banking strains materialized, EMDE credit spreads jumped—especially those in more vulnerable economies, such that those with non-investment-grade ratings (figure 3.1.D).

The analysis presented in this chapter makes several contributions to the literature on the determinants of U.S. interest rates and their spillovers to EMDEs:[1]

- It decomposes the evolution of U.S. interest rates since the onset of the COVID-19 pandemic into real, inflation, and reaction shocks in order to understand the evolving drivers of recent movements in U.S. interest rates.
- It extends the sample of EMDEs studied and employs a battery of econometric techniques to develop a full picture of the different channels through which U.S. interest rates affect EMDE financial markets.
- It examines how different types of U.S. interest rate shocks—real, inflation, and reaction—affect the likelihood of EMDE financial crises.
- It analyzes the influence of financial vulnerabilities and macroeconomic imbalances on the effects of U.S. interest rate movements on EMDEs.
- Finally, it discusses the practical implications of these results for policy makers.

Methodology and data

Each of the questions to investigate—the sources of shocks to U.S. interest rates, the effects of such shocks on EMDE financial markets, and their effects on the probability of crisis—requires analyzing different sets of data based on different modeling approaches. To that end, this chapter employs three distinct empirical methodologies (see the appendix for further details). First, to identify the mix of real, inflation, and reaction

[1] See Arteta, Kamin, and Ruch (2022) for a comprehensive literature review.

shocks that have been driving U.S. interest rates, the analysis applies a *sign-restricted Bayesian vector autoregression (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 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.

Differentiating between real, inflation, and reaction shocks

A key factor behind the effects of rising U.S. interest rates is the differentiation between inflation, reaction, and real shocks. Inflation shocks are defined as changes in interest rates that reflect changing prospects for inflation—for example, a disruption to supply chains that boosts inflation expectations would likely also boost interest rates. Reaction shocks are defined as changes in interest rates due to changing market perceptions of the Fed's reaction function—for example, if comments from a Fed official were to indicate an especially pronounced distaste for ongoing inflation trends, and such comments led markets to believe that the Fed would tighten policy by more than expected, the resultant rise in interest rates would be considered a reaction shock. Finally, real shocks are defined as changes in interest rates that are caused by changing prospects for U.S. economic activity—an example would be a rise in rates triggered by a new fiscal support program.

In large part, the changes in market interest rates described above reflect markets' expectations of how the Fed will adjust monetary policy. However, the analysis focuses on these rates—in particular, U.S. Treasury bond yields—rather than directly on Fed policy rate actions for two reasons. First, more than the overnight Federal funds rate that the Fed directly controls, it is longer-term rates that most directly affect economic agents. Second, economic developments may prompt changes in expectations of Fed policy that trigger changes in interest rates, even in the absence of immediate Fed actions.

The shocks to interest rates described above are identified using sign restrictions in a Bayesian VAR model that includes four variables: 2-year and 10-year U.S. Treasury bond yields, the S&P 500 index, and inflation expectations as measured (primarily) by breakeven inflation rates derived from inflation-protected Treasury bonds. The identification strategy is as follows:

- Inflation shocks are identified as those that raise U.S. yields and inflation expectations but reduce equity prices.
- Reaction shocks 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.
- Real shocks are identified as those that raise U.S. yields, inflation expectations, and U.S. equity prices.

Estimating the impact on EMDEs

Next, armed with the identification of the different types of U.S. interest rate shocks, the analysis then uses panel local projection models to assess the impact of these shocks on EMDE financial variables, including bond yields, sovereign spreads, equity prices, capital flows, and exchange rates. These models are estimated using data for up to 40 EMDEs from 1997Q1 to 2019Q4. The models also include control variables, which vary slightly depending on the dependent variable but generally include GDP, CPI, capital flows, government debt, the real exchange rate, and the policy interest rate in EMDEs.

Modeling financial crisis probability

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

Assessing the role of financial market vulnerabilities and macroeconomic imbalances

Finally, to further scrutinize the role of financial vulnerabilities and macroeconomic imbalances, the local projection and logit models are extended to take into account interactions between U.S. interest rate shocks and measures of EMDE vulnerability. First, EMDE responses are divided across creditworthiness, between investment grade and non-investment grade, using the average foreign-currency long-term sovereign debt rating by Fitch Ratings, Moody's, and Standard and Poor's (Kose et al. 2017). Second, EMDEs are divided into those with high (above median) and low sovereign risk spreads. Third, EMDEs are divided into those with both fiscal and current account deficits (twin deficits) and those without. Finally, frontier markets—those with less developed financial markets and more limited access to international capital markets—are compared with emerging markets.

Shocks to U.S. interest rates and impact on EMDE financial markets

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

This section explores how different shocks drove changes in U.S. Treasury yields during major episodes of sharp U.S. interest rate movements in the past decade. These episodes include the 2013 "taper tantrum"; the onset of the COVID-19 pandemic; and the response of the Fed to rising inflation since early 2022. The discussion is informed by the decomposition of movements in Treasury yields into the respective contributions of real, inflation, and reaction shocks.

The 2013 taper tantrum. In 2013, Fed Chairman Bernanke unexpectedly signaled that the Fed would soon 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 their yield rose significantly, by about 100 basis points—an event known as the taper tantrum. The 2-year bond yield rose little, likely indicating that the Fed was perceived as adjusting its unconventional policy but not expected to raise short-term rates for some time. Nearly all the initial increase in 10-year yields following Bernanke's remarks (through June 2013) was accounted for by reaction shocks (figure 3.2.A).

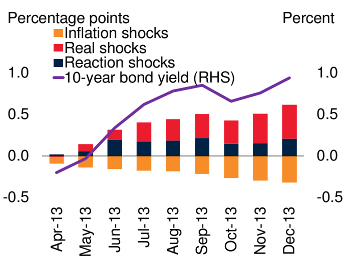
COVID-19. At the onset of COVID-19, economic activity collapsed, inflation declined, the Fed pushed the federal funds rate back to zero, and Treasury yields plummeted (figure 3.2.B). These developments are illustrated by the sizable negative real shocks that followed the emergence of the pandemic. Subsequently, by late 2020, 10-year yields rose, driven by the recovery in economic activity and inflation. The recovery, however, did not translate into higher 2-year yields, as in August 2020 the Fed announced a new monetary policy strategy that implied an extended period of low rates. Specifically, the Fed would seek to achieve inflation "that averages 2 percent over time" by aiming for inflation above its 2 percent target following periods of persistent inflation below 2 percent; it would also desist from tightening policy solely in response to tightening labor markets unless accompanied by evidence of inflationary pressures (Federal Reserve 2020). In part reflecting this dovish announcement, the analysis indicates mounting negative reaction shocks starting at about this time. However, in 2021, inflation started to rise above pre-pandemic levels, and, by September of the same year, 2-year yields began to increase in anticipation of Fed tightening (figure 3.2.B).

The Fed's response to rising inflation. By the start of 2022, it had become clear to the Fed that the surge in inflation was not transitory and would require a concerted response. The Russian Federation'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. Starting in March 2022, the Fed started raising policy rates briskly, and yields also rose precipitously, reflecting both rising inflation

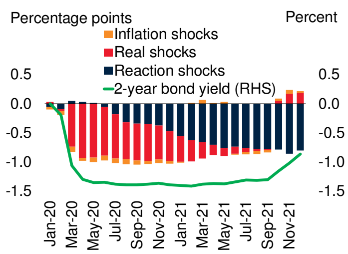
FIGURE 3.2 Decomposition of U.S. interest rates

During the 2013 taper tantrum, a substantial part of the initial increase in 10-year U.S. yields was accounted for by perceptions of a more hawkish stance by the Fed. At the onset of the COVID-19 pandemic, 2-year U.S. yields fell, first reflecting a collapse in activity and, subsequently, expectations of more dovish Fed policy. The current hiking cycle has predominately been driven by a perceived hawkish shift by the Fed. This cycle differs from all cycles since the mid-1980s, as it is mainly driven by reaction shocks, and it is also one of the most uncertain.

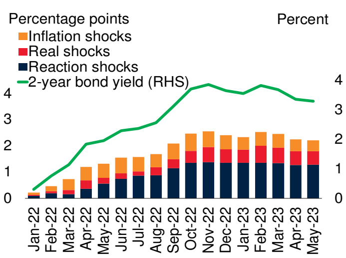
A. 2013 taper tantrum, cumulative



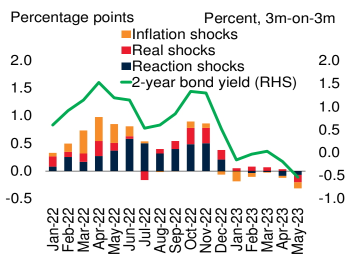
B. COVID-19 pandemic, cumulative



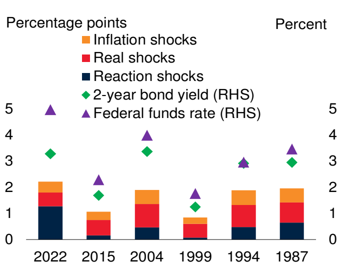
C. Current hiking cycle, cumulative



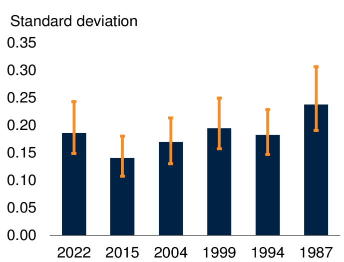
D. Current hiking cycle, change



E. Contributions of shocks during Fed hiking cycles, cumulative



F. Uncertainty in 2-year U.S. Treasury yields



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

Note: Based on a sign-restricted Bayesian VAR model with stochastic volatility. Inflation shocks are prompted by rising expectations of U.S. inflation. Reaction shocks are prompted by investors' assessments that the Federal Reserve has shifted toward a more hawkish stance. Real shocks are prompted by anticipation of improving U.S. economic activity.

A. Cumulative change in underlying shocks and yield.

B.C.D. Data for May reflects an average to the 15th of the month.

D. Figure reflects the 3-month change in the 2-year bond yield (for example, January to April) and underlying drivers.

F. Figure reflects average model-based volatility in 2-year yields during Fed hiking cycles. Orange whiskers reflect 95 percent confidence intervals.

expectations as well as a reassessment of the Fed's reaction function as being more hawkish than previously believed (figure 3.2.C). Since January 2022, and over the course of the current hiking cycle, reaction and inflation shocks have accounted for three-quarters of the explained cumulative increase in yields.

By early 2023, yields flattened out and estimated shocks to interest rates fell as markets anticipated the Fed's tightening cycle to end soon (figure 3.2.D). Then, in early March, yields declined as markets came to expect the Fed to soon reverse some of its tightening in response to U.S. bank stress. Subsequent declines appear to have reflected negative real and inflation shocks as expectations of U.S. growth slowed.

The current hiking cycle is different from most hiking cycles since the mid-1980s (figure 3.2.E). First, it is the steepest and fastest hiking cycle in nearly four decades, given inflation outcomes not seen since the early 1980s. Since early 2022, the Fed increased its policy rate by 500 basis points. In contrast, the hiking cycle that started in 2015 was about half the size but took almost four times as long, while the 2004 hiking cycle was about equal in size but twice as long. Second, the underlying drivers of the 2022 hiking cycle are different from all cycles since the mid-1980s. The 1987, 1994, 1999, 2004, and 2015 hiking cycles were prominently a response to expectations of firming economic activity. The current hiking cycle, however, has mainly been driven by reaction shocks as the Fed has pivoted toward more aggressive action.[2] Finally, the current hiking cycle is one of the most uncertain (as measured by the volatility of 2-year U.S. yields) since that of the late 1980s (figure 3.2.F).

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

In the initial pandemic-related turmoil of March 2020, all gauges of EMDE financial markets—

[2] The large role of reaction shocks in the current tightening cycle in large part reflects the Fed's delay in responding to rising inflation. Had the Fed started tightening in the second half of 2021, 2-year bond yields would have risen sooner, and the methodology would likely have estimated a much larger role for inflation shocks and a smaller role for reaction shocks.

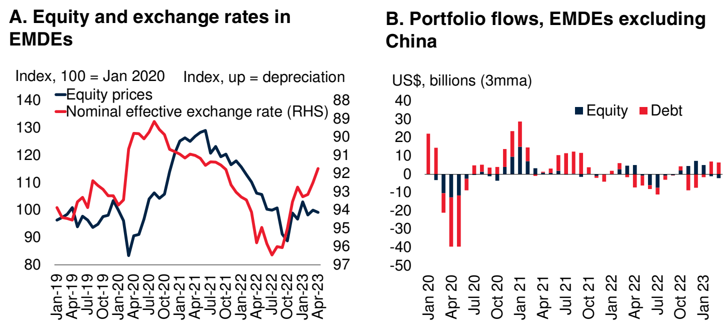
currencies, bond valuations, and equities—collapsed and then, following accommodative actions by the Fed and other major central banks, steadily improved through the first half of 2021 (figure 3.3.A). At that point, EMDE financial markets generally plateaued. After September 2021, they began to deteriorate to various degrees, when anticipations of Fed tightening mounted and shorter-term 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 (figure 3.3.B). Bond issuance in the first quarter of 2022 across EMDEs was weaker than in any first quarter since 2016. The invasion of Ukraine in March 2022 saw equity and debt flows to EMDEs turn sharply negative, while EMDE financial conditions deteriorated further through much of the year, reaching their tightest level since the start of the pandemic.

Since late 2022, financial conditions in EMDEs have remained tight but have eased somewhat, aided by declines in U.S. inflation that signaled an eventual end to the Fed's tightening cycle and, as a related matter, a decline in the value of the U.S. dollar since its peak last year. Portfolio debt and equity flows to EMDEs picked up in 2023, albeit predominantly because of optimism regarding China's reopening. However, following the stress in the U.S. and European banking sectors that began in March, EMDE credit spreads ratcheted up but remain well below their early 2020 levels.

How well do developments in EMDEs since the pandemic conform to the historical experience of spillovers from U.S. reaction shocks? To address this question, this section compares the effects on financial variables in EMDEs, as estimated using local projections models, of the U.S. interest rates shocks identified by the VAR analysis described above. Figures 3.4A and 3.4B describe the impact of a 25-basis-point shock—real, inflation, or reaction—to U.S. 2-year bond yields on EMDE variables.[3] The size of the shock corresponds to

FIGURE 3.3 EMDE financial developments since the onset of the pandemic

At the onset of the pandemic, key gauges of financial markets in emerging market and developing economies (EMDEs) initially worsened markedly. Following accommodative actions by the Fed and other major central banks, EMDE financial markets steadily improved throughout the first half of 2021. However, as U.S. interest rates began to rise toward the end of that year, EMDE financial markets began to deteriorate. The onset of the invasion of Ukraine was accompanied by a further deterioration in EMDE capital flows.



Sources: Haver Analytics; IIF (database); J.P. Morgan.
Note: EMDEs = emerging market and developing economies.
A. "Equity prices" is the Morgan Stanley Capital International (MSCI) index for emerging markets. "Nominal effective exchange rate" is based on J. P. Morgan's nominal broad effective exchange rate for emerging markets. Last observation is April 2023.
B. 3mma = 3-month moving average. Figure shows debt and equity nonresident portfolio flows for 25 EMDEs excluding China. Last observation is March 2023.

roughly a one standard deviation monthly move in the 2-year yield as measured since the 1980s.

Increases in U.S. interest rates driven by reaction shocks are associated with adverse movements in EMDE financial markets. This includes significant increases in 10-year yields and sovereign spreads (EMBI), declines in capital flows, and depreciation of real exchange rates. 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, depreciating real exchange rates, 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. Ten-year government bond yields rise, but this is to be expected, since bond markets are integrated

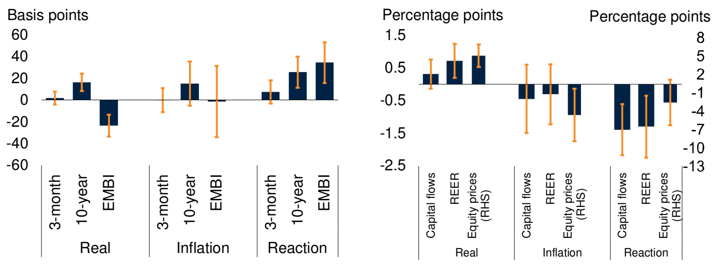
[3] The terms "25-basis-point increase in interest rates driven by an inflation shock," "25-basis-point inflation shock," and "inflation shock" are used interchangeably in this section. This is also true of real and reaction shocks. U.S. interest rates reflect changes in 2-year bond yields.

FIGURE 3.4 Impact of U.S. interest rate shocks on EMDE financial markets

Increases in U.S. interest rates driven by real shocks are generally benign for emerging market and developing economies (EMDEs). In contrast, inflation and, particularly, reaction shocks are associated with adverse impacts on EMDEs, such as rising borrowing costs and risk spreads, capital outflows, depreciating currencies, and falling equity prices.

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



Sources: Haver Analytics; J.P. Morgan; World Bank.

Note: Panel local projection models with fixed effects and robust standard errors. See table 3.2 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. Blue bars reflect estimated impact in first quarter (y_{t+1}). Orange whiskers reflect 90 percent confidence intervals.

A. EMBI = emerging market bond index. Based on EMBI global spreads.

B. REER = real effective exchange rate. 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.

globally, and the bond yields of advanced economies tend to move together closely as well.

In summary, the dislocations in EMDE financial markets experienced during the Fed's most recent tightening cycle are consistent with the predictions of the estimated models.

Correlates of financial crises

This section describes the findings of a logit model used to assess the effects of real, inflation, and reaction shocks to U.S. interest rates on the likelihood of financial crisis in EMDEs. 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 (an "any crisis" model is also estimated).[4] The dependent variable is a dummy equal to one when there is a crisis and 0 otherwise.

The results suggest that reaction shocks exert large and significant effects on the likelihood of EMDE financial crises within one year, especially currency crises (figure 3.5.A; table 3.1).[5] By comparison, inflation shocks are associated with only small and insignificant effects. Real shocks reduce the likelihood of EMDE debt crises, consistent with their benign effects on financial markets, and perhaps reflecting their positive implications for EMDE exports and capital inflows; while they raise the likelihood of currency crises, they do so by much less than reaction shocks.

In the average EMDE, the probability of facing a crisis of any type in any one year (when the explanatory variables are at their sample mean) from 1985 to 2018 was 3.5 percent. 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 (figure 3.5.B).

In the 12 months ending in mid-May 2023, reaction shocks accounted for a 72-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 increased 15 percentage points, to about 19 percent, assuming all other variables remain at their sample averages; in particular, the probability of a currency crisis jumped to 26 percent (figure 3.5.C). This large increase is explained by the non-linear relationship between the interest rate shock and the probability of financial crisis: a doubling of the interest rate shock leads to a more-than-doubling of the rise in the crisis probability.[6]

[4] 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, accompanied by substantial 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).

[5] The greater effect of reaction shocks on the likelihood of currency crises compared with debt or banking crises may reflect that currency crises are more common.

[6] This non-linearity flows from the use of the logistic 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.

To be sure, a very large confidence interval must be placed around the estimate, as no rise in yields as large and fast as what took place in 2022 occurred during the 1985-2018 estimation period. That said, there have indeed been various incidences of financial stress in 2022, with six EMDEs experiencing full-fledged currency crises (based on the definition in Laeven and Valencia 2020), several governments defaulting on their debts, and 21 EMDEs reaching agreements with the IMF for additional financing (figure 3.5.D).

Role of EMDE vulnerabilities and macroeconomic imbalances

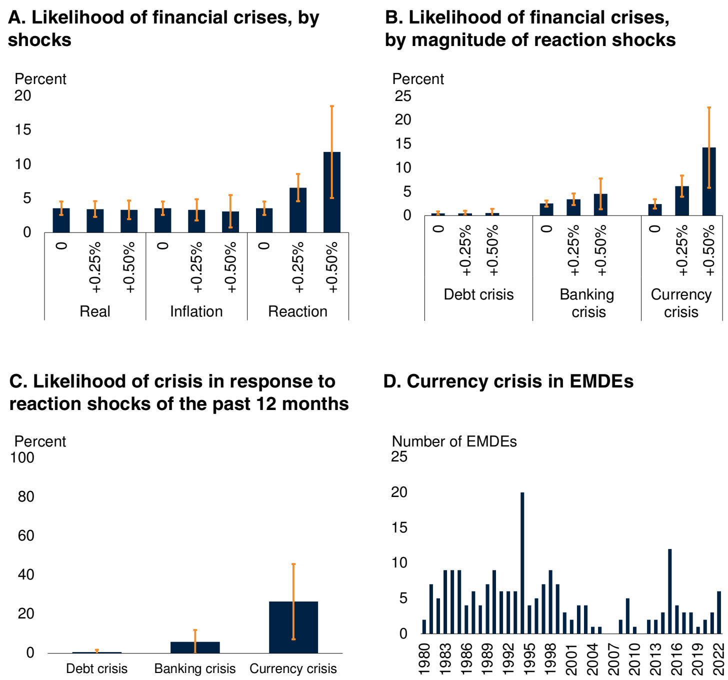
Recent indications of EMDE financial distress have been somewhat less widespread and pronounced than might have been expected, given aggressive Fed tightening driven by reaction shocks. While the number of EMDE financial crises, and especially currency crises, has somewhat increased in recent years, it remains well below levels reached in earlier decades. Particularly in many middle-income EMDEs, credit spreads have remained contained. This likely reflects their stronger economic management, which has reduced susceptibility to external shocks; additionally, international investors may have become better at distinguishing between credit risks in different EMDEs. Some EMDEs have also benefitted from still-elevated commodity prices.

Conversely, many poorer and less structurally sound EMDEs have been harder hit by the combination of increased debt levels and higher interest rates, with almost 60 percent of low-income countries judged to be either in or at high risk of debt distress (Chelsky 2021; World Bank 2022). Indeed, sovereign risk spreads rose faster in EMDEs with weaker credit ratings (figure 3.6.A). And since the end of 2021, there has been a surge in the number of EMDEs with sovereign spreads exceeding 10 percentage points, a benchmark suggesting loss of market access and an elevated likelihood of default (figure 3.6.B). This is consistent with a widely held view that more vulnerable economies are more likely to exhibit adverse responses to higher U.S. interest rates and tighter global financing conditions than more resilient economies.[7]

More generally, the fact that credit spreads for non-investment-grade EMDEs rose more sharply

FIGURE 3.5 Financial crises in EMDEs

Reaction shocks significantly raise the probability of financial crisis—in particular, currency crisis—in emerging market and developing economies (EMDEs). In particular, the reaction shocks seen in the past twelve months have substantially boosted the likelihood of a currency crisis. This follows a number of full-fledged EMDE currency crises seen in 2022.

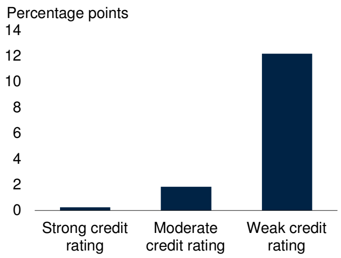


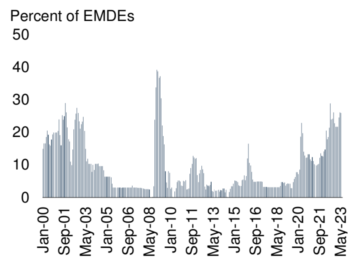
Sources: Laeven and Valencia (2020); World Bank.
Note: Based on results from panel logit model with random effects.
A.B. "0" indicates the probability of a crisis in a given year when there is no change in the underlying shock and all other variables included in the regression are at their sample means. "+0.25%" and "+0.50%" indicate the crisis probabilities in the case of 25- and 50-basis-point increases in the 2-year U.S. Treasury yield driven by the underlying shock. Orange whiskers reflect 90 percent confidence intervals.
A. Probability of any crisis conditional on underlying shocks to U.S. interest rates.
C. Reflects a 0.72 percentage point increase in the 2-year U.S. Treasury yield driven by a reaction shock (the increase seen in the 12 months to mid-May 2023). Orange whiskers reflect 90 percent confidence intervals.
D. A currency crisis is 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).

[7] That said, the role of vulnerabilities or inadequate policy frameworks is subject to some debate. Some researchers find that spillovers from U.S. monetary policy are smaller for countries with stronger fundamentals (for example, Ahmed, Coulibaly, and Zlate 2017; Bowman, Londono, and Sapriza 2015; and Chen, Mancini-Griffoli, and Sahay 2014) while others find a limited role for fundamentals (for example, Aizenman, Binici, and Hutchison 2016 and Eichengreen and Gupta 2015).

FIGURE 3.6 Sovereign spreads in EMDEs

More vulnerable emerging market and developing economies (EMDEs), particularly those with weak credit ratings, have experienced larger increases in sovereign risk spreads since the start of 2022. About one in four EMDEs currently have sovereign risk spreads exceeding 10 percentage points.





Sources: J.P. Morgan; Moody's; World Bank.

Note: EMDEs = emerging market and developing economies.

A. Change in emerging market bond index global (EMBIG) spreads from January 2022 across long-term foreign-currency sovereign debt ratings by Moody's. "Strong credit rating" includes "Aaa," "Aa," "A," and "Baa." "Moderate credit rating" includes "Ba" and "B." "Weak credit rating" includes "Caa," "Ca," and "C." Sample size includes 45 EMDEs. Sample excludes Belarus, Lebanon, the Russian Federation, Ukraine, and República Bolivariana de Venezuela. Last observation is May 24, 2023.

B. Figure shows the share of countries with J.P. Morgan emerging market bond index global (EMBIG) spread above 10 percentage points. Sample includes 50 EMDEs.

than those for investment-grade EMDEs following the emergence of U.S. and European banking problems in March 2023 suggests that economies with weak fundamentals are more vulnerable to many types of adverse shocks, not only rising U.S. interest rates. Some of these more vulnerable economies are so-called "frontier markets," which only recently gained access to international capital markets in an environment of low global interest rates, and which have been ill-prepared for the subsequent rise in those rates.

This section examines whether the effects of reaction shocks to U.S. interest rates are more detrimental in EMDEs with greater financial vulnerabilities or macroeconomic imbalances. First, EMDEs are classified by their degree of sovereign risk and ability to repay debts. To do so, the analysis explores the role of credit ratings and sovereign spreads. Second, EMDEs are classified by their fiscal and external positions. The analysis explores whether EMDEs that run both fiscal and current account deficits experience greater spillovers than other EMDEs.

Role of credit ratings and sovereign risk

To assess the role of sovereign risks and credit ratings, the analysis compares the response of investment-grade and non-investment-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.

Indeed, the effects of reaction shocks are more detrimental for non-investment-grade EMDEs than their investment-grade peers (figure 3.7.A). Non-investment-grade EMDEs showed greater increases in EMBI spreads and 10-year yields than did investment-grade EMDEs, and in the latter case, the difference was statistically significant. The increase in yields in non-investment-grade EMDEs is nearly twice as large as the increase in U.S. interest rates. Equity prices declines are also slightly more pronounced in non-investment-grade EMDEs.

There is limited evidence that the investment-grade rating of EMDEs also plays a role in the likelihood of a financial crisis (figure 3.7.B). EMDEs that have higher credit rating scores tend to see a lower probability of facing a crisis due to U.S. reaction shocks, though the differences are not statistically significant.

An alternative way to explore the role of sovereign risk is to compare EMDEs based on their sovereign risk spreads (figure 3.7.C). EMDEs with EMBI spreads below the median tend to see smaller impacts of reaction shocks on their 10-year local currency bond yields and their sovereign spreads. These economies also tend to see smaller equity price losses in response to reaction shocks.[8]

[8] The evidence for exchange rate movements and capital flows (not shown) are less intuitive. EMDEs with investment-grade ratings and with low sovereign spreads see more pronounced outflows of portfolio investments and larger currency depreciation in the face of rising U.S. interest rates. It is possible that investment-grade EMDEs have greater exposure to international capital markets through inclusion in global benchmark indexes, making these economies more sensitive to global financing conditions (Arslanalp and Tsuda 2015; Cerutti, Claessens, and Puy 2019; Miyajima and Shim 2014).

Role of twin deficits

Countries running fiscal and current account deficits often depend on foreign investors to finance such deficits, and therefore are especially exposed to U.S. interest rates. During the 2013 taper tantrum, for example, EMDEs that were running large current account and fiscal deficits suffered particularly adverse consequences (figure 3.7.D). To assess this measure of vulnerability, the analysis classifies EMDEs between twin-deficit countries—those running both primary fiscal and current account deficits—and others.

The results of the econometric analysis suggest that twin-deficit EMDEs experience more adverse impacts from reaction shocks than their non-twin-deficit peers (figure 3.7.E). Twin-deficit EMDEs tend to see an increase in 10-year local currency yields that is greater than the change in U.S. interest rates, and which is statistically different from the response in economies that do not have twin deficits. Twin deficits are also associated with larger increases in sovereign risk spreads and larger falls in equity prices. In addition, the increase in the probability of financial crisis—especially a currency crisis—due to reaction shocks is magnified in twin-deficit EMDEs (figure 3.7.F).

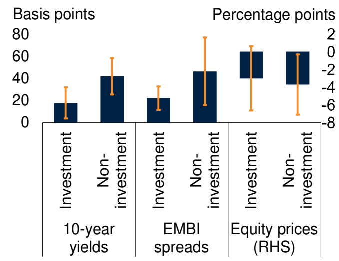
Role of frontier market status

There are notable differences across EMDEs in terms of their financial development (the number of companies listed on stock exchanges), depth (the size of their market capitalization and liquidity), and infrastructure (their regulatory structure and trading rules), which offer different levels of opportunity, access, and risk for international investors. They also differ in their macroeconomic and political stability and institutional quality. So-called "frontier market" economies are those with less developed financial markets and more limited access to international capital markets than "emerging markets," but which have more advanced markets and greater access to external private investment than the poorest and least developed EMDEs. Market participants usually invest in frontier markets to access higher returns, but at greater risk, and to diversify portfolios. In the years following the global financial crisis of

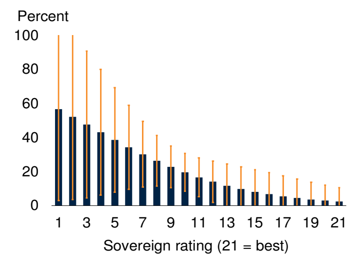
FIGURE 3.7 Impact of reaction shocks on EMDE financial variables, by vulnerabilities

Reaction shocks are more detrimental for emerging market and developing economies (EMDEs) that have non-investment-grade credit ratings, exhibit higher sovereign risk spreads, and run twin current account and fiscal deficits. The probability of crisis is also higher in EMDEs that have non-investment-grade ratings or run twin deficits.

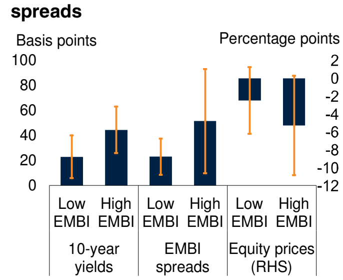
A. Impact of 25-basis-point reaction shock on EMDE financial variables after one quarter, by credit rating



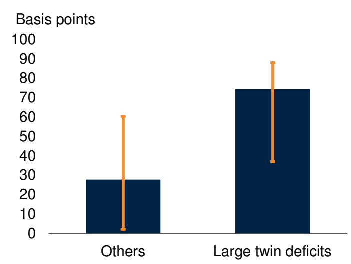
B. Likelihood of a financial crisis in response to reaction shocks of the past 12 months



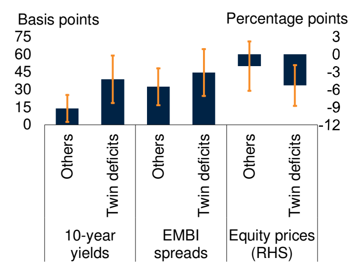
C. Impact of 25-basis-point reaction shock on EMDE financial variables after one quarter, by sovereign spreads



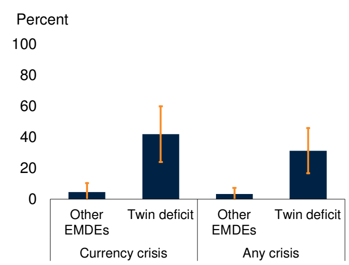
D. Change in sovereign risk spreads, 2013 taper tantrum



E. Impact of 25-basis-point reaction shock on EMDE financial variables after one quarter, by twin deficit status



F. Likelihood of crisis in response to reaction shocks of the past 12 months



Sources: J.P. Morgan; World Bank.

Note: Panel non-linear local projection model with fixed effects and robust standard errors. Models exclude observations during global financial crisis (2008Q4-2009Q4) and the COVID-19 pandemic. EMBI = emerging market bond index.

A.C.E. Blue bars reflect estimated impact in first quarter (y_{t+1}). Orange whiskers reflect 90 percent confidence intervals.

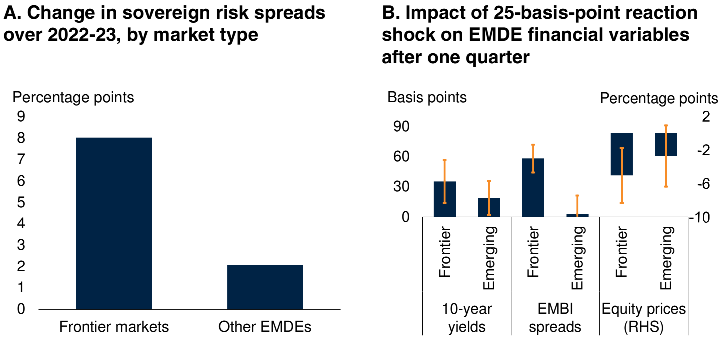
B. Figure reflects the probability of any crisis across sovereign debt ratings of EMDEs where the credit score is translated to numerical ratings. Ratings below 12 are non-investment grade while those above are investment grade. Based on a logit model with random effects that includes an interaction term for sovereign credit rating. Reflects a 0.72 percentage point increase in the 2-year U.S. Treasury yield driven by a reaction shock (the increase seen in the 12 months to mid-May 2023). Orange whiskers reflect 68 percent confidence intervals.

D. Large twin deficit economies are those that had a current account deficit wider than 2.5 percent of GDP and a primary fiscal deficit wider than 1 percent of GDP. Based on data for 50 EMDEs. Change in EMBI from 2013Q1 to 2013Q4. Orange whiskers reflect interquartile range across economies.

F. Based on a logit model with random effects that includes an interaction term for economies that run twin current account and primary fiscal deficits. Reflects a 0.72 percentage point increase in the 2-year U.S. Treasury yield driven by a reaction shock (the increase seen in the 12 months to mid-May 2023). Orange whiskers reflect 68 percent confidence intervals.

FIGURE 3.8 Impact of reaction shocks on EMDE financial variables, by market status

Frontier markets—countries with less well-developed financial markets and more limited access to international capital markets—have seen a much larger increase in sovereign risk spreads since the start of 2022. Frontier markets tend to see much larger adverse impacts from reaction shocks.



Sources: J.P. Morgan; MSCI; World Bank.

Note: Panel non-linear local projection model with fixed effects and robust standard errors. Models exclude observations during global financial crisis (2008Q4-2009Q4) and the COVID-19 pandemic. EMBI = emerging market bond index; MSCI = Morgan Stanley Capital International.

A. Based on data for 45 EMDEs, of which 11 are frontier markets, using the 2022 classification from MSCI. Average change in EMBI global spreads from January 2022 to May 2023.

B. Based on the MSCI country classification in 2022. Frontier markets include up to 9 economies while emerging markets include up to 19 economies. Frontier markets include Argentina, Bahrain, Croatia, Georgia, Jordan, Kazakhstan, Morocco, Nigeria, Romania, Serbia, Sri Lanka, and Vietnam. Emerging markets include Brazil, Chile, China, Arab Republic of Egypt, Hungary, Indonesia, India, Kuwait, Malaysia, Mexico, Peru, Philippines, Poland, Qatar, Saudi Arabia, South Africa, Thailand, and Türkiye. Orange whiskers reflect 90 percent confidence intervals. "EMBI spreads" based on EMBI global.

2008—a period of low global interest rates and limited risk aversion—frontier markets enjoyed substantial capital inflows and accumulated considerable external debt. However, in recent years, as sentiment shifted and rising interest rates offered better returns in developed markets, flows to frontier markets declined. This is exemplified by the outsized rise in sovereign risk spreads of these economies (figure 3.8.A).

To test the impact of reaction shocks on frontier markets, EMDEs are classified as "frontier markets" and "emerging markets" based on the MSCI country classification in 2022 (MSCI 2022).[9] Frontier markets tend to see much larger impacts from reaction shocks than those classified as emerging markets (figure 3.8.B). Ten-year local currency bond yields tend to increase by 50 percent more in frontier markets than other EMDEs. Sovereign risk spreads in frontier markets tend to increase by more than three times the size of the increase seen in other EMDEs; this difference is statistically significant. Finally, equity prices decline by almost twice as much in frontier markets.

Conclusions and policy implications

The global context is particularly challenging for EMDEs. To rein in persistent inflation pressures, the U.S. Federal Reserve and other major central banks will likely need to maintain an aggressive policy stance for an extended period, leading to substantial financial spillovers to EMDEs. This is taking place in an environment of unprecedented high debt levels both in the public and private sectors in many EMDEs.

The ultimate impact of rising U.S. interest rates depends on the types of shocks that drive them. This chapter decomposes U.S. interest rate moves into those driven by better economic activity (real shocks), inflation expectations (inflation shocks), and changes in the central bank's policy stance (reaction shocks). The analysis finds that the rapid increase in U.S. interest rates over the past year and a half predominantly reflected both rising inflation expectations and, especially, a perceived shift in the Fed's reaction function toward a more hawkish stance. The recent moderation in U.S. yields since the onset of U.S. banking sector stress appears to reflect negative real shocks amid heightened risk aversion and expectations of slower U.S. growth. Even so, these yields remain quite elevated.

With the rise in U.S. interest rates being driven principally by inflation and reaction shocks, the outlook for EMDEs is worrisome. The analysis of the spillovers of U.S. interest rates indicates that inflation and, especially, reaction shocks are associated with tighter financial conditions and more adverse outcomes for EMDEs: a widening of sovereign spreads, declining capital flows, decreasing equity prices, and depreciating real exchange rates. They also suggest that increases in U.S.

[9] The classification of an EMDE into frontier market status differs across firms that provide classifications. Despite these differences, frontier markets generally show a higher tendency to be adversely affected by spillovers from rising U.S. interest rates. For example, using the frontier market classification in the S&P Extended Frontier 150 index yields similar results to the MSCI classifications.

interest rates driven by reaction shocks substantially boost the likelihood that EMDEs could face financial crisis, especially a currency crisis.

These findings also underscore the role of financial vulnerabilities and less robust macroeconomic management. More vulnerable EMDEs—as indicated by weaker credit ratings, wider risk spreads, and fiscal and current account deficits—face more adverse impacts from reaction shocks than do EMDEs with stronger fundamentals. They experience larger increases in risk spreads, larger declines in equity prices, and larger increases in long-term local currency bond yields; in fact, for the more vulnerable EMDEs, these increases in bond yields amount to nearly twice the size of the original increases in U.S. interest rates.

To date, developments in EMDEs since the start of the Fed's tightening cycle last year have been largely in line with the findings described above. Driven by the spillovers of increases in U.S. interest rates that predominantly reflected reaction shocks, EMDE yields have risen, currencies have depreciated, credit spreads have widened, and capital inflows have tailed off. This tightening of financial conditions has been greater for more vulnerable EMDEs, including so-called "frontier market" economies, than for economies with stronger fundamentals and more prudent macroeconomic management. Moreover, the recent decline in U.S. yields and downshift in expectations for further Fed tightening triggered by ongoing banking difficulties will do little to help EMDEs, since that downshift reflects worries about the U.S. economy and financial sector, which will in turn weigh on conditions in EMDEs.

The risks to EMDEs posed by the tightening of monetary policy in the United States, and across the world, call for concerted policy responses. To start, central banks in advanced economies can attenuate the risk of disruptive spillovers to global financial markets by communicating their intentions as clearly as possible and calibrating their strategies so as to avoid abrupt changes in the policy outlook. (For example, during the 2016-2018 period, the Fed pursued a path of monetary tightening that was both gradual and well-telegraphed through policy statements, press conferences, and economic projections.) Clear communication to the public will reduce the likelihood of shocks to markets' assessments of central bank reaction functions, which has been shown to be especially destabilizing for EMDEs. Enhanced communication among central banks aimed at mitigating financial stability risks and monitoring cross-border spillovers will also be helpful in this regard (Avdjiev et al. 2020; Obstfeld 2022a). Finally, coordination among authorities in advanced economies to improve financial regulations and strengthen the resilience of their financial systems will redound to the benefit of EMDEs.

Second, in response to tighter monetary policies in advanced economies, EMDE monetary authorities may need to tighten their own policies in order to moderate capital outflows, currency depreciation, and resultant increases in inflation, all of which could destabilize domestic financial markets and lead to further rounds of capital outflows and depreciation. Indeed, over the past couple of years, some EMDE monetary authorities have been able to limit the rise in inflation and avert disruptive exchange rate dynamics through early and swift increases in policy rates. In countries where inflation remains elevated, authorities may have to continue tightening monetary policy. Critically, communicating monetary policy decisions clearly, leveraging credible monetary frameworks, and safeguarding central bank independence will help EMDEs to keep inflation expectations from becoming de-anchored and avoid disruptive capital outflows. In some countries, monetary policy responses to high inflation may need to be complemented by fiscal consolidation. At the same time, monetary and financial authorities need to be mindful of contractionary "overkill" by taking into account the effects of both domestic tightening and cross-border spillovers from higher policy rates in advanced economies (Guénette, Kose, and Sugawara 2022; Obstfeld 2022b).

To smooth disruptive short-term volatility in currency markets and bolster investor sentiment, EMDEs with adequate reserves may also consider complementing monetary tightening with foreign exchange interventions. In 2022, about one-fifth of EMDEs liquidated more than 15 percent of gross official reserves to cushion the fall in domestic currencies, with larger losses among countries contending with higher inflation. However, while these actions may alleviate immediate pressures, policy makers will eventually need to rebuild foreign exchange reserve buffers and realign prudential policy to prepare for the possibility of financial stress.

Third, besides directly responding to rising advanced-economy interest rates through monetary and foreign exchange policies, authorities in EMDEs can mute the effects of disruptive spillovers by reducing the fundamental vulnerabilities of their economies and financial systems. As noted earlier, countries with lower credit ratings, higher risk spreads, and larger fiscal and current account deficits face more adverse impacts from such spillovers. The credible monetary policy frameworks and inflation containment referred to earlier not only address the direct effects of external shocks but also help to reduce the economy's vulnerabilities more generally. On top of that, reducing vulnerability will require strengthening financial and fiscal policies.

To build the resilience of the financial system, prudential (and macroprudential) policy efforts will need to prioritize, among other things, adequate bank capital and liquidity, better currency alignment of assets and liabilities, better management of currency and rollover risk, and appropriate levels of leverage in the household and corporate sectors. Such measures, while generally important, may be particularly crucial for frontier markets that are early in the process of opening up to international capital flows. Credit quality, nonperforming loans, and currency mismatches need to be reported transparently such that prompt corrective action can be taken. The buffers of both banks and non-bank financial institutions need to be sufficient to absorb the impact of dislocating adverse shocks and should be stress-tested where institutions pose potentially systemic risks. In addition, risks from highly indebted corporate sectors can be allayed through insolvency reform and rapid, transparent treatment of nonperforming loans.

A key measure of vulnerability utilized in the analysis relates to the fiscal position. For many EMDEs, promoting and/or restoring fiscal sustainability will require concerted action on many fronts. Tax collection and administration must be improved to boost often-inadequate revenue levels. Fiscal spending may need to be reduced while ensuring that fiscal support is carefully targeted toward vulnerable populations and critical capital and infrastructure investments. In low-income EMDEs, special care must be taken to ensure that funding sources are low-cost (concessional) and debt maturities are carefully managed to reduce rollover risk.

Fourth and finally, the international community can take steps to address the spillovers of monetary tightening in the advanced economies by strengthening the global financial safety net. This involves ensuring that international financial institutions are adequately funded and focused on rapid support for EMDEs in distress. It also requires further efforts to facilitate the restructuring of external debts for EMDEs in debt distress. As noted above, the weaker and more vulnerable EMDEs have been especially hard-hit by the rise in interest rates, and helping them meet their challenges is a global priority.

ANNEX 3.1 Identifying U.S. interest rate shocks

The vector autoregression model employed to decompose U.S. monetary policy shocks is based on the frameworks used in Matheson and Stavrev (2014); Arteta et al. (2015); and Hoek, Kamin, and Yoldas (2021, 2022).[10] The model includes four variables: 2-year and 10-year bond yields, the S&P 500 index, and inflation expectations as measured by inflation compensation derived from Treasury inflation-protected bonds.[11] The data are monthly, from January 1982 to mid-May 2023. (Use of daily data did not appear to offer any advantages in terms of identification of shocks.) 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, as well as to identify the effects of unconventional monetary policy decisions that might not show up in 2-year yields. The model is specified as:

$$Y_t = BX_t + M_t,$$

where Y_t is an N × 1 vector of endogenous variables, X_t is an N × 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 N × 1 vector of residuals. As part of the identification strategy, the following sign restrictions are imposed on a four-variable VAR model as:

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

where μ_t^{TB2} and μ_t^{TB10} represent reduced-form residuals to 2-year and 10-year U.S. Treasury bond yields, μ_t^{SPX} represents a residual to the S&P 500 index, and $\mu_t^{E\pi}$ represents reduced-form residuals 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 (*E*π), 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.

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).

The data included in the VAR model used to decompose U.S. interest rate shocks are provided in table 3.3. The table indicates the transformation used in the model and the data source. Because of 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. As a measure of inflation expectations, the 5-year breakeven inflation rate is used from 2003 onward.[12]

ANNEX 3.2 Estimating the impact of U.S. interest rate shocks on EMDEs

Panel local projection models are used to link the U.S. interest rate shocks identified earlier to EMDE variables. The methodology, following

[10] 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 were run, with the first 5,000 discarded and only every 5th iteration kept. The model includes 12 lags. The prior mean on the residual variance (that is, stochastic volatility) is 0 and the prior's variance is 10,000.

[11] Inflation expectations are measured at a 5-year maturity based on data availability and as a compromise between capturing information in both the 2-year and 10-year yields.

[12] Prior to 2003, the inflation expectations series is based on model estimates by Haubrich, Pennacchi, and Ritchken (2012).

Jorda (2005), identifies impulse response functions through consecutive regression models at different horizons (*h*):

$$y_{i,t+h} = \alpha_{i,h} + x_{i,t}\,\delta_h + shock_{j,t}\,\beta_h + \mu_{i,t+h}\ ,$$

where $\alpha_{i,h}$ are cross-section (EMDE) fixed effects, $x_{i,t}$ are a vector of control variables, and $shock_{j,t}$ are the U.S. interest rate shocks with $j \in \{reaction; real; inflation\}$. The models are estimated recursively eight quarters ahead. They are estimated separately for each of the three U.S. interest rate shocks and each of the dependent variables, covering between 20 and 39 EMDEs, depending on the availability of data for the specific EMDE variable of focus. The dependent variables include 3-month and 10-year local-currency government bond yields, sovereign spreads, capital flows, and the real effective exchange rate (see table 3.4 for details).[13] The control variables differ slightly depending on the dependent variable, as shown in table 3.2, but generally include GDP, CPI, capital flows, government debt, the real exchange rate, and the policy interest rate (table 3.4 indicates the transformations of the control variables).

The data are mainly sourced from Haver Analytics, collected for as long a time period as possible at a quarterly frequency. Seasonally adjusted data are used when available or adjusted using X13-ARIMA-SEATS (U.S. Census Bureau 2017). The datasets used to measure the impacts of different U.S. interest rate shocks differ based on the dependent variable. The sample size for the short-term yields is the most limited, consisting of 20 economies from 1997Q4 to 2019Q4, resulting in an unbalanced panel of 750 total observations (table 3.2).[14] The largest country sample used, such as in the case of capital flows, includes 39 EMDEs from 1997Q2 to 2019Q4, resulting in an unbalanced panel of 1,537 observations. The EMDEs included across all regressions are provided in table 3.5.

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

[14] To avoid the outsized impact of outliers, models exclude observations between 2008Q4-2009Q4 to account for the period of the global financial crisis.

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 ensure comparability of the interpretation across shocks, the contribution of all shocks from the historical decomposition of the 2-year yield is used.[15]

ANNEX 3.3 Modeling financial crisis probability

A logit model, as in Kose et al. (2021), is used 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:

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

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; $X_{i,t\text{-}1}$ 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 tests, see Arteta, Kamin, and Ruch (2022).

The variables selected are based on empirical findings in the early warning indicators literature on crises (see Chamon and Crowe 2012; Frankel and Saravelos 2012; and Kaminsky, Lizondo, and Reinhart 1998 for an extensive review) and Kose et al. (2021). The panel includes data on debt (public and private), balance of payments, and real, banking, and financial sectors (table 3.6).

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

ANNEX 3.4 Assessing the role of EMDE vulnerabilities

The models are also extended to consider potential variations in responses based on specific characteristics of EMDEs. Four characteristics are studied. First, in each quarter of the estimation range, EMDEs are divided into investment grade and non-investment grade. The rating of investment-grade and non-investment-grade EMDEs is based on Kose et al. (2017) and uses the average foreign-currency long-term sovereign debt rating by Fitch Ratings, Moody's, and Standard and Poor's. Second, in each quarter, EMDEs are divided into those with high sovereign risk spreads (EMBI above the sample median) and those with low sovereign risk. Third, in each quarter, EMDEs are classified as twin deficit economies—running both a current account and primary fiscal deficit—and those that are not. Finally, economies are divided into "frontier markets" or "emerging markets" based on the MSCI classification for 2022.

A dummy variable approach is used, where, in separate regressions for each vulnerability measure, I_t is set equal to one if an EMDE's average rating at time t is below investment grade, if it has sovereign risk spreads (EMBI) below the sample median, if it runs twin deficits, or if it is a frontier market; and 0 otherwise. Consequently, the state-dependent impulse response function becomes a function of the dummy variable and the endogenous variables:

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

$$(1 - I_t)[\alpha_{B,i,h} + x_{B,i,t}\,\delta_{B,h} + shock_{j,t}\,\beta_{B,h}] + \mu_{i,t+h} \;.$$

ANNEX 3.5 Robustness analysis

The results of the VAR-based decomposition of U.S. interest rates, including their estimated impact on EMDEs, are generally robust with respect to alternative specifications of that VAR. A wide range of alternative specifications were tested, including:

- the inclusion of measures of current economic conditions (including industrial production and PCE inflation, and assuming no contemporaneous impact on both variables);
- the specification of only two types of shocks, real and "monetary" (combining reaction and inflation shocks);
- the use of alternative measures of inflation expectations;
- the use of the Russell 2000 equity price index instead of the S&P 500 to verify the model's robustness to changes in the composition of the S&P 500 index and to different interest rate sensitivities between the two indexes;
- the removal of the 10-year bond yield from the VAR, leaving only the 2-year yield as a measure of U.S. interest rates; and
- the inclusion of two additional variables in the VAR, the World Bank's CPI-deflated energy price index and the Chicago Board Options Exchange's VIX, in order to assess the possibility that measured reaction shocks might instead reflect surges in financial uncertainty or commodity prices.[16]

In all cases, the results were not materially different from the benchmark estimates, and the narrative regarding the evolution of U.S. interest rates around notable tightening events remained broadly unchanged. Moreover, the results continued to suggest that the impacts of inflation and reaction shocks on EMDE financial variables and the likelihood of crisis are more adverse than those of real shocks.[17]

There were minor differences between the benchmark and alternative specifications. The model including the Russell 2000 index suggests that inflation shocks played a larger role in the current hiking cycle but indicates little change in the

[16] To do so, the following restrictions are imposed. In addition to existing sign restrictions, the reaction shock is identified as one that has no contemporaneous impact on the VIX (zero restriction) and decreases real energy prices; the inflation shock is identified as that which has no contemporaneous impact on real energy prices; and the real shock leads to an increase in real energy prices.

[17] The first three of these robustness checks are explained in greater detail in the accompanying background paper (see Arteta, Kamin, and Ruch 2022).

impacts of these shocks on EMDE financial variables. The model controlling for commodity prices and the VIX suggests that the reaction shocks played a smaller but still-dominant role in the current hiking cycle. Moreover, this model highlights an amplification of the impact of reaction and real shocks on EMDE financial markets, though the differences with the benchmark model are not statistically significant.

The local projection models exclude the COVID-19 pandemic and the global financial crisis periods to avoid the impact of outliers and extreme events. An alternative approach would be to include these observations with a dummy variable. Robustness tests using this alternative approach amplified the adverse impact of reaction shocks on EMDEs financial variables as well as the benign impact of real shocks.

TABLE 3.1 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*	-0.001
			[0.003]	[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

Source: World Bank.
Note: Estimated on annual data from 1985-2018 excluding 2009. FDI = foreign direct investment. Standard errors in brackets.
*** p<0.01, ** p<0.05, * p<0.1

TABLE 3.2 Samples by dependent variable in panel local projection models

Dependent variable	Total observations	Number of economies	Sample*	Control variables
Long-term yields	926	24	2000Q2-2019Q4	GDP, CPI, portfolio inflows, Debt, REER, policy interest rate
Short-term yields	750	20	1997Q4-2019Q4	GDP, CPI, portfolio inflows, Debt, REER, policy interest rate
EMBIG spread	1261	34	1999Q3-2019Q4	GDP, CPI, portfolio inflows, debt, REER, policy interest rate
Capital flows	1537	39	1997Q2-2019Q4	GDP, CPI, debt, REER, policy interest rate
Real effective exchange rate	1225	21	1996Q3-2019Q4	GDP, CPI, portfolio inflows, policy interest rate
Equity prices	1744	35	1994Q1-2019Q4	GDP, CPI, REER, portfolio inflows, policy interest rate

Source: World Bank.
Note: *Sample excludes 2008Q4-2009Q4. CPI = consumer price index; EMBIG = emerging market bond index global; REER = real effective exchange rate.

TABLE 3.3 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 inflation-protected TIPS yield)	First difference	Federal Reserve Bank of St. Louis

Source: World Bank.

TABLE 3.4 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
EMBIG* spread	First difference	J.P. Morgan
Gross debt (general government or central government) to GDP	First difference	Haver Analytics; Quarterly Public Sector Debt Database, World Bank

Source: World Bank.
Note: *EMBIG = emerging market bond index global.

TABLE 3.5 Sample for panel local projection models

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

Source: World Bank.
Note: *Indicates countries that are non-investment grade based on average ratings in 2019Q4.

TABLE 3.6 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 constant market prices based on 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 (2018)
Foreign direct investment	Net inflows of foreign direct investment as a share of GNI	WDI

Source: World Bank.
Note: GFDD = Global Financial Development Database; WDI = World Development Indicators; WEO = World Economic Outlook; IDS = International Debt Statistics.

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