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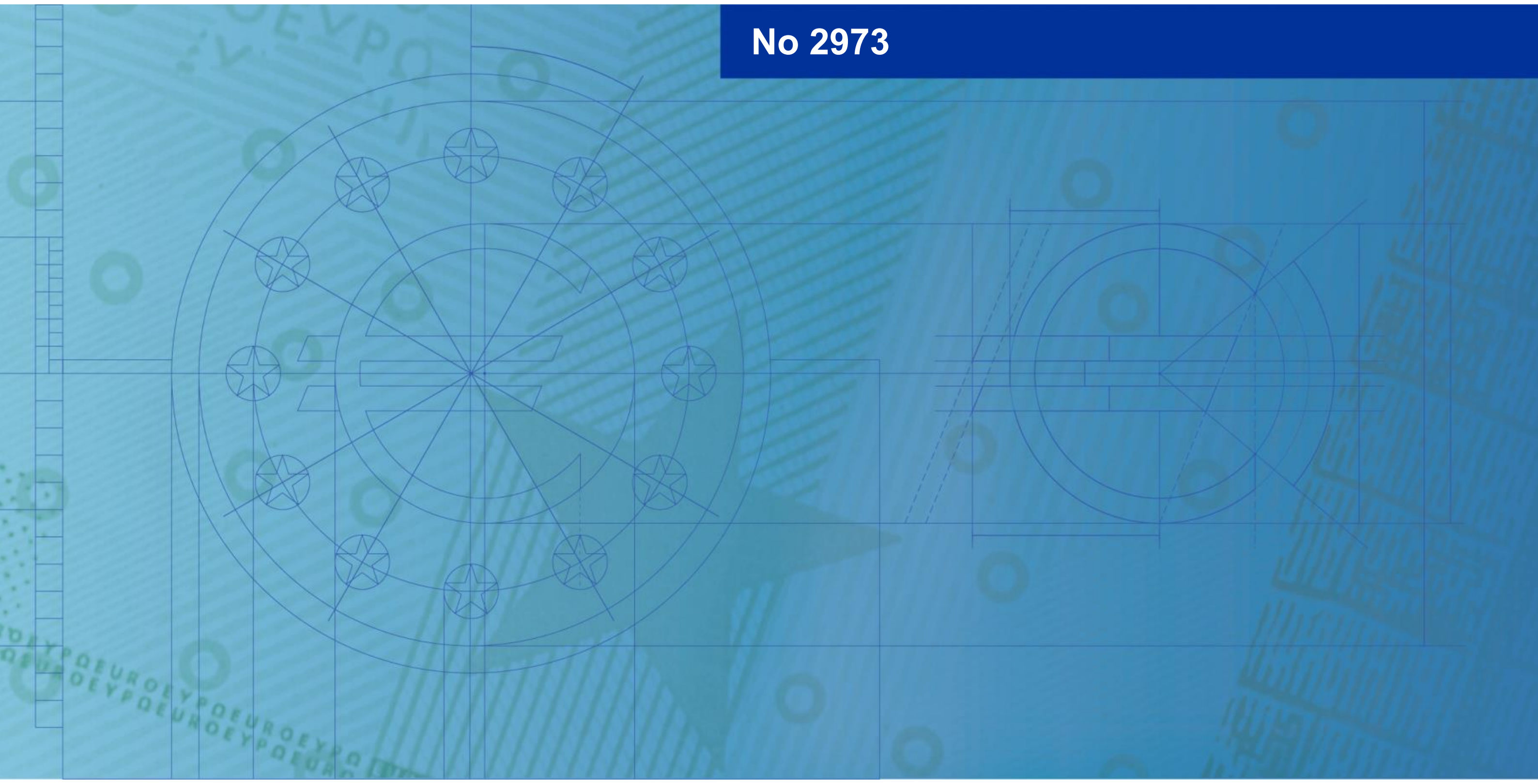
What shapes spillovers from monetary policy shocks in the United States to emerging market economies?



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Abstract

Monetary policy decisions by the Federal Reserve System in the US are widely recognised to have spillover effects on the rest of the world. In this paper, we focus on the asymmetric effects of US monetary policy shocks on macro-financial outcomes in emerging market economies (EMEs). We shed light on how domestic factors shape external monetary policy spillover effects using indicators on the macro-financial vulnerabilities and monetary policy stances of EMEs. We find that a surprise tightening of monetary policy in the US leads to an immediate tightening of financial conditions which leads to a decline in activity and prices in EMEs over one year. Importantly, these effects are amplified in periods of high vulnerabilities and attenuated when EMEs follow a prudent monetary policy stance. Our findings help explain the greater resilience of many EMEs to the Fed's post-COVID-19 tightening cycle, and highlight the benefits of the broad improvements of monetary policy frameworks in these countries.

JEL Classification: F42, E58, E52, C32.

Keywords: Monetary policy, spillovers, emerging markets.

Non-technical Summary

The aftermath of the COVID-19 pandemic created a challenging and uncertain macroeconomic environment for emerging market economies (EMEs). Weakening external demand, a series of supply shocks, rising inflation, and a synchronised and rapid tightening of monetary policy all emerged as powerful headwinds to growth. Yet, despite this, EMEs demonstrated considerably greater resilience than in the past (IMF (2024)). This occurred after EMEs generally began tightening monetary policy before many advanced economies, in contrast to previous tightening cycles. These events have sparked a debate whether early tightening in EMEs reduced their macro-financial vulnerability to external shocks (The Economist (2022)).

In this paper we study the impacts of one of those external shocks: monetary policy tightening by the Federal Reserve System (Fed) in the United States. We begin our empirical analysis by constructing a panel dataset on macroeconomic conditions in 14 EMEs stretching back to 2000. We then estimate the spillovers of monetary policy shocks from the US to industrial production, consumer prices, and financial conditions in EMEs. To do so, we estimate a panel version of local projections from Jordà (2005), and proxy US monetary policy shocks using series of monetary policy surprises identified from high-frequency financial market data by Jarociński and Karadi (2020). In line with the literature, we confirm that US monetary policy shocks have significant and economically meaningful spillover effects to EMEs (Iacoviello and Navarro (2019); Ca' Zorzi et al. (2020); Ahmed et al. (2021); Caballero and Upper (2023)). A surprise one standard deviation increase in 5-year US Treasury bond yields leads to an immediate tightening of financial conditions in EME's. Over time, real activity and prices decline with peak effects of -0.5 and -0.1 percentage points (pp), respectively.

We then study how the spillovers from US monetary policy vary with EMEs' (1) level of macro-financial vulnerability and (2) domestic monetary policy stance. The macro-financial vulnerability metric we use summarises EMEs' vulnerability in terms of exchange rate misalignment, the anchoring of inflation expectations and US dollar-denominated foreign liabilities. These variables are particularly relevant at the recent juncture in the presence of high inflation and a strengthening US dollar. We capture the domestic monetary policy stance by comparing realised monetary policy with an estimated monetary policy reaction function. This provides a basic but useful benchmark indicator of how central bank policy rates in an EME typically react to changes in expected inflation and output and the cyclical position of the economy. Our results suggest that the effects of US monetary policy shocks are around 3 to 4 times larger than the baseline for EMEs that are in a more vulnerable state, or 2 times larger if the EME is in a state where monetary policy is abnormally loose, according to our metrics for the states.

In addition to providing evidence of asymmetric spillover effects, this paper innovates by synthesising strands of the existing literature to formulate strong policy conclusions. We argue that the key EME vulnerabilities that amplify monetary policy spillovers are those closely linked to domestic monetary policy. It follows that improved monetary policy frameworks and actions at the national level can mitigate US monetary policy spillovers to EMEs. Logically, by maintaining a prudent monetary policy stance, central banks in emerging markets can avoid the accumulation of macro-financial vulnerabilities (Grimm et al. (2023)) and provide reassurance to domestic and foreign economic agents and investors in times of global financial tightening. Indeed we argue that this mechanism explains why major EMEs have proven more resilient than in the past during the recent US monetary policy tightening cycle. Thus, the resilience many EMEs have shown in the post-pandemic global tightening cycle is partly a consequence of the broad improvement in monetary policy frameworks achieved in these countries.

1 Introduction

The aftermath of the COVID-19 pandemic created a challenging and uncertain macroeconomic environment for emerging market economies (EMEs). Weakening external demand, a series of supply shocks, rising inflation, and a synchronised and rapid tightening of monetary policy all emerged as powerful headwinds to growth. Yet, despite this, EMEs demonstrated considerably greater resilience than in the past (IMF (2024)). This occurred after EMEs generally began tightening monetary policy before many advanced economies, in contrast to previous tightening cycles. These events have sparked a debate whether early tightening in EMEs reduced their macro-financial vulnerability to external shocks (The Economist (2022)).

In this paper we study the impacts of one of those external shocks: monetary policy tightening by the Federal Reserve System (Fed) in the United States. In particular, we focus on the extent to which US monetary policy shocks spillover to EMEs, and the factors shaping the strength of these spillovers. The novelty of our analysis lies on using a non-linear panel local projections model to explicitly allow for asymmetric spillover effects on activity, prices and the financial sector. Using a series of indicators on EMEs' macro-financial vulnerabilities and monetary policy stance we are able to shed light on how domestic factors shape external monetary policy spillover effects. Different from other studies, we use monthly frequency for the domestic state variables reflecting monetary policy frameworks and vulnerabilities. This higher frequency in the source of the asymmetries allows us to better assess the immediate and short-term non-linear spillover effects.

In our baseline specification we find that Fed tightening has a significant impact on macroeconomic conditions in EMEs, in line with the literature (Georgiadis (2016); Iacoviello and Navarro (2019); Miranda-Agrippino and Rey (2020); Ca' Zorzi et al. (2020); Ahmed et al. (2021)). In particular, we find that a surprise tightening of monetary policy in the US leads to an immediate tightening of financial conditions which leads to a decline in activity and prices in EMEs over one year. Then, using our state-dependent local projections we are able to disentangle that the strength of these spillover effects are larger when EMEs exhibit a higher degree of vulnerability, and when countries have a bigger discrepancy between actual monetary policy and a prescribed stance based on macroeconomic fundamentals. The results of this study can help to explain the greater resilience of many EMEs to the Fed's post-COVID-19 monetary policy tightening cycle.

Against the backdrop of rising inflation during the post-pandemic recovery, the Fed communicated its intention to tighten monetary policy in the autumn of 2021. In March 2022, it started raising its key policy rates in what became one of the most aggressive hiking cycles in the Fed's history. Policy tightening in the US was proceeded by tightening in several EMEs starting as early as March 2021 when, for example, the Central Bank of Brazil increased its main policy rate (see Figure A.1). This stands in contrast to previous global tightening cycles when EMEs generally only began to tighten after advanced economies had already started to do so (see Figure A.2). The early reaction of several EME central banks could be a reflection of improved policy frameworks and lessons learned from the past. Many EME central banks now have mandates to target price stability and were establishing a successful track record in keeping inflation around its targeted level.[1] These improvements in monetary policy frameworks may be linked to the broader improvement in indicators of macro-financial vulnerability observed in EMEs in recent years. In turn, lower macro-financial vulnerability may explain the resilience EMEs have shown during the most recent tightening cycle. The goal of this paper is to provide an empirical study of these possibilities.

We begin our empirical analysis by constructing a panel dataset on macroeconomic conditions in 14 EMEs stretching back to 2000. Using panel local projections (Jordà (2005)) we estimate the spillovers of monetary policy shocks from the US on industrial

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[1] Historically, EMEs with fixed or managed floating exchange rates used interest rate hikes to support their currency, including in times when their exchange rates came under pressure from monetary policy tightening in advanced economies. The use of interest rate policies to create or maintain a positive interest differential vis-à-vis anchor currencies such as the US dollar, often came in conjunction with direct exchange rate interventions through the sale of foreign exchange reserves. However, recent tightening by EMEs may be different in so far as many countries have moved toward fully floating exchange rate regimes, see Carstens (2019).

production, consumer prices, and financial conditions in EMEs. To do so, we proxy US monetary policy shocks using series of monetary policy surprises identified from high-frequency financial market data by Jarociński and Karadi (2020). We confirm that US monetary policy shocks have significant and economically meaningful spillover effects on EMEs. A surprise one standard deviation increase in 5-year US Treasury bond yields leads to an immediate tightening of financial conditions in EME's.[2] Over time, real activity and prices decline with a peak effects of -0.5 and -0.1 percentage points (pp), respectively.

We then study sources of asymmetric spillovers effects from US monetary policy using domestic EMEs' factors: (1) macro-financial vulnerability; and (2) domestic monetary policy stance. The macro-financial vulnerability metric summarises vulnerability in terms of exchange rate misalignment, the anchoring of inflation expectations and US dollar-denominated foreign liabilities. These variables are particularly relevant at the recent juncture in the presence of high inflation and a strengthening US dollar. We capture the domestic monetary policy stance by comparing realised monetary policy with an estimated monetary policy reaction function. This provides a basic but useful benchmark indicator of how central bank policy rates in an EME typically react to changes in expected inflation and output and the cyclical position of the economy. Our results suggest that the effects of US monetary policy shocks are around 3 to 4 times larger than the baseline for periods when EMEs are more vulnerable, or 2 times larger if EMEs are in periods of abnormally loose monetary policy. Hence, through our state-dependent panel local projections we are able to provide evidence on how domestic factors in EMEs disentangle the shape of external monetary policy spillovers.

This paper relates to a large literature studying the spillovers of monetary policy across borders. In a seminal paper, Rey (2013) argues that countries which are open to the free movement of capital are exposed to monetary policy spillovers from major

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[2] We use the 5-year US Treasury bond yields which is a maturity that lies in the middle of the yield curve to capture both conventional (i.e., policy rate changes) and unconventional monetary policies prevalent after the Global Financial crisis, such as quantitative easing or forward guidance, that affect longer maturities through the term premium component.

developed economies.[3] In subsequent work, Miranda-Agrippino and Rey (2020) show that the co-movements in the international financial variables that characterise the global financial cycle are to a considerable extent due to US monetary policy shocks. Although the literature has also studied spillovers from other major central banks, such as the ECB (Falagiarda et al. (2015)), we focus on spillovers from the Fed, which have been shown to have the most pronounced effect (Ca' Zorzi et al. (2020)).

Previous work has focused on the role of general macroeconomic and financial conditions (Georgiadis (2016)) and network effects (Dées and Galesi (2021)) in moderating the strength of US monetary policy shocks abroad.[4] Kalemli-Özcan (2019) argues that monetary policy divergence vis-à-vis the US has larger spillover effects for emerging markets than for advanced economies. The author further argues that domestic monetary policy in EMEs is ineffective in mitigating spillover effects, as the pass-through of policy rate changes to short-term interest rates is imperfect. Leo et al. (2022) rationalise this disconnect in a theoretical model where banks rely on international markets for funding. In recent work, Caballero and Upper (2023) document non-linear effects of spillovers from increases in long-term US yields on foreign financial markets.[5] The authors show that spillovers are more pronounced when the US term premium is rising and the US dollar is strong, yet find little evidence that domestic variables amplify spillovers. Ahmed et al. (2021) investigate the spillovers of US monetary policy shocks using a New Keynesian model. The authors highlight the importance of distinguishing between US monetary policy tightening that is driven by stronger US demand, which can have mildly positive spillovers in less vulnerable EMEs, and tightening prompted

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[3] Rey (2013) argues that the international finance trilemma, by which policy makers can only choose two of the following three policies: i) a fixed exchange rate, ii) free movement of capital, and iii) independent monetary policy, has been transformed in to a dilemma thanks to the global financial cycle.

[4] Georgiadis (2016) uses a mixed cross-section global VAR model with sign restrictions to show that US monetary policy shocks have significant spillovers abroad. The strength of these spillovers is shown to vary with the receiving country's trade and financial integration, degree of financial openness, exchange rate regime, financial market development, labour market rigidities, industry structure, and participation in global value chains. Dées and Galesi (2021) use a large-scale global VAR to model the world economy as a network of interdependent countries and demonstrate how network effects amplify monetary policy spillovers.

[5] In their work, Caballero and Upper (2023) study sharp increases in long-term US yields — not limited to those caused by US monetary policy shocks. Further, they select their set of conditioning variable using advanced machine learning techniques.

by a more hawkish stance, which has adverse spillovers to all EMEs irrespective of their level of vulnerability.

This paper contributes to this literature in a number of ways. First, using a nonlinear panel model we provide empirical evidence of asymmetric responses to US monetary policy surprises that depend on EMEs' factors. This sheds light on the heterogeneity in monetary policy spillovers and how domestic macro-financial fundamentals and policy frameworks can shape such effects. We do this by means of state-dependent local projections taking into account the latest refinements in state-dependent econometric methods outlined in Gonçalves et al. (2024) and Cloyne et al. (2023). Accordingly, we provide valuable new evidence on the extent to which periods of higher vulnerabilities or more prudent domestic monetary policy stance can render EMEs more or less exposed to external monetary policy shocks, which remains a key topic in policy discussions (IMF (2021)).

In contrast to the existing literature, we use state-of-the-art US monetary policy surprises to estimate foreign spillovers effects on EMEs' macroeconomic and financial variables. We follow the recent literature on monetary policy shock identification and use high-frequency identified monetary policy surprises from Jarociński and Karadi (2020) to proxy US monetary policy shocks. Recent literature (i.e., Dedola et al. (2017), Kearns et al. (2022), Georgiadis and Jarocinski (2023)) uses these modern policy shocks to study spillovers but they do not analyse the effects through the lens of the more general smooth-transition local projections model as we do (Tenreyro and Thwaites (2016)). The smooth-transition specification allows us to specify the speed in changes between states (i.e., how fast you move from a high to a low vulnerability state), which is a more realistic setup than a dummy variable approach (see Section 4 for further discussion). Furthermore, we build on Iacoviello and Navarro (2019) by employing a comparable non-linear transformation to the responses using a logistic function, but use high-frequency-identified monetary policy surprises. In addition, we also use monthly frequency state variables, which allow us to provide evidence of short-term asymmetric spillover effects.

This paper also innovates by synthesising strands of the existing literature to formulate strong policy conclusions. We argue that the key EMEs' vulnerabilities that amplify monetary policy spillovers are those closely linked to domestic monetary policy. It follows that improved monetary policy frameworks and actions at the national level can mitigate US monetary policy spillovers to EMEs. Logically, by maintaining a prudent monetary policy stance, central banks in EMEs can avoid the accumulation of macro-financial vulnerabilities (Grimm et al. (2023)) and provide reassurance to domestic and foreign economic agents and investors in times of global financial tightening. Indeed we argue that this mechanism explains why major EMEs have proven more resilient than in the past during the recent US monetary policy tightening cycle. Thus, the resilience many EMEs have shown in the post-pandemic global tightening cycle is partly a consequence of the broad improvement in monetary policy frameworks achieved in these countries.

The rest of this paper is structured as follows. Section 2 outlines our empirical framework and describes data used in the model. Section 3 presents our main results and Section 4 presents robustness results. Section 5 concludes.

2 Empirical model and data

2.1 Empirical Model

We estimate a local projections model following Jordà (2005) for a panel of EMEs:

$$y_{i,t+h} = \alpha_{i,h} + \beta_h shock_t + \sum_{j=1}^{q} \rho_{i,j} y_{i,t-j} + \sum_{k=1}^{p} \phi_k x_{t-k} + \delta_h COVID_t + \epsilon_{i,t+h}. \quad (1)$$

$y_{i,t+h}$ are our outcome variables for country i in month t at horizon h. As outcomes, we consider industrial production in manufacturing, the consumer price index, and an index of financial conditions.

$\alpha_{i,h}$ is a country fixed effect. $shock_t$ is our explanatory variable of interest capturing US monetary policy shock proxies derived from high-frequency financial market data following Jarociński and Karadi (2020), as described in section 2.2 below. $\{y_{i,t-j}\}_{j=1}^{q}$ includes lags of the endogenous variables whilst $\{x_{t-k}\}_{k=1}^{p}$ is a set of control variables including lags of the monetary policy shock, a synthetic commodity price index, equity market volatility, and an indicator of geopolitical uncertainty.[6] We include $q = p = 6$ lags for each control variable.[7] Endogenous variables and controls variables are all expressed in log levels. $COVID_t$ is a dummy variable set equal to one during acute phases of the COVID-19 pandemic.[8] Including this term helps to account for the high volatility of our outcome variables observed during these periods. $\epsilon_{i,t+h}$ is the error term. When estimating (1) we compute robust standard errors as in Driscoll and Kraay (1998), consistent with the literature on panel local projections.

The sequence of β_h at different horizons is our main parameter of interest capturing the dynamic impact of US monetary policy spillovers on the outcome variables in EMEs. As is common in panel local projections (e.g., Jordà et al. (2015)) we compute cumulative impulse responses (i.e., $y_{i,t+h} - y_{i,t-1}$ as endogenous variable). To study how our estimates vary in a state-dependent setup, we augment our local projections model in equation (1) with a smooth-transition function, as popularised by Tenreyro and Thwaites (2016) and Ramey and Zubairy (2018). Specifically, we transform the state variable in a non-linear fashion using a logistic function. The resulting value is the weight attached to the state-dependent impulse response. The logistic function is defined as:

$$F(z_{i,t}) = \frac{\exp(-\gamma z_{i,t})}{(1 + \exp(-\gamma z_{i,t}))}. \tag{2}$$

For each EME i in month t, $z_{i,t}$ is the standardised state variable. In our setting, the state variables are a vulnerability index or the difference between the actual policy

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[6] There is extensive research on the important role of commodity prices as a driver of output in investment, particularly in EMEs dependent on commodity exports (Drechsel and Tenreyro, 2018). We control for equity market volatility as Rey (2015) argues that that the VIX is an important proxy for the global financial cycle that affects financial and economic conditions in EMEs. We control for geopolitical uncertainty, as this has also been shown to be an important determinant of output and investment (Caldara and Iacoviello, 2022).

[7] The estimates are robust to the choice of different lag lengths.

[8] We include a dummy variable for each month between March and July 2020, and an additional dummy with ones between August 2020 and December 2021.

rate and that implied by an estimate of their monetary policy reaction functions (see Section 2.3 below for further details).[9] The parameter $\gamma > 0$ controls the speed of transitioning between states. The lower the value of γ, the smoother transition. We set $\gamma = 2$ to have relatively smooth transition between states (i.e., persistence in the changes of the monthly state variables). We provide tests of the robustness of this calibration in Section 4.

Next, we include the logistic function from equation (2) in our panel local projections model, interacting it with all terms. As explained by Cloyne et al. (2023) it is important to account for potential co-determination between the state and the shock variable. Following their suggestions we add interaction terms of our shock variable with our lagged controls.[10] Doing so allows us to control for the effects of a number of competing amplifying channels of US monetary policy shocks.[11] Additionally, as stated in Gonçalves et al. (2024), for the local projection estimator to be valid at longer horizons the state variable cannot be endogenously determined. This is usually the case when the state variable is constructed on the basis of the endogenous variable (i.e., a recession/expansion state variable based on GDP growth which is the outcome variable). However, in our case, the state variables are not a function of the endogenous variables (see next section for details on how the state variables are constructed) and therefore, the state-dependent local projection estimates should be consistent. Accordingly, the state-dependent panel local projections specification is:

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[9] The approach used in this paper is similar to that of Grimm et al. (2023) who also use state-dependent local projections to study the implications of monetary policy stance for the stability of the financial system.

[10] We further compute correlations between the EME state variables and the US monetary policy shocks used in the empirical analysis (see the last table in Appendix C). In all cases the correlation is almost zero and not statistically significant.

[11] The literature has identified other potential amplifiers of monetary policy spillovers, including exchange rate regimes (Ilzetzki et al., 2019) and capital controls (Cesa-Bianchi et al., 2018). The sample of countries and time frame we consider in this paper are less suitable for estimating the amplifying impacts of US monetary policy via these channels as variation in exchange rate and capital control regimes is minimal.

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\begin{aligned}
y_{i,t+h} = (1 - F(z_{i,t-1})) & \left[\alpha^{s_1}_{i,h} + \beta^{s_1}_{h} shock_t + \sum_{j=1}^{q} \theta^{s_1}_{i,j} \mathcal{Y}_{i,t-j} + \sum_{k=1}^{p} \varphi^{s_1}_{k} \mathcal{X}_{t-k} + \delta^{s_1}_{h} COVID_t \right] \\
& + F(z_{i,t-1}) \left[\alpha^{s_2}_{i,h} + \beta^{s_2}_{h} shock_t + \sum_{j=1}^{q} \theta^{s_2}_{i,j} \mathcal{Y}_{i,t-j} + \sum_{k=1}^{p} \varphi^{s_2}_{k} \mathcal{X}_{t-k} + \delta^{s_2}_{h} COVID_t \right] + \epsilon_{i,t+h}.
\end{aligned}
\tag{3}
$$

Note that the logistic function enters the regression model with one lag. This is to avoid contemporaneous feedback between the state variables and the US monetary policy shock proxy as argued in Auerbach and Gorodnichenko (2013). Now each regression coefficient is dependent on the states $s \in (s_1, s_2)$, β^s_h define the state-dependent impulse responses, and $\{\mathcal{Y}_{i,t-j}\}^q_{j=1}$ and $\{\mathcal{X}_{t-k}\}^p_{k=1}$ denote the augmented set of controls that include interaction terms with the shock variable.[12]

The measure of monetary policy stance we consider, i.e., the difference between the actual policy rate and that predicted by a central bank reaction function, is an estimated parameter with its own sampling error. As discussed in Lloyd and Manuel (2023) using this generated parameter as an independent variable in (3) could introduce noise in our measure of policy stance that will widen the standard errors of the estimates of β^s_h.

2.2 Data

We construct a dataset at the monthly frequency for a sample of 14 EMEs spanning from January 2000 to November 2022.[13] For each country we collect seasonally adjusted manufacturing industrial production and consumer price indices from national sources, retrieved via Haver Analytics. We also collect data on financial conditions from Goldman Sachs, Bloomberg's commodity spot index, the VIX volatility index from the Chicago Board Options Exchange, as well as an index of geopolitical risk

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[12] The implementation of the model is largely based on the `R` library `lpirfs` documented in Adämmer (2019).

[13] Our sample of countries includes the following EMEs: Brazil, Chile, China, Czechia, Hungary, India, Malaysia, Mexico, Poland, Russia, South Africa, South Korea, Thailand and Türkiye.

from Caldara and Iacoviello (2022).[14]

We proxy US monetary policy shocks by high-frequency identification of monetary policy surprises as in Jarociński and Karadi (2020). To identify monetary policy shocks the authors focus on the movement of prices in financial markets in a tight window around policy announcements by the Fed. Central bank announcements reveal information both about the monetary policy stance as well as about the central bank's assessment of the economic outlook. Examining the movement of financial market prices in a tight window around policy announcements helps to distil the surprise in the central bank policy announcement, and also whether this relates to new information about the outlook (central bank information shock) or about the policy stance (pure monetary policy shock). The high-frequency co-movement of interest rates and stock prices around monetary policy announcements is used to distinguish pure monetary policy shocks, whereby a tightening shock would raise interest rates and reduce stock prices, from central bank information shocks (which would raise both). In our analysis we use pure monetary policy shocks shown in Figure A.3.[15] We derive monetary policy shocks for the 5-year US Treasury bond yields, which lie in the middle of the yield curve, which in our view captures both conventional monetary policies like key policy rate changes and unconventional monetary policies prevalent after the Global Financial crisis, such as quantitative easing or forward guidance, that affect longer maturities through the term premium component.[16]

To determine the macro-financial vulnerability of the countries in our sample, we use the vulnerability index developed in Georgiadis and Jarocinski (2023), which is plotted in Figure A.4. The vulnerability index is based on the average of three component series that reflect vulnerabilities measured by high inflation rates, pronounced

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[14] The availability of data varies between countries and across specifications. For regressions with financial conditions as the target variable the sample starts in March 2007 and for regressions involving the monetary policy reaction function as the state variable the sample starts in January 2005.

[15] The grey shaded area reports absolute value of pure monetary policy shocks and suggest that their value has been gradually declining over time. This may be linked to the evolution of Fed communications strategy over recent years.

[16] We also test our results by using the central bank information shocks and we get the expected signs for the responses of our outcome variables in line with Jarociński and Karadi (2020). Also, we check if our results change using the more conventional 2-year US Treasury bill to derive monetary policy surprises. We get similar results for the shorter horizons of the responses.

exchange rate misalignment, and large stocks of dollar-denominated foreign liabilities.[17] For the analysis of the domestic monetary policy stance we collect data on policy rates, real effective exchange rate, and real GDP from national sources, retrieved via Haver Analytics. Brent crude oil spot prices are sourced from Bloomberg. Finally, we collect 1-year-ahead expectations survey data for inflation and output gap from Consensus Economics. The details on the construction of the domestic monetary policy stance index is described in the next subsection and shown in Figure A.5.

The endogenous and control variables are expressed in log-levels, the shock proxy in basis points, and the state variables are standardised. A detailed description of the data can be found in Appendix C.

2.3 Determining monetary policy stance using central banks reaction functions

We consider a central bank reaction function as in Coibion and Gorodnichenko (2012) to determine the prescribed policy rate. To define the stance of monetary policy, we then take the difference between the actual policy rate and the rate suggested by the central bank's historical reaction function. First, we estimate the following monetary policy reaction function for each country i,

$$r_{i,t} = \theta_{i,0} + \theta_{i,1}\pi^{e}_{i,t+12} + \theta_{i,2}gap^{e}_{i,t+12} + \theta_{i,3}gap_{i,t} + \theta_{i,4}REER_{i,t} + \theta_{i,5}OIL_{t} + \nu_{i,t}, \quad (4)$$

$r_{i,t}$ is the actual policy rate in time t. $\pi^{e}_{i,t+12}$ and $gap^{e}_{i,t+12}$ are the expected rates of inflation and the expected output gap 1 year ahead. $gap_{i,t}$ is the contemporaneous output gap. To construct the output gap we apply the HP filter to GDP data extrapolated with an ARIMA model to address the filter's end-point bias. $REER_{i,t}$ is the real effective exchange rate and OIL_{t} is the global price of oil. $\nu_{i,t}$ is the error term.

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[17] This vulnerability index has the advantage of being parsimonious and available for a large number of countries but a variety of other variables, such as the size of current account deficits, net international investment position and foreign exchange reserves adequacy metrics, corporate and sovereign indebtedness, and banking and real estate vulnerabilities are not included and are also potentially important determinants of EME resilience.

Given data limitations, we are only able to estimate the policy function for 12 out of 14 EMEs.[18]

Next, we use the estimate coefficients from equation (4) to predict the policy rate $\hat{r}_{i,t}$ in each month. The predicted policy rate is interpreted as a benchmark indicator of the way monetary policy in a country typically reacts to changes in expected economic fundamentals. This approach prescribes a policy rate which is consistent with each central banks' past and future average behaviour, and is, therefore, less normative than using a standard Taylor rule.

Finally, we take the difference between the actual policy rate and $\hat{r}_{i,t}$. As detailed in section 2, we apply the same logistic transformation in (2) to these differences, substituting them for $z_{i,t}$. Positive values of the resulting state variable indicate that monetary policy is tighter than the estimated central bank reaction function would imply, and vice versa.

3 Results

Panel baseline estimations. Our findings indicate that monetary policy shocks have substantial spillovers to EMEs. In the panel regressions, a US pure monetary policy shock leads to a prompt tightening of EME financial conditions, with a peak effect after around 2-months (Figure 1, top panel). The effect of US pure monetary policy shocks on EME industrial production takes longer to materialise, with the maximum effect apparent after around 8 months (Figure 1, middle panel). Consumer prices decline and the effects peaks around one-and-a-half years (Figure 1, lower panel). The effects have the expected sign and have an economically meaningful magnitude. In particular, a monetary policy shock that results in a one standard deviation increase in the 5-year US Treasury bond yield is associated with a 2.5 standard deviation (0.05 pp) tightening of financial conditions, almost a 2 standard deviation (0.5 pp) decline in industrial production and half standard deviation (0.1 pp) decrease in consumer prices.

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[18] All EMEs besides Mexico and Türkiye due to data availability.

The size of the effect on financial conditions and then on industrial production is particularly notable. Economic theory suggests that US monetary policy transmits to real activity and prices in the rest of the world through several channels. These include (i) the financial channel: Fed tightening increases interest rates, depresses asset prices and tightens balance sheet constraints; (ii) the demand channel: Fed tightening dampens US consumption and investment, reducing demand for imports from the rest of the world; and (iii) the expenditure switching channel: Fed tightening induces an appreciation of the US dollar which curbs both imports and exports in non-US economies.[19]

The effect on consumer prices is not as big as for activity and financial conditions possibly linked to the offsetting effects of tighter financial conditions and reduced external demand (which would tend to reduce inflation), and a stronger US dollar increases import and commodity prices in EMEs (which puts upward pressure on inflation).

Panel state-dependent estimations. Next, we explore heterogeneity of country responses to US monetary policy shocks by estimating a state-dependent version of our regression model.[20] We define states along two dimensions discussed above, namely by a degree of macro-financial vulnerabilities and by domestic monetary policy stance.

The results in Figure 2 suggest that the impact of US monetary policy shocks is greater if macro-financial vulnerabilities are higher. The estimated tightening of financial conditions, and reduction in industrial production and consumer prices is more pronounced when the vulnerability state is high (red lines) than when the vulnerability state is low (green lines). Similarly, relative to the baseline results reported above, the

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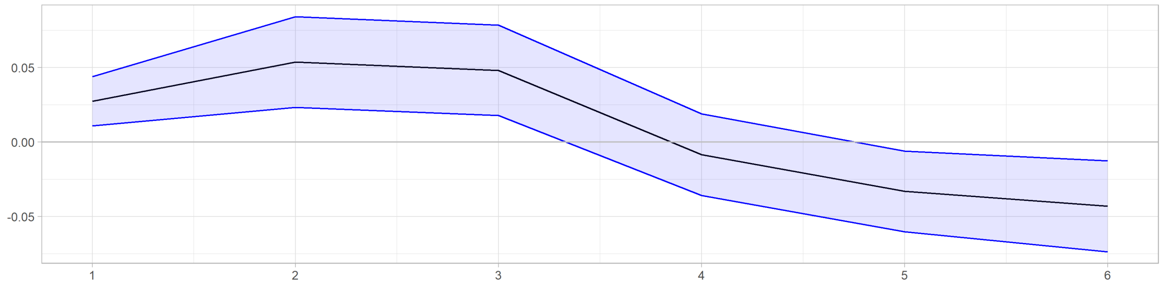
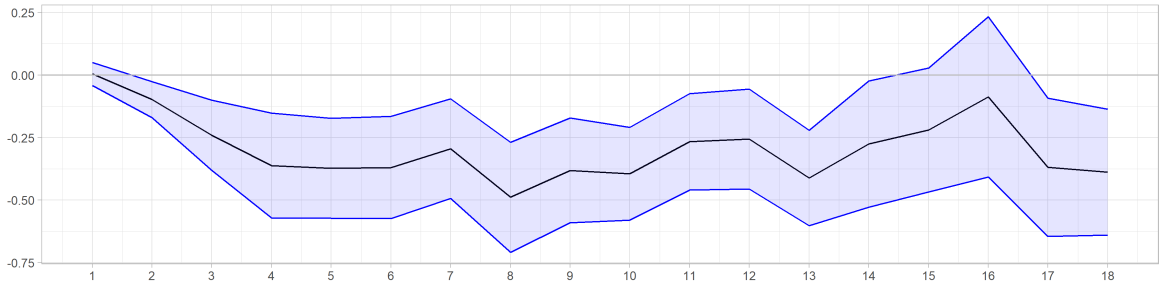
[19] According to Georgiadis and Schumann (2021) under full dominant currency pricing, both exports and imports fall because prices of intra-regional imports in the rest of the world are sticky in US dollars. Therefore, multilateral US dollar appreciation triggers expenditure switching away from imports from other economies in the rest of the world towards domestically-produced goods.

[20] To better understand what the state-dependent results are capturing, consider an individual country as an example. In this case, the state-dependent impulse responses capture two distinct average dynamic effects: one conditioned on being in periods of a relative high state, another conditioned on being in periods of a relative low state (i.e., relative in the sense that the country is in one particular state compared to its own past). That is, for the states we consider, being in a more vulnerable state or having a loose monetary policy stance is measured by being above or below the historical average of the state variable considered.

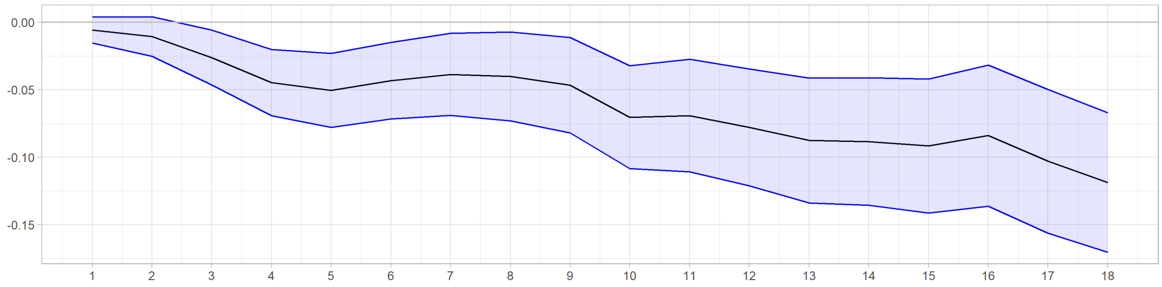
Figure 1: Impact of US pure monetary policy shocks on EMEs
(percentage points)



(a) Financial conditions



(b) Industrial production



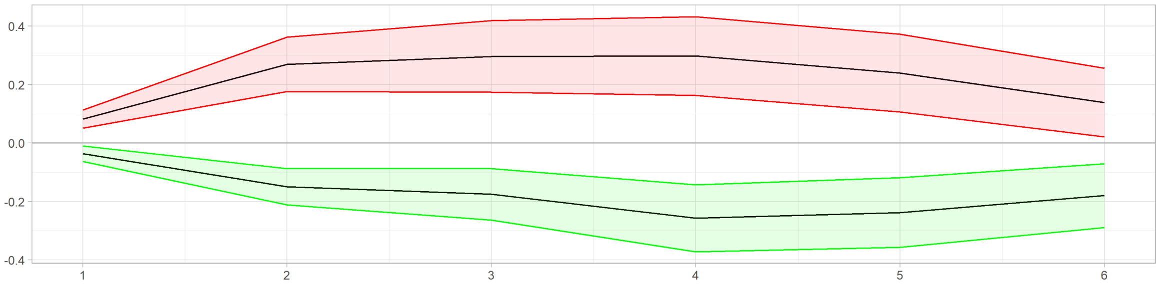
(c) Consumer prices

Sources: Haver Analytics, Refinitiv Datastream, Jarociński and Karadi (2020), and authors calculations.
Note: The chart shows the impulse responses of each dependent variable at different horizons (x-axis). In a panel local projection's framework, we use monthly data for the period January 2000 (March 2007 for FCI due to data availability) to November 2022. The shaded area shows the 68% percent confidence intervals. For financial conditions, higher values indicate tighter financial conditions. Responses have been scaled to show the impact of a US pure monetary policy shock that results in a 1 standard deviation change in the yield of the underlying financial instrument (5-year US Treasury bonds).

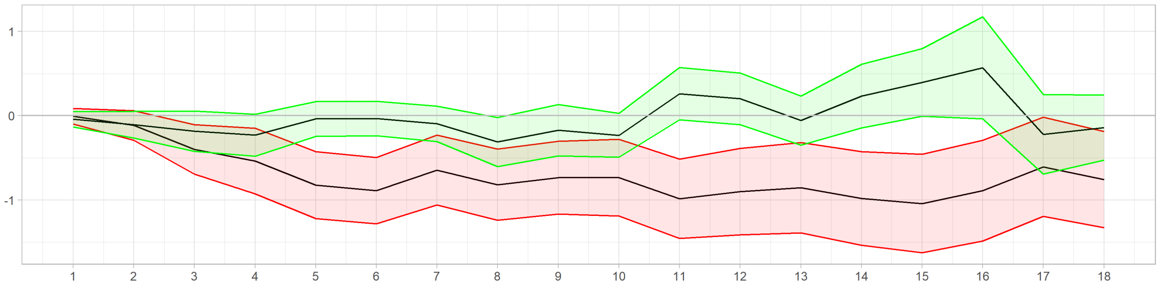
effects of US monetary policy shocks are around 3 to 4 times larger when EMEs are in a more vulnerable state.

The panel estimates in Figure 3 also show that the domestic monetary policy stance of EMEs shapes the response of the economies to US monetary policy shocks. The results suggest that an EME in a state where monetary policy is at least as tight as that

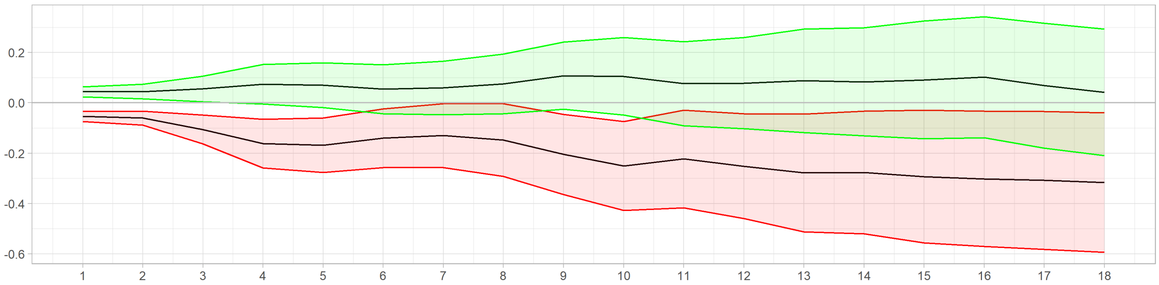
Figure 2: The impact of US pure monetary policy shocks on EMEs by level of vulnerability
(percentage points)



(a) Financial conditions



(b) Industrial production



(c) Consumer prices

Sources: Haver Analytics, Refinitiv Datastream, Jarociński and Karadi (2020), Georgiadis and Jarocinski (2023), and authors calculations.
Note: The chart shows the impulse responses of each dependent variable at different horizons (x-axis) with differing levels of vulnerability. Using a monthly state-dependent panel local projections framework (Jan-2000 - Nov-2022 for all target variables besides for financial conditions where the sample starts in Mar-2007), we report estimates for the high-vulnerability state (red lines) and a low-vulnerability state (green lines). The shaded areas show the 68% percent confidence intervals. For financial conditions, higher values indicate tighter financial conditions. Responses have been scaled to show the impact of a US pure monetary policy shock that results in a 1 standard deviation change in the yield of the underlying financial instrument (5-year US Treasury bonds).

implied by the monetary policy reaction function experience more limited spillovers from US monetary policy shocks (green lines). Conversely, if an EME monetary policy is looser than implied by their estimated monetary policy reaction function (red lines) then financial conditions tighten more, and industrial production and consumer prices decline more in response to US monetary policy shock. Our results suggest that the effects of US monetary policy shocks are around 2 times larger than the baseline when EMEs are in a state where monetary policy is abnormally loose.

As a result, both, domestic macro-financial vulnerabilities and domestic monetary policy stance play a significant role in shaping external monetary policy spillovers. Our empirical evidence of non-linear asymmetric responses suggest that robust policy frameworks in EMEs that aim at having low macro-financial vulnerabilities and conducting prudent monetary policy helps mitigate potential adverse effects from the Fed's unexpected policy decisions.

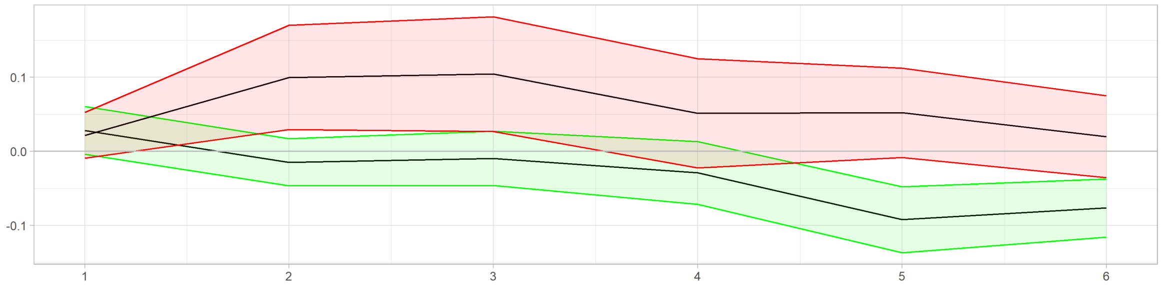
4 Robustness

In this section we carry out a number of exercises to test for robustness of our main results. First, we run the regressions separately at an individual country level. Second, we define an alternative state variable for the stance of domestic monetary policy based on a more normative Taylor rule. Third, we consider central bank transparency as an additional state variable to test for improving policy frameworks in EMEs in a broader sense. Fourth, we explain our choice of modelling state-dependency using a logistic function.

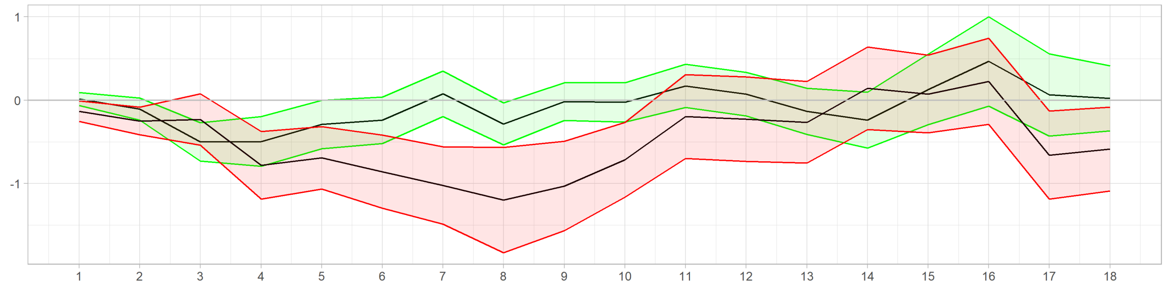
4.1 Individual country results

When regressions are run separately for each country, our findings confirm that monetary policy shocks have substantial spillovers to EMEs, but indicate that there is sizeable heterogeneity in the performance of countries in this regard. The left panel of Figure B.1 shows that financial conditions tighten in response to a pure monetary shocks, with the peak effect in the second month, in line with the results of the panel regression. By contrast, the dampening effect of US monetary policy shocks on industrial production and consumer prices only occurs with a substantial lag, with the maximum effect typically apparent after around 18 months (Figure B.1, centre and

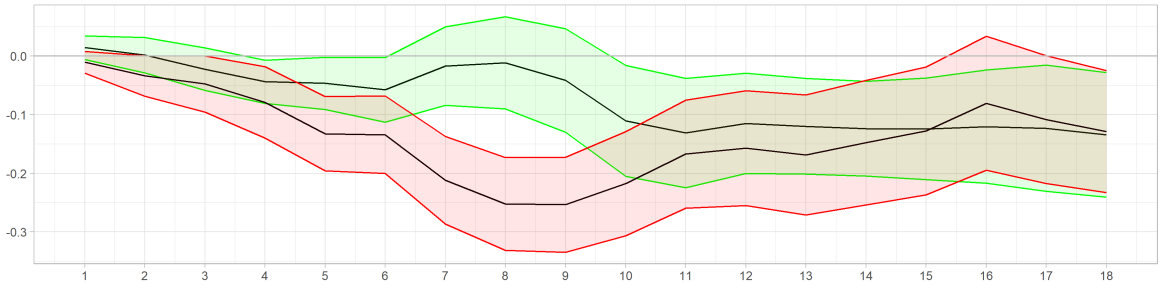
Figure 3: The impact of US pure monetary policy shocks on EMEs by monetary policy stance
(percentage points)



(a) Financial conditions



(b) Industrial production



(c) Consumer prices

Sources: Haver Analytics, Refinitiv Datastream, Jarociński and Karadi (2020) and authors calculations.

Note: The chart shows the impulse responses of each dependent variable at different horizons (x-axis) with differing domestic monetary policy stances. Using a monthly state-dependent panel local projections framework (Jan-2005 - Nov-2022 for all target variables besides financial conditions where the sample starts in Mar-2007), we report estimates for states where policy rates are below the levels implied by central bank reaction functions (red lines) and where policy rates are above the levels implied by central bank reaction functions (green lines). The shaded areas show the 68% percent confidence intervals. For financial conditions, higher values indicate tighter financial conditions. Due to data availability on the central bank reaction function, the EMEs conform a pool of 12 countries. Responses have been scaled to show the impact of a US pure monetary policy shock that results in a 1 standard deviation change in the yield of the underlying financial instrument (5-year US Treasury bonds).

right-hand side panels), somewhat longer than the 8 months estimated in the panel regressions for industrial production.

The estimated results are in line with panel regressions in terms of expected sign and have a somewhat smaller magnitude for the median effect. A monetary policy shock that results in one standard deviation increase in the 5-year US Treasury bond yield is associated with around a 1 standard deviation (0.02 percentage points, pp) tightening of financial conditions, a 1 standard deviation (0.3 percentage point) decline in industrial production, and one third of a standard deviation (0.08 percentage points) decline in consumer prices for the median EME. As with the panel estimates, the smaller estimated effect on consumer prices may reflect counterbalancing forces at play. The high degree of heterogeneity in the responses of the individual countries is represented in the grey shaded area, which shows range of estimates between 25th and 75th percentile of the pool of EMEs.

Similar to the panel regressions, we further explore heterogeneity of country responses to US monetary policy shocks by estimating a state-dependent version of our regression model. In line with the baseline panel regressions, the results of the individual country regressions suggest that the impact of US monetary policy shocks is greater if macro-financial vulnerabilities are higher. Specifically, we find that, when including the vulnerability state variable in the regressions, the response of financial conditions, industrial production, and consumer prices is larger when a country is in a high vulnerability state (red dots) as compared to a low vulnerability state (green dots), as shown in Figure B.2.[21] Figure A.6 illustrates that the estimated peak response of EMEs' financial conditions and industrial production are more pronounced in countries that on average had higher average vulnerabilities over the sample period.

Similarly, the domestic monetary policy stance of EME also shapes their response to US monetary policy shocks. Once again, the results suggest that the impact of monetary policy shocks originating in the United States can be mitigated by prudent domestic monetary policy in EMEs. When an EME's monetary policy is at least as tight as that implied by estimates of its central bank reaction function, spillovers from

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[21] If we examine the individual country regressions, the vulnerability states are consistently statistically significantly different for at least one time horizon for all countries, and the coefficients are statistically significantly different in 44% of financial conditions regressions at different time horizons, 48% for industrial production, and 46% for consumer prices.

US monetary policy to financial conditions and industrial production are typically more limited (green dots in Figure B.3), relative to a situation where monetary policy is looser than the reaction function would suggest (red dots in Figure B.3).

4.2 Monetary policy stance relative to Taylor Rule

Describing a country's monetary policy stance requires a normative policy. In our main results we consider monetary policy rates prescribed by central banks' reaction functions and use these to determine a central bank's policy stance. As an alternative benchmark, we also examine policy rates implied by a standard Taylor rule.[22] Our Taylor rule specification takes the following form

$$r_{i,t}^{TR} = r_{i,t}^{*} + \pi_{i,t} + \beta_1 gap_{i,t} + \beta_2(\pi_{i,t} - \pi_{i,t}^{*}) \tag{5}$$

$r_{i,t}^{TR}$ is the policy rate implied by the Taylor rule for country i in month t. $r_{i,t}^{*}$ is the natural real rate of interest. We estimate $r_{i,t}^{*}$ by taking a moving average of the actual real policy rate over a 10-year window. $\pi_{i,t}$ is the actual rate of inflation. $gap_{i,t}$ is the output gap. We estimate the output gap by applying the HP filter to quarterly real GDP extrapolated with an ARIMA model to address the HP filter's well known end-point bias. $\pi_{i,t}^{*}$ is the target inflation rate. We set $\beta_1 = 1.0$ and $\beta_2 = 0.5$ as is standard in modern Taylor rule parameterisations. As before, we define a country's domestic monetary policy stance by considering the distance between actual policy rates and tat prescribed by the Taylor rule. Our indicator of domestic monetary policy stance using the Taylor rule is plotted in Figure B.4.

The results suggest that an EME in a state where monetary policy is at least as tight as that implied by the Taylor rule experience more limited spillovers from US monetary policy shocks (Figure B.5, green lines). Conversely, if an EME is in the monetary policy state that is looser than implied by the Taylor rule (Figure B.5, red

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[22] As mentioned above, this indicator does not account for whether inflation is driven by supply or demand factors. However, even supply shocks could imply some increase in policy rates, as central banks may also act to contain supply-driven increases in inflation to keep inflation expectations anchored.

lines) then financial conditions tighten and industrial production and consumer prices deteriorate more in response to US monetary policy shocks.

4.3 Central bank transparency

To test our intuition about improved policy frameworks in EME central banks we conduct an additional robustness check using the monetary policy transparency index of Dincer et al. (2022). This index captures several dimensions of transparency regarding how monetary policy is conducted. Openness about the policy objectives, disclosure of economic data and models used for economic analysis, being explicit on the monetary strategy are some examples of the aspects included in the measure. In line with Dincer et al. (2022) the index for our pool of EME countries displays a clear upward trend indicating improved transparency over the last two decades. Given the slow-moving nature of the metric for most countries one can only disentangle two states in the sample: lower transparency at the beginning of the periods and higher transparency towards the end. The index is shown in Figure B.6.

When using the transparency index as an alternative state variable to proxy for the quality of the monetary policy framework, we get results that complement our message from the monetary policy stance analysis.[23] Figure B.7 shows that in the presence of US monetary policy surprises, financial conditions tighten more in a state of low central bank transparency (red line) relative to being more transparent (green line). For consumer prices we get a similar pattern where effects of tighter US monetary policy are initially more pronounced in a state where the monetary policy framework is less transparent (red lines). For the case of industrial production, there are no statistically significant differences between the responses of both states. Therefore, besides for activity, the results are aligned with the ones of the central bank reaction function to gauge the monetary policy stance, reinforcing our message that the greater resilience

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[23] There are two main drawbacks with the index for our application. In particular, the first caveat is that the index is only available on annual frequency whilst a strength of our paper is that we use monthly state variables that allow us to estimate short-term non-linear effects. We tackle this by linearly interpolating the annual data into months given the index is a slow-moving variable. The second caveat is that the index is updated until 2019, leaving out the most recent post-COVID-19 hiking cycle.

of EMEs in the recent tightening cycle may partly reflect more robust monetary policy frameworks.

4.4 Modelling state-dependency

Modelling state-dependent responses using a logistic function allows to control for the speed of transitioning between states. For state variables at monthly frequency used in this analysis it is considered more realistic to assume a smooth transition between states rather than allowing the states to change abruptly (i.e., using a dummy variable). In fact, our setup is a more general version of modelling asymmetric responses, with a threshold or dummy variable approach being a specific case of our model when $\lim_{\gamma \to \infty} F(z) = I$, with $I = 0$ or $I = 1$. We illustrate the difference in Figure B.8 where we plot as an example how the vulnerability state variable would enter the panel regressions under a dummy variable approach and a smooth-transition approach. One can observe that being able to allow for persistence in the changes between states through γ (e.g., move from high to low vulnerability states) resembles the actual state variable realistically and in a more reliable way.

Finally, to contrast our choice of $\gamma = 2$ we run the panel local projection regressions for different values of γ. Figure B.9 documents the state-dependent impulse responses for our vulnerability exercise at different smooth-transition parameter values. We observe that our responses deliver qualitatively similar results.

5 Conclusion

EMEs have remained resilient against the backdrop of global monetary policy tightening after the pandemic. Taking into account the pace at which monetary policy tightened in the US and across the globe, their recent resilience is remarkable. In this paper we explored a role of macro-financial vulnerabilities and domestic monetary policy conduct across EMEs as factors shaping the impact of spillovers from US monetary policy.

While EMEs were not immune to these spillovers, we show that they could be attenuated or amplified by macro-financial vulnerabilities and domestic monetary policy actions. These findings support a narrative whereby the greater resilience of EMEs in the current monetary policy tightening cycle may partly reflect the observed gradual reduction of macro-financial vulnerabilities over the course of recent decades and a more prudent conduct of monetary policy. EMEs faced the same kinds of inflationary pressures and supply shocks as advanced economies. Their central banks have participated in—and are even somewhat ahead of—the current global tightening cycle, striving to maintain their credibility and keep inflation anchored. Our findings suggest that maintaining a prudent policy stance helps to mitigate spillovers from US monetary policy. Looking ahead, the analysis suggests that it will be crucial for central banks in EMEs, as in advanced economies, to stay to the course and maintain an appropriate monetary policy stance until inflation has sustainably returned to target levels.

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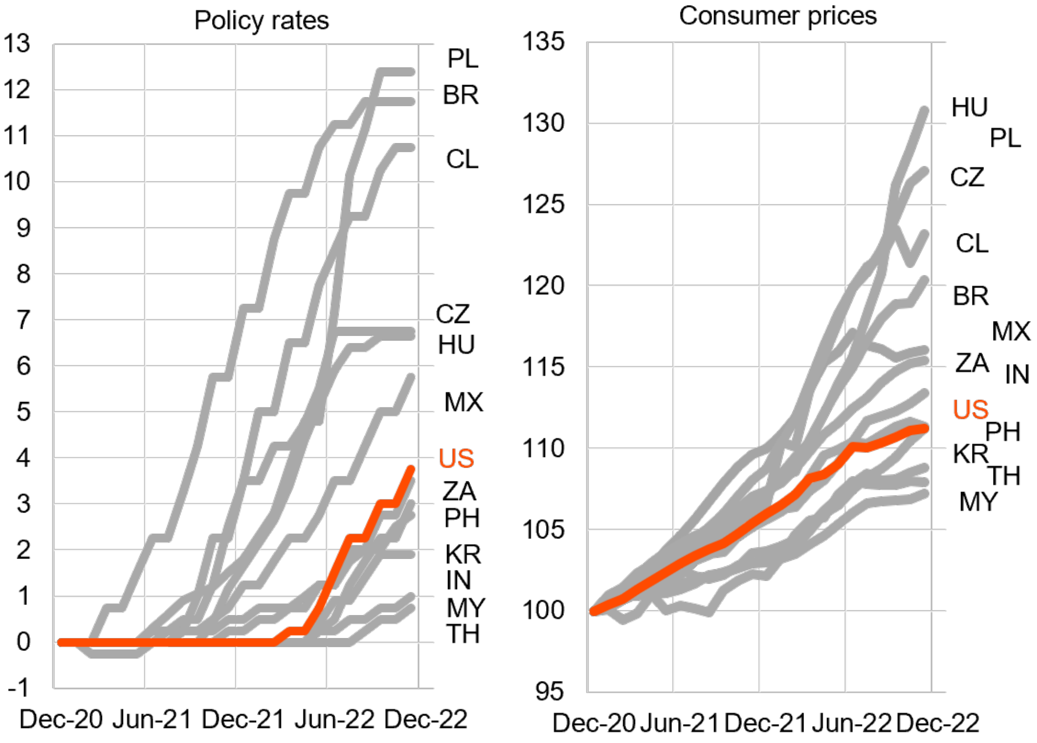
Appendix

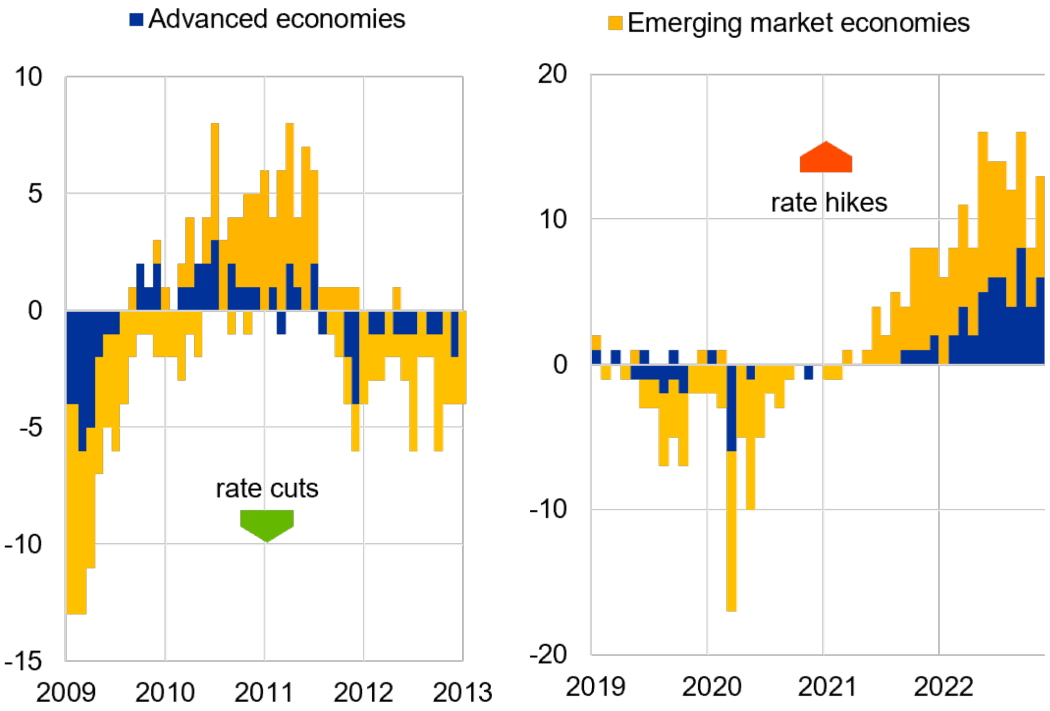
A Additional figures

Figure A.1: EMEs monetary policy tightening and price developments compared to the US
(lhs: policy rates in percent; rhs: consumer price index, December 2020=100)



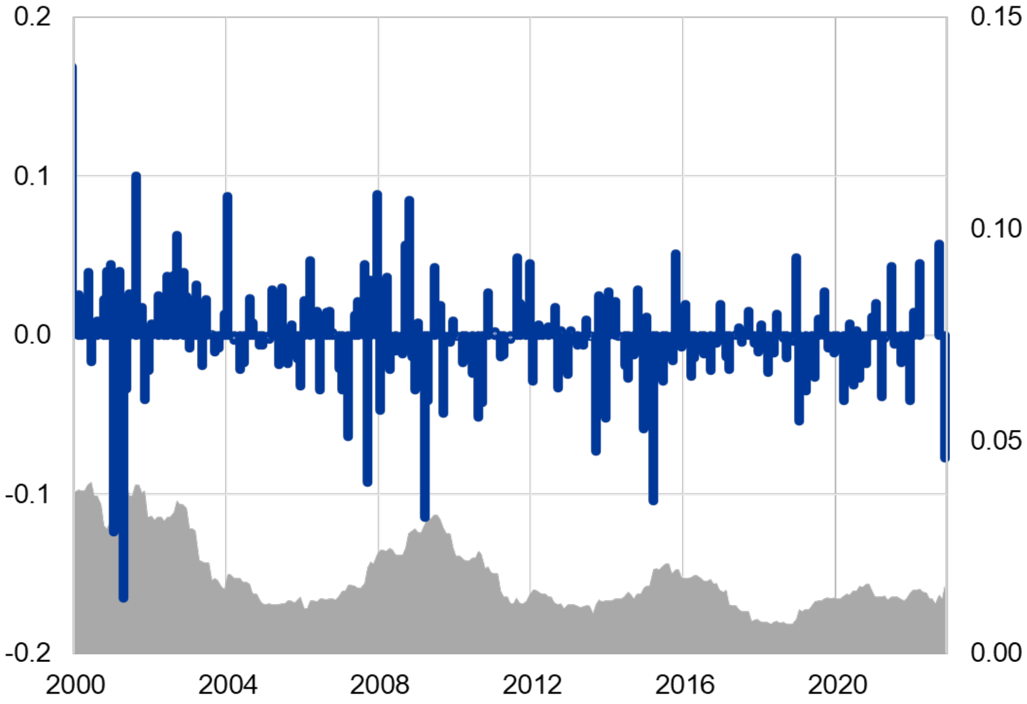
Sources: Haver Analytics and authors calculations.
Note: CN, RU, TR are not included in the chart but are part of our country sample used in the empirical analysis. For a better readability of cross-country developments we set policy rates to 0 (left panel) and inflation rates to 100 (right panel) in December 2020.
Last observation: November 2022.

Figure A.2: Central banks tighten monetary policy in sync
(number of central banks raising or lowering rates)



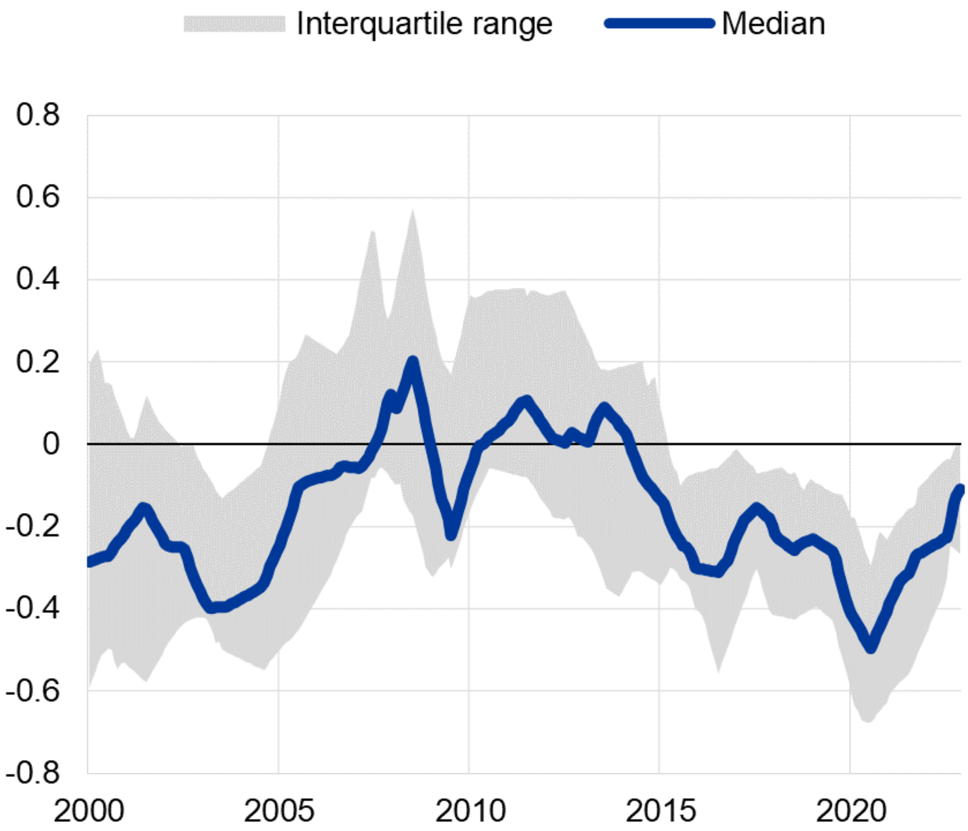
Sources: Haver Analytics and authors calculations.
Note: The sample consists of 10 advanced economies (Australia, Canada, euro area, Japan, New Zealand, Norway, Sweden, Switzerland, United Kingdom and United States) and 14 EMEs (Brazil, China, Chile, Czechia, Hong Kong, Hungary, India, Israel, Mexico, Poland, Romania, South Africa, South Korea and Thailand). The chart refers to the periods of monetary policy tightening in the recovery phase following the Great recession (left panel) and the coronavirus (COVID-19) pandemix (right panel).
Last observation: November 2022.

Figure A.3: Proxy of US pure monetary policy shocks based on high-frequency financial data
(lhs: bars - basis points; rhs: shaded area - basis points, absolute value)



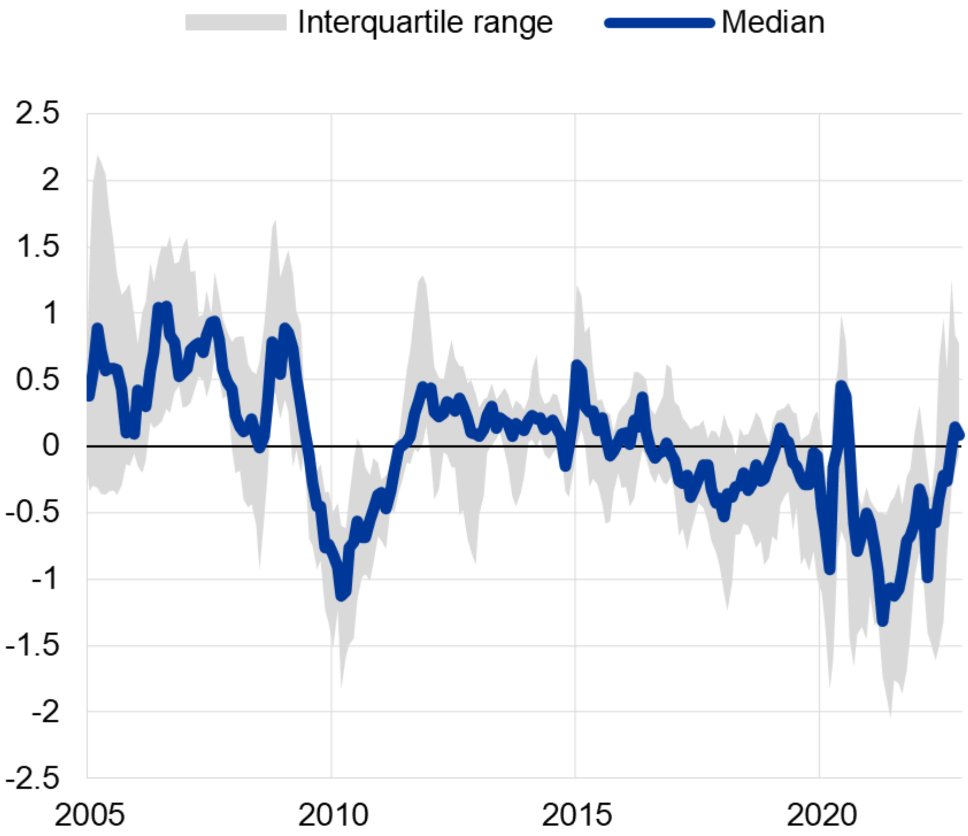
Sources: Haver Analytics, Refinitiv Datastream, Jarociński and Karadi (2020), and authors calculations.
Note: The chart shows in blue the surprise effects based on movements in 5-year Treasury bond yields during a 30-minute event window around monetary policy announcements (Jarociński and Karadi (2020)). The grey shaded area is the 2-year moving average of absolute values of surprises to capture how the magnitude of the surprises has evolved over time.
Last observation: November 2022.

Figure A.4: Vulnerability metric for EMEs
(index)



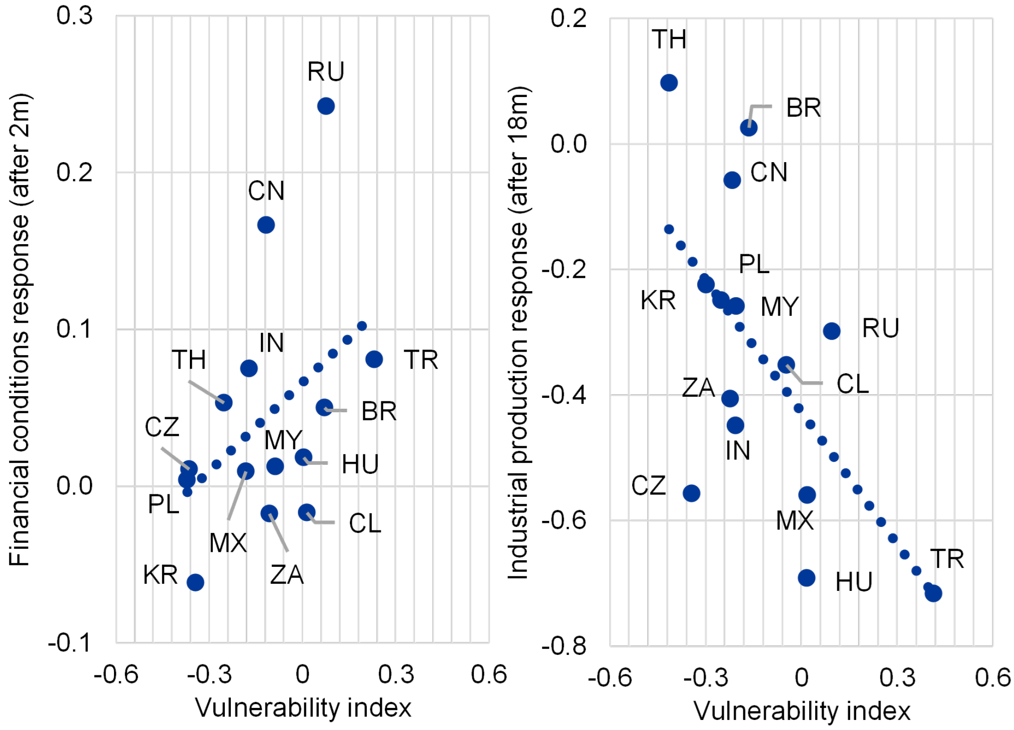
Sources: Haver Analytics, Refinitiv Datastream, Georgiadis and Jarocinski (2023), and authors calculations.
Note: The index is based on an average of the 3 first principal components of four main variables, namely: (i) the real effective exchange rate gap calculated as the deviation from the linear trend (to account for the Balassa-Samuelson effect); (ii) the real effective exchange rate gap calculated as the deviation from the average for advanced economies (included because overvaluations have been shown to be predictors of crises, as in Gourinchas and Obstfeld (2012)); (iii) past inflation rates (to capture weakly anchored inflation expectations, as in Ahmed et al. (2021)); and (iv) US dollar-denominated portfolio debt liabilities relative to GDP (to capture external balance sheet vulnerabilities). The country sample comprises 14 EMEs (Brazil, Chile, China, Czechia, Hungary, India, Malaysia, Mexico, Poland, Russia, South Africa, South Korea, Thailand and Türkiye). Higher values indicate greater vulnerability. The grey shaded area refers to the interquartile range of the vulnerability index in our country sample over time.
Last observation: November 2022.

Figure A.5: Domestic monetary policy stance metric for EMEs
(index)



Sources: Haver Analytics, Refinitiv Datastream and authors calculations.
Note: This index is constructed as the difference between (i) the EME's actual policy rate and (ii) the policy rate implied by an empirically estimated central bank reaction function (Coibion and Gorodnichenko (2012)). The key explanatory variables include expected inflation and output growth one year ahead, and the cyclical position of the economy as captured by contemporaneous estimates of the output gap. In addition, we control for the real effective exchange rate and oil prices. The sample comprises nine EMEs (Brazil, Chile, China, India, Malaysia, Russia, South Africa, South Korea and Thailand) and three EU Member States (the Czech Republic, Hungary and Poland). The sample is smaller than in Chart A, and the time series is shorter, owing to the availability of data required to estimate central bank reaction functions. Positive values mean that monetary policy is tighter than the estimated central bank reaction function would imply, and vice versa. The latest observations are for November 2022.
Last observation: November 2022.

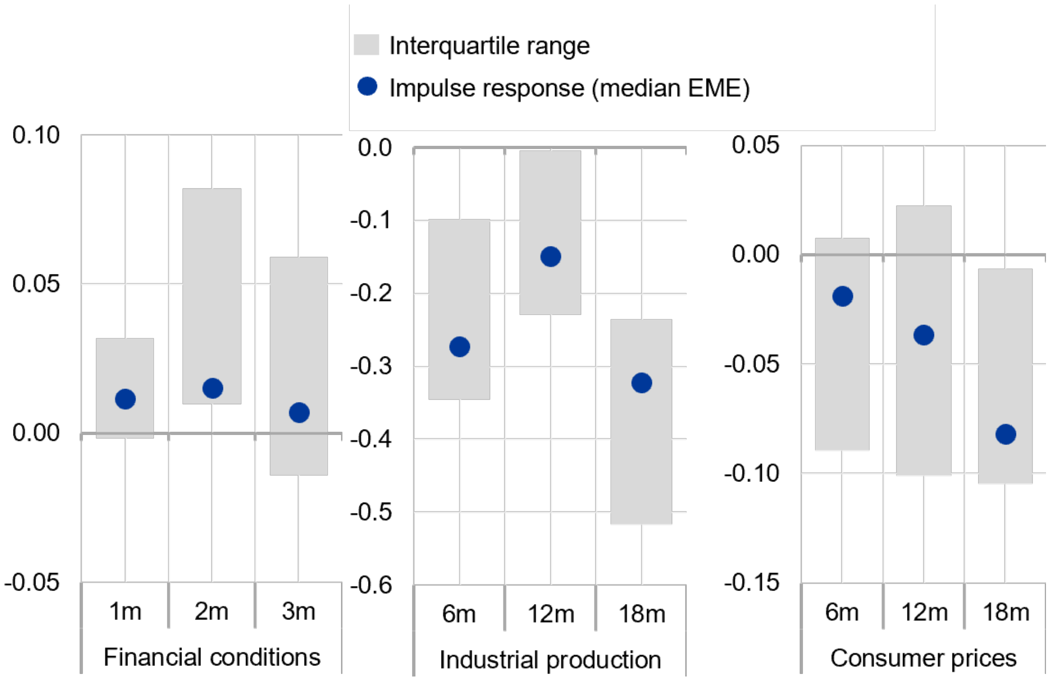
Figure A.6: Cross-country variation in EME responses to US pure monetary policy shocks and EME vulnerabilities
(y-axis: peak responses in percentage points; x-axis: index)



Sources: Haver Analytics, Refinitiv Datastream, Jarociński and Karadi (2020), Georgiadis and Jarocinski (2023), and authors calculations.
Note: The left-hand chart relates the estimated peak response of EMEs' financial conditions to the average vulnerability index during 2007-2022. The right-hand chart relates the estimated peak response of EMEs' industrial production to the average vulnerability index in 2000-2022.

B Robustness figures

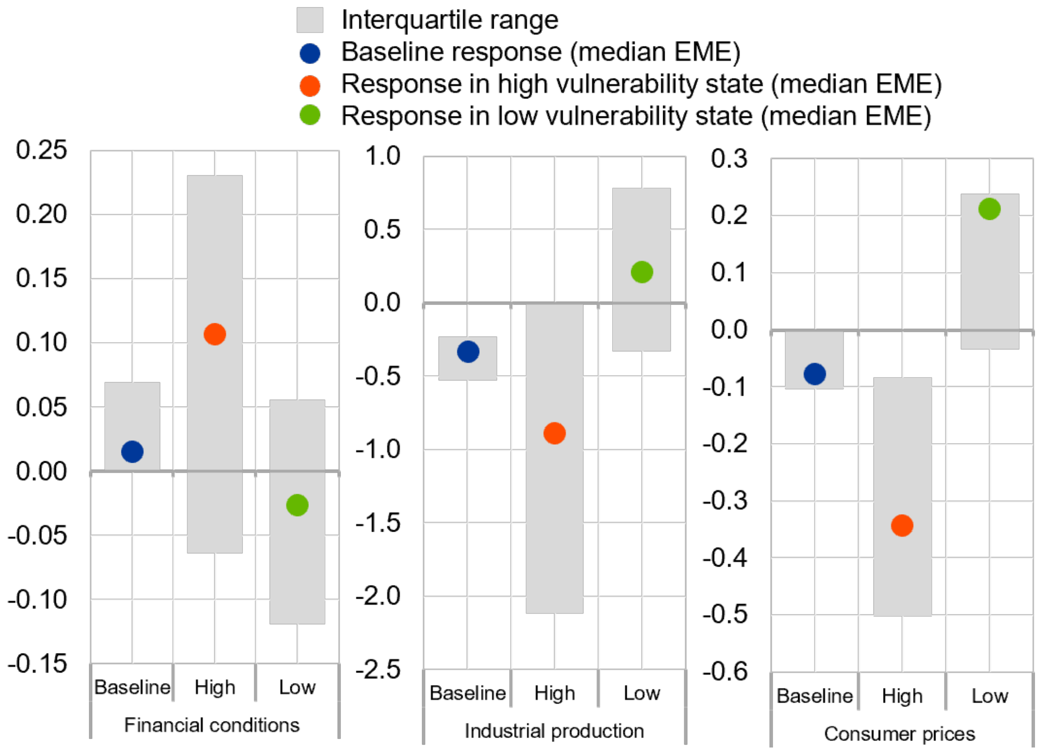
Figure B.1: Impact of US pure monetary policy shocks on EMEs
(percentage points at selected horizons)



Sources: Haver Analytics, Refinitiv Datastream, Jarociński and Karadi (2020), Georgiadis and Jarocinski (2023), and authors calculations.
Note: The x-axis shows the responses of each dependent variable at different horizons. In a local projection's framework, we use monthly data for the period January 2000 (March 2007 for FCI due to data availability) to November 2022 and run regressions separately for 14 EMEs. Median estimate is denoted by the blue dot, grey shaded area shows range of estimates between 25th and 75th percentile of the pool of EMEs. In the left-hand panel, higher values indicate tighter financial conditions. Responses have been scaled to show the impact of a US pure monetary policy shock that results in a 1 standard deviation change in the yield of the underlying financial instrument (5-year US Treasury bonds).

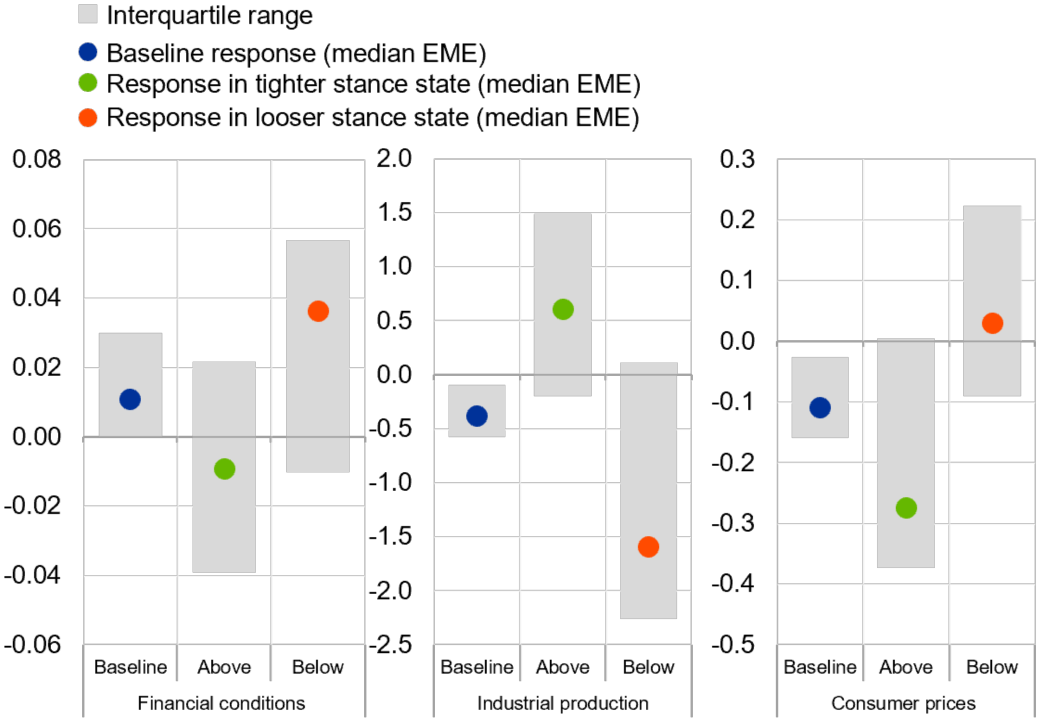
(peak responses in percentage points)

Figure B.2: The impact of US pure monetary policy shocks on EMEs by level of vulnerability
(peak responses in percentage points)



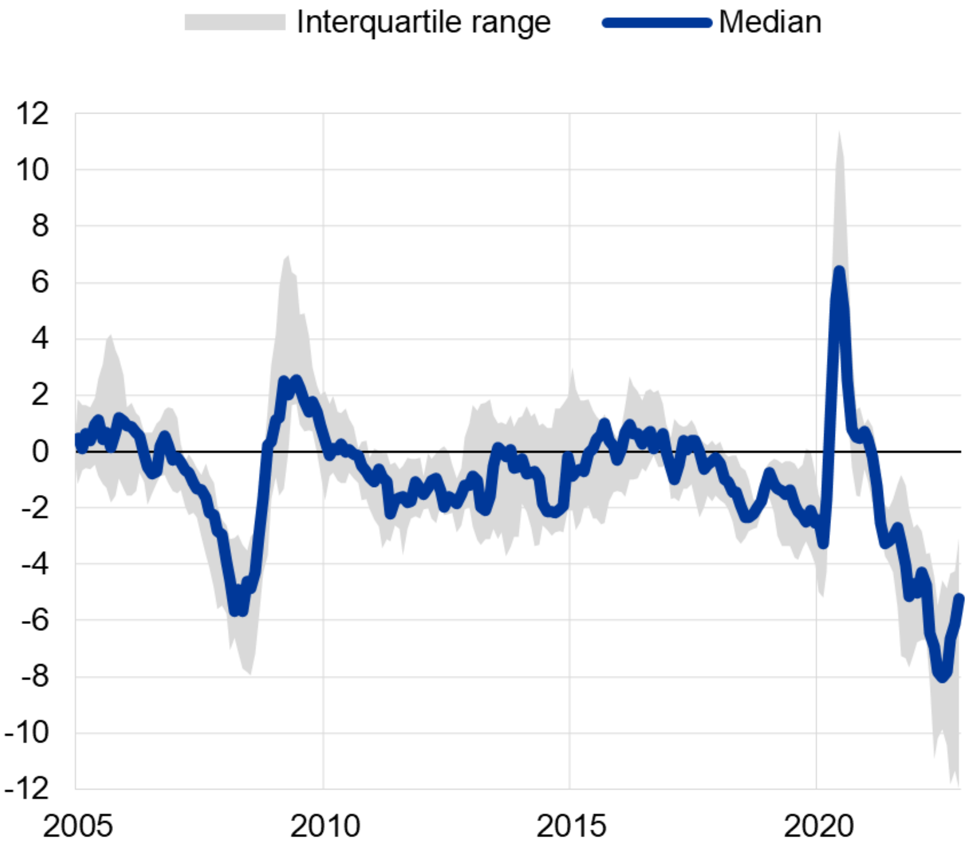
Sources: Haver Analytics, Refinitiv Datastream, Jarociński and Karadi (2020), Georgiadis and Jarocinski (2023), and authors calculations.
Note: This chart shows the responses of dependent variables in log terms for economies with differing levels of vulnerability. Using a monthly state-dependent local projections framework (based on Auerbach and Gorodnichenko (2013)), we report median estimates for the baseline specification (blue dots), a high-vulnerability state (red dots) and a low-vulnerability state (green dots). The grey bars show the interquartile ranges, indicating the heterogeneity of responses. In the left-hand panel, higher values indicate tighter financial conditions. Responses have been scaled to show the impact of a US pure monetary policy shock that results in a 1 standard deviation change in the yield of the underlying financial instrument (5-year US Treasury bonds).

Figure B.3: The impact of US pure monetary policy shock on EMEs by monetary policy stance relative to estimated monetary policy reaction function
(peak responses in percentage points)



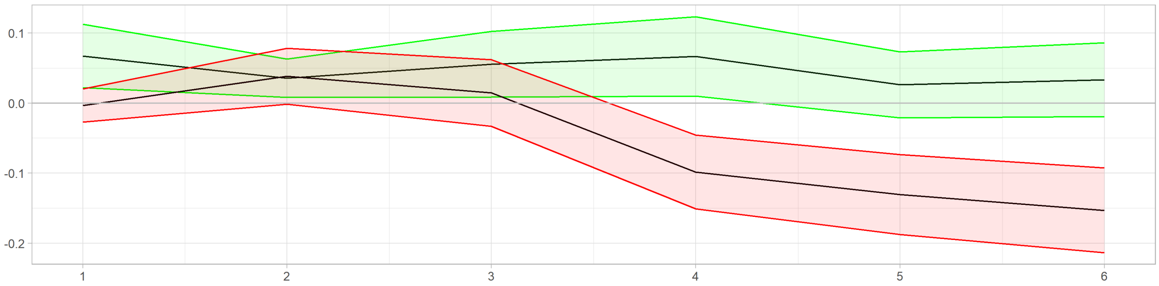
Sources: Haver Analytics, Refinitiv Datastream, Jarociński and Karadi (2020), Georgiadis and Jarocinski (2023), and authors calculations.
Note: This chart shows the responses of dependent variables in log terms depending on economies' monetary policy stances relative to their central bank reaction functions. Using a monthly state-dependent local projections framework (Auerbach and Gorodnichenko (2013)), we report median estimates for the baseline specification (blue dots), a state where policy rates are below the levels implied by central bank reaction functions (red dots) and a state where policy rates are above the levels implied by central bank reaction functions (green dots). The grey bars show the interquartile ranges, indicating the heterogeneity of responses. In the left-hand panel, higher values denote tighter financial conditions. Responses have been scaled to show the impact of a US pure monetary policy shock that results in a 1 standard deviation change in the yield of the underlying financial instrument (5-year US Treasury bonds). Due to data availability on the central bank reaction function, the EMEs conform a pool of 12 countries and estimation starts in January 2005.

Figure B.4: Alternative domestic monetary policy stance metric for EMEs
(index)

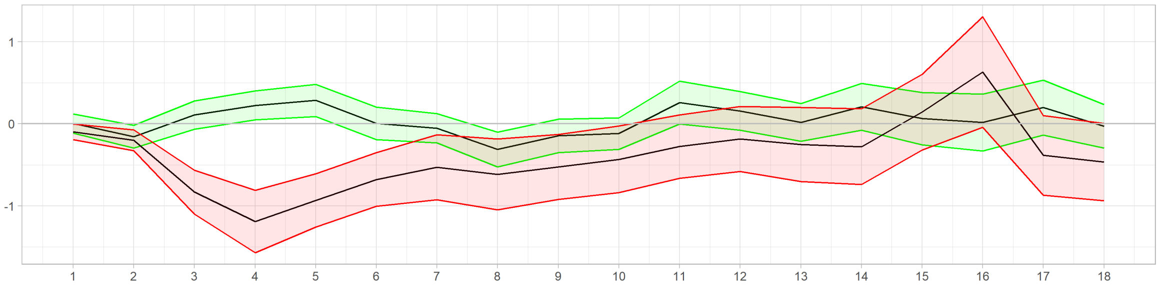


Sources: Haver Analytics, Refinitiv Datastream and authors calculations.
Note: This index is constructed as the difference between (i) the EME's actual policy rate and (ii) the policy rate implied by a standard Taylor rule as described in Section 4.2. The sample comprises 11 EMEs (Brazil, Chile, China, Hungary, Mexico, Poland, Russia, South Africa, South Korea, Thailand and Türkiye). The sample is smaller owing to the availability of data required to estimate Taylor rules. Positive values mean that monetary policy is tighter than the Taylor rule would imply, and vice versa.
Last observation: November 2022.

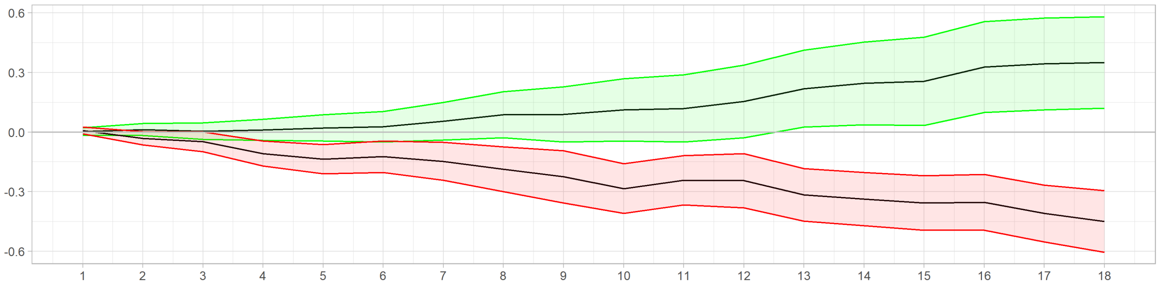
Figure B.5: The impact of US pure monetary policy shocks on EMEs by alternative monetary policy stance
(percentage points)



(a) Financial conditions



(b) Industrial production

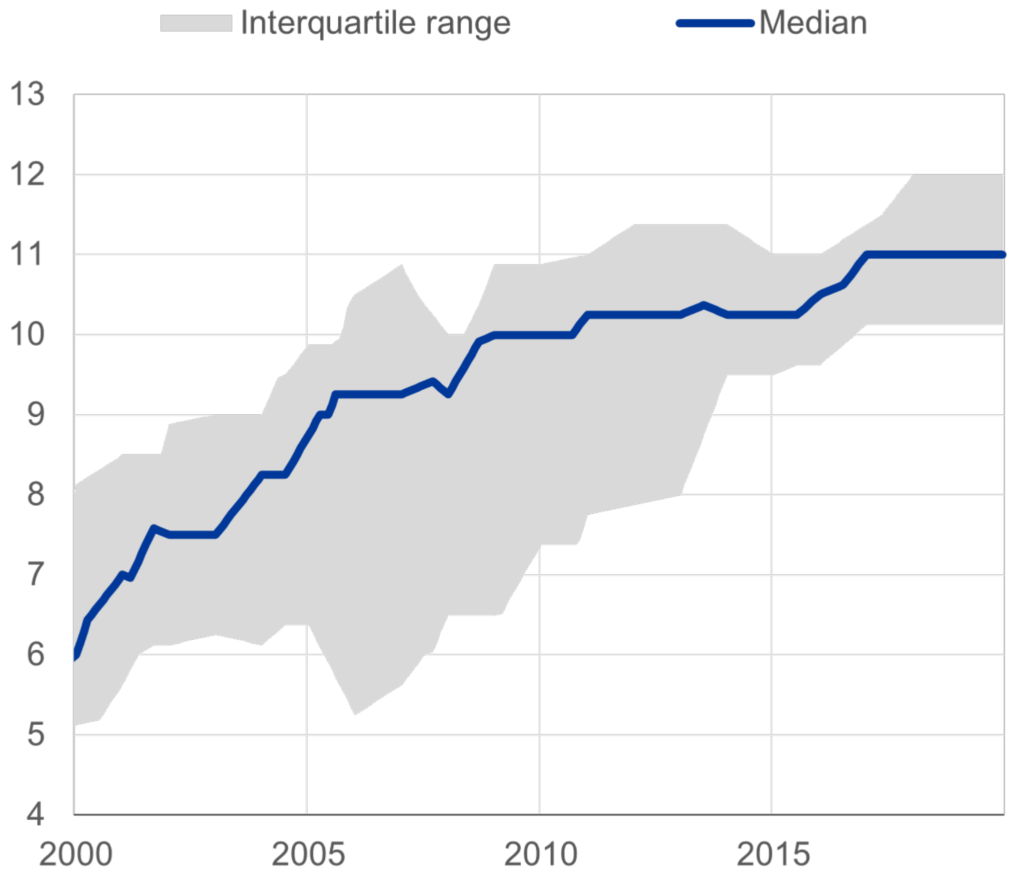


(c) Consumer prices

Sources: Haver Analytics, Refinitiv Datastream, Jarociński and Karadi (2020) and authors calculations.

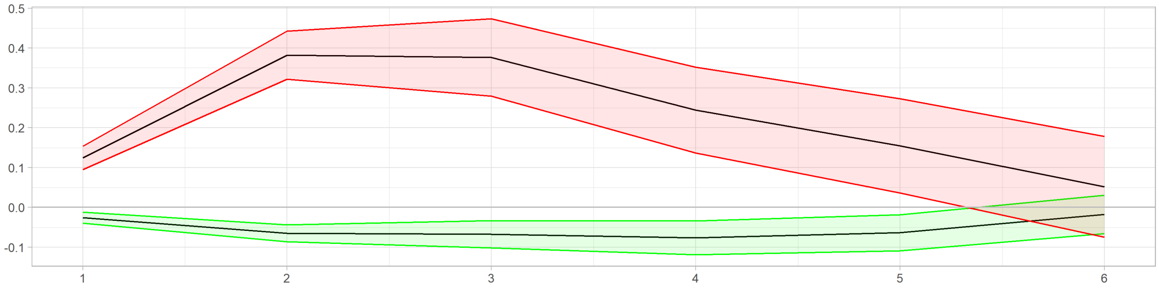
Note: The chart shows the impulse responses of each dependent variable at different horizons (x-axis) with differing alternative domestic monetary policy stances. Using a monthly state-dependent panel local projections framework (Jan-2005 - Nov-2022 for all target variables besides financial conditions where the sample starts in Mar-2007), we report estimates for states where policy rates are below the levels implied by a Taylor rule (red lines) and where policy rates are above the levels implied by a Taylor rule (green lines). The shaded areas show the 68% percent confidence intervals. For financial conditions, higher values indicate tighter financial conditions. Due to data availability on the central bank reaction function, the EMEs conform a pool of 11 countries. Responses have been scaled to show the impact of a US pure monetary policy shock that results in a 1 standard deviation change in the yield of the underlying financial instrument (5-year US Treasury bonds).

Figure B.6: Monetary policy transparency metric for EMEs
(index)

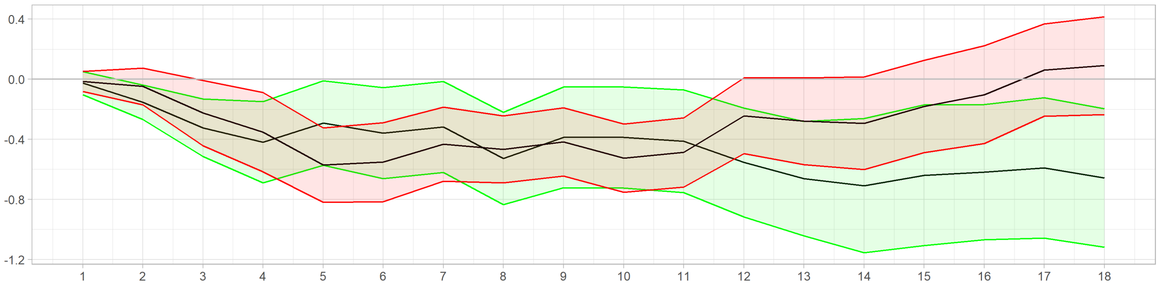


Sources: Dincer et al. (2022) and authors calculations.
Note: The index captures 5 broad dimensions of transparency in central banks (i) political transparency refers to openness about policy objective, (ii) economic transparency refers to the economic information used in the formulation of monetary policy, (iii) procedural transparency refers to the manner in which monetary policy decisions are reached, (iv) policy transparency captures whether or not the central bank promptly discloses its policy decisions and provides the associated explanation and rationale, and whether or not it provides forward guidance, (v) operational transparency refers to the information the central bank provides about problems of policy implementation and execution. To be able to run the local projection regressions at our baseline frequency (monthly) we linearly interpolate the annual data points of the index.
Last observation: December 2019.

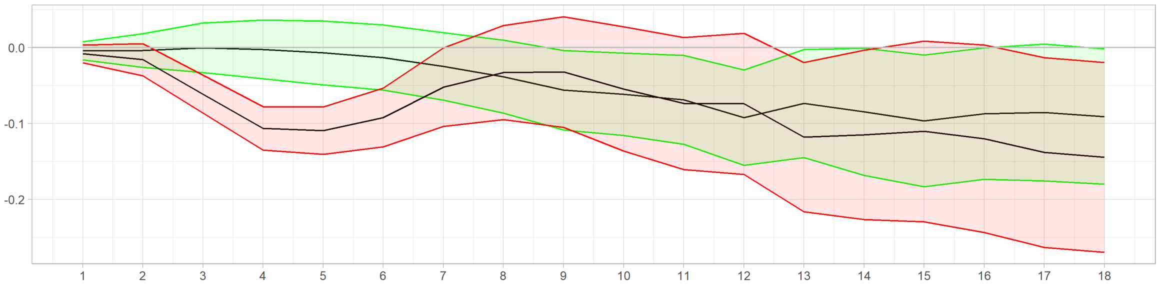
Figure B.7: The impact of US pure monetary policy shocks on EMEs by level of central bank transparency
(percentage points)



(a) Financial conditions



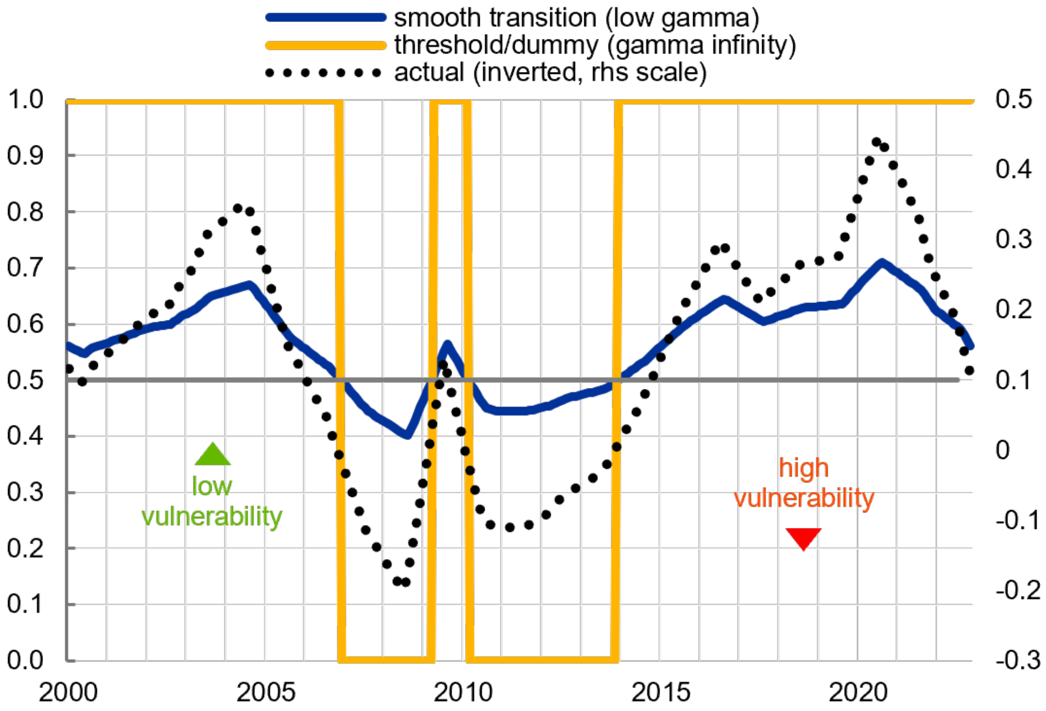
(b) Industrial production



(c) Consumer prices

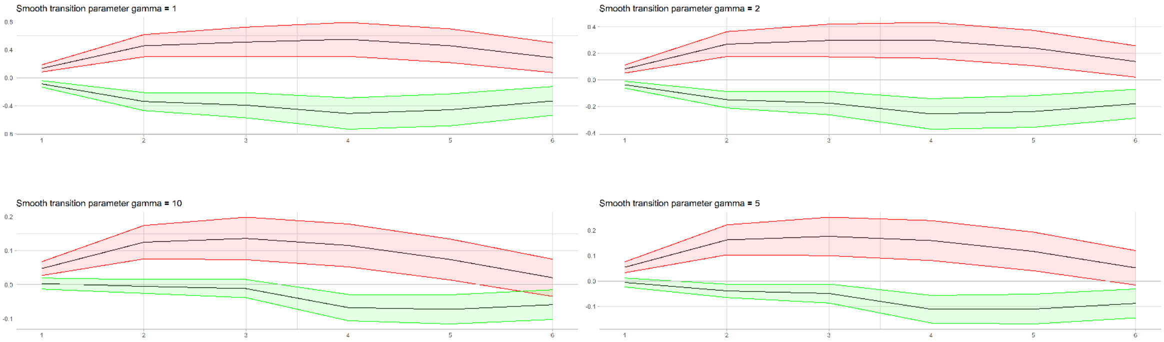
Sources: Haver Analytics, Refinitiv Datastream, Jarociński and Karadi (2020) and authors calculations.
Note: The chart shows the impulse responses of each dependent variable at different horizons (x-axis) with differing domestic monetary policy transparency levels. Using a monthly state-dependent panel local projections framework (Jan-2000 - Dec-2019 for all target variables besides financial conditions where the sample starts in Mar-2007), we report estimates for states where central banks are historically less transparent (red lines) and more transparent (green lines). The shaded areas show the 68% percent confidence intervals. For financial conditions, higher values indicate tighter financial conditions. Responses have been scaled to show the impact of a US pure monetary policy shock that results in a 1 standard deviation change in the yield of the underlying financial instrument (5-year US Treasury bonds).

Figure B.8: Implications of using different modelling approaches for state-dependent analysis: illustration for the vulnerability states
(index)

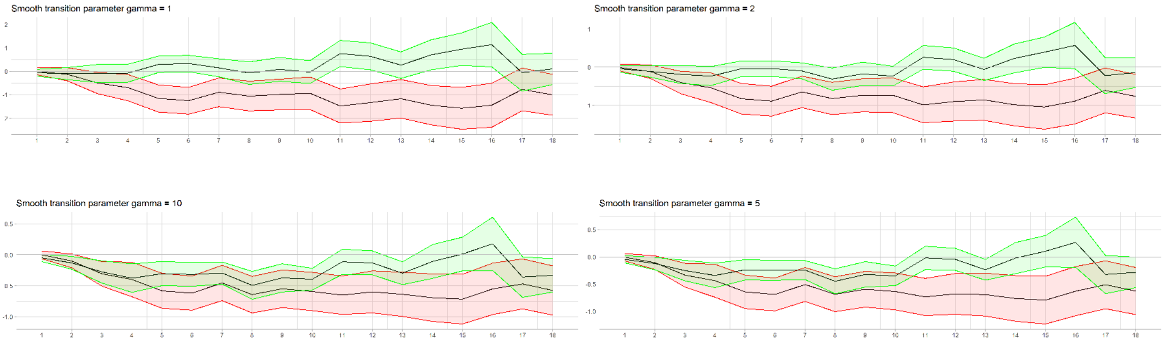


Sources: Georgiadis and Jarocinski (2023) and authors calculations.
Note: This chart shows the effect modelling the source of asymmetry in responses using a dummy variable or a smooth-transition approach. We take the vulnerability index for the median EME of our sample as an illustrative example. After fitting the logistic function in the state variable (i.e., vulnerability index), the parameter γ governs how smooth the transition is between both states. When γ is large, the transition is abrupt as in the case of a dummy variable (limiting case). When γ takes a smaller value, the transition is smoother and captures better the persistence of the underlying vulnerability index. The grey line delimits the periods when the economy is one of the two states.

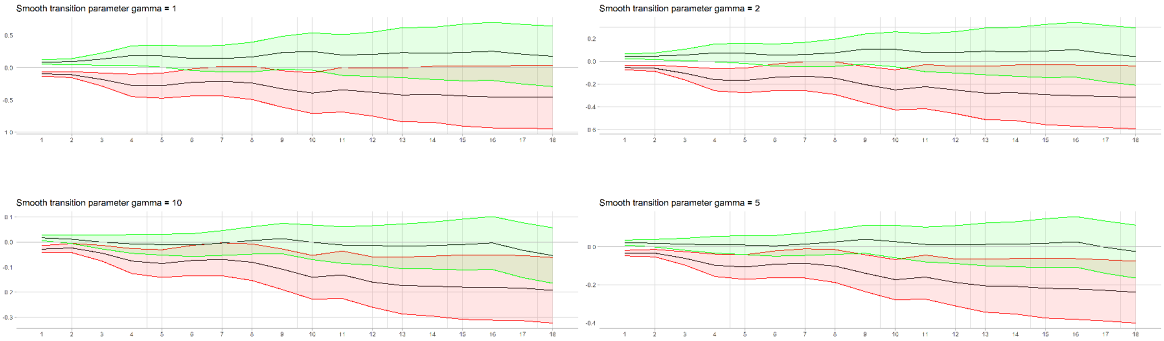
Figure B.9: Effect on the state-dependent impulse responses of endogenous variables depending on the choice of γ
(percentage points)



(a) Financial conditions



(b) Industrial production



(c) Consumer prices

Sources: Authors calculations.
Note: This chart shows the effect of the parameter γ on the state-dependent impulse responses. We compare $\gamma = 1, 2, 5, 10$ where the higher values correspond to a more abrupt transition between states (resembling the effect of having a dummy variable instead of a logistic function).

C Data details

Table C.1: Data codebook

Variable	**Description**	**Sources**	**Transformation**
IP	Manufacturing industrial production index (seasonally adjusted)	National statistics offices via Haver Analytics	log
CPI	Consumer price index (seasonally adjusted)	National statistics offices via Haver Analytics	log
FCI	Financial conditions index	Goldman Sachs	log
Commodities	Commodities spot index	Bloomberg via Haver Analytics	log
VIX	Global market volatility index	CBOE via Haver Analytics	log
GPR	Geopolitical risk index	Caldara and Iacoviello (2022)	log
US monetary policy shocks	High-frequency identified surprises around FOMC meetings	Jarociński and Karadi (2020)	basis points
Vulnerabilities	Macro-financial vulnerabilities index	Georgiadis and Jarocinski (2023)	standardised
Monetary policy stance	Monetary policy stance index	Schroeder and Tirpák (2023)	standardised

Note: Domestic variables (all except US monetary policy shocks, commodities, VIX, and GPR) correspond to 14 large EMEs: Brazil, Chile, China, Czechia, Hungary, India, Malaysia, Mexico, Poland, Russia, South Africa, South Korea, Thailand and Türkiye.

Table C.2: Descriptive statistics

	Global variables			
	US MP shock	**Geopolitical risk**	**VIX**	**Commodities**
Count	275	275	275	275
Mean	-0.001	4.579	2.937	5.673
Std	0.029	0.351	0.357	0.447
Min	-0.165	3.808	2.316	4.681
25% pct	-0.011	4.384	2.654	5.492
Median	0.000	4.511	2.894	5.807
75% pct	0.007	4.735	3.183	5.998
Max	0.100	6.239	4.137	6.479

	Domestic variables				
BR	**Industrial production**	**Consumer prices**	**Financial conditions**	**Vulnerability**	**Monetary policy stance**
Count	275	275	189	275	215
Mean	4.611	4.346	4.591	-0.169	-0.040
Std	0.095	0.390	0.022	0.523	2.838
Min	4.243	3.612	4.540	-1.007	-6.341
25% pct	4.549	4.065	4.580	-0.699	-1.927
Median	4.596	4.342	4.591	-0.161	-0.305
75% pct	4.704	4.714	4.608	0.205	1.713
Max	4.774	5.013	4.638	0.758	7.115

CN	**Industrial production**	**Consumer prices**	**Financial conditions**	**Vulnerability**	**Monetary policy stance**
Count	275	275	189	275	215
Mean	4.091	4.492	4.615	-0.214	0.000
Std	0.702	0.166	0.024	0.299	0.399
Min	2.745	4.246	4.537	-0.816	-1.045
25% pct	3.501	4.323	4.598	-0.425	-0.235
Median	4.276	4.521	4.625	-0.115	-0.021
75% pct	4.698	4.633	4.633	-0.041	0.279
Max	5.070	4.749	4.650	0.483	1.077

IN	**Industrial production**	**Consumer prices**	**Financial conditions**	**Vulnerability**	**Monetary policy stance**
Count	275	275	189	275	215
Mean	4.343	4.280	4.596	-0.205	-0.001
Std	0.377	0.428	0.019	0.141	1.047
Min	3.615	3.581	4.562	-0.492	-2.520
25% pct	3.997	3.845	4.585	-0.297	-0.662
Median	4.494	4.301	4.592	-0.214	0.165
75% pct	4.657	4.674	4.610	-0.152	0.804
Max	4.827	4.956	4.654	0.162	2.069

KR	**Industrial production**	**Consumer prices**	**Financial conditions**	**Vulnerability**	**Monetary policy stance**
Count	275	275	189	275	215
Mean	4.425	4.498	4.599	-0.298	-0.001
Std	0.275	0.155	0.009	0.347	0.651
Min	3.865	4.185	4.588	-0.967	-1.876
25% pct	4.184	4.368	4.594	-0.556	-0.513
Median	4.582	4.550	4.597	-0.327	-0.002
75% pct	4.642	4.631	4.601	-0.202	0.395
Max	4.798	4.748	4.628	0.613	2.035

MX	**Industrial production**	**Consumer prices**	**Financial conditions**	**Vulnerability**	**Monetary policy stance**
Count	275	275	189	275	-
Mean	4.526	4.451	4.590	0.016	-
Std	0.103	0.275	0.020	0.392	-
Min	4.248	3.931	4.555	-0.693	-
25% pct	4.439	4.218	4.577	-0.310	-
Median	4.504	4.457	4.589	-0.013	-
75% pct	4.621	4.673	4.602	0.250	-
Max	4.720	4.966	4.641	0.820	-

RU	Industrial production	Consumer prices	Financial conditions	Vulnerability	Monetary policy stance
Count	275	275	189	275	215
Mean	4.423	4.170	4.599	0.093	0.041
Std	0.225	0.570	0.035	0.566	1.544
Min	3.971	2.915	4.545	-0.964	-3.804
25% pct	4.284	3.727	4.581	-0.398	-0.661
Median	4.439	4.272	4.593	0.068	0.147
75% pct	4.597	4.698	4.604	0.638	0.738
Max	4.820	5.026	4.752	1.042	11.695

TR	Industrial production	Consumer prices	Financial conditions	Vulnerability	Monetary policy stance
Count	275	275	189	275	-
Mean	4.334	4.289	4.594	0.410	-
Std	0.387	0.739	0.026	0.507	-
Min	3.607	2.465	4.551	-0.760	-
25% pct	4.055	3.830	4.578	0.117	-
Median	4.351	4.283	4.589	0.530	-
75% pct	4.664	4.757	4.603	0.790	-
Max	5.012	6.060	4.668	1.345	-

ZA	Industrial production	Consumer prices	Financial conditions	Vulnerability	Monetary policy stance
Count	275	275	189	275	215
Mean	4.561	4.389	4.584	-0.218	-0.005
Std	0.075	0.340	0.028	0.330	1.128
Min	3.868	3.798	4.529	-1.098	-1.814
25% pct	4.520	4.048	4.564	-0.378	-0.836
Median	4.571	4.388	4.575	-0.184	-0.215
75% pct	4.608	4.709	4.615	0.024	0.771
Max	4.699	4.976	4.636	0.288	3.746

CL	Industrial production	Consumer prices	Financial conditions	Vulnerability	Monetary policy stance
Count	275	275	189	275	215
Mean	4.520	4.466	4.612	-0.047	-0.013
Std	0.128	0.219	0.015	0.187	1.190
Min	4.209	4.098	4.581	-0.476	-2.706
25% pct	4.461	4.260	4.601	-0.154	-0.778
Median	4.569	4.469	4.612	-0.034	-0.067
75% pct	4.612	4.659	4.624	0.092	0.821
Max	4.679	4.938	4.649	0.283	4.179

MY	Industrial production	Consumer prices	Financial conditions	Vulnerability	Monetary policy stance
Count	275	275	189	275	215
Mean	4.449	4.502	4.610	-0.202	0.001
Std	0.281	0.147	0.009	0.216	0.328
Min	3.896	4.260	4.587	-0.640	-0.813
25% pct	4.254	4.362	4.605	-0.318	-0.224
Median	4.445	4.516	4.611	-0.191	0.047
75% pct	4.675	4.650	4.616	-0.102	0.226
Max	4.981	4.740	4.627	0.199	1.300

TH	Industrial production	Consumer prices	Financial conditions	Vulnerability	Monetary policy stance
Count	275	275	189	275	215
Mean	4.443	4.496	4.608	-0.412	0.005
Std	0.243	0.140	0.011	0.282	0.786
Min	3.857	4.243	4.592	-0.953	-2.385
25% pct	4.325	4.384	4.600	-0.653	-0.335
Median	4.566	4.544	4.605	-0.305	0.005
75% pct	4.616	4.614	4.615	-0.221	0.431
Max	4.707	4.705	4.652	0.071	2.016

CZ	Industrial production	Consumer prices	Financial conditions	Vulnerability	Monetary policy stance
Count	275	275	189	275	215
Mean	4.460	4.538	4.613	-0.337	0.034
Std	0.226	0.150	0.013	0.342	0.593
Min	3.920	4.264	4.591	-0.909	-1.604
25% pct	4.301	4.403	4.601	-0.634	-0.356
Median	4.484	4.550	4.613	-0.350	0.062
75% pct	4.656	4.631	4.619	-0.076	0.412
Max	4.778	4.934	4.654	0.581	1.271

PL	Industrial production	Consumer prices	Financial conditions	Vulnerability	Monetary policy stance
Count	275	275	189	275	215
Mean	4.382	4.522	4.605	-0.255	0.131
Std	0.385	0.156	0.011	0.368	1.214
Min	3.643	4.205	4.592	-0.804	-2.228
25% pct	4.062	4.384	4.599	-0.627	-0.732
Median	4.449	4.562	4.602	-0.305	-0.014
75% pct	4.671	4.616	4.609	-0.038	0.944
Max	5.077	4.937	4.646	0.549	3.882

HU	Industrial production	Consumer prices	Financial conditions	Vulnerability	Monetary policy stance
Count	275	275	189	275	215
Mean	4.457	4.458	4.587	0.012	0.182
Std	0.236	0.251	0.033	0.389	1.647
Min	3.933	3.905	4.539	-0.616	-2.948
25% pct	4.279	4.242	4.559	-0.333	-0.960
Median	4.466	4.534	4.577	0.003	0.034
75% pct	4.641	4.628	4.615	0.353	0.572
Max	4.860	5.007	4.654	0.834	4.771

Note: Descriptive statistics for the global and domestic variables used in the empirical analysis. The domestic variables correspond to 14 large EMEs: Brazil (BR), Chile (CL), China (CN), Czechia (CZ), Hungary (HU), India (IN), Malaysia (MY), Mexico (MX), Poland (PL), Russia (RU), South Africa (ZA), South Korea (KR), Thailand (TH) and Türkiye (TR).

Table C.3: Correlation between US monetary policy shock proxy and EME state variables

Vulnerability	BR	CN	IN	KR	MX	RU	TR	ZA	CL	MY	TH	CZ	PL	HU
Correlation coefficient	-0.072	-0.076	-0.030	0.007	0.111	0.029	0.099	-0.072	-0.039	-0.078	-0.115	0.062	0.087	0.049
P-value	0.235	0.209	0.625	0.908	0.066	0.632	0.102	0.231	0.523	0.199	0.058	0.309	0.150	0.422

Central bank reaction function	BR	CN	IN	KR	RU	ZA	CL	MY	TH	CZ	PL	HU
Correlation coefficient	0.103	-0.041	0.032	-0.050	-0.039	0.020	0.058	-0.009	-0.025	-0.078	0.051	0.078
P-value	0.132	0.554	0.645	0.462	0.571	0.776	0.401	0.900	0.713	0.253	0.461	0.254

Note: The calculation of correlation coefficients are based on the sample for each of the state-dependent model specifications. For the vulnerability (vul) states the sample spans Jan-2000 to Nov-2022, whereas for the central bank reaction function (cbr) the sample starts in Jan-2005. The p-values evaluate the statistical significance of the coefficients using a two-tailed t-test.

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