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SPILLOVERS FROM US MONETARY SHOCKS: ROLE OF POLICY DRIVERS AND CYCLICAL CONDITIONS

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Abstract

We provide new evidence on the spillover effects from US interest rate changes, focusing on factors that are pertinent to the current conjuncture: weak recovery prospects in emerging market and developing economies (EMDEs), and the confluence of macroeconomic shocks shaping the path of interest rates in the US. The drivers of US monetary policy matter for the nature of spillovers. With an SVAR-IV model used to identify structural monetary policy, demand, and supply shocks, we find that an increase in US interest rates driven by demand shocks engenders a positive spillover to economic activity in the near term, while an exogenous tightening of monetary policy would have a large negative spillover effect. Spillovers from US monetary policy shocks also depend on the state of the business cycle, exerting larger effects when growth is weak outside the US. Finally, tighter US monetary policy affects the left tail of the growth distribution disproportionately: the fat left tail highlights the salience of growth at risk.

Keywords: US monetary policy, foreign spillovers

JEL Classification: F4, E5, C3

1 Introduction

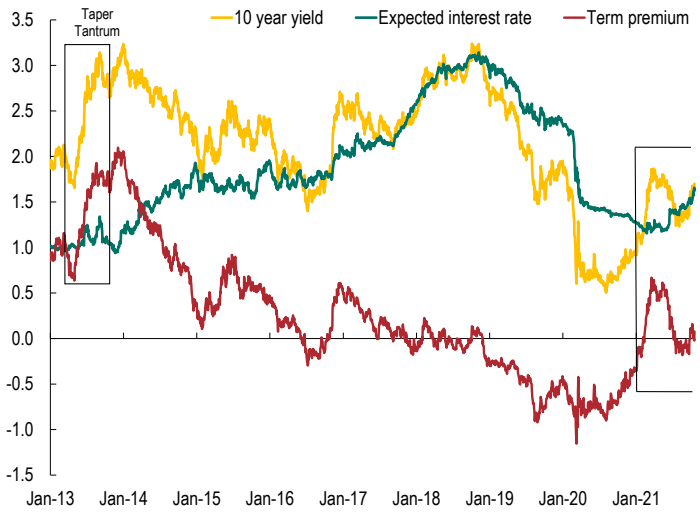
Long-term US interest rates have been increasing recently amid heightened uncertainty around the pace of monetary policy normalization in the US; concerns about potential international spillovers are rising (Figure 1). Two notable aspects of the current conjuncture are likely to play a defining role in international spillovers from higher US interest rates. First is the weak economic prospects in emerging market and developing economies (EMDEs). While growth is projected to rebound in 2021-22, many EMDEs are still characterized by large economic slack and medium-term output losses relative to the pre-COVID-19 trend. A key question is how real sector economic weakness (and diminished policy space alongside substantial financial sector frictions) in EMDEs will interact with tighter global financial conditions. Second are the potential drivers of US policy normalization going forward, including not only stronger domestic demand but also supply disruptions that are pushing up inflation and raising the risk of persistence of high inflation and policy reactions that are sharper than markets expect.

This paper aims to shed light on financial and real spillovers from changes in US interest rates on advanced and emerging market economies, with special reference to the Asia-Pacific region. To assess financial spillovers, we rely exclusively on high-frequency movements around FOMC dates in different financial indicators in a broad set of EMDEs and advanced economies, which help us to identify the causal impact of US interest rate shocks. In assessing real spillovers, we focus on three elements: first, the role of different drivers of US interest rates, distinguishing between demand, supply shocks, and monetary policy shocks estimated by an SVAR for the US economy; second, the dependence of spillovers on the cyclical position, an under-explored aspect in the literature; third, the impact of US policy changes on the distribution of growth, and the potential for fat left tail effects (growth at risk).

For financial spillovers, we use high frequency movements in different US interest rate futures around FOMC meetings to identify US monetary policy shocks. This has the advantage that the implied monetary policy shocks only capture unanticipated changes in monetary policy. For real spillovers, we use a SVAR model for the US to identify monetary policy shocks[1], given the quarterly frequency of our analysis and the fact that monetary policy shocks identified around FOMC meetings do not capture all monetary policy shocks/news.

[1]While monetary policy shocks based on high-frequency movements in interest rate futures are not used directly in assessing real spillovers, they are used in identifying the contemporaneous impact of US monetary policy shocks on other macroeconomic indicators in the SVAR.

Figure 1: Decomposition of 10-Year US Bond Yield: Expected Interest Rate and Term Premium (Percentage)



Source: Federal Reserve Bank of New York.
Note: Expected interest rate captures the expected average level of short-term Treasury yields over the next 10 years.

While the SVAR implied structural shocks depend on the model specification being correct, it is possible to construct a more comprehensive set of monetary policy shocks.

Four key findings emerge from our results. First, we find that US monetary policy shocks can have sizable effects on financial conditions and economic activity on EMDEs. A 100 basis points unanticipated monetary policy shock is estimated to increase long-term domestic bond yields in advanced economies by about 25 basis points, with a higher pass-through for EMDEs (35 basis points) and in the period after the global financial crisis for both advanced economies and EMDEs. A 100 basis points monetary policy shock is estimated to reduce output and investment by 0.4 and 1.6 percent, respectively. Second, the driving source for the change in US interest rates has a bearing on spillovers. If interest rates in the US increase reflecting a positive demand shock in the US, the near-term impact on other countries is positive. By contrast, if the interest rate increases due to a monetary policy shock, there is a significant negative impact on economic activity in other countries. Our results suggest that supply shocks also have sizable effects on economic activity in

other countries notwithstanding the fact that the response of U.S. interest rates to supply side shock is not precisely estimated. Third, monetary policy shocks affect the left tail of the distribution of economic activity more than the median, potentially reflecting the amplification of monetary policy shocks through financial frictions. Fourth, spillovers depend on the state of the business cycle, with larger adverse effects when the underlying economic activity is weak.

The remainder of the paper proceeds as follows. Section 2 provides a brief literature review. Section 3 presents estimates of financial spillovers from US monetary policy using a high-frequency event-study approach. In Section 4, we discuss our empirical strategy to assess real spillovers. In Section 5 present results and Section 6 concludes.

2 Spillovers from US interest rates

There is a large literature studying international spillovers from US monetary policy. The main focus of this literature has been on the size and nature of financial spillovers and is related to studies on the global financial cycle Miranda-Agrippino and Rey (2020). Albrizio et al. (2020), for example, find that an exogenous US monetary policy tightening leads to an economically and statistically significant decline in cross-border bank lending. Several papers have explored the dependence of financial spillovers on the type of US monetary policy shocks, with complementary evidence on the relative importance of conventional versus unconventional US monetary policies. Chen et al. (2014) and Albagli et al. (2019) find larger financial spillovers to domestic bond yields after the global financial crisis. Gilchrist et al. (2019) focus on dollar-denominated sovereign bond yields and find that the pass-through from unconventional policy actions to foreign bond yields is, on balance, comparable to that of conventional policy actions and in fact notes a larger impact from conventional monetary policies on credit spreads for countries with a speculative-grade credit rating.

Several studies highlight differences between emerging market and advanced economies in terms of spillovers to domestic interest rates. For example, Kalemli-Özcan (2019) notes that pass-through to interest rates in emerging market economies is significantly larger than in advanced economies. Albagli et al. (2019) find that spillovers work through different channels across countries, being concentrated in risk-neutral rates (expectations of future monetary policy rates) for advanced economies and predominantly on term premium in emerging markets. Obstfeld et al. (2019) and Obstfeld et al. (2018) find that exchange rate regime matters for the transmission of global financial shocks to domestic financial conditions

and economic activity in emerging market economies, with magnified effects under fixed exchange rate regimes. Our empirical approach for assessing financial spillovers essentially follows International Monetary Fund (2021), which considers spillovers from unanticipated US monetary policy shocks and macroeconomic news (for example macroeconomic data releases) on high-frequency movements in different financial indicators across a broader set of countries.

This paper is also related to a group of relatively few studies that focus on real spillovers. Model-based and empirical studies on real spillovers conclude that spillovers can vary across countries depending on the relative strength of different transmission channels and country-specific exposure factors. For example, Ammer et al. (2016) use the large-scale policy model (SIGMA) of Federal Reserve to highlight that international spillovers from monetary policy may be positive or negative depending on the relative strength of three channels of transmission: the exchange rate channel, the domestic demand channel, and the impact on foreign financial conditions. They find that in the case of monetary policy easing, the negative effect of the depreciation of the dollar (reducing expenditures abroad) is outweighed by the expenditure increasing effects of higher US domestic demand (increasing US imports) and a loosening of financial conditions.

Bluedorn and Bowdler (2011) find that contractionary monetary policy shocks lead to an appreciating US dollar exchange rate, strong positive interest rate pass-through to foreign countries, and mixed foreign output level response. Georgiadis (2016) and Iacoviello and Navarro (2019) find that real spillovers depend on country characteristics including trade and financial integration, exchange rate regime, financial market development, and macroeconomic fundamentals. Iacoviello and Navarro (2019) further find that in advanced economies, trade openness with the United States and the exchange rate regime account for a large portion of the contraction in activity, while in emerging market economies, the responses do not depend on the exchange rate regime or trade openness; and depend more on macroeconomic fundamentals—such as current account, inflation and, reserves .On the other hand, Bräuning and Sheremirov (2019) focus on the role of trade versus financial linkages, and find a larger role for the former, with trade networks playing an important amplifying role. Our paper contributes to this literature by focusing on real spillovers through estimating not only the first moment impact but also the impact on the distribution of real variables, with a focus on the left tails of the distribution.

There are relatively few papers that explore differences in spillovers depending on the source of movements in US interest rates. Hoek et al. (2020) differentiate between growth

shocks and monetary policy shocks as drivers of US interest rates movements, using high-frequency movements in U.S. Treasury yields and stock prices around FOMC announcements and U.S. employment report releases. They find that the former has more modest spillovers on foreign financial conditions and that for EMDEs with very low levels of vulnerability, a growth-driven rise in U.S. interest rates may even ease financial conditions in some markets. Caceres et al. (2016) also explore spillovers from "real" versus "money" shocks to US interest rates and find "money" shocks significantly affect bond yields around the world and explain a larger fraction of the variability in domestic rates than those driven by "real" shocks.

There are several papers that focus on spillovers in Asian economies. Miyajima et al. (2014) study how US unconventional monetary policy affects domestic conditions and monetary policy decisions in Asian economies. They find that a one percentage point increase in the US 10-year term premium leads to an approximately 0.6 pp increase in Asian domestic long-term bond yields. Eichengreen and Gupta (2014) study the impact of the 2013 taper episode on India. Xu and La (2017) assess spillover effects from unconventional monetary policy measures in the US on Asian credit markets. They find that the growth of dollar credit in Asia increased in response to quantitative easing and that there was evidence of cross-border liquidity spillovers in the syndicated loan market. Tran and Pham (2020) find that US unconventional monetary policy shocks are associated with a surge in equity prices, a decline in long-term interest rates, and an appreciation of currencies in Asian developing markets. Tran et al. (2021) investigate the spillovers from US monetary policy to selected Asian economies employing a Bayesian VAR model. They find that the magnitude of spillovers across countries is different - countries with a fixed-exchange rate regimes and open to trade have a stronger response to US monetary policy shocks.

Finally, while there is a large literature looking at the effect of US monetary policy on US economic activity over the business cycle (Tenreyno and Thwaites (2016), and literature cited therein), to the best of our knowledge, we are the first to look at how the magnitude of US monetary spillovers varies depending on the business cycle of affected countries.

3 Spillovers from US monetary policy: An event study approach

As discussed in Section 2, there is significant evidence of financial spillovers from US interest rates in other countries. Also in Asia and Pacific region, there is considerable co-movement between domestic interest rates and US interest rates (Figure 2) and capital flow volatility

has posed significant policy challenges.[2] In this section, we evaluate the behavior of key financial indicators within a short time interval around FOMC meetings for advanced and emerging market economies, focusing on the Asia-Pacific region. In particular, we estimate the following regression where the 2-day change (between one day after and one day before FOMC meetings) in different financial indicators in foreign countries is related to a measure of unanticipated US monetary policy shocks estimated around FOMC meetings:

$$y_{i,t+1} - y_{i,t-1} = \alpha_i + \beta_1 s_t + u_{i,t+1} \tag{1}$$

where $y_{i,t+1}$ is a macroeconomic variable of interest for country i, 1 day after the FOMC meeting and s_t represents the unanticipated US monetary policy shock/surprise. The equation is estimated with country fixed effects with Driscoll and Kraay (1998) standard deviations.

We use a broad set of dependent variables to capture the effect of the monetary policy shocks; government bond yields at different maturities, the EMBI, the logarithm of the benchmark equity index and capital flows (as a share of nominal GDP). Our empirical approach essentially follows International Monetary Fund (2021) but focuses solely on US monetary policy shocks and considers both advanced and emerging market economies and Asia and Pacific countries separately.

We use the set of shocks from Gurkaynak et al. (2020) which measure monetary policy shocks as movements in different interest rate futures within a 45 minute window around FOMC meeting announcements.[3] Using high-frequency movements in interest rates ensures that the measured monetary policy shock only reflects the unanticipated component of monetary policy. The estimation is carried out using data spanning February 1994 to December 2017. Additionally, we look at whether the impact of US monetary policy shocks are different after the global financial crisis by considering two samples: before the global financial crisis (BFC) and after the global financial crisis(AFC)[4]. For additional details regarding the composition of the sample and sources of data see Appendix 7.1.

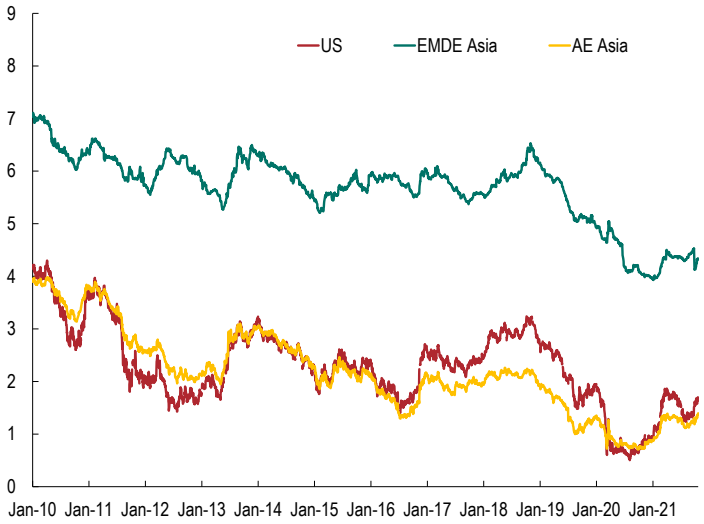
Figure 3 shows the estimated coefficients β_1 from equation (1) for government bond yields at different maturities, the EMBI spread, equity prices and nominal exchange rates where the

[2]See Ostry et al. (2012) and International Monetary Fund (2019) for a discussion of the challenges and risks associated with managing capital flows, with the latter focused on the Asia and Pacific region.

[3]We thank Refet Gurkaynak for sharing estimates of monetary policy shocks based on different interest rate futures.

[4]We use the bankruptcy of Lehman Brothers on September 15th, 2007 to split the sample in the BFC period. AFC starts in June 2009,date defined by NBER as the end of the US recession.

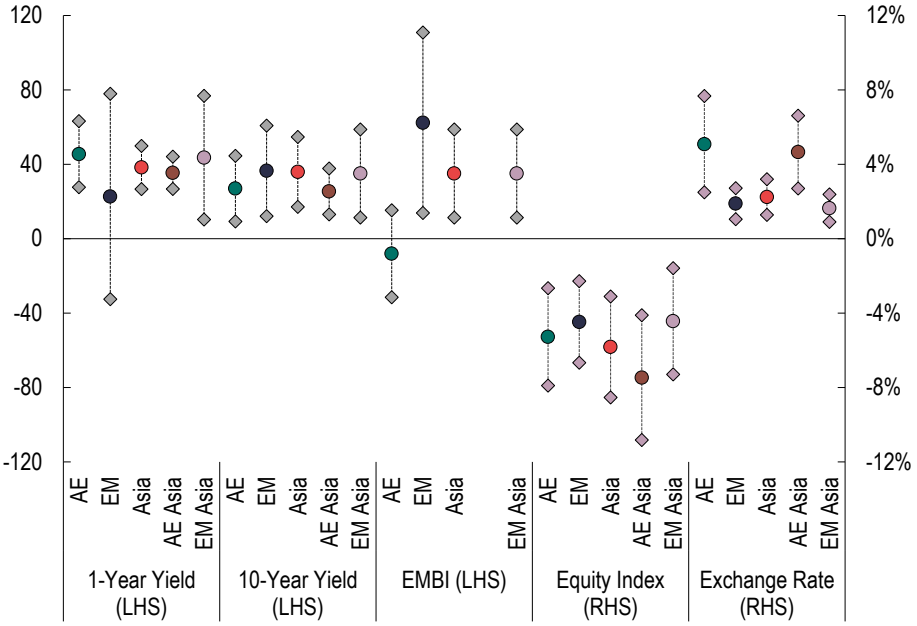
Figure 2: US and Asia 10-Year yields (In percent)



Source: Federal Reserve Bank of San Francisco, Bloomberg LP and authors own calculations. Note: Simple average of 10 year yields.EMDE Asia includes: the People's Republic of China (PRC), India, Indonesia, Malaysia, Philippines,Sri Lanka, Thailand and Vietnam.AE Asia includes: Australia, Hong Kong, China, Japan, Republic of Korea, New Zealand, Singapore and Taipei,China.

surprise in the 6-month ahead future on three-month Eurodollar deposits (ED2) is used as the monetary policy shock. The results show that US monetary policy surprise is associated with higher bond spreads both in the short and the long end of the yield curve and for different groups of countries (advanced, emerging markets, Asia-Pacific). A 100 basis points positive US interest rate surprises are associated with a 36 basis points increase in the 10-year bond yield for emerging markets. The impact on the 1-year bond yields is about 22 basis points, but the impact is not significant. There is also a large and statistically significant impact on the EMBI (increasing by about 60 basis points), reflecting the response in a larger country sample.

Figure 3: Estimated Impact of U.S. Monetary Policy Surprise on Selected Financial Variables (LHS - Basis points and RHS - Percent)

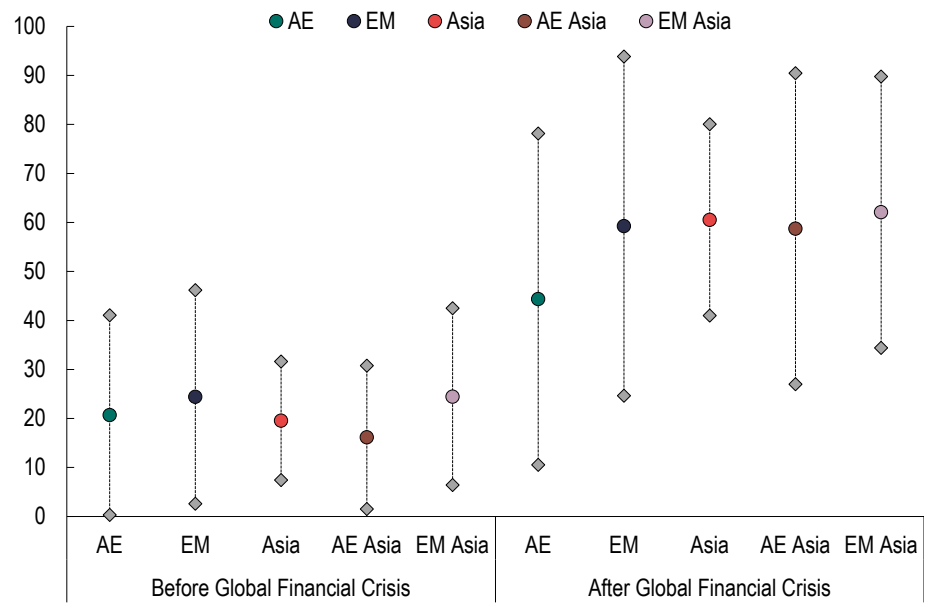


Source: Authors' own calculations.
Note: The colored dots show the estimate effects of a 100 basis point US monetary policy shock (ED2) across government bond yields at 1-year and 10-year maturities and on equity price index. The deviation bars depict the 90 percent confidence interval. LHS = left-hand scale and RHS = right-hand scale

For Asian emerging market economies, the impact is slightly larger for both the 1-year and the 10-year yields and is statistically significant (38 and 35 basis points respectively). Spillovers to domestic bond yields are also sizable and statistically significant for advanced economies, with the estimated impact larger at the 1 -year maturity (45 basis points for 1-year and 25 basis points for the 10-year). For the advanced economies in the Asia and Pacific region we find broadly a similar result but with a slightly lower estimated impact for the short-end (36 and 25 basis points for 1-year and 10-year respectively). US monetary policy shocks also have significant effects on domestic equity prices. Equity prices decline by about 4 percent in the broader emerging market and Asian emerging market sample, by about 5 percent in the advanced economy sample and by 7 percent in the Asian advanced economy

sample. Nominal exchange rates depreciate roughly by 5 percent in advanced economies and by about 2 percent in emerging markets. The results for different measures of monetary policy shocks are similar in terms of magnitude and significance and the full set of results are reported in Appendix 7.2.

Figure 4: Estimated Impact of U.S. Monetary Policy Surprise on 10-Year Government Bond Yield (Basis points)

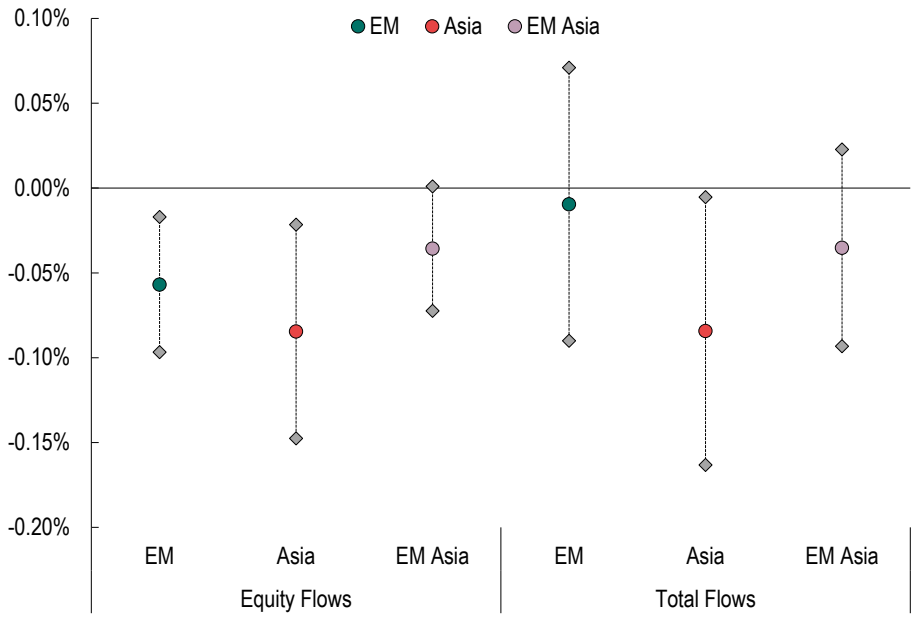


Source: Authors' own calculations.
Note: The colored dots show the estimated effects of a 100 basis point US monetary policy shock (ED2) on 10-Year government bond yields. The error bars depict the 90 percent confidence interval.BFC: Before the Financial Crisis and AFC: After the Financial Crisis. BFC comprises data before the bankruptcy of Lehman Brothers on September 15th of 2007.AFC comprises data after the June 2009 (date defined by NBER as the end of the US recession).

We next evaluate the effect of monetary policy surprises on the long-term government bond yields before and after the global financial crisis. Figure 4 shows that the sensitivity of government bond yields has increased during the period after the financial crisis for both the emerging market and the advanced country samples. In the case of the Asia region, the

estimated impact triples from 20 to 60 basis points in the post-global financial crisis period. The impact on Asian emerging markets in the post-global financial crisis period (62 basis points) is similar to the impact for the broader emerging market sample. These set of results hold true for different measures of US monetary policy shocks. For additional details see Appendix 7.2.

Figure 5: Estimated Impact of U.S. Monetary Policy Surprise on Capital Flows (Percent of GDP)



Source: Authors' own calculations.
Note: The colored dots show the estimate effects of a 100 basis point US Monetary policy surprise (ED2) on capital flows as a percent of GDP. The error bars depict the 90 percent confidence interval.

Finally, we analyze the impact of monetary policy surprises on capital flows across the entire sample period for emerging market economies and the Asia-Pacific region.[5] Figure 5 displays the estimated coefficients for the impact of US monetary policy shock on daily capital flows. Our dependent variable is defined as total/equity capital flows as a percentage of GDP

[5]We exclude the sample of advanced economies due to data limitations.

observed on the FOMC day and the day after. Our estimates have the expected sign but are not statistically significant for total flows. For equity flows, the estimates are statistically significant for both the emerging market and the Asia-Pacific sample. We take the limited response of capital flows with some reservation, given the relatively limited country and time coverage of daily data on capital flows.[6] For additional details see Appendix 7.2.

4 Assessing Real Spillovers: Empirical Approach

Our empirical strategy involves estimating a structural VAR (SVAR) for the US economy to identify "demand", "supply" and "monetary" shocks as drivers of changes in US interest rates. Our strategy for identifying US interest rate shocks combines elements of external instruments and sign restrictions: (i) We adopt an instrumental variable (IV) approach using high frequency movements in Fed funds futures as external instruments for the monetary policy shocks; (ii) We use sign restrictions to identify "demand" and "supply" shocks by imposing the theoretical prediction that demand and supply shocks imply different co-movements between output and prices. In the next step, we aggregate the estimated monthly shocks to quarterly frequency and we use Jordà (2005)'s local projection (LP) method in a panel quantile framework to estimate the effects of these structural shocks on macroeconomic developments in advanced and emerging market economies.

4.1 SVAR model to identify drivers of US interest rates

We estimate a monthly SVAR model for the US economy to estimate different macroeconomic shocks as drivers of US interest rates. Our SVAR model consists of log industrial output, log consumer price index, Gilchrist and Zakrajšek (2012)'s excess bond premium and 2-year bond yield and is estimated for the period 1973M1-2019M12. We use the 2-year bond yield as our proxy for monetary policy as it better captures forward guidance.

For identification, we rely on a combination of external instruments and sign restrictions. We follow Gertler and Karadi (2015) and use high-frequency movements in Fed Funds futures around FOMC announcements as external instruments for monetary policy shocks. We use sign restrictions to identify demand and supply shocks. We discuss below the identification strategy in more detail.

[6] In fact, estimates of the impact of US monetary policy shocks later in Section 5.2 using quarterly data and a broader sample of countries over a longer period suggests a statistically significant impact.

Let $y_t = (y_{1t}, ..., y_{nt})'$ denote a $n \times 1$ vector of endogenous variables, which depend on its past values plus an innovation u_t:

$$A(L)y_t = u_t \qquad u_t \sim (0, \Sigma_u) \tag{2}$$

$$u_t = B\varepsilon_t \qquad \varepsilon_t \sim (0, I_n) \tag{3}$$

where $A(L) = I - A_1 L - A_2 L^2 - ....$ and the reduced form innovations u_t is related linearly to a vector of structural shocks ε_t given by the $n \times n$ structural impact matrix B.

In our case, the structural VAR includes 4 structural shocks in the following order, where we stack the monetary policy shock which is the only shock identified using IV last: demand shocks, supply shocks, shocks to excess bond premium and monetary policy shocks. We order the endogenous variables accordingly as follows: ln(industrial production), ln(cpi), excess bond premium and 2-year bond yield. We partition the B matrix so that $B = [B_1 : B_2]$ where B_2 denotes the last column of the B matrix which identifies the impact of monetary policy shocks on the endogenous variables in the SVAR. We use high-frequency movements in interest rate futures around FOMC meetings as an external instrument for monetary policy shocks (denote m_t). The identification relies on relevance (equation (4)) and exogeneity (equation (5)) conditions for the external instrument.

$$E(m_t, \varepsilon_{4,t}) \neq 0 \tag{4}$$

$$E(m_t, \varepsilon_{j,t}) = 0 \qquad j \neq 4 \tag{5}$$

First stage regression results confirm instrument relevance and exogeneity follows from the assumption that high-frequency movements in interest rate futures around FOMC meetings are driven purely by monetary policy shocks.[7] Under these conditions, it is possible to identify B_2 up to sign and scale, while the additional restriction $B_2' \Sigma_u^{-1} B_2 = 1$ normalizes the shock to one standard deviation.

Following Gertler and Karadi (2015), we test different combinations of instruments (six/nine-month and one-year ahead on three-month Eurodollar deposits, current/one/two-month Fed funds futures). Based on the F-test of the joint model (the F-statistic on the first stage) and the critical values, we chose to use the three month ahead monthly Fed Funds futures (FF4)

[7] We aggregate the implied monetary policy shocks observed around FOMC meetings to monthly frequency and regress the monthly monetary policy shocks on the VAR reduced form residuals for the 2-year bond yield.

as our benchmark instrument.[8]

As mentioned earlier, to identify the other structural shocks, we rely on sign restrictions. In particular, we impose the following sign restrictions on B_1: effect of demand shocks on output, prices and interest rates have the same sign, supply shocks have opposite effects on output and prices, and a positive shocks to the excess bond premium has a negative effect on output.

$$B_1 = \begin{pmatrix} + & + & - \\ + & - & . \\ . & . & + \\ + & . & . \end{pmatrix} \tag{6}$$

We follow the algorithm proposed in Braun and Bruggemann (2017) and randomly draw a series of 5,000 B matrices subject to the instrumental variable (B_2) and sign restrictions.[9] As in Matheson and Stavrev (2014), the particular choice of B that we use to back out the structural shocks (denoted as B^*) is the B matrix that minimizes the difference with respect to the median impact among the draws of the B matrix:

$$B^* = \min_B \sum_{i,j=1}^{5} (B_{i,j} - \overline{B}_{i,j})^2 \tag{7}$$

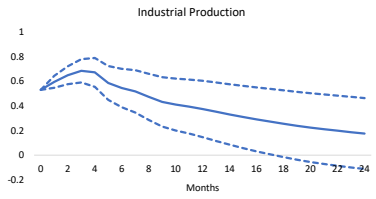
where $\overline{B}_{i,j}$ is the median value for the i,jth element of the B matrix among all the draws. Figure 6 shows the estimated impulse responses to a one standard deviation demand, supply and monetary policy shock implied by the SVAR corresponding to the chosen B matrix. As assumed through the sign restrictions, a positive demand shock increases output, prices and the 2-year bond yield. A positive supply shock increases output and reduces prices, while the impact on interest rates is not statistically significant. A positive monetary policy shock is estimated to reduce output and prices, although the impact on prices is fairly limited.[10]

[8]The Cragg-Donald and Kleibergen-Paap robust F-statistics for FF4 are 14.5 and 6.65 respectively.

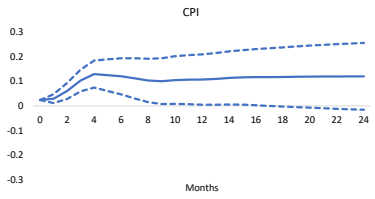
[9]See Appendix 7.4 for more details on the particular algorithm used to randomly draw B matrices.

[10]While we do not observe the "price puzzle" in our estimates—only an insignificant impact of monetary policy shocks on inflation—some of the explanations put forward to explain the "price puzzle" could perhaps also help explain our results. Explanations of the "price puzzle" revolve around limited effect of US monetary policy shocks on inflation, impact of supply shocks and potential mismeasurement of monetary policy shocks. See Eichenbaum (1992), Sims (1992), Bernanke and Mihov (1998), Barth and Ramey (2002) and references therein for more on the "price puzzle".

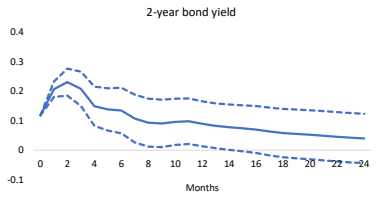
Figure 6: US SVAR Model Implied Impulse Responses to Structural Shocks



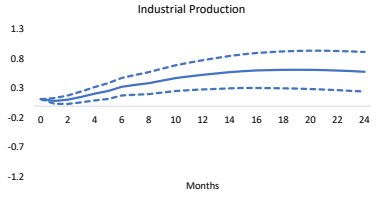
(a) Response to demand shock



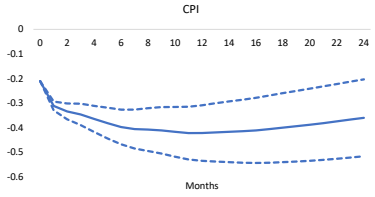
(b) Response to demand shock



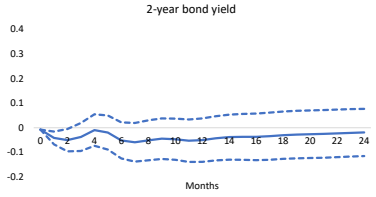
(c) Response to demand shock



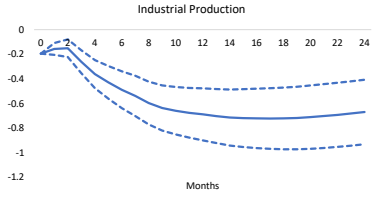
(d) Response to supply shock



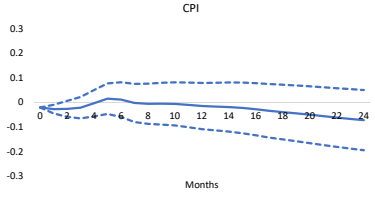
(e) Response to supply shock



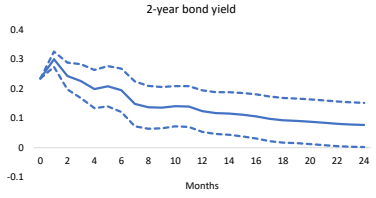
(f) Response to supply shock



(g) Response to monetary policy shock



(h) Response to monetary policy shock



(i) Response to monetary policy shock

Notes: The figures show the response of log industrial production (percent), log CPI (percent) and the 2-year US bond yield (basis points) to one standard deviation demand, supply and monetary policy shocks estimated using a SVAR model for the US.

4.2 Quantile regressions

We use quantile regressions to estimate the effects of different US macroeconomic shocks on the distribution of real GDP and investment over different horizons using a panel data composed of 62 advanced and emerging market economies. In particular, we estimate the following panel quantile model:

$$y_{i,t+h} - y_{i,t-1} = \alpha_{i,h,q} + \beta_{h,q} s_t + \theta_{h,q} Z_{i,t} + \epsilon_{i,t} \tag{8}$$

where $y_{i,t+h}$ is a macroeconomic variable of interest for country i, h quarters ahead, q denotes different percentiles of the distribution, and s_t is the estimated structural shocks for the US and $Z_{i,t}$ is a set of macroeconomic controls. In the baseline, we use four lags of the dependent variable as controls.

To explore the dependence of spillovers on the state of the business cycle, we follow Tenreyno and Thwaites (2016) and Auerbach and Gorodnichenko (2012) and estimate the following model where $\beta^E_{h,q}$ and $\beta^R_{h,q}$ denote impact of US interest rate shocks during high growth (denote "expansion" state) and low growth (denote "recession" state) states respectively, and $F(\Delta y_{i,t})$ is a smooth decreasing function of the state of the business cycle, and in particular the deviation of 4 quarter moving average real GDP growth from its country-specific long-run trend (calculated using the HP filter with a large smoothing parameter ($\lambda = 10000$)).

$$y_{i,t+h} - y_{i,t-1} = (1 - F(\Delta y_{i,t}))(\alpha^E_{i,h,q} + \beta^E_{h,q} s_t + \theta^E_{h,q} Z_{i,t}) + F(\Delta y_{i,t})(\alpha^R_{i,h,q} + \beta^R_{h,q} s_t + \theta^R_{h,q} Z_{i,t}) + \epsilon_{i,t} \tag{9}$$

$$F(\Delta y_{i,t}) = \frac{exp(\gamma \frac{\Delta y_{i,t} - \bar{\Delta y_i}}{\sigma_{\Delta y,i}})}{1 + exp(\gamma \frac{\Delta y_{i,t} - \bar{\Delta y_i}}{\sigma_{\Delta y,i}})} \tag{10}$$

We follow Tenreyno and Thwaites (2016) in setting $\gamma = -3$ which implies a pretty high probability of being in one of the two states once growth deviates by 1 standard deviation from its long-run trend.

We use the method of Machado and Santos Silve (2019) for estimating quantile regressions with fixed effects. For inference, we use block-bootstrapping methods, where blocks of four quarters of data from the temporal dimension of the dataset are resampled. In addition, the block-bootstrapping is performed so that the cross-sectional structure of the panel is unchanged. For all presented results, 1,000 bootstrap replications are used.

5 Assessing Real Spillovers: Results

In this section, we present the estimated impulse responses for real GDP and investment to different structural shocks identified using the estimated SVAR model for the US. We present

the median (50th percentile) impulse responses and also show the difference between the 50th and 5th percentiles to capture the impact on downside risks to output and investment.

Our panel dataset is unbalanced and includes quarterly data for 62 emerging market and advanced economies over the period 1975Q1-2019Q4. The list of countries and data sources are reported in Appendix 7.3.

5.1 Estimated impulse responses to different macroeconomic shocks

Figure 7 shows the impact of a one standard deviation "demand", "supply", and "monetary policy" shock in the US on the 50th percentile of real GDP and investment in other countries.[11] A one standard deviation demand shock in the US, which raises US industrial production by 0.6 percent initially (quarterly average impact) is estimated to increase output in other countries, possibly reflecting the positive impact of higher demand in the US on other countries through trade linkages, despite the associated increase in interest rates in the US (by 20 basis points) (9a). The impact on investment is also positive in the short-run but it is not significant. The impact of the demand shock is reversed after 6 quarters, and becomes significantly negative for both output and investment.

The impact of a positive supply shock in the US on output and investment in other countries is positive and significant after the second quarter, with the impact increasing gradually, and following a similar pattern in terms of the impact of the shock on US output which at its peak increases industrial production in the US by 0.60 percent. Within our framework, we find that the response of U.S. interest rates to our estimates of supply side shocks is not statistically significant. The sizable impact on output and investment in other countries could reflect the spillover impact on other countries' output through supply chains but also due to global supply shocks (e.g. a supply-driven oil price shock) which could be affecting all countries at the same time.

A key concern in the current conjuncture is that increasing inflationary pressures which seems to be driven by supply-side disruptions can prompt a larger than expected tightening in US interest rates. We capture this in the SVAR for the US through a positive monetary policy shock. Figures 7e-7f show the estimated response of output and investment in other countries to a one standard deviation shock to the 2-year interest rate in the US (about 25 basis points). The impact is negative and significant in the short run for both output and investment, with a more persistent impact on investment. The average impact in the first

[11] See Figure 6 for the impact of a one standard deviation shock for different macroeconomic shocks on US industrial production, prices and 2-year bond yield.

year on output and investment is -0.1 and -0.4 percent respectively, which corresponds to -0.4 and -1.6 percent in terms of impact for a 100 basis points shock.

While so far we have focused on the median impact of different structural shocks, our panel quantile framework allows us to estimate the impact on the whole distribution of outcomes. This approach allows us to explore the downside risks to growth from spillovers. Figure 8 shows the impact of different structural shocks on the difference between the 50th and 5th percentiles of real GDP and investment. A positive value suggests a larger impact on the 5th percentile than on the median and hence an increase in downside risks.

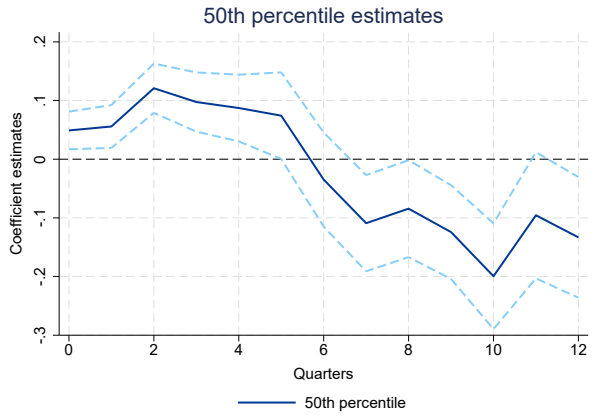
All structural shocks have significant effects on the left tail of the distribution of output and investment. A positive demand shock is associated with lower downside risks to output and investment in the short run but higher downside risks in the medium-term, which could reflect financial amplification taking precedence over the medium-term. For the supply shock, downside risks increase in the short-term but are lower beyond the one year horizon for real GDP. A positive monetary policy shock is associated with an increase in downside risks to both output and investment, with a more persistent impact on investment. This could reflect financial frictions playing an amplifying role, similar to the findings in Adrian et al. (2019). In Appendix 7.5, we report the estimated impact of different structural shocks on the broader distribution of real GDP, covering a wider range of percentiles in the distribution (for example, 10th, 25th, 75th and 90th percentiles). Our estimates show that all structural shocks have larger effects on the left tail of the distribution, with the estimated impact declining for higher percentiles, and with the impact on the distribution varying over different horizons.

Finally, to assess whether the magnitude of spillovers differ between emerging market and advanced economies, we replicate our estimates of the impact of monetary policy shocks for these two country samples separately. Consistent with the existing literature, the median impact is estimated to be higher in emerging market economies for both output and investment. Furthermore, our results indicate that monetary policy shocks also have larger near-term effects on downside risks to growth in the emerging market sample (Figure 9).

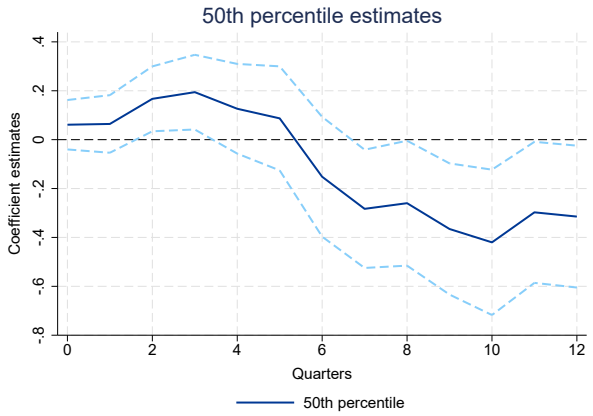
While it is not the main focus of this paper, we also explore the role of different country characteristics (exposure factors and macroeconomic fundamentals) in affecting spillovers—an area that has been studied extensively in earlier papers using similar cross-country samples. In particular, we explore the role of trade linkages with the US, external vulnerabilities (e.g. reserves, external debt and current account) and fiscal vulnerabilities (public debt and fiscal balance). We find a significant role for external vulnerabilities, suggesting that countries

with higher reserves, higher current accounts and lower external debt experience a smaller negative impact on economic activity when there is a monetary policy tightening in the US. We found no statistically significant role for trade dependence with the US or different measures of fiscal vulnerabilities. Appendix 7.6 has more details on our empirical approach and results.

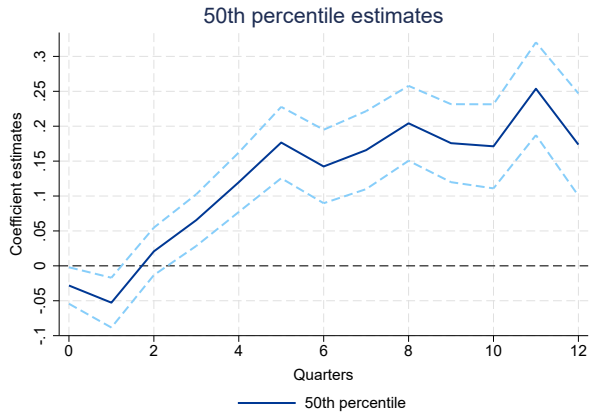
Figure 7: Impulse Responses to Different Structural Shocks: 50th percentile



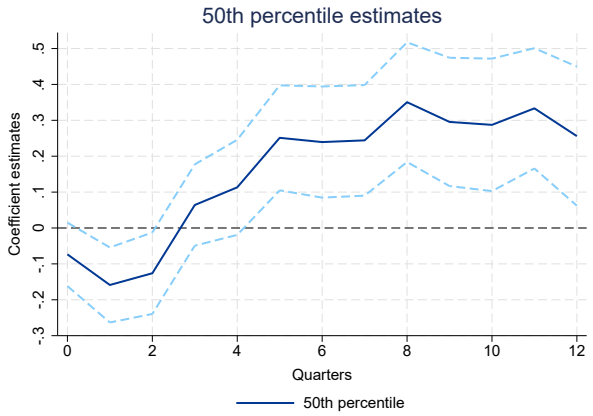
(a) Real GDP: Resp. to demand shock



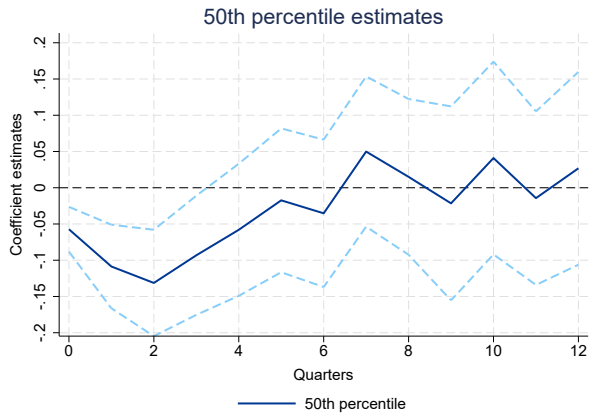
(b) Real Investment: Resp. to demand shock



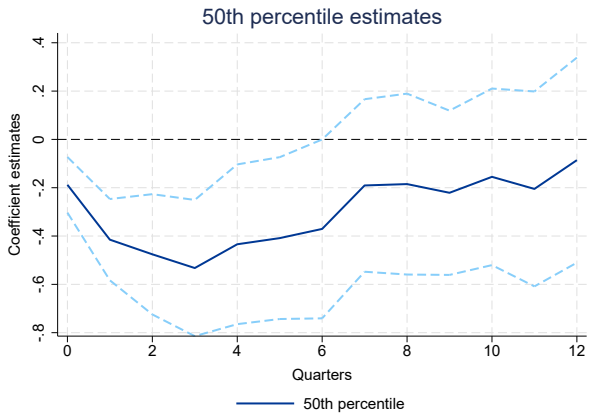
(c) Real GDP: Resp. to supply shock



(d) Real Investment: Resp. to supply shock



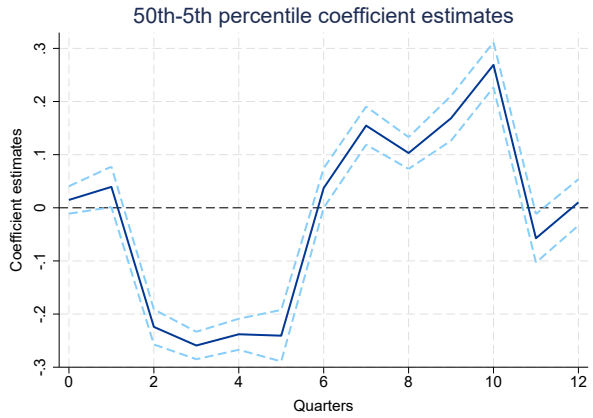
(e) Real GDP: Resp. to monetary policy shock



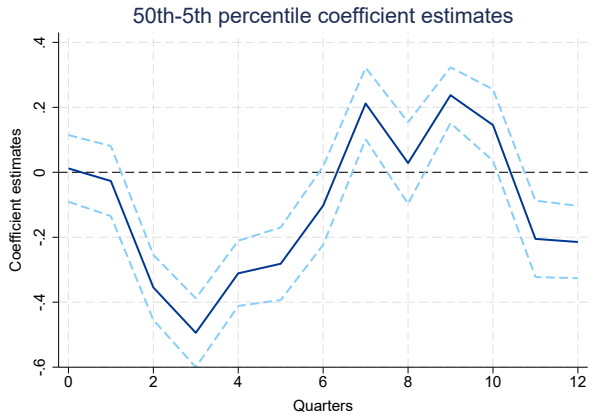
(f) Real Investment: Resp. to monetary policy shock

Notes: Figures show the estimated coefficients for $\beta_{h,q}$ for different horizons $h = 0...12$ where $q = 50$, and +/- 2 standard deviations. Standard errors are generated using block bootstrapping.

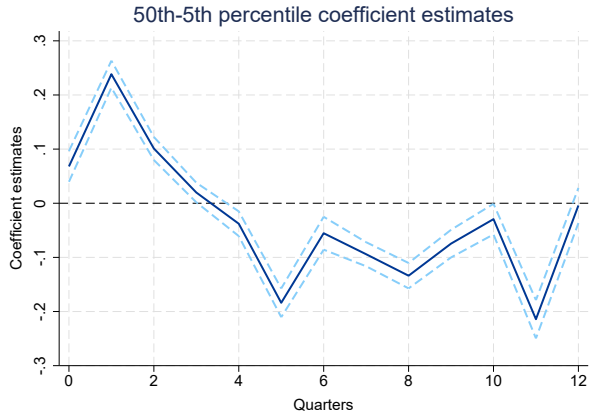
Figure 8: Impulse Responses to Different Structural Shocks: Difference between 50th and 5th percentile



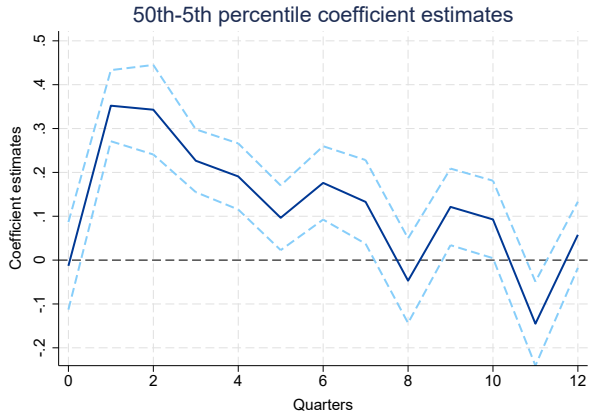
(a) Real GDP: Resp. to demand shock



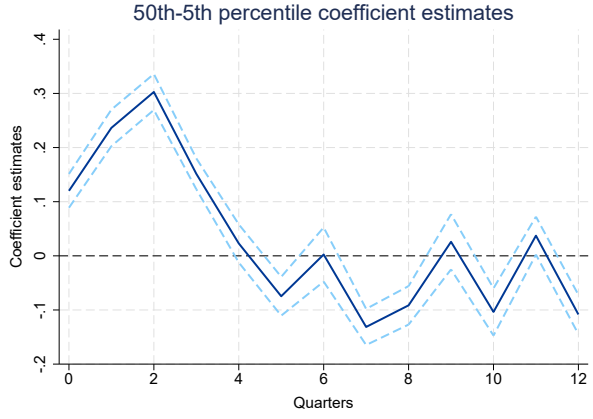
(b) Real Investment: Resp. to demand shock



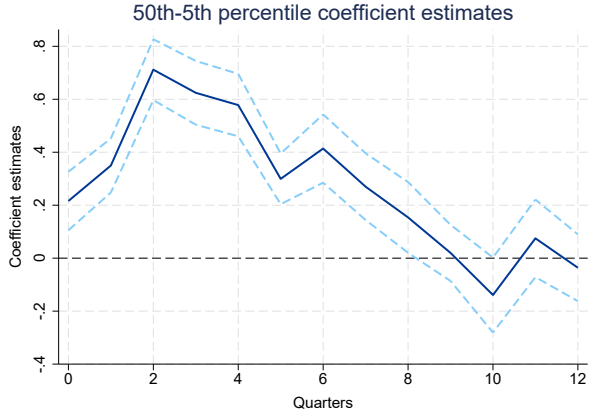
(c) Real GDP: Resp. to supply shock



(d) Real Investment: Resp. to supply shock



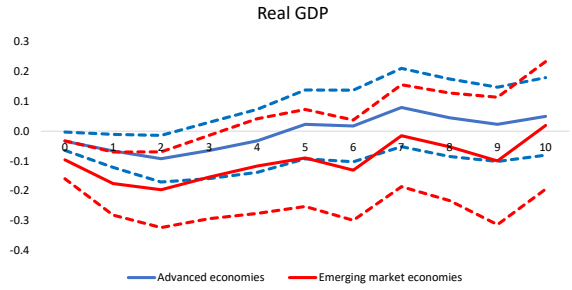
(e) Real GDP: Resp. to monetary policy shock



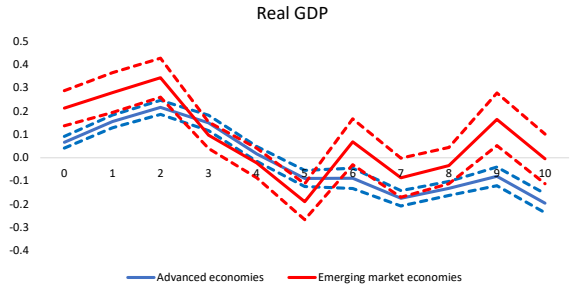
(f) Real Investment: Resp. to monetary policy shock

Notes: Figures show the difference between $\beta_{h,50}$ and $\beta_{h,5}$ for different horizons $h = 0...12$ and +/- 2 standard deviations. Standard errors are generated using block bootstrapping.

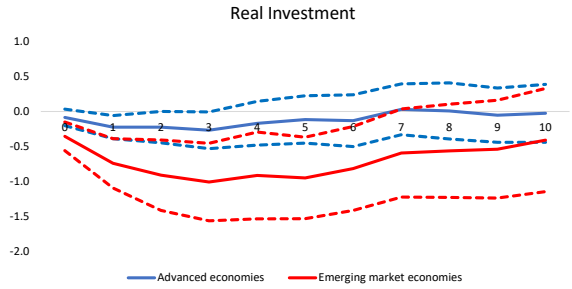
Figure 9: Impulse Responses to Monetary Policy Shock: Emerging Market vs Advanced Economy Samples



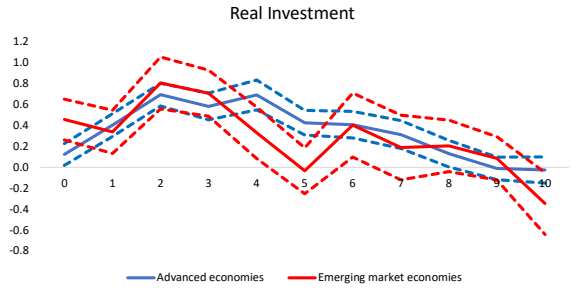
(a) Real GDP: 50th percentile



(b) Real GDP: 50th-5th percentile



(c) Real Investment: 50th percentile



(d) Real Investment: 50th-5th percentile

Notes: Figures show the estimated coefficients for $\beta_{h,50}$ and $\beta_{h,50} - \beta_{h,5}$ for different horizons $h = 0...12$, and +/- 2 standard deviations for different country samples. Standard errors are generated using block bootstrapping.

5.2 Dependence on business cycle

We also explore dependence of spillovers from US monetary policy shocks on the state of the business cycle. Figure 10 shows the estimated coefficients that correspond to the impact of US monetary policy shocks when the economy is in an "expansion" versus "recession" state. As described in Section 4.2, the state of the business cycle depends on the 4-quarter moving

average growth relative to a long-term trend and affects the size of spillovers following a smooth transition function.

Our results suggest that the impact of US monetary policy shocks is larger when the underlying growth momentum is weak, and this result seem robust to alternative parameter assumptions determining the smoothness of the transition from one state to the other (the *gamma* parameter).[12] Following a positive US monetary policy shock, output and investment rebound quickly if the economy is on a high growth phase, but in a low growth phase the impact on output and investment remain negative over the medium term.[13] The asymmetry in spillovers could reflect different factors. First, it could be that financial spillovers are amplified when the underlying growth momentum is weak. We find some suggestive evidence for this hypothesis. In particular, we find that the impact of US monetary policy shocks on capital flows is larger and more persistent when growth is weak (Figures 10e-10f). Another potential reason for the larger impact during low growth states could be more limited domestic policy space (for example because policy rates are typically reduced during slowdowns and fiscal balance deteriorates), which would imply less scope for domestic policies to play an offsetting role. To explore this, we ran simple regressions between monetary and fiscal policy stances in our sample of countries and our measure of the state of the business cycle. In particular, we estimate two regressions: (i) for monetary policy stance, we estimate the relationship between the "recession" regime variable F and the probability of being close to the zero-lower bound (defined as policy rate at or below 0.5 percent) using a simple probit model; (ii) for fiscal policy we estimated the response of the fiscal balance (as percent of GDP) to F, purging for country-fixed effects to capture differences in the averahe fiscal balance across countries:

$$y_{i,t} = \alpha_i + \theta_t + \beta F(\Delta y_{i,t}) + \epsilon_{i,t} \tag{11}$$

We report our estimates in Table 1 below. As expected, being in a "recession" state is associated with a higher probability of being close to the zero lower bound and lower fiscal balances. While this does not directly capture policy response to US monetary policy shocks, it does imply that policy space may be more limited in cyclical downturns. Similarly, we see

[12]See Appendix 7.7 for estimates of the impact of US monetary policy shocks in different states of the business cycle using alternative values of *gamma*.

[13]The impact of US monetary policy shocks is not significant in the first year when the underlying growth momentum is weak (i.e. recession state). A potential explanation for this could be that during recessions, the transmission of US monetary policy shocks to economic activity is initially weaker, reflecting the already weak demand.

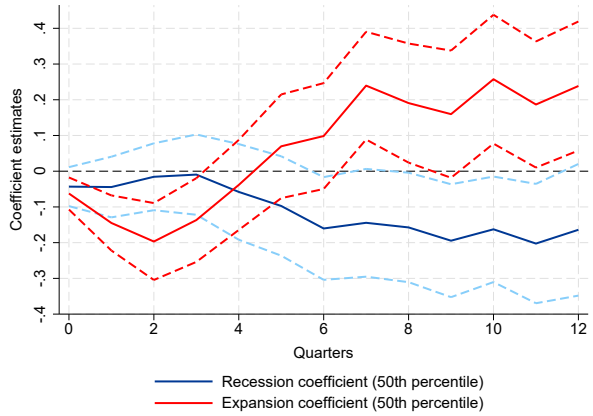
that countries have, on average, lower fiscal space during recessions.

Table 1: Estimated Impact of Business Cycle on Monetary and Fiscal Policy Indicators

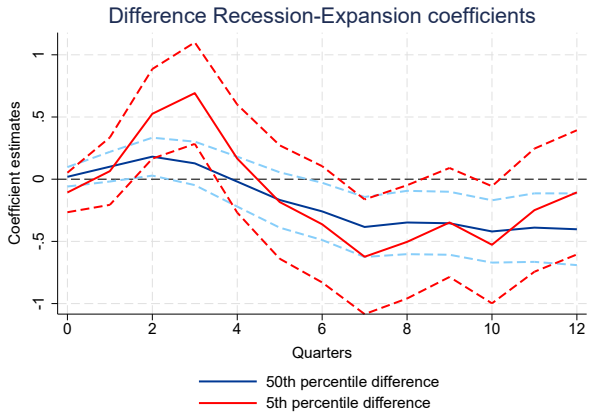
Variables	**Prob(Policy Rate=<0.5)**	**Fiscal Balance (% of GDP)**
F	0.32**	-1.87***
	(0.14)	(0.40)
Observations	1436	1706
Number of countries	52	62

*Notes: Regression for the policy rate is based on a simple probit model. Both regressions are based on annual data. Regression for the fiscal balance includes country and time fixed effects and reported standard errors are Driscoll-Kraay standard errors. P-values *** p<0.01, ** p<0.05, * p<0.1.*

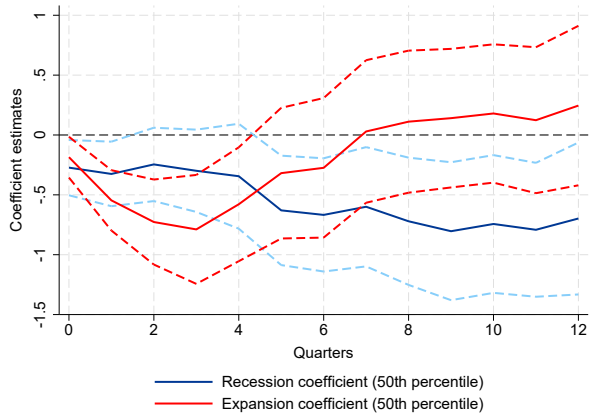
Figure 10: Impulse Responses to Monetary Policy Shocks: Dependence on State of the Business Cycle



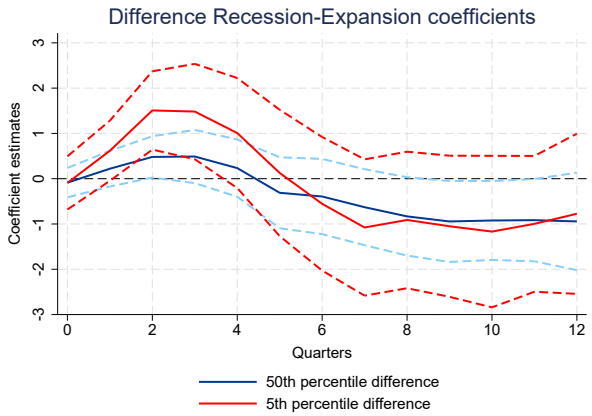
(a) Real GDP: Recession vs Expansion



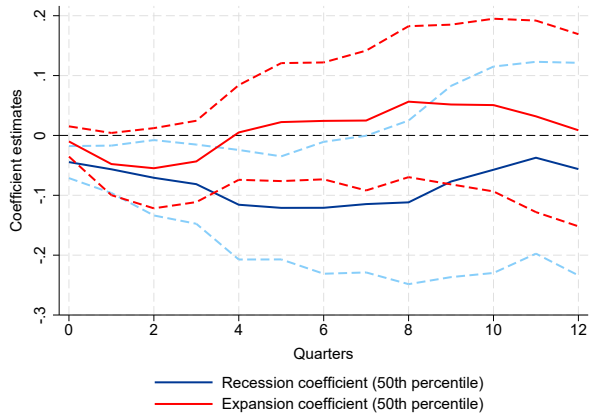
(b) Real GDP: Diff. between Recession and Expansion



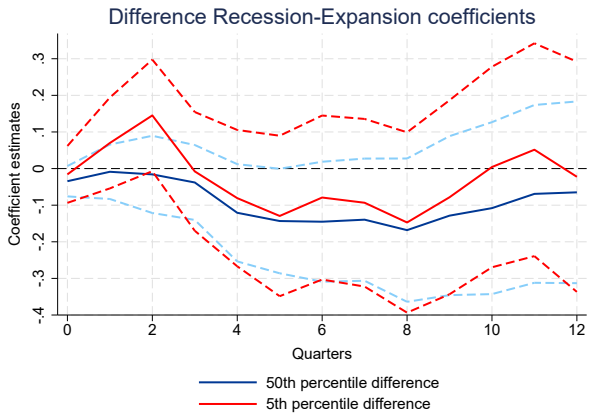
(c) Real Investment: Recession vs Expansion



(d) Real Investment: Diff. between Recession and Expansion



(e) Capital Flows: Recession vs Expansion



(f) Capital Flows: Diff. between Recession and Expansion

Notes: Figures show the estimated coefficients $\beta^E_{h,50}$ *and* $\beta^R_{h,50}$ *for different horizons* $h = 0...12$ *and +/- 2 standard deviations. Standard errors are generated using block bootstrapping.*

6 Conclusions

We provide new evidence on financial and real spillovers from changes in US interest rates on advanced and emerging market economies and how they vary depending on the source of the shock affect US rates and cyclical conditions in affected countries. . The results confirm that US monetary policy shocks have sizable effects on financial conditions and economic activity, with larger effects on emerging market economies: A 100 basis points unanticipated monetary policy shock is estimated to increase long-term domestic bond yields in other countries by about 25-35 basis points, with a higher pass-through for emerging market economies and during the period after the global financial crisis.

We differentiate between "demand", "supply", and "monetary policy" shocks that are estimated using a SVAR for the US economy. Our novel identification strategy for the SVAR combines high-frequency movements in interest rate futures to identify monetary policy shocks and sign restrictions to identify "demand" and "supply" shocks. The driving source for the change in US interest rates has a bearing on spillovers. We find that, for example, if interest rates in the US increase reflecting a positive demand shock in the US (e.g. a fiscal stimulus package), the near-term impact on other countries is estimated to be positive, while an exogenous tightening of US monetary policy is estimated to have a large negative spillover effect. Our results suggest that supply shocks also have sizable effects on economic activity in other countries notwithstanding the fact that the response of U.S. interest rates to supply side shock is not precisely estimated.

Spillovers also depend on the state of the business cycle, with larger adverse effects when the underlying growth momentum is weak. Finally, US monetary policy shocks are estimated to not only affect economic activity, but also the distribution of macroeconomic outcomes, with a larger impact on the left tail of the distribution of economic activity than on the median and impacting downside risks to growth and investment.

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7 Appendix

7.1 Event Study: Description of Data

The following summary tables explain the different sources of data and samples used in the event study analysis.

Table 2: Description of Indicators: Event Study Analysis

Variable	Description	Source
Government bond yields	Government bond yields at 2,5 and 10 years.	Bloomberg L.P
EMBI	Bechmark index for measuring the total performance of international government bonds issued mostly by emerging market economies.	Bloomberg L.P - JPM
Equity Index	Benchmark equity index.	Bloomberg L.P
Equity Flows	Daily portfolio of country equity flows in millions of USD.	Institute for International Finance
Total Flows	Sum of Equity and Debt Flows	Institute for International Finance
Nominal Exchange Rate	Nominal exchange rate USD-LCU	Bloomberg L.P
GDP	Gross domestic product in USD.	IMF World Economic Outlook Database - October 2021
MP1	FOMC Surprise	Refet Gurkaynak
FF4	FED Funds Futures - 4 months	Refet Gurkaynak
ED2	Euro Dollar Deposits - 2 months	Refet Gurkaynak
ED3	Euro Dollar Deposits - 3 months	Refet Gurkaynak
ED4	Euro Dollar Deposits - 4 months	Refet Gurkaynak

Table 3: Sample of Advanced and Emerging Market Economies for Government Bond Yields (1-year and 10-year maturities)

Advanced Economies (26)	**Emerging Market Economies (21)**	**Asia Pacific (10)**	**Asia Pacific Advanced(6)**	**Asia Pacific Emerging (4)**
Australia	Brazil	Australia	Australia	the People's Republic of China
Austria	Bulgaria	the People's Republic of China (PRC)	Hong Kong, China	India
Canada	Chile	Hong Kong, China	Japan	Indonesia
Czech Republic	the People's Republic of China (PRC)	India	Republic of Korea	Philippines
Denmark	Colombia	Indonesia	New Zealand	
Finland	Costa Rica	Japan	Singapore	
France	Hungary	Republic of Korea		
Germany	India	New Zealand		
Greece	Indonesia	Philippines		
Hong Kong, China	Jamaica	Singapore		
Ireland	Kenya			
Israel	Lebanon			
Italy	Mexico			
Japan	Nigeria			
Republic of Korea	Philippines			
Lithuania	Poland			
New Zealand	Romania			
Norway	Russian Federation			
Portugal	South Africa			
Singapore	Turkey			
Slovenia	Ukraine			
Spain				
Sweden				
Switzerland				
United Kingdom				
United States				

7.2 Event Study: Detailed Regression Results

Table 4: Advanced Economies: Estimated Impact of U.S. Monetary Policy Surprise on Selected Financial Variables

Variables	**1-Year**	**10-Year**	**EMBI**	**Equity Index**	**Exchange rate**
MP1	33.041***	7.394	-8.212	-0.016	0.026***
	(7.024)	(6.63)	(5.674)	(0.019)	(0.009)
FF4	47.507***	18.755	-15.175	-0.056**	0.048***
	(14.205)	(13.485)	(16.298)	(0.025)	(0.016)
ED2	45.475***	26.932**	-8.093	-0.053***	0.051***
	(10.759)	(10.68)	(14.175)	(0.016)	(0.016)
ED3	37.471***	25.389***	-5.15	-0.049***	0.048***
	(9.646)	(9.479)	(12.468)	(0.014)	(0.013)
ED4	33.946***	25.038***	-3.743	-0.047***	0.045***
	(9.609)	(7.878)	(11.558)	(0.014)	(0.013)
Observations	3,100	3,708	255	6,027	6,930
Number of countries	26	26	4	35	35

*Notes: Each number reported in the table correspond to estimates from separate regressions, capturing the impact of different monetary policy shocks (listed in rows) on different financial variables (listed in columns). Each regression includes country fixed effects and the standard errors reported in parenthesis are Driscoll-Kraay standard errors. P-values *** p<0.01, ** p<0.05, * p<0.1.*

Table 5: Emerging Market Economies: Estimated Impact of U.S. Monetary Policy Surprise on Selected Financial Variables

Variables	1-Year	10-Year	EMBI	Equity Index	Exchange rate
MP1	15.309*	11.262	4.848	-0.005	0.005
	(9.045)	(12.618)	(28.954)	(0.013)	(0.004)
FF4	15.871	35.223*	60.977	-0.042**	0.015**
	(23.074)	(19.51)	(42.225)	(0.02)	(0.006)
ED2	22.684	36.48**	62.338**	-0.045***	0.019***
	(33.474)	(14.749)	(29.412)	(0.013)	(0.005)
ED3	27.429	37.866***	59.898**	-0.04***	0.017***
	(34.463)	(13.922)	(25.021)	(0.012)	(0.005)
ED4	32.007	39.377***	59.978**	-0.039***	0.017***
	(35.191)	(13.142)	(23.366)	(0.011)	(0.004)
Observations	1,879	1,906	6,850	8,347	28,677
Number of countries	21	21	59	57	152

*Notes: Each number reported in the table correspond to estimates from separate regressions, capturing the impact of different monetary policy shocks (listed in rows) on different financial variables (listed in columns). Each regression includes country fixed effects and the standard errors reported in parenthesis are Driscoll-Kraay standard errors. P-values *** p<0.01, ** p<0.05, * p<0.1.*

Table 6: Asia Pacific Economies: Estimated Impact of U.S. Monetary Policy Surprise on Selected Financial Variables

Variables	1-Year	10-Year	EMBI	Equity Index	Exchange rate
MP1	28.123***	14.448*	-25.554	-0.014	0.008***
	(5.937)	(7.441)	(23.115)	(0.02)	(0.003)
FF4	39.628***	31.591**	23.998	-0.056**	0.02***
	(9.033)	(14.609)	(23.459)	(0.022)	(0.007)
ED2	38.289***	35.887***	35.012**	-0.058***	0.022***
	(7.043)	(11.396)	(14.366)	(0.016)	(0.006)
ED3	32.614***	34.945***	32.858***	-0.054***	0.021***
	(7.836)	(9.771)	(11.231)	(0.014)	(0.005)
ED4	30.72***	34.583***	32.265***	-0.052***	0.02***
	(8.558)	(8.852)	(10.708)	(0.013)	(0.005)
Observations	1,450	1,442	957	3,061	6,982
Number of countries	10	10	8	18	36

*Notes: Each number reported in the table correspond to estimates from separate regressions, capturing the impact of different monetary policy shocks (listed in rows) on different financial variables (listed in columns). Each regression includes country fixed effects and the standard errors reported in parenthesis are Driscoll-Kraay standard errors. P-values *** p<0.01, ** p<0.05, * p<0.1.*

Table 7: Asia Pacific - Advanced Economies: Estimated Impact of U.S. Monetary Policy Surprise on Selected Financial Variables

Variables	1-Year	10-Year	EMBI	Equity Index	Exchange rate
MP1	32.986***	14.667***		-0.024	0.02***
	(4.573)	(4.833)		(0.027)	(0.006)
FF4	36.672***	19.669*		-0.072**	0.044***
	(5.916)	(10.051)		(0.029)	(0.012)
ED2	35.394***	25.41***		-0.075***	0.047***
	(5.259)	(7.473)		(0.02)	(0.012)
ED3	26.105***	25.944***		-0.07***	0.044***
	(4.988)	(6.526)		(0.017)	(0.011)
ED4	22.462***	25.741***		-0.066***	0.042***
	(4.634)	(5.394)		(0.017)	(0.01)
Observations	907	900		1,341	1,386
Number of countries	6	6		7	7

*Notes: Each number reported in the table correspond to estimates from separate regressions, capturing the impact of different monetary policy shocks (listed in rows) on different financial variables (listed in columns). Each regression includes country fixed effects and the standard errors reported in parenthesis are Driscoll-Kraay standard errors. P-values *** p<0.01, ** p<0.05, * p<0.1.*

Table 8: Asia Pacific - Emerging Market Economies: Estimated Impact of U.S. Monetary Policy Surprise on Selected Financial Variables

Variables	1-Year	10-Year	EMBI	Equity Index	Exchange rate
MP1	18.849*	14.031	-25.554	-0.006	0.005**
	(10.674)	(17.353)	(23.115)	(0.017)	(0.002)
FF4	45.387**	54.781*	23.998	-0.043*	0.014***
	(21.876)	(28.338)	(23.459)	(0.023)	(0.005)
ED2	43.548**	54.712**	35.012**	-0.044**	0.016***
	(20.161)	(22.585)	(14.366)	(0.017)	(0.004)
ED3	44.49**	51.279**	32.858***	-0.04***	0.015***
	(20.305)	(20.47)	(11.231)	(0.015)	(0.004)
ED4	45.384**	50.128**	32.265***	-0.04***	0.015***
	(21.286)	(19.918)	(10.708)	(0.014)	(0.004)
Observations	543	542	957	1,720	5,596
Number of countries	4	4	8	11	29

*Notes: Each number reported in the table correspond to estimates from separate regressions, capturing the impact of different monetary policy shocks (listed in rows) on different financial variables (listed in columns). Each regression includes country fixed effects and the standard errors reported in parenthesis are Driscoll-Kraay standard errors. P-values *** p<0.01, ** p<0.05, * p<0.1.*

Table 9: 10-Year Government Bond Yields Response to U.S. Monetary Policy Surprises

	BFC					AFC				
Variables	**AE**	**EM**	**APD**	**AE-Asia**	**EM-Asia**	**AE**	**EM**	**APD**	**AE-Asia**	**EM-Asia**
MP1	6.056	28.816*	17.583**	8.436	31.38**	111.987***	74.958**	75.93***	66.993***	83.751**
	(8.54)	(16.808)	(7.542)	(5.414)	(15.458)	(29.325)	(32.767)	(26.319)	(24.069)	(37.06)
FF4	11.995	25.063	16.682	9.277	28.01*	116.109***	90.396*	96.536***	107.481***	86.96***
	(14.843)	(19.995)	(10.216)	(9.611)	(16.388)	(29.957)	(49.481)	(20.16)	(29.869)	(32.387)
ED2	20.68*	24.408*	19.539***	16.148*	24.454**	44.346**	59.246***	60.517***	58.725***	62.084***
	(12.344)	(13.208)	(7.327)	(8.869)	(10.932)	(20.481)	(20.979)	(11.827)	(19.229)	(16.786)
ED3	19.74*	16.799**	16.259***	16.375**	16.096***	32.689*	50.714***	50.018***	48.345***	51.481***
	(10.379)	(8.09)	(5.096)	(7.406)	(6.119)	(17.581)	(14.651)	(8.171)	(13.179)	(12.384)
ED4	19.848**	14.353**	14.961***	16.31***	13.124**	30.352**	45.409***	44.576***	43.113***	45.856***
	(7.97)	(6.795)	(4.145)	(6.149)	(5.706)	(15.339)	(11.905)	(7.375)	(10.979)	(10.301)
Observations	1,747	584	807	447	360	1,836	1,156	1,020	476	544
Number of countries	27	17	15	7	8	27	17	15	7	8

*Notes: Each number reported in the table correspond to estimates from separate regressions, capturing the impact of different monetary policy shocks (listed in rows) on 10-year government bond yields for different country samples (listed in columns). Each regression includes country fixed effects and the standard errors reported in parenthesis are Driscoll-Kraay standard errors. P-values *** p<0.01, ** p<0.05, * p<0.1.*

Table 10: Equity and Total Flows Responses to U.S Monetary Policy Surprises

	Equity Flows(t) + Equity Flows (t+1)/ GDP			**Total Flows(t) + Total Flows (t+1)/ GDP**		
Variables	**EM**	**APD**	**EM-Asia**	**EM**	**APD**	**EM-Asia**
MP1	-0.0003	-0.0007*	-0.0004	0.0001	-0.0006	-0.0002
	(0.0004)	(0.0004)	(0.0003)	(0.0007)	(0.0005)	(0.0004)
FF4	-0.0005	-0.0008**	-0.0003	0.0002	-0.0008	-0.0003
	(0.0004)	(0.0004)	(0.0003)	(0.0008)	(0.0005)	(0.0004)
ED2	-0.0006**	-0.0008**	-0.0004	-0.0001	-0.0008*	-0.0004
	(0.0002)	(0.0004)	(0.0002)	(0.0005)	(0.0005)	(0.0004)
ED3	-0.0004*	-0.0004	-0.0002	-0.0002	-0.0005	-0.0002
	(0.0002)	(0.0004)	(0.0002)	(0.0004)	(0.0004)	(0.0003)
ED4	-0.0002	-0.00005	-0.0001	-0.0001	-0.0001	-0.0001
	(0.0002)	(0.0004)	(0.0002)	(0.0004)	(0.0005)	(0.0003)
Observations	763	676	488	1,093	677	489
Number of countries	11	9	7	15	9	7

*Notes: Each number reported in the table correspond to estimates from separate regressions, capturing the impact of different monetary policy shocks (listed in rows) on different types of capital flows for different country samples (listed in columns). Each regression includes country fixed effects and the standard errors reported in parenthesis are Driscoll-Kraay standard errors. P-values *** p<0.01, ** p<0.05, * p<0.1.*

7.3 Spillover Analysis: Data

The following summary tables explain the different sources of data and variables used in the estimation of SVAR and quantile regression analysis.

Table 11: Description and Sources of Data for SVAR

Variable	Description	Source
Industrial Production	US Industrial Production Index : Total Index	FRED
Consumer Price Index	Consumer Price Index	FRED
Excess Bond Premium	Component that captures firm-specific information on expected defaults and a residual component	Gilchrist and Zakrajšek (2012)
2-Year bond yield	Market yield on US-Treasury securities 2 Year Maturity	FRED

Table 12: Description of Sources of Data for Quantile Regression Analysis

Variable	Description	Source
Real GDP	Real Gross Domestic Product.	Haver Analytics, CEIC and IMF-IFS.
Real Investment	Gross Fixed Capital Formation.	Haver Analytics, CEIC and IMF-IFS.
Debt Flows	Debt flows in millions of USD. Compilation of different sources of debt flows from Koepke and Paetzold (2020), Balance of Payments Statistics (BOP) and Emerging Portfolio Fund Research (EPFR). For BOP we define debt flows as incurrence of liabilities (debt securities) minus the acquisition of financial assets (debt securities).	Koepke and Paetzold (2020), EPFR and BOP.
Equity Flows	Equity flows in millions of USD. Compilation of different sources of equity flows from Koepke and Paetzold (2020), Balance of PaymentsStatistics (BOP) and Emerging Portfolio Fund Research (EPFR). For BOP we define equity flows as incurrence of liabilities (equity and investment fund shares) minus the acquisition of financial assets (equity and investment fund shares).	Koepke and Paetzold (2020), EPFR and BOP.
Total Flows	Sum of Debt and Equity flows in millions of USD.	Koepke and Paetzold (2020), EPFR and BOP.
General Government Gross Debt	Gross debt consists on all liabilities that require payment/s of interest and/or principal by the debtor to the creditor at a date/s in the future. In percent of GDP.	World Economic Outlook Database.
Fiscal Balance	Fiscal Balance Position in percent of GDP.	World Economic Outlook Database.
Policy Rates	Central Bank Policy Rates.	BIS and Haver Analytics.
Current Account Balance	Current Account Balance in percent of GDP.	World Economic Outlook Database.
External Debt	External Debt in percent of GDP.	World Economic Outlook Database.
Reserves	International reserves - Official reserves in US Dollars, in percent of GDP.	IMF-IFS
Trade exposure to US	Exports and imports to the US relative to the rest of the world.	IMF-Direction of Trade Statistics.

Table 13: Sample of Advanced and Emerging Market Economies

Advanced Economies (33)	**Emerging Market Economies (29)**
Australia	Argentina
Austria	Belarus
Belgium	Bolivia
Canada	Brazil
Cyprus	Bulgaria
Czech Republic	Cameroon
Denmark	Chile
Estonia	the People's Republic of China (PRC)
Finland	Colombia
France	Costa Rica
Germany	Croatia
Greece	Ecuador
Hong Kong, China	Honduras
Ireland	Hungary
Israel	India
Italy	Indonesia
Japan	Iran
Republic of Korea	Malaysia
Latvia	Mexico
Lithuania	Paraguay
Malta	Peru
Netherlands	Philippines
New Zealand	Poland
Norway	Romania
Portugal	Russian Federation
Singapore	South Africa
Slovak Republic	Thailand
Slovenia	Turkey
Spain	Ukraine
Sweden	
Switzerland	
Taipei,China	
United Kingdom	

7.4 Algorithm Used For Computing Random Draws for Estimating SVAR Using Sign Restrictions

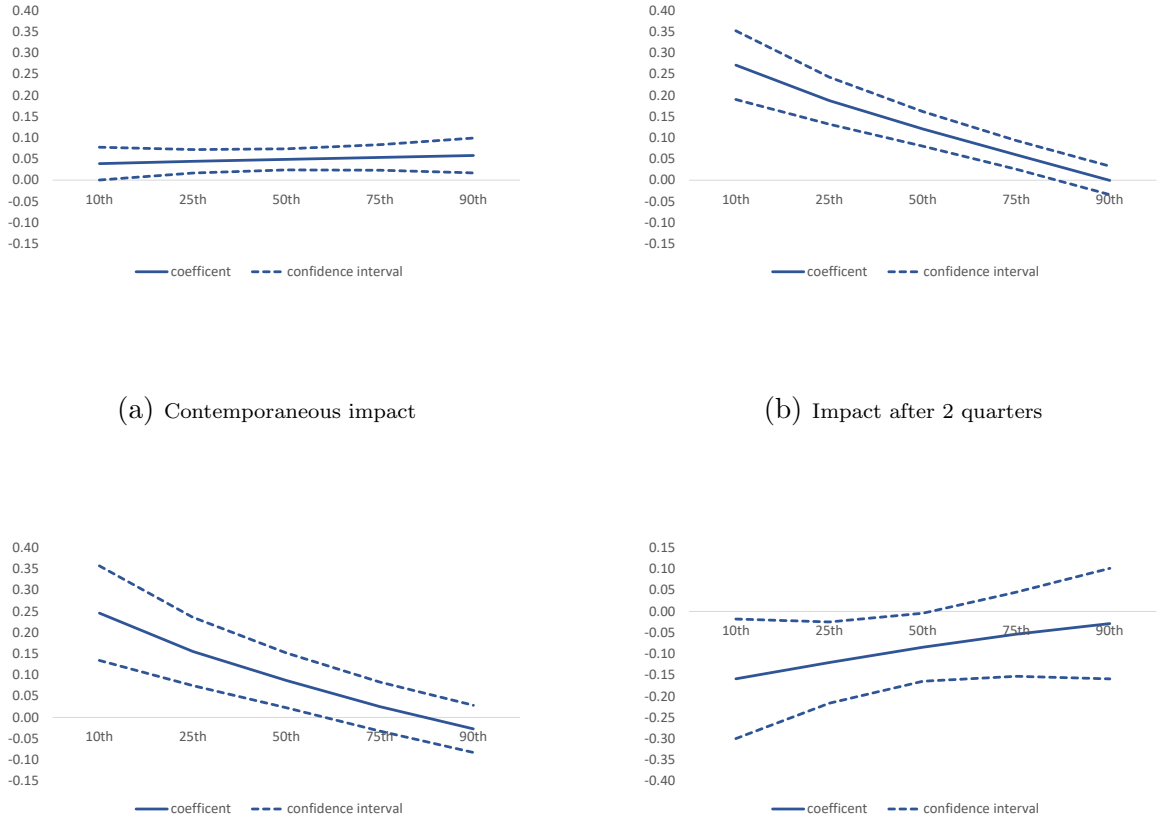
We follow the algorithm proposed in Braun and Bruggemann (2017) to draw an orthogonal matrix Q subject to the instrumental variable and sign restrictions which is described in Braun and Bruggemann (2017) as follows:

- Compute $\tilde{q_1} = P^{-1}\beta_2$ and define $n \times n$ matrix $\tilde{Q} = [N^*, \tilde{q_1}]$ where N^* is an orthonormal basis for the null space of $\tilde{q_1'}$ such that $N^{*'}\tilde{q_1} = 0$ and $N^{*'}N^* = I$.
- Draw Q_3^* from the uniform prior over the space of all 3×3 dimensional orthogonal matrices and define $\overline{Q} = \begin{pmatrix} Q_3^8 & 0 \\ 0 & I_k \end{pmatrix}$.
- Compute $Q = \tilde{Q}\overline{Q}$ and the associated structural impact matrix $B = PQ$. Accept the draw of B if all sign restrictions are satisfied.

7.5 Estimated Impact of Different Structural Shocks on the Broader Distribution of Real GDP Outcomes

We present below estimated impact of different structural shocks on real GDP for a wide range of percentiles of the GDP distribution (for example, the 10th, 25th, 75th and 90th percentiles) and at different horizons.

Figure 11: Estimated Impact of a Positive Demand Shock on Real GDP for Different Percentiles



(a) Contemporaneous impact

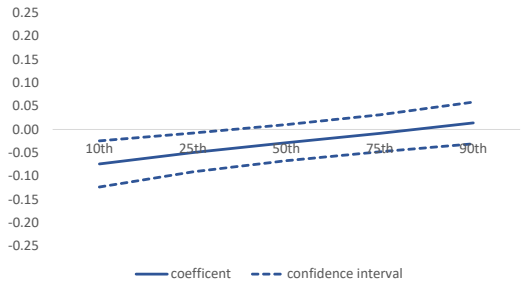
(b) Impact after 2 quarters

(c) Impact after 4 quarters

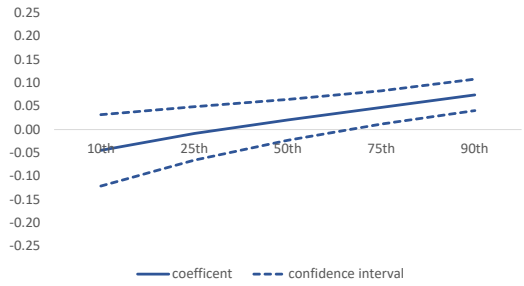
(d) Impact after 8 quarters

Notes: Figures show the estimated coefficients $\beta_{h,p}$ for different horizons $h = 0, 2, 4, 8$ and $p = 10, 25, 50, 75, 90$ and +/- 2 standard deviations. Standard errors are generated using block bootstrapping.

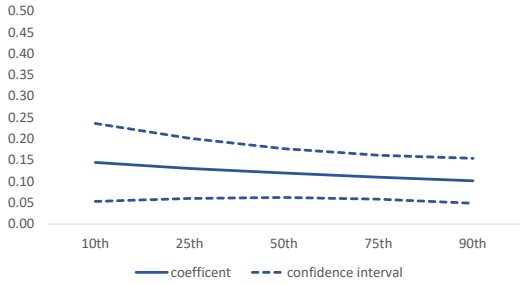
Figure 12: Estimated Impact of a Positive Supply Shock on Real GDP for Different Percentiles



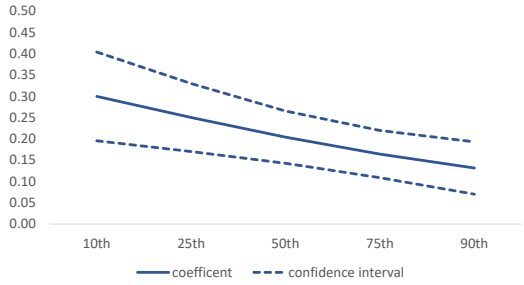
(a) Contemporaneous impact



(b) Impact after 2 quarters



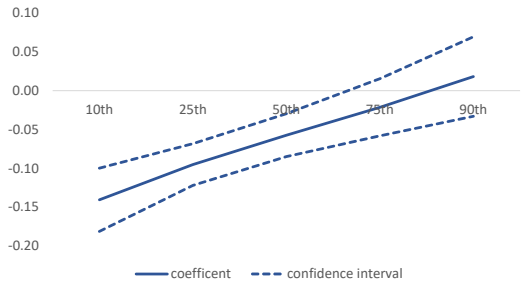
(c) Impact after 4 quarters



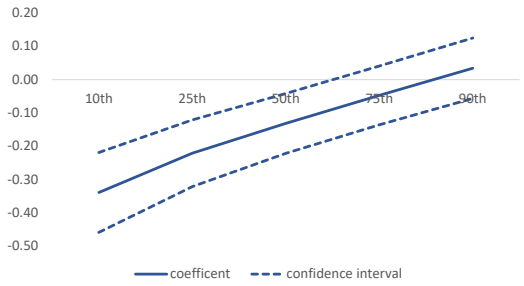
(d) Impact after 8 quarters

Notes: Figures show the estimated coefficients $\beta_{h,p}$ *for different horizons* $h = 0, 2, 4, 8$ *and* $p = 10, 25, 50, 75, 90$ *and +/- 2 standard deviations. Standard errors are generated using block bootstrapping.*

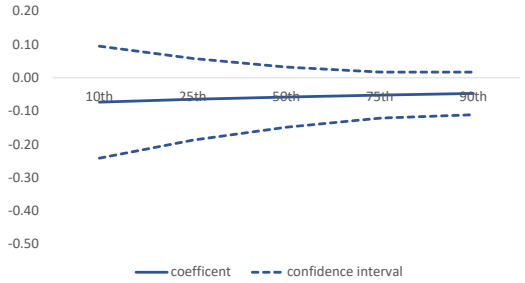
Figure 13: Estimated Impact of a Positive Monetary Policy Shock on Real GDP for Different Percentiles



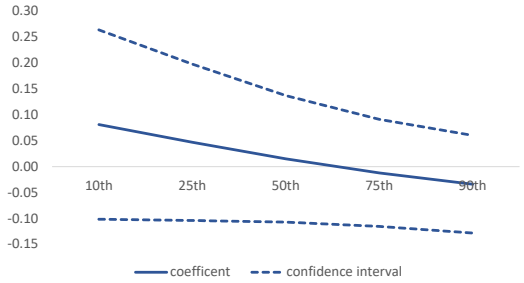
(a) Contemporaneous impact



(b) Impact after 2 quarters



(c) Impact after 4 quarters



(d) Impact after 8 quarters

Notes: Figures show the estimated coefficients $\beta_{h,p}$ for different horizons $h = 0, 2, 4, 8$ and $p = 10, 25, 50, 75, 90$ and +/- 2 standard deviations. Standard errors are generated using block bootstrapping.

7.6 Dependence of the Impact of US Monetary Policy Shocks on Country Characteristics

Dependence of the impact of US monetary policy shocks on country characteristics is modeled using a smooth transition function, varying with the underlying exposure or vulnerability, denoted $\tilde{x}_i$. Exposure and vulnerability indicators are characterized using the country-specific average over the sample period x_i and its deviation from the cross-country average $\bar{x}$.

We estimate the following equation:

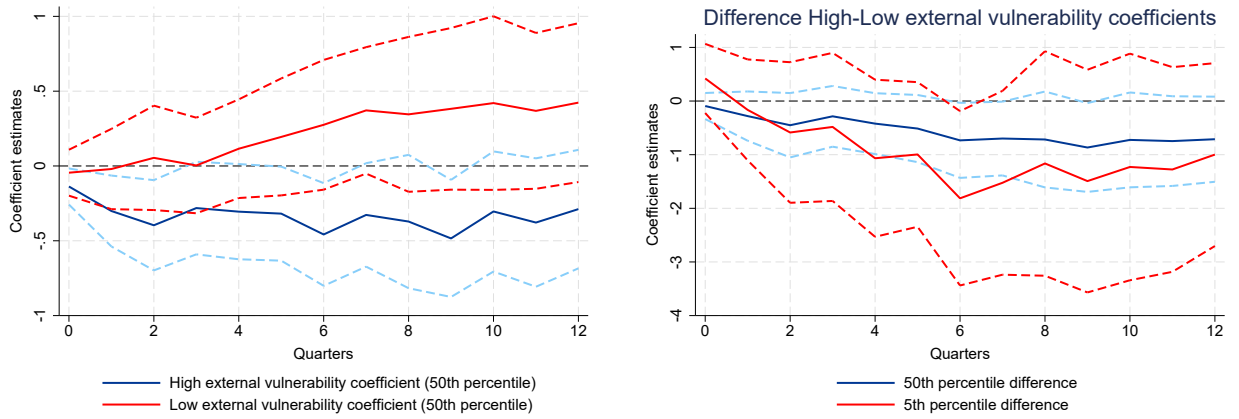
$$y_{i,t+h} - y_{i,t-1} = \alpha_{i,h,q} + (1 - F(\tilde{x}_i))(\beta^H_{h,q} s_t) + F(\tilde{x}_i)(\beta^L_{h,q} s_t) + \theta_{h,q} Z_{i,t}) + \epsilon_{i,t} \quad (12)$$

$$F(\tilde{x}_i) = \frac{exp(\gamma \frac{x_i - \bar{x}}{\sigma_{x,i}})}{1 + exp(\gamma \frac{x_i - \bar{x}}{\sigma_{x,i}})} \quad (13)$$

where $\beta^H_{h,q} s_t$ and $\beta^L_{h,q} s_t$ denote impact of US monetary policy shocks when the underlying exposure/vulnerability indicator is high versus low, and $F(\tilde{x}_i)$ is a smooth decreasing function of $\tilde{x}_i$. We set γ=-3.

Our results suggest that external vulnerabilities play some role in explaining country heterogeneity in the degree of spillovers. To capture external vulnerabilities, we consider external debt, current account balance, and international reserves, all expressed as percent of GDP and normalized relative to the cross-country average during the sample. We explored these normalized indicators both individually and using a simple average (with current account and reserves entering with a negative sign) to construct an average vulnerability index given the multi-dimensional nature of vulnerabilities. Our results using the external vulnerability index suggest that countries with higher external vulnerabilities experience larger spillovers from US monetary policy shocks and this effect is significant only in the emerging market sample (reported in Figure 14).

Figure 14: State Dependence of the Impact of US Monetary Policy Shocks on Real GDP: Role of External Vulnerabilities Using an Average Vulnerability Index (Emerging Markets)



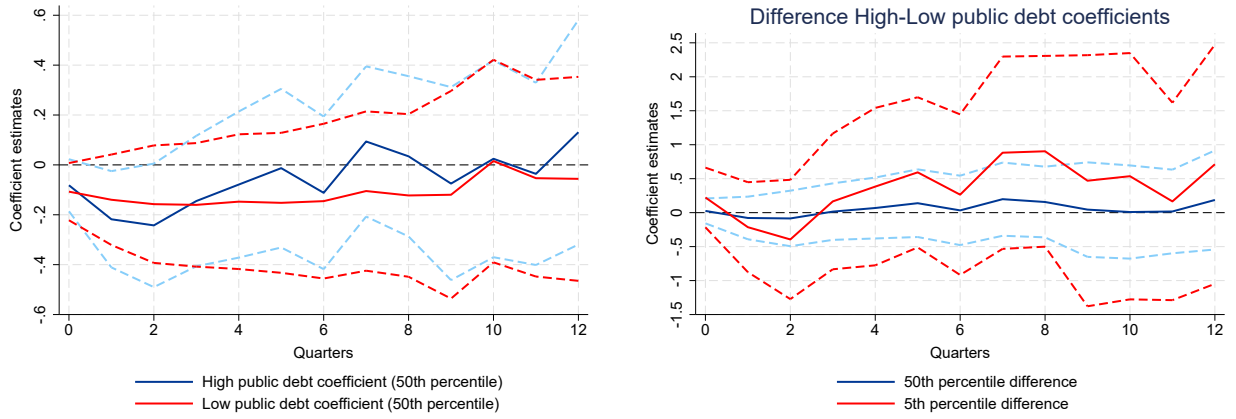
(a) Coefficient estimates for high and low vulnerabilities (b) Difference in coefficient estimates (high-low coefficients)

Notes: Figures show the estimated coefficients $\beta^H_{h,50}$ *and* $\beta^L_{h,50}$ *for different horizons* $h = 0...12$ *and +/- 2 standard deviations. Standard errors are generated using block bootstrapping.*

Next, we explore the role of fiscal vulnerabilities, using public debt and fiscal deficit to GDP ratio as proxies. We find no significant difference in terms of the impact of US monetary policy shocks based on the level of public debt or fiscal balance. Figure 15 below shows the

estimated response for the emerging market sample and using public debt as a proxy. Our results for fiscal balance and for the broader sample of countries are similar.

Figure 15: State Dependence of the Impact of US Monetary Policy Shocks on Real GDP: Role of Fiscal Vulnerabilities (Emerging Markets)



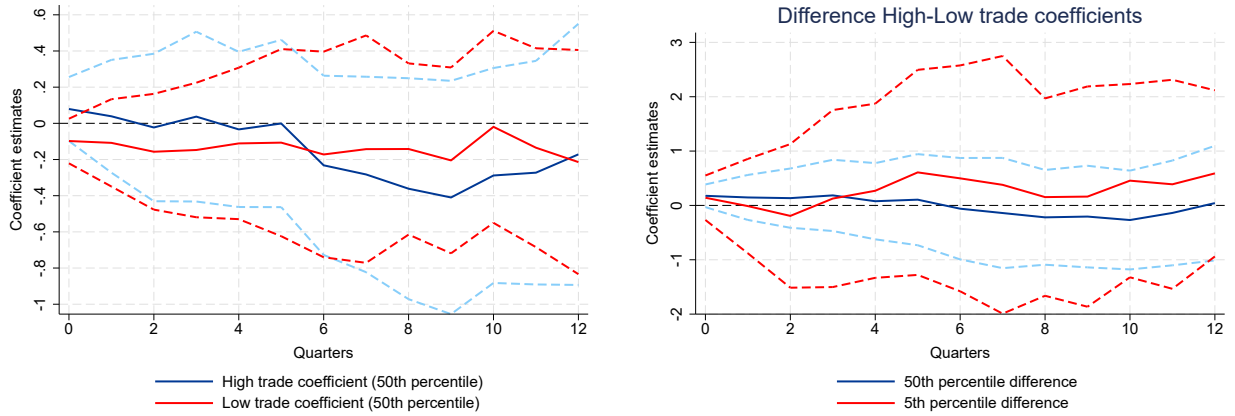
(a) Coefficient estimates for high and low debt

(b) Difference in coefficient estimates (high-low coefficients)

Notes: Figures show the estimated coefficients $\beta^H_{h,50}$ *and* $\beta^L_{h,50}$ *for different horizons* $h = 0...12$ *and +/- 2 standard deviations. Standard errors are generated using block bootstrapping.*

Finally, we explore the role of trade exposure to the US by using the share of a country's exports and imports to the US relative to its total exports and imports. Our results for the emerging market economies sample suggests no significant relationship between spillovers and trade exposure to the US (see Figure 16), and our results for the full sample are similar.

Figure 16: State Dependence of the Impact of US Monetary Policy Shocks on Real GDP: Role of Trade Exposure to the US (Emerging Markets)



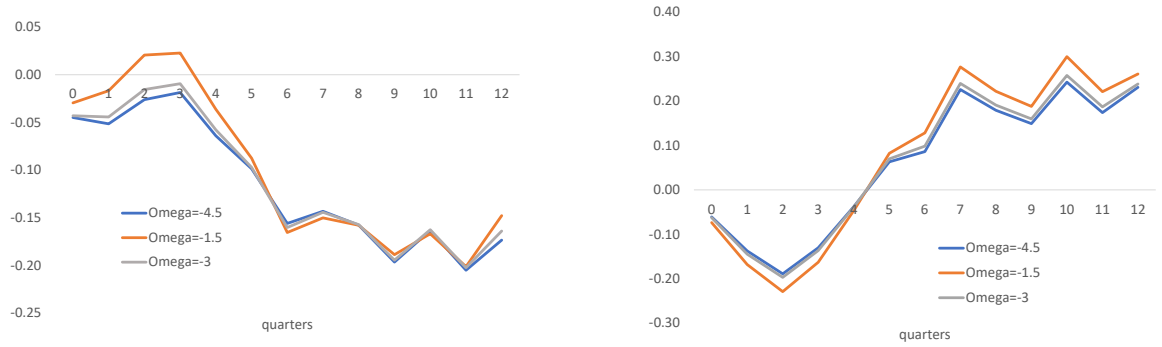
(a) Coefficient estimates for high and low trade exposure (b) Difference in coefficient estimates (high-low coefficients)

Notes: Figures show the estimated coefficients $\beta^H_{h,50}$ *and* $\beta^L_{h,50}$ *for different horizons* $h = 0...12$ *and +/- 2 standard deviations. Standard errors are generated using block bootstrapping.*

7.7 Dependence of Spillovers from US Monetary Policy Shocks on the Business Cycle: Robustness to Alternative Parameter Assumptions

We report our results for the impact of US monetary policy shocks on real GDP for different states of the business cycle using alternative assumptions for γ. In particular, we compare our results for γ=-1.5,-4.5 with γ=-3 which is the benchmark parameter used in the paper. Our results (reported in 17) suggest that the estimated impact is fairly robust to alternative values of γ.

Figure 17: State Dependence of the Impact of US Monetary Policy Shocks on Real GDP: Alternative Parameter Assumptions)



(a) Recession state

(b) Expansion state

Notes: Figures show the estimated coefficients $\beta^E_{h,50}$ *and* $\beta^R_{h,50}$ *for different* γ *parameters over different horizons* $h = 0...12$.