DISCUSSION PAPER SERIES

DP14533

THE GLOBAL TRANSMISSION OF U.S. MONETARY POLICY

Riccardo Degasperi, Simon Hong and Giovanni Ricco

INTERNATIONAL MACROECONOMICS AND FINANCE

MONETARY ECONOMICS AND FLUCTUATIONS

ISSN 0265-8003

THE GLOBAL TRANSMISSION OF U.S. MONETARY POLICY

Riccardo Degasperi, Simon Hong and Giovanni Ricco

Discussion Paper DP14533
Published 26 March 2020
Submitted 24 March 2020

Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

This Discussion Paper is issued under the auspices of the Centre's research programmes:

- International Macroeconomics and Finance
- Monetary Economics and Fluctuations

Any opinions expressed here are those of the author(s) and not those of the Centre for Economic Policy Research. Research disseminated by CEPR may include views on policy, but the Centre itself takes no institutional policy positions.

The Centre for Economic Policy Research was established in 1983 as an educational charity, to promote independent analysis and public discussion of open economies and the relations among them. It is pluralist and non-partisan, bringing economic research to bear on the analysis of medium- and long-run policy questions.

These Discussion Papers often represent preliminary or incomplete work, circulated to encourage discussion and comment. Citation and use of such a paper should take account of its provisional character.

Copyright: Riccardo Degasperi, Simon Hong and Giovanni Ricco

THE GLOBAL TRANSMISSION OF U.S. MONETARY POLICY

Abstract

This paper studies the transmission of US monetary shocks across the globe by employing a high-frequency identification of policy shocks and large VAR techniques, in conjunction with a large macro-financial dataset of global and national indicators covering both advanced and emerging economies. Our identification controls for the information effects of monetary policy and allows for the separate analysis of tightenings and loosenings of the policy stance. First, we document that US policy shocks have large real and nominal spillover effects that affect both advanced economies and emerging markets. Policy actions cannot fully isolate national economies, even in the case of advanced economies with flexible exchange rates. Second, we investigate the channels of transmission and find that both trade and financial channels are activated and that there is an independent role for oil and commodity prices. Third, we show that effects are asymmetric and larger in the case of contractionary US monetary policy shocks. Finally, we contrast the transmission mechanisms of countries with different exchange rates, exposure to the dollar, and capital control regimes.

JEL Classification: E5, F3, F4, C3

Keywords: monetary policy, trilemma, Exchange Rates, Foreign Spillovers

Riccardo Degasperi - r.degasperi@warwick.ac.uk
University of Warwick

Simon Hong - s.hong.3@warwick.ac.uk
University of Warwick

Giovanni Ricco - G.Ricco@warwick.ac.uk
University of Warwick, CEPR, OFCE-SciencesPo and Now-Casting Economics and CEPR

Acknowledgements
We are grateful to Boragan Aruoba, Gianluca Benigno, Andrea Carriero, Luca Dedola, Alex Luiz Ferreira, Georgios Georgiadis, Linda Goldberg, Marek Jaroci\'nski, Sebnem Kalemli-Ozcan, Bartosz Ma\'ckowiak, Silvia Miranda-Agrippino, H\'el\`ene Rey, Alberto Romero, Barbara Rossi, Fabrizio Venditti and participants at the Third Annual Meeting of CEBRA's International Finance and Macroeconomics Program, the 2019 Annual Conference of the Chaire Banque de France, the European Central Bank, and Warwick macroeconomics workshop for insightful comments. We are grateful to Now-Casting Economics and CrossBorderCapital Ltd for giving us access to the Global Liquidity Indexes dataset. We thank V\'aclav \v{Z}d\'arek for excellent research assistance. The authors acknowledge support from the British Academy: Leverhulme Small Research Grant SG170723.

The Global Transmission of U.S. Monetary Policy

Riccardo Degasperi* Seokki Simon Hong†
University of Warwick University of Warwick

Giovanni Ricco‡
University of Warwick, CEPR, OFCE-SciencesPo and Now-Casting Economics

First Version: 31 May 2019
This version: 25 March 2020

Abstract

This paper studies the transmission of US monetary shocks across the globe by employing a high-frequency identification of policy shocks and large VAR techniques, in conjunction with a large macro-financial dataset of global and national indicators covering both advanced and emerging economies. Our identification controls for the information effects of monetary policy and allows for the separate analysis of tightenings and loosenings of the policy stance. First, we document that US policy shocks have large real and nominal spillover effects that affect both advanced economies and emerging markets. Policy actions cannot fully isolate national economies, even in the case of advanced economies with flexible exchange rates. Second, we investigate the channels of transmission and find that both trade and financial channels are activated and that there is an independent role for oil and commodity prices. Third, we show that effects are asymmetric and larger in the case of contractionary US monetary policy shocks. Finally, we contrast the transmission mechanisms of countries with different exchange rates, exposure to the dollar, and capital control regimes.

Keywords: Monetary policy, Trilemma, Exchange Rates, Foreign Spillovers.
JEL Classification: E5, F3, F4, C3.

*Department of Economics, The University of Warwick. Email: R.Degasperi@warwick.ac.uk
†Department of Economics, The University of Warwick. Email: S.Hong.3@warwick.ac.uk
‡Department of Economics, The University of Warwick, The Social Sciences Building, Coventry, West Midlands CV4 7AL, UK. Email: G.Ricco@warwick.ac.uk Web: www.giovanni-ricco.com

We are grateful to Boragan Aruoba, Gianluca Benigno, Andrea Carriero, Luca Dedola, Alex Luiz Ferreira, Georgios Georgiadis, Linda Goldberg, Marek Jarociński, Sebnem Kalemli-Ozcan, Bartosz Maćkowiak, Silvia Miranda-Agrippino, Hélène Rey, Alberto Romero, Barbara Rossi, Fabrizio Venditti and participants at the Third Annual Meeting of CEBRA's International Finance and Macroeconomics Program, the 2019 Annual Conference of the Chaire Banque de France, the European Central Bank, and Warwick macroeconomics workshop for insightful comments. We are grateful to Now-Casting Economics and CrossBorderCapital Ltd for giving us access to the Global Liquidity Indexes dataset. We thank Václav Ždárek for excellent research assistance. The authors acknowledge support from the British Academy: Leverhulme Small Research Grant SG170723.

1 Introduction

What is the global impact of US monetary policy actions? The adoption of the US dollar by the transnational banking system and ever deeper trade and financial integration mean that the implications of Fed decisions extend well beyond the borders of the United States. A critical question for policymakers in advanced and emerging markets is how to adjust monetary policy to neutralise spillovers from US monetary policy actions. We contribute to this debate by providing robust evidence on the propagation of US monetary policy. We use a state-of-the-art high-frequency identification of monetary shocks and large data techniques to assess outcomes for global and national indicators covering 30 advanced and emerging economies.

The classic Mundell-Fleming model identifies two international transmission channels for US monetary policy. First, an increase in US interest rates has a contractionary effect domestically which translates to lower demand for both domestic and foreign goods (demand-augmenting effect). Second, as the dollar appreciates, foreign goods become relatively cheaper, moving the composition of global demand away from US goods and towards foreign goods (expenditure-switching effect). These two channels should at least partially offset each other. However, there can be a third, financial transmission channel – risk-taking and international credit – which occurs through the balance sheets of global financial intermediaries (Rey, 2013, 2016; Farhi and Werning, 2014; Bruno and Shin, 2015a,b). A Fed rate hike transmits along the yield curve at longer maturities and reduces the price of risky financial assets. Portfolio rebalancing by investors in the integrated global financial market determines capital outflows in foreign countries and induces upward pressure on foreign longer-term yields and downward price revisions of foreign assets. Furthermore, a higher US interest rate raises the funding cost of major global banks, which provide credit to many advanced and emerging economies. Due to such adverse balance sheet effects, financial conditions abroad may deteriorate substantially with powerful destabilising effects.

The combined effect of the three channels implies a difficult trade-off for central banks. Faced with a contractionary policy action in the US, a foreign central bank would want to lower its rate to counter the negative demand shock. However, such an action risks worsening the adverse balance sheet effects, leading to even larger capital outflows and further destabilisation. As observed by Rey (2013) in her seminal work, this trade-off between open capital flows and independent monetary policies can reduce the Mundell and Fleming's trilemma to a 'dilemma'.[1] Importantly, movements in risk premia can shift the yield curve and further impair the transmission of monetary policy actions to the economy, limiting the policy space of central banks (see Kalemli-Özcan, 2019).

The effect of US monetary policy spillovers is ultimately an empirical question, yet the existing literature is still fairly limited due to the technical difficulties in identifying monetary policy shocks and summarising their transmission over hundreds of variables across several economies. In his Mundell-Fleming lecture, Bernanke (2017) summarised the challenges to the existent evidence. First, monetary policy actions are largely endogenous to the economic conditions and have strong signalling and coordination effects, also documented in the recent literature – see, for example, Miranda-Agrippino and Ricco (2017) and Jarociński and Karadi (forthcoming). Second, the limited availability of data at a higher frequency on financial and cross-border flows has constrained much of the literature.[2] Finally, there are many dimensions along which countries may differ – their cyclical positions and structural features such as trade exposure, financial exposure, openness to capital flows, exchange rate and policy regimes. These dimensions have been largely left unexplored due to a lack of data.

We take on these three challenges to provide robust estimates of the impact of US monetary policy across the globe. First, we employ a state-of-the-art high-frequency identification (HFI) obtained from intraday price revisions of federal funds futures in tight windows around policy announcements, as originally proposed by Gürkaynak et al. (2005) and adopted in the VAR literature by Gertler and Karadi (2015). We disentangle policy shocks from signalling effects, by directly controlling for the information channel

[1]According to Mundell and Fleming's Trilemma, a country can only choose two out of three simultaneously impossible objectives – free capital flow, independent monetary policy, and a flexible or targeted exchange rate. Hence, central banks of economies with a floating exchange rate can set interest rates autonomously with the goal of stabilising their economy, while allowing for free capital flows.

[2]Given the lack of data at a higher frequency on cross-border flows, a large part of the existent empirical research, using quarterly data, has reported the effects of US monetary policy on capital inflows and outflows taking place over long periods of time – i.e. 12-16 quarters – well beyond the expected time-scale for high-frequency phenomena. These reported effects are possibly due to other structural shocks contaminating the identification.

of monetary policy as proposed by Miranda-Agrippino and Ricco (2017).[3] This is critical to not confounding the effects of monetary policy shocks with the propagation of other global shocks to which the Fed may be responding.

Second, we construct a large global dataset including a comprehensive set of macroeconomic and financial variables covering the US, 15 advanced and 15 emerging economies, and a rich set of global indicators. Importantly, we include a large dataset of indexes of credit flows and liquidity conditions.[4] All of our data and our instrument for monetary policy shocks are at monthly frequency and span the period 1990:1 to 2018:9 – hence the coverage and the frequency of the data allow for the study of the effects of US policy on financial variables and capital flows at reasonably high frequency. Containing over 150,000 data-points in total, our dataset qualifies as 'big data'.[5]

Third, we investigate the global transmission of US monetary policy shocks on the global economy as a whole and on 15 advanced and 15 emerging economies. Using the high-frequency instrument, we identify the effects of a US monetary policy shock in a large-scale Bayesian SVAR-IV/Proxy SVAR incorporating 30 global and US macroeconomic indicators (see Stock and Watson, 2012 and Mertens and Ravn, 2013). Then, we study the responses of individual economies and provide median responses for selected groups of countries based on bilateral Bayesian SVAR-IV specifications.[6] Our rich empirical framework allows us to control for the heterogeneity among countries due to their cyclical/financial market position via the VAR structure. Moreover, we group countries

[3]Our instrument is constructed as the residual of a regression of high-frequency market surprises of Gürkaynak et al. (2005) onto their own lags and Greenbook forecasts and revisions. In doing so we directly control for the informational component of the policy announcements, due to the systematic component of the monetary policy rule. Hence, we define monetary policy shocks as the component of market surprises triggered by policy announcements, unforecastable by past market surprises and orthogonal to the central bank's macroeconomic forecasts.

[4]We employ Cross Border Capital Ltd indicators on liquidity and financial conditions, covering all of the economies of interest at monthly frequency. The underlying data are mostly publicly available data from BIS, statistical offices, and markets. The dataset is described in Table A.1 in the online appendix.

[5]Our dataset is between two and three orders of magnitude larger than the typical dataset used to study the domestic effects of U.S. monetary shocks, given the assessment of Iacoviello and Navarro (2018).

[6]We incorporate large information sets in our VAR models by employing Bayesian big data techniques. In particular, we estimate a battery of large Bayesian VARs with asymmetric Minnesota priors (see Banbura et al., 2010, Carriero et al., 2019 and Chan, 2019). In bilateral VARs, the asymmetric priors allow for parameter restrictions that rule out a direct response of the US policy variable to economic conditions in a foreign country. This is important in reducing parameter uncertainty and alleviates multicollinearity regression problems.

by their (i) income levels, (ii) degree of openness to capital, (iii) exchange rate regimes, (iv) dollar trade invoicing, and (v) gross dollar exposure to compare median responses across groups.

Our framework also delivers new insight into the channels of propagation of US monetary policy shocks, as well as on the potentially asymmetric response of foreign economies to loosenings and tightenings in the US. We study these asymmetric effects (i) in the US, (ii) at the global level, (iii) for the advanced, and (iv) for the emerging economies. We also control for potential non-linearities and model misspecification by adopting a flexible multivariate local projection setting, in a robustness exercise.

We report a rich set of novel findings. First, we document that following a contractionary (expansionary) US monetary policy shock the global economy contracts (expands), in line with the US. OECD industrial production, CPI, global real economic activity and commodity prices exhibit negative (positive) responses, while foreign currencies depreciate (appreciate). This creates a striking visual image of the role of the Fed as the global central bank. Importantly, commodity prices, global risk appetite and global cross-border financial flows all contract (expand). All of them display a strong co-movement with US credit spreads and VIX. We interpret these results as supporting the idea that US monetary policy is a driver of the global financial cycle, confirming Rey (2013)'s observations.

Second, following US shocks, the 'median' advanced economy displays strong responses in output and CPI (less so for core CPI), which move in the same direction as the US counterparts. Importantly, its trade balance deterioration is a gauge for the relative strength of price and demand effects. The central bank attempts to counteract the recessionary pressure by lowering marginally its interest rate, but prices do not revert for at least 18 months. The trade-off between financial stability and countercyclical effects is evident. Indeed, the US monetary policy shock also moves the long end of the foreign economy's yield curve, which reduces the effectiveness of domestic monetary policy. Moreover, financial conditions deteriorate and cross-border flows turn negative. Importantly, the country-level responses are much less heterogeneous than previously reported. We read these results as a strong indication that due to the global financial cycle and credit-channel effects inflation-targeting central banks in advanced economies are confronted with an important trade-off and tend to fail in their price stabilisation mandates.

Third, the 'median' emerging economy responds similarly to the advanced counterpart. It contracts in response to contractionary US monetary policy shocks. Industrial production and prices decrease significantly, asset markets adjust downwards and long term interest rates increase, while risk appetite and financial conditions deteriorate. The responses of these variables are fairly homogeneous at country level, while interest rates, capital flows, and policy variables show a marked heterogeneity ascribable to different policy regimes. Interestingly, the movements in the long term interest rates indicate an important role for risk premia both in limiting the central bank policy space, and in creating a constraint to governments borrowing overseas at longer maturities (these results complement findings in Kalemli-Özcan, 2019 on the effects of risk premia on short term rates and domestic borrowing). We analyse in detail the responses of some of the largest emerging economies – China, India, and Mexico – and compare policy regimes and outcomes while benchmarking them against the Euro Area. We further explore this heterogeneity by grouping the countries by structural characteristics. Importantly, advanced and emerging economies that are more open in terms of capital flows, as classified by the Chinn and Ito (2006)'s index, exhibit stronger negative responses of industrial production and CPI compared to less-open ones. This points to a potential role for capital controls as an additional policy tool.

Fourth, we provide new evidence on the relative importance of the channels at play. We study responses of the main macroeconomic indicators of interest to US policy shocks when selectively zeroing out transmission coefficients of the estimated VAR models on variables capturing some of the channels of interest. In particular, we consider the role of (i) the policy rate, (ii) oil and commodity prices, (iii) exchange rates, and (iv) financial indicators. For the advanced economies, we find that the contractionary response of oil and commodity prices is an important determinant of the contraction in CPI, while financial variables and cross-border flows matter for stock market and output responses. We obtain similar but less clear results for the emerging economies.

Finally, in analysing the differential responses to contractionary and expansionary US monetary policy shocks, we find some evidence of asymmetric effects. The responses of output and stock prices of the US, the global economy, and third countries are more persistent in a tightening than in a loosening. CPI instead shows downward rigidity, that is accounted for by the downward rigidity of oil and commodity prices.

This paper contributes to the literature on the transmission of US monetary policy in several respects. First, to the best of our knowledge it is the first to adopt a modern high-frequency identification of US monetary policy that controls for signalling effects and potential endogeneities. Second, it uses a comprehensive monthly dataset of US, global, and national macroeconomic variables including data on liquidity, risk appetite, and cross-border flows. Third, the use of large data techniques allows us to incorporate and compress into multivariate models information of hundreds of variables across 30 countries and the Euro Area. Fourth, we provide detailed results on the channels and the asymmetric response to tightenings and loosenings.

Related Literature. Our work is closely related to Rey (2013)'s Jackson Hole lecture and to a number of her subsequent works with different co-authors Miranda-Agrippino and Rey (2015), Passari and Rey (2015) and Gerko and Rey (2017) which have documented a 'global financial cycle' in the form of a common factor in international asset prices and different types of capital flows, closely related to the VIX. In this body of work Hélène Rey has argued that flexible exchange rates cannot fully insulate economies from the global financial cycle and provided evidence, by using a high-frequency identification, that US monetary policy is one of the main drivers of the global financial cycle. Our work is related to this, but distinguished by our use of an extensive set of countries and variables, and importantly a high-frequency identification that controls for information effects that are likely to appear as strong confounding factors at the international level. The works of Dedola et al. (2017), and Iacoviello and Navarro (2018) are the most closely related to ours in terms of data coverage. Compared to them, we use a cutting-edge SVAR-IV approach with only monthly data and a pure high-frequency identification, which does not rely on sign restrictions or recursive identification. Moreover, compared to the latter, we do not focus just on the GDP responses of foreign economies but on a wider set of indicators, and we do not have to rely on a recursive identification with timing restrictions that can be problematic in analysing financial variables. Georgiadis (2016) and Dées and Galesi (2019) have also used large panels of countries in a GVAR setting. Unlike this approach, we do not need to use GDP or trade weights to model international interactions, and we do not use sign restrictions to identify monetary policy.[7] Most of these works find spillovers of US monetary policy to prices and (sometimes) to real quantities, but report large heterogeneity in the response of individual countries.[8] Our results only concern conventional monetary policy and not the more recent unconventional monetary policy actions, that are discussed in Rogers et al. (2014), Rogers et al. (2018), and in Stavrakeva and Tang (2015). More broadly, our results fits into the literature on reference (see Ilzetzki et al., 2019) and dominant currencies (see Gourinchas and Rey, 2007, Gourinchas et al., 2019 and Gopinath et al., 2016).

The structure of the paper is the following. Section 2 describes the methodology and the data used in our empirical exercises. Section 3 discusses the effects of U.S. monetary policy on the global economy. Section 4 and Section 5 study the transmission of US shocks to a set of advanced and emerging economies respectively, and explore the domestic dilemmas faced by the domestic central banks. Section 6 focuses on some of the largest economies – the Euro Area, China, India, and Mexico. Section 7 explores the role of structural features: capital controls, exchange rate regimes, and the dollar exposure. Section 8 analyses potentially asymmetric responses to loosenings and tightenings in the US. Section 9 concludes.

2 Data and Empirical Methodology

To study the effects of US monetary policy shocks to other countries and the global economy, we adopt a SVAR-IV (also known as Proxy-SVAR) approach (see Stock and

[7]Some early estimations of spillovers from the US monetary policy are in Kim (2001), Canova (2005) and in Mackowiak (2007). Other more recent contributions to this literature are in Ehrmann and Fratzscher (2009), Bluedorn and Bowdler (2011), Akıncı (2013), Ciccarelli et al. (2012), Feldkircher and Huber (2016), Bhattarai et al. (2017), Crespo Cuaresma et al. (2018), Cesa Bianchi and Sokol (2017), Vicondoa (2019), Gilchrist et al. (2019), Kalemli-Özcan (2019).

[8]A related literature has focussed on spillovers of US monetary policy through banks using aggregate banking flows Cetorelli and Goldberg (2012), Bremus and Fratzscher (2015), Buch and Goldberg (2015) Bruno and Shin (2015b), Argimon et al. (2019), Temesvary et al. (2018), Buch et al. (2019), or using disaggregated (interbank and intragroup) flows Reinhardt and Riddiough (2015).

Watson, 2012 and Mertens and Ravn, 2013). We estimate our models with Bayesian large VAR techniques as in Banbura et al. (2010) and elicit asymmetric Normal Inverse-Wishart priors, while selecting optimal hyperparameters with the approach proposed by Giannone et al. (2015). In the following, we describe the building blocks of our empirical specification: the dataset, the instrument for US monetary policy shocks, the VAR models and priors adopted.

2.1 Data

In total, our dataset contains over 150,000 data-points covering the US, 30 foreign economies, the Euro Area as an aggregate, and global economic indicators. All variables are monthly.[9] Most of our data are publicly available and provided by national statistical offices, treasuries, central banks or international organisations (IMF, OECD, and BIS). We also employ liquidity and cross-border flows data at a global and national level from CrossBorder Capital Ltd, a private data provider specialised in the monitoring of global liquidity flows.

The dataset contains 16 US macro and financial indicators, including 5 macroeconomic aggregates (industrial production index, CPI, core CPI, export-import ratio, and trade volume), 5 financial indicators (stock price index, nominal effective exchange rate, excess bond premium from Gilchrist and Zakrajšek (2012), 10-year Treasury Bond yield rate, and VIX), and a monetary policy indicator (1-year Treasury constant maturity rate). Additionally, we include 5 financial and liquidity indices from CrossBorder Capital Ltd – financial conditions, risk appetite, cross-border flows, fixed income and equity holdings. The financial conditions index represents short-term credit spreads, such as deposit-loan spreads. Risk appetite is based on the balance sheet exposure of all investors between equity and bonds. The cross-border flows index captures all financial flows into a currency, including banking and all portfolio flows (bonds and equities). Finally, equity and fixed income holdings measure respectively holdings of listed equities and both corporate and government fixed income assets.

The dataset also includes 15 global economic indicators: industrial production, CPI, and stock price index of OECD countries, the differential between average short-term

[9] If the original series are collected at a daily frequency, we take the end-of-month value.

TABLE 1: Country coverage

Advanced	Estimation sample	Emerging	Estimation Sample
Australia	1990:01 - 2018:08	Brazil	1999:12 - 2018:09
Austria	1990:01 - 2018:09	Chile	1995:05 - 2013:11
Belgium	1990:01 - 2018:09	China	1994:08 - 2018:08
Canada	1990:01 - 2018:08	Colombia	2002:09 - 2018:09
Denmark	1999:10 - 2018:09	Czech Rep.	2000:04 - 2018:09
Finland	1990:01 - 2018:09	Hungary	1999:02 - 2018:09
France	1990:01 - 2018:09	India	1994:05 - 2018:04
Germany	1990:01 - 2018:09	Malaysia	1996:01 - 2017:12
Italy	1990:01 - 2018:09	Mexico	1998:11 - 2018:02
Japan	1997:10 - 2018:09	Philippines	1999:02 - 2018:02
Netherlands	1990:01 - 2018:09	Poland	2001:01 - 2018:09
Norway	1995:10 - 2018:09	Russia	1999:01 - 2018:06
Spain	1990:01 - 2018:09	South Africa	1990:01 - 2018:09
Sweden	2001:10 - 2018:09	Thailand	1999:01 - 2018:05
UK	1990:01 - 2018:08	Turkey	2000:06 - 2018:09

Notes: The table lists the advanced and emerging countries in our data set and reports the estimation sample for the exercises in Sections 4 and 5. The set of endogenous variables for the median AE and the median EME exercises are different (see notes in Table A.2).

interest rate across 15 advanced economies in our dataset and the US, the global economic activity index constructed by Kilian (2019), CRB commodity price index, the global price of Brent crude oil, and 3 major currency exchange rates per USD – i.e. Euro, Pound Sterling, and Japanese Yen.[10,11] Finally, the dataset includes 5 world-aggregated liquidity indexes from CrossBorder Capital Ltd, that are the counterparts of US indices described above.[12]

At a national level, our dataset covers 30 economies – 15 advanced and 15 emerging (see Table 1).[13] For each country in our sample and the Euro Area, we collect 15 indicators – industrial production, CPI, core CPI, stock price index, export-import ratio, trade volume, nominal bilateral exchange rate, short-term interest rate, policy

[10] Table A.7 in the online appendix lists the short-term rates used in construction of the interest rate differential.

[11] Kilian (2019)'s index is the corrected and updated version of the global real economic activity index originally proposed in Kilian (2009) and criticised in Hamilton (2019).

[12] Table A.1 in the online appendix lists all global aggregates and the US variables in our dataset and details the sources, sample availability, and transformations.

[13] A comprehensive list of the countries and sample availability for each variable can be found in the online appendix, Table A.3.

rate, long-term interest rate, plus the five liquidity indices (financial conditions, risk appetite, cross-border flows, fixed income and equity holdings). Hence, we have at our disposal a set of variables that reflect the US counterparts for each economy.[14]

Our benchmark estimation sample generally spans January 1990 to September 2018 to minimise the impact of historical transformations of the global economy – e.g. the end of the Soviet bloc, or the accession of China to the WTO – and also to align the data with our US monetary policy instrument.[15,16]

In Section 7 we classify the countries in our dataset based on selected observables – the degree of capital market openness, exchange rate regime, trade shares invoiced in USD, and dollar exposure. We divide countries into more or less-open capital markets based on Chinn and Ito (2006)'s index. We also provide a robustness check based on the measure provided in Fernández et al. (2016a). Classification into pegging, managed floating, and freely floating regimes is based on Ilzetzki et al. (2019). Data on the US dollar trade invoicing is from Gopinath (2015). Our measure of dollar exposure is based on Bénétrix et al. (2015).

2.2 Identification of the US Monetary Policy Shock

Recent literature on monetary policy shocks has documented the existence of a signalling channel of monetary policy, i.e. the fact that policy actions convey to imperfectly informed agents signals about macroeconomic developments (see Romer and Romer, 2000 and Melosi, 2017). Indeed, to informationally constrained agents a policy rate hike can signal either a deviation of the central bank from its monetary policy rule, i.e. a contractionary monetary shock, or better-than-expected fundamentals to which the monetary authority endogenously responds. Miranda-Agrippino and Ricco (2017) and Jarociński and Karadi (forthcoming) have shown that the high-frequency surprises obtained from intraday price revisions of federal funds futures in tight windows around central bank announcements combine policy shocks with information about the state of the economy

[14]Table A.2 in the online appendix lists variables we collect for each country and the US counterparts, detailing the transformations.

[15]The estimation sample for the global exercise described in Section 3 spans 1990:01 to 2018:09. However, given the different availability of data across countries, the estimation sample used in the 'median economy' exercises described in Sections 4 and 5 varies. Table 1 in the online appendix details the estimation samples used in each bilateral system.

[16]All data sources are listed in the online appendix, in Tables A.1 and A.5.

due to the information disclosed through the policy action (see Gürkaynak et al., 2005 for the original high frequency methodology). Miranda-Agrippino and Ricco (2017) related these signalling effects of monetary policy to the emergence of the empirical price and output puzzles reported in the literature (see for example, Ramey, 2016), and they proposed a new high-frequency instrument for monetary policy shocks that accounts for informational rigidities.

As observed by Bernanke (2017), the fact that monetary policy has strong signalling and coordination effects is a major challenge to the identification of international spillovers of the Fed's policy actions. An identification approach not disentangling monetary policy shocks from signals about macroeconomic and financial conditions would confound spillovers from US monetary policy and the effects of macroeconomic and global shocks. Hence, apparently strong effects could reflect factors that drive the global business and financial cycles – such as changes in risk appetite, oil shocks, trade shocks and technology shocks. For this reason, we adopt the informationally robust instrument proposed by Miranda-Agrippino and Ricco (2017) that directly controls for the signalling channel of monetary policy.

This instrument is obtained in three steps. First, the high-frequency market-based surprises in the fourth federal funds futures (FF4) around FOMC announcements of Gürkaynak et al. (2005) are projected on Greenbook forecasts and forecast revisions for real output growth, inflation (measured as the GDP deflator) and the unemployment rate. The following regression is run at FOMC meeting frequency:

$$FF4_m = \alpha_0 + \sum_{j=-1}^{3} \theta_j F_m^{cb} x_{q+j} + \sum_{j=-1}^{2} \vartheta_j \left[F_m^{cb} x_{q+j} - F_{m-1}^{cb} x_{q+j} \right] + MPI_m. \qquad (1)$$

where $FF4_m$ denotes the high-frequency market-based monetary surprise computed around the FOMC announcement indexed by m. $F_m^{cb} x_{q+j}$ denotes Greenbook forecasts for the vector of variables x at horizon $q+j$ that are assembled prior to each meeting, and $\left[F_m^{cb} x_{q+j} - F_{m-1}^{cb} x_{q+j}\right]$ denotes revisions to forecasts between consecutive FOMC meetings. The forecast horizon is expressed in quarters, and q denotes the current quarter. These forecasts are typically published a week prior to each scheduled FOMC meeting and can be thought of as a proxy of the information set of the FOMC at the time of making the policy decision. For each surprise, the latest available forecast is used.

Second, the monthly instrument $\overline{MPI}_t$ is constructed by summing the daily MPI_m within each month. In the vast majority of cases, there is only one FOMC decision per month; the monthly surprise simply equals the daily one in these cases. Similarly, months without FOMC meetings are assigned a zero.

Finally, the autoregressive component in the monthly surprises is removed. Let $\overline{MPI}_t$ denote the result of the monthly aggregation described in the previous step. Our monthly monetary policy instrument MPI_t is constructed as the residuals of the following regression:

$$\overline{MPI}_t = \phi_0 + \sum_{j=1}^{12} \phi_j \overline{MPI}_{t-j} + MPI_t \ . \tag{2}$$

The intuition for the construction of this instrument is that the Greenbook forecasts (and revisions) directly control for the information set of the central bank and hence for the macroeconomic information transferred to the agents through the announcement (the signalling channel of monetary policy). The removal of the autoregressive components accounts for the slow absorption of information by the agents – a crucial implication of models of imperfect information (see Coibion and Gorodnichenko, 2015). This instrument is available from January 1990 to December 2009. It is worth stressing that in the SVAR-IV/Proxy-SVAR approach of Stock and Watson (2012) and Mertens and Ravn (2013), in which the proxy is employed as an external instrumental variable, the VAR estimation sample needs not coincide with the sample over which the instrument is available.

2.3 BVARs and Asymmetric Priors

In our analysis we consider two main empirical specifications:

- A **US-global VAR** incorporating 30 variables, including 15 global economic indicators and 15 of the US macroeconomic indicators described above.[17]

[17]Table A.1 in the online appendix lists all global and the US variables in our dataset.

- A battery of 31 **US-foreign country bilateral VARs**, each one containing 16 US macroeconomic variables, 15 financial and macroeconomic indicators of the foreign economy, and two global controls, i.e. the global price of Brent crude oil and Kilian (2019)'s global economic activity index. We do this for each one of the 30 countries considered plus the Euro Area.[18]

Specifically, we consider bilateral VAR models with 12 lags of the endogenous variables – in line with the standard macroeconometric practice for monthly data – of the form:

$$Y_{it} = c_i + \sum_{j=1}^{p} A_{ij} Y_{i,t-j} + u_{it}, \quad p = 12 \tag{3}$$

where i is the index of the unit of interest (the global economy, one of the 30 economies considered or the Euro Area). The vector of endogenous variables, Y_{it}, consists of the macroeconomic and financial variables described in Section 2.1 ($y^i_{1:n,t}$), together with the US counterparts ($y^{US}_{1:n,t}$), and, for the country models, the global controls ($x_{1:m,t}$):

$$Y_{it} = [(y^i_{1,t}, \dots, y^i_{n,t}), (y^{US}_{1,t}, \dots, y^{US}_{n,t}), x_{1,t}, \dots, x_{m,t}]' \,. \tag{4}$$

It is important to stress that the adoption of large endogenous information sets in our bilateral VAR models captures potentially rich economic dynamics at the country level, the US and periphery's positions in the business cycles, and the many potential channels through which the US monetary policy can affect the rest of the world. Importantly, global controls in the bilateral system allow for higher-order transmission channels induced by interactions among countries, that are important in correctly capturing international spillovers (see discussion in Georgiadis, 2017).

The use of large information sets requires efficient big data techniques to estimate the models. We adopt a Bayesian approach with informative Minnesota priors (Litterman, 1986). These are the most commonly adopted macroeconomic priors for VARs and formalise the view that an independent random-walk model for each variable in the system is a reasonable centre for the beliefs about their time series behaviour (see Sims and Zha, 1998). While not motivated by economic theory, they are computation-

[18]Due to data availability, Core CPI, Fixed Income and Equity Holdings are used only in the endogenous set of advanced economies. Hence, the bilateral system of emerging economies includes only 12 domestic variables and 13 US variables.

ally convenient priors, meant to capture commonly held beliefs about how economic time series behave. It is worth stressing that in scientific data analyses, priors on the model coefficients do not incorporate the investigator's subjective beliefs: instead, they summarise stylised representations of the data generating process.

In particular, in estimating the VAR models we elicit asymmetric Minnesota priors that assume the coefficients $A_1, \ldots, A_p$ to be a priori independent and normally distributed, with the following moments[19]

$$\mathbb{E}\left[(A_\ell)_{ij}|\Sigma\right] = \begin{cases} \delta_i & i=j,\ \ell=1 \\ 0 & \text{otherwise} \end{cases} \qquad \mathbb{V}ar\left[(A_\ell)_{ij}|\Sigma\right] = \begin{cases} \frac{\lambda_1^2}{f(\ell)} & \text{for } i=j, \forall \ell \\ \chi_{ij}\frac{\lambda_1^2}{f(\ell)}\frac{\Sigma_{ij}}{\omega_j^2} & \text{for } i \neq j, \forall \ell. \end{cases} \tag{5}$$

where $(A_\ell)_{ij}$ denotes the coefficient of variable j in equation i at lag ℓ and δ_i is either 1 for variables in levels or 0 for rates. The prior also assumes that lags of other variables are less informative than own lags, and that most recent lags of a variable tend to be more informative than distant lags. This intuition is embedded in the function $f(\ell)$, that we assume to be a harmonic lag decay – $f(\ell) = \ell^{\lambda_2}$, for $\lambda_2 = 2$. The factor Σ_{ij}/ω_j^2 accounts for different scales of variables i and j. In our specification, the hyperparameters ω_j^2 are fixed using sample information, i.e. the variance of residuals from univariate regressions of each variable onto its own lags. λ_1 is a hyperparameter that controls the overall tightness of the random walk prior.[20]

Taking one step further from the standard Minnesota priors, the hyperparameter χ_{ij} breaks the symmetry across the VAR equations and allows for looser or tighter priors for some lags of selected regressors in a particular equation i. The adoption of asymmetric priors complicates the estimation problem, as discussed in Carriero et al. (2019) and Chan (2019), making it impossible to use dummy variables to implement the priors. We

[19]Tables A.1 and A.2 in the online appendix contain information about transformations and priors of all the variables discussed above.

[20]If $\lambda_1 = 0$, the prior information dominates, and the VAR shrinks to a vector of independent random walks or white noise processes according to the prior we impose. Conversely, as $\lambda_1 \to \infty$, the prior becomes less informative, and the posterior asymptotically only reflects sample information.

employ the efficient methodology proposed in those papers to estimate our models.[21]

In our setting, the hyperparameter χ_{ij} is crucially important, because it enables us to rule out a direct response of some US variables to economic conditions in another country. Specifically, in the US-global system, we set $\chi_{ij} = 0$ for all coefficients directly connecting US indicators to major exchange rates, global liquidity and the OECD variables. This rules out a direct response of US indicators to these variables, while allowing the possibility of a direct response via the global economic activity, oil price, and commodity price index. It reduces potential collinearity problems between OECD aggregates and US counterparts, and among the exchange rates.[22] In the bilateral systems, we impose that all coefficients directly connecting the US variables to periphery country indicators are zero. However, global indicators allow for an indirect response via higher-order effects (as proposed in Georgiadis, 2017). These restrictions are of great importance in reducing parameter uncertainty and alleviating multicollinearity problems. This is particularly relevant in selectively studying the channels of transmission of US policy shocks.

2.4 Estimation of Median-Group Responses

In several exercises we estimate median group dynamic responses for selected groups of countries to US monetary policy shocks. The goal is to provide an indication about what responses of a synthetic 'median' economy to the shock would look like. The underlying groups of countries can be thought as being homogeneous along some specific structural characteristics, such as the degree of capital market openness, the exchange rate regime, or dollar exposure.

We estimate bilateral country VARs individually and obtain the median result across countries, which we interpret as the median group estimator. While less efficient than

[21]Standard Minnesota priors are implemented as Normal-Inverse Wishart priors that force symmetry across equations, because the coefficients of each equation are given the same prior variance matrix (up to a scale factor given by the elements Σ_{ij}). This implies that own lags and lags of other variables must be treated symmetrically. Hence, it is not possible to cast the Minnesota prior in its original formulation as presented in Litterman (1986), which imposes extra shrinkage on the cross-variable coefficients.

[22]Specifically, this assumption implies that all variables in the bottom half of Table A.1 in the online appendix plus the last three variables of the top half (global economic activity, commodity price, and oil price) do not respond endogenously to the remaining variables in the top half of the table. They are however allowed to respond endogenously among themselves, so that global activity, commodity prices, and oil price directly affect all US variables.

the pooled estimator under dynamic homogeneity, it delivers consistent estimates of the average dynamic effect of shocks if dynamic heterogeneity is present (see Canova and Ciccarelli, 2013, for a discussion).[23] Importantly, we opt for the median group estimator instead of the mean group estimator in order to reduce the importance of outliers (e.g. episodes of hyperinflation in some countries within the sample period).

In our empirical approach, the estimation of confidence bands for the parameters of interest relies on the standard Gibbs sampling algorithm. For each bilateral VAR model, we obtain s draws (after burn-in) from the conditional posterior distribution of A, the companion matrix of equation 4 expressed in SUR form, and Σ, the corresponding variance-covariance matrix, and compute the impulse response for each draw. Now we have s impulse responses for each country, and the goal is to aggregate them into the responses of the 'median' economy. We do this by taking sequentially each draw of the impulse responses, starting with the first one, for each country and obtaining the median response across countries at each horizon.[24] Eventually, we are left with s draws that can be interpreted as the response of the 'median' economy to the shock. The aggregation algorithm is the following:

1. For each Gibbs sampler iteration, stack the impulse responses of all countries in the group and compute the median across countries at each horizon.
2. Repeat the procedure for each iteration and store all median values obtained.
3. Sort these values and pick the median and corresponding bands at each horizon.
4. Repeat the above steps for all the variables in the endogenous set.[25]

[23] If we were willing to assume that the data generating process featured dynamic homogeneity across countries (and to condition on the initial values of the endogenous variables), a pooled estimation with fixed effects, capturing idiosyncratic but constant heterogeneities across units, would be the standard approach to estimate the parameters of the model. However, in our setting dynamic heterogeneity seems to be a likely property of the systems.

[24] This is equivalent to drawing without replacement a draw from the set of draws we have available for each country, and taking at each horizon the median value across countries. We proceed sequentially purely because of coding convenience.

[25] For US indicators and global controls, we do not obtain the median across bilateral country-pair models, as we would be taking the median across several instances of the same country. We just stack all IRFs coming from the various bilateral models.

3 The Global Propagation of U.S. Monetary Policy

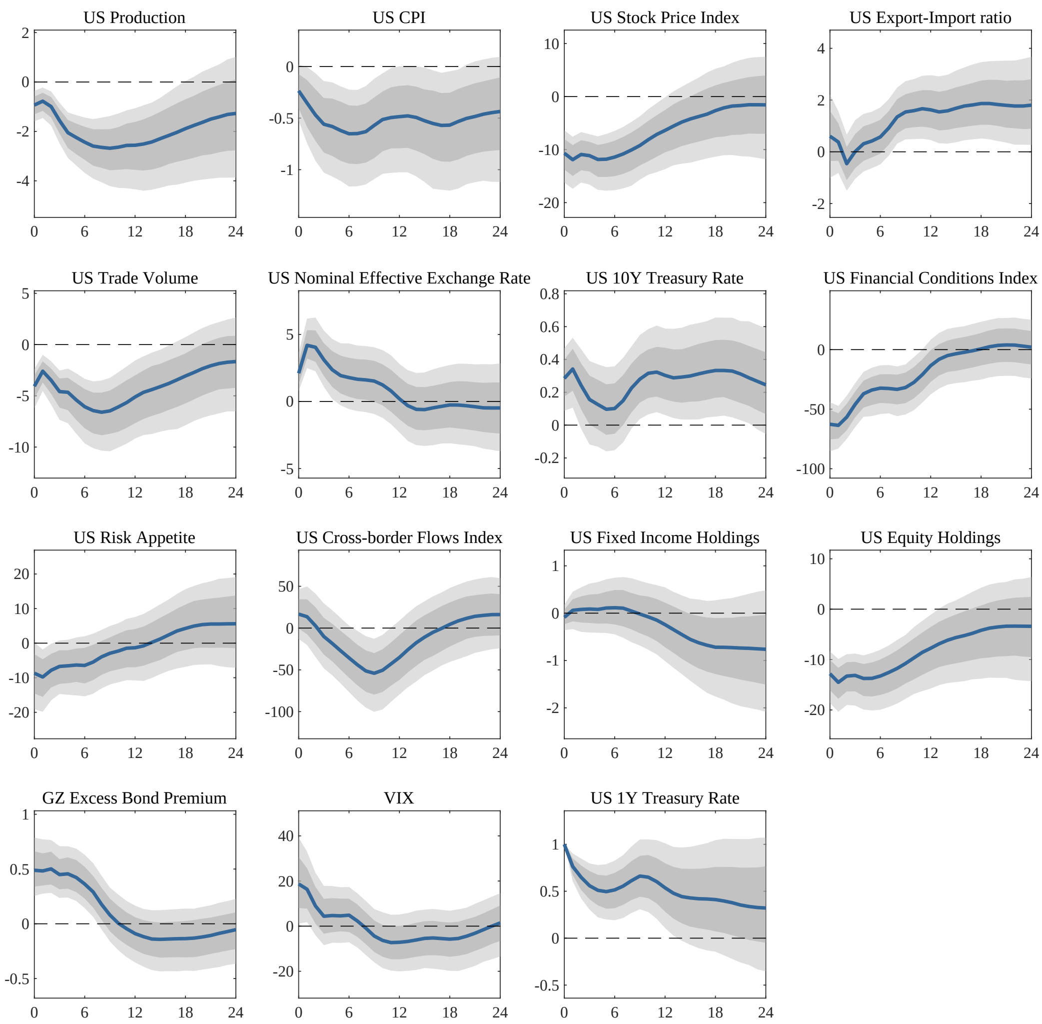
In this section we report the dynamic responses to conventional US monetary policy shocks obtained by estimating the US-Global BVAR, described in Section 2.3. Following the convention, we plot the responses to a contractionary monetary policy shock: it is important to observe that since the system is linear, responses for expansionary and contractionary shocks are symmetric. Results are obtained by employing the full sample from January 1990 to September 2018 for the estimation of the VAR coefficients. Impacts are identified via the instrument for conventional monetary policy shocks discussed in Section 2.2, that is available from January 1990 to December 2009. In each plot, we report median responses, 68% and 90% posterior coverage bands.

The US indicators in the VAR system have been constrained by means of the asymmetric priors to endogenously respond only to other US indicators and to a few proxies of global economic conditions – the global economic activity index, the commodity price index and the price of oil. The parameters of the equations of global variables are instead left unconstrained. In other words, the system allows US variables to be endogenously affected by the higher order response of the three proxies of global economic conditions – sometimes referred to as 'spillback' effects – while global variables respond endogenously to every other variable in the system. This alleviates some of the collinearity between global aggregates and US counterparts and allows for more precise estimates of the responses. The US monetary policy shock is normalised to induce a 100bp increase in our policy indicator, the 1-year Treasury constant maturity rate. All the IRFs reported in this section are jointly obtained in a large Bayesian VAR. We first assess the domestic effects of monetary policy shocks on the US economy, and then their propagation to the global economy.

3.1 Domestic Effects of U.S. Monetary Policy

Figure 1 reports the effects of a monetary policy tightening. The shock transmits along the yield curve by moving the shorter maturities more than the long end of the curve, as shown by the increase in the 10-year rates. The term spread decreases and the the yield curve flattens down, while prices of risky financial assets (the S&P index)

Figure 1: Domestic Effects of U.S. Monetary Policy Shocks



Note: Domestic responses to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample 1990:01 – 2018:09. BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

strongly revise downwards. The policy hike affects both real and nominal quantities. US industrial production and CPI sharply contract on impact to remain significantly below equilibrium over a horizon of 24 months. Importantly, there is no trace of price or output puzzles in the responses.

The interest rate movement induces an exchange rate appreciation of the US dollar vis-à-vis the other currencies, as is visible in the positive response of the nominal effective exchange rate. Despite the dollar appreciation, the monetary policy contraction has an overall positive impact on the balance of trade and the exports-imports ratio improves. This happens through a compression of imports that adjust downwards more than exports.[26] The overall effect of the shock on trade is negative and traded volumes contract. The demand-augmenting effect dominates the expenditure-switching effect: lower domestic demand makes imports fall more than exports, despite the US goods becoming more expensive.

The monetary tightening affects the financial system as is evident in the response of the indicators of financial distress: Gilchrist and Zakrajšek (2012)'s excess bond premium response soars on impact and remains above trend for roughly 10 months, with the VIX showing similar dynamics. The financial conditions index – an index of very short-term credit spreads, e.g. deposit loan spreads – also shows a deterioration in credit conditions. The broad picture of these responses indicates activation of the credit channel of monetary policy transmission (Bernanke and Gertler, 1995).

Interestingly, risk appetite is reduced by the policy tightening (risk-off). This is also visible in the response of equity holdings that fall significantly on impact while safe asset holdings slightly increase, pointing to a portfolio rebalancing towards less-risky assets.[27] Cross-border flows seem to indicate capital inflows on impact but the overall response is not significant, possibly due to the movement of capital to US dollar denominated assets held outside the US.

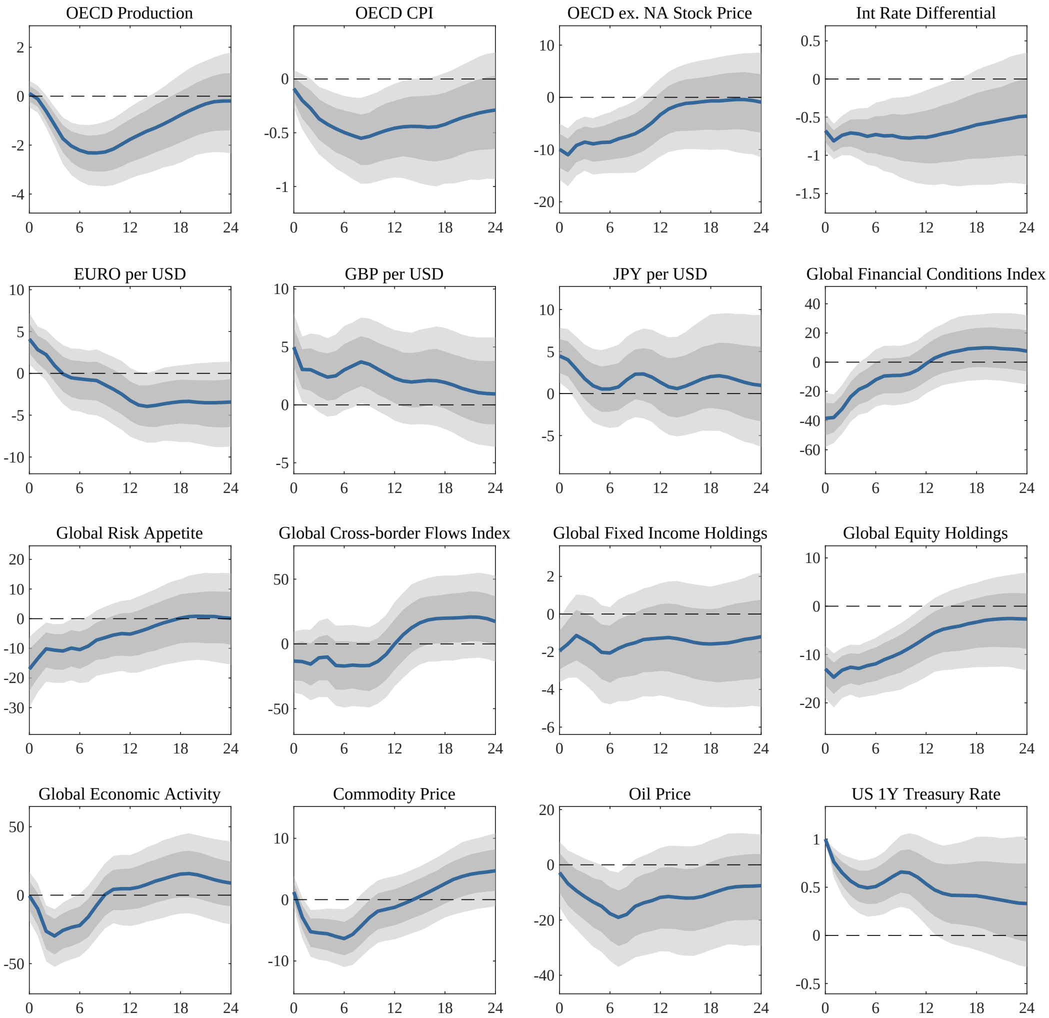
3.2 Global Spillovers

The global economy responds to US monetary policy tightenings by mirroring the economic contraction in the US, albeit with a slight delay. This is visible in Figure 2, which displays the IRFs of a set of global indicators to the contractionary US monetary policy shock reported in Figure 1 (IRFs are obtained from the same BVAR model). The broad picture is that there are strong spillovers from the US to the global economy to both real and nominal variables. OECD industrial production and global economic activity contract, with the trough of the former matching that of US output – around -2.5%.

[26] In the benchmark model, we only include the import/export ratio and traded volumes to avoid collinearity problems. IRFs for imports and exports with a similar model are reported in Miranda-Agrippino and Ricco (2017).

[27] This composite index obtained from CBC is computed as the difference between the equity exposure index and the bond exposure index. The two indexes are based on the balance sheet exposure of all investors by type in the relevant asset class.

Figure 2: Global Effects of U.S. Monetary Policy Shocks



Note: Global responses to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample 1990:01 – 2018:09. BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands. These responses are estimated jointly to those reported in the previous figure. The response of the policy indicator appears in both figures for readability.

OECD CPI declines, and the peak effect is of the same scale as its US counterpart – around -0.5%. Commodity prices, especially oil price, also contract.

The US dollar appreciation is visible in the exchange rate against three of the major currencies – the Euro, British Pound sterling, and Japanese Yen. The average interest rate differential between 15 advanced economies and the US falls by 0.7 percentage points on impact and does not revert for at least 18 months. This means that, on average, non-US central banks raise their interest rates by roughly 30bp in response to a

100bp movement in the US policy indicator. The contraction in the differential persists for at least one year.

Global risk appetite falls, and equity holdings decrease in both the US and the rest of the world, suggesting worldwide portfolio rebalancing towards safe assets (risk-off). These adjustments lead to a global contraction in cross-border flows, inducing outflows and immobilizing capital. The deterioration of global economic conditions and portfolio rebalancing out of risky assets put downward pressure on foreign asset prices, and the world's stock markets revise downwards.[28] Financial conditions tighten on impact, pointing to an increase in short-term rate spreads and activation of the financial channel.

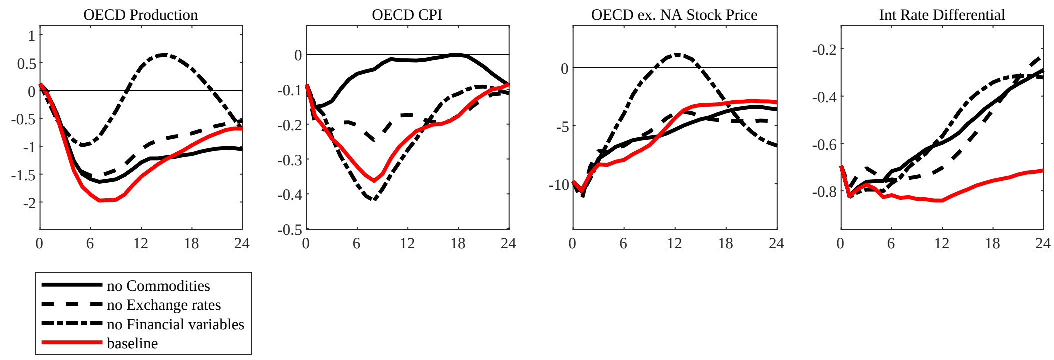
The landscape view of the response of global economy to US monetary policy provides a powerful image of the Fed as a global central bank. Interestingly, our results are consistent with Rey (2013)'s 'global financial cycle' argument: the dynamics of stock prices and other financial variables in the US and in the global economy appear to be synchronised and financial conditions deteriorate. These responses are also compatible with the risk-taking and credit channels of monetary policy (Bruno and Shin, 2015b): a contractionary shock shrinks asset demand and increases risk premia. Financial spreads increase, followed by a deterioration in financial and credit market conditions. A fall in asset prices pushes financial intermediaries to de-leverage to meet their value-at-risk constraints, and it further contracts the economy. Results in this section show that the financial channel operates not only domestically but also globally. We further investigate these mechanisms in the next sections by looking at advanced and emerging economies separately.

3.3 Disentangling the Channels

To gauge the importance of the various channels at play in the international propagation of the shock, we perform a counterfactual exercise (see, for example Ramey, 1993 and Uribe and Yue, 2006) in which we shut down the feedback from specific endogenous variables that are thought to capture some channels of interest. In particular, we would

[28]This index is a weighted average of stock prices in advanced economies excluding North America, so the commonality with US stock prices is not mechanical.

Figure 3: Channels of Transmission, Global economy



Note: Lines correspond to impulse responses obtained with the baseline specification (solid red); assuming the Brent crude and commodity prices do not react (solid black); exchange rates do not react (dashed black); financial conditions, risk appetite, cross-border flows, the excess bond premium, and VIX do not react (dashed-dotted black). Shock is normalised to induce a 100 basis point increase in the 1-year rate. High-frequency identification. Sample 1990:01 – 2018:09. BVAR(12). Equity and fixed-income holdings are not in the endogenous set to avoid collinearity issues.

like to answer the following question: how would the response of a variable of interest, e.g. CPI or industrial production in a foreign economy, differ if the U.S. monetary policy did not have a direct effect on exchange rates, liquidity, or commodity prices?

We proceed by selectively zeroing out the transmission coefficients of estimated VAR models on variables of interest and comparing the response of this modified system to our pre-zeroing-out benchmark. This back-of-the-envelope exercise can give us a sense of the relative importance of selected variables in the transmission of the shock.[29]

Specifically, we employ the VAR model estimated in this section and sequentially shut down the following variables: (i) commodity and oil prices, (ii) nominal exchange rates, and (iii) some of the financial variables (financial conditions, risk appetite, and cross-border flows). This reveals the importance of commodity prices, the exchange rate channel, and the financial channel.

Figure 3 reports the median responses (without bands) for our set of experiments on the global economy.[30] Two results stand out. First, OECD industrial production and the stock price contract less and rebound more quickly when the endogenous responses of financial conditions, risk appetite, and cross-border flows are shut. These results suggest that the financial channel plays a significant role in global spillovers, following

[29]Results in this section are not to be interpreted as a policy exercise, since they are subject to Lucas' critique.

[30]A full set of responses can be found in the online appendix B.3.

the deepening of financial integration that started in the 1990s.

Second, the response of CPI becomes immaterial when oil and commodity prices cannot respond to the shock. It highlights that nominal contractionary effects are possibly due to the response of oil and commodities and their importance in the headline inflation basket. Once their effect is factored out, the upward pressure from the pass-through of higher dollar prices and the downward pressure from weaker demand roughly balance out. Finally, the role of three major exchange rates seems to be limited – they affect CPI and the stock price marginally and only in the medium run. No responses of the interest rate differential are qualitatively different relative to the baseline when we shut down any of the transmission channels. It suggests that no channel is predominant in explaining the transmission of U.S. policy shocks to the short-term rate spreads between the US and other advanced economies.

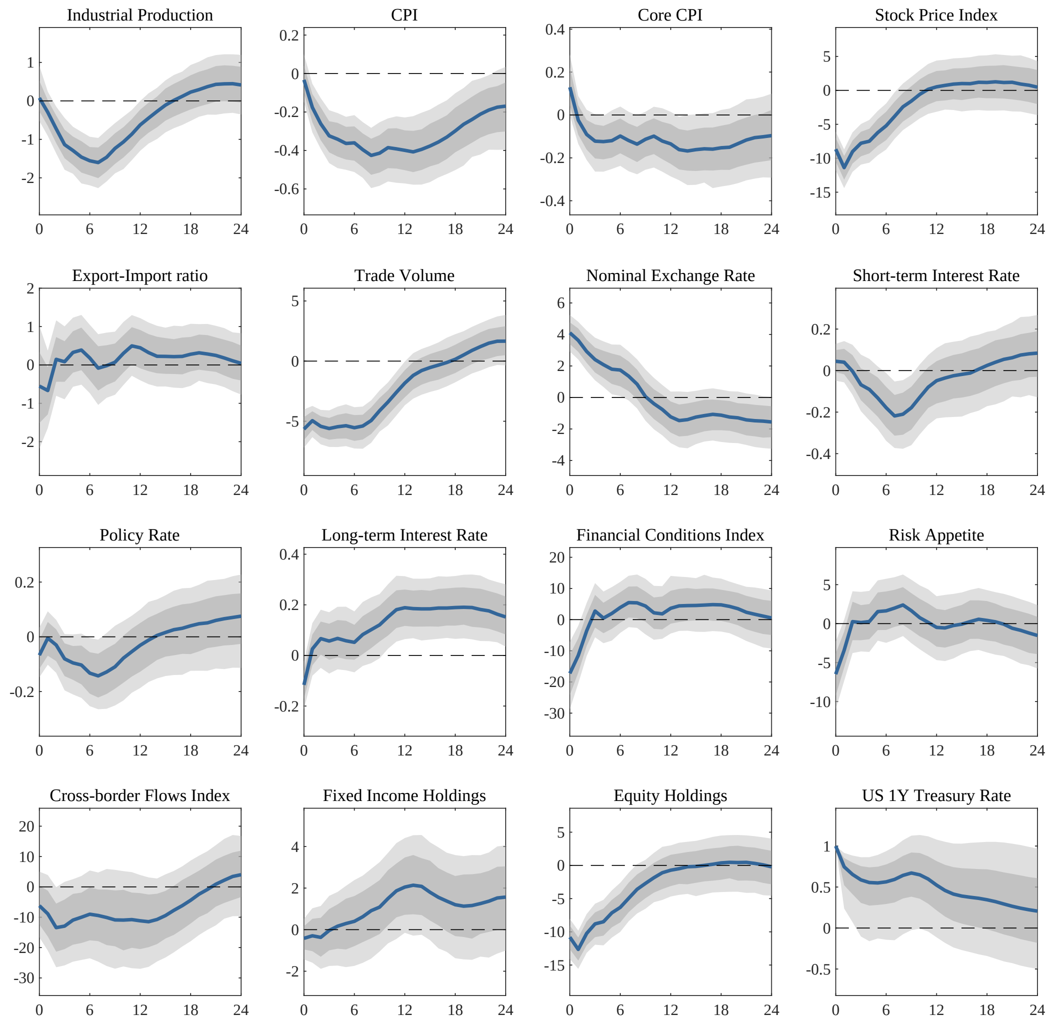
There are two caveats to the analysis in this section. First, some of the variables (for example, OECD indicators) mechanically capture the direct response of the US economy. Second, results only hold for global aggregates: they can mask large heterogeneity across countries in terms of cyclical positions, structural features, and financial market conditions, all of which could be important determinants of differential sensitivity to the shock. We further explore these dimensions in the next sections.

4 Transmission to Advanced Economies

We now focus on the effects of US monetary policy on advanced economies. In doing so, we study the responses to a US tightening obtained in a set of US-periphery bilateral VARs that include one of the advanced economies at the time. We estimate these bilateral systems for all 15 advanced economies in our sample (see Table 1 for a list of the countries included in our analysis). In these models, the asymmetric priors rule out a direct response of US variables to economic conditions in a periphery country, while spill-back effects via the global variables are still allowed. We present median IRFs, aggregated across countries, to a contractionary monetary policy shock.[31] The US monetary policy shock is normalised to induce a 100bp increase in our policy indicator,

[31] The IV used for identification of the MP shock and the methodology used for the aggregation of IRFs into the responses of the median advanced economy are discussed in Section 2.2.

Figure 4: Impulse responses of the median advanced economy



Note: Median responses of 15 advanced economies to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample reported in Table 1. BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

the 1-year Treasury constant maturity rate. Importantly, since the system is linear, responses to expansionary and contractionary shocks are symmetric.

4.1 Median Responses of Advanced Economies

Figure 4 displays the impulse responses of the median advanced economy. Following a contractionary MP shock in the US, the currency of the median advanced economy depreciates. The demand-reducing effect from the US offsets the expenditure-switching effect: the overall trade volume drops while the export-import ratio does not change significantly.

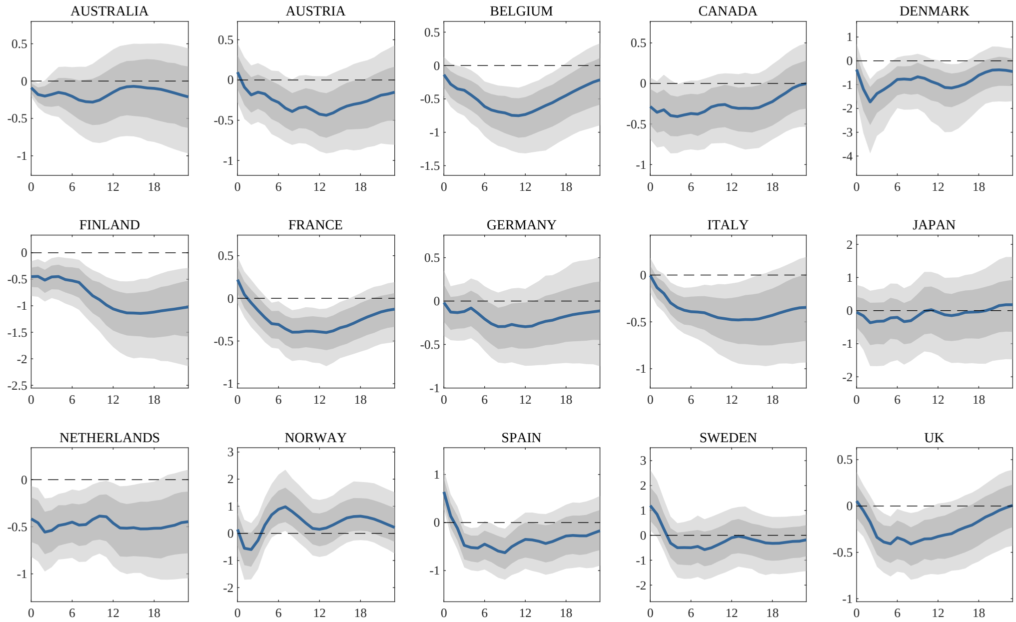
The US policy shock transmits to both real and nominal variables in the median advanced economy. There is a sharp decline in domestic industrial production, accompanied by a very persistent drop in CPI. Core CPI also falls, though it is only significant at the 68% level. The policy rate rate does not move on impact but subsequently eases for around 6 months. This is compatible with policy easing of a central bank responding to deteriorating internal conditions and following the Taylor rule. The easing is transmitted to the short-term interest rate, while the the long-term rate moves up, inducing a steepening of the yield curve. This indicates that movements in risk premia impair the transmission of the policy change to the long-end of the yield-curve, and hence to the economy (a similar disconnect but between short rates and monetary policy rates for emerging economies has been reported by Kalemli-Özcan, 2019). Indeed, the economic contraction is sizeable but smaller than the one suffered by the global and the US economies (-2.5% in industrial production and -0.5% in CPI). Notably, flexible exchange rates and policy easing partially insulate the advanced economy, yet the US monetary shock contracts output in the median advanced country. Cross-border flows indicate outflows while financial conditions and risk appetite deteriorate, and investors switch their portfolios from risky to safe assets. This suggests both a portfolio rebalancing across assets and a risk-rebalancing across countries.

At the country level, responses are fairly homogeneous and do not show the degree of heterogeneity previously reported. This provides robustness to our results and justifies the choice of pooling across advanced economies to present median estimated IRFs. Figure 5 shows the response of CPI to a contractionary US MP shock for 15 countries in our sample.[32] CPI is contracting for at least 11 out of 15 economies and the responses of the remaining countries are either not significant or marginally significant. Interestingly, Australia and Norway are commodities exporters.

Financial variables also respond in a strongly homogeneous way across countries. Stock prices (online appendix B.5) contract in all 15 countries, and the long-term government bond yields (online appendix B.6) shift upwards for all except Belgium and Spain. Cross-border flows (online appendix B.7) dry up with only few exceptions:

[32] These are the IRFs that we obtain from the bilateral models. In other words, each country's subplot comes out of a model that includes only the US and country itself.

Figure 5: Response of CPI in Advanced Economies

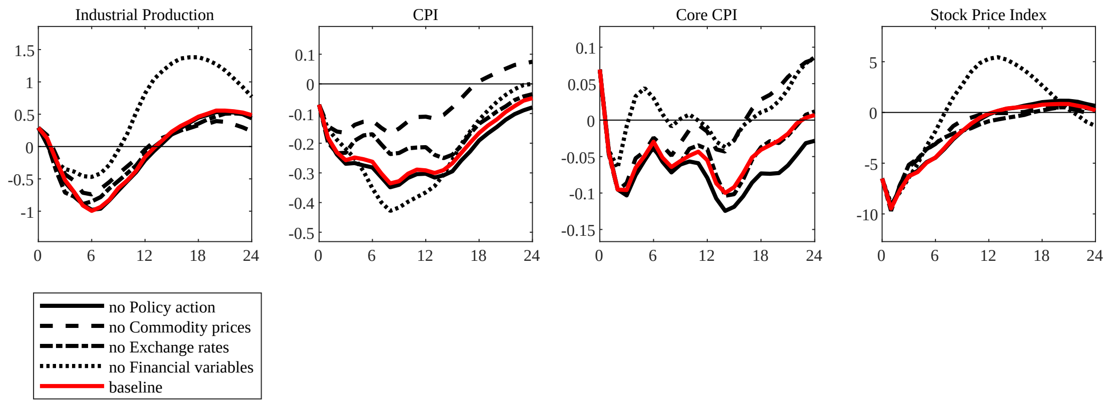


Note: Responses of CPI in 15 advanced economies to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample reported in Table 1. BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

France, Germany, Sweden, and UK. All financial variables display identical dynamics with both the US and the global economy – we read these results as a strong indication of credit-channel effects from the global financial cycle.

In sum, a contractionary US monetary policy shock leads to a recession in advanced economies. The financial channel seems to play a significant role in the transmission, given strong co-movements of financial variables with the US counterparts. As the global financial cycle negatively affects financial conditions, cross-border flows, and asset prices, the developed world suffers from credit shortages and the resulting contraction of the real economy. Traditional trade channels do not change the outcome substantially, as price and demand effects seem to offset each other. Central banks attempt to counteract the recessionary pressure by lowering interest rates marginally, but they tend to fail in their price stabilisation mandates: prices do not revert for at least 18 months.

Figure 6: Channels of Transmission, Advanced economies



Note: Lines correspond to impulse responses obtained with the baseline specification (solid red); assuming the policy rate does not react (solid black); the Brent crude and commodity prices do not react (dashed black); exchange rates do not react (dashed-dotted black); financial conditions, risk appetite, cross-border flows, the excess bond premium, and VIX do not react (dotted black). Shock is normalised to induce a 100 basis point increase in the 1-year rate. High-frequency identification. Sample reported in Table 1. BVAR(12). Equity and fixed-income holdings are not in the endogenous set to avoid collinearity issues.

4.2 Disentangling the Channels

We further assess the importance of various transmission channels at play by selectively zeroing out the coefficients of some of the variables of interest in the estimated models, as done in the previous section. Along with the three sets of variables we examined in the global case – commodity and oil prices, exchange rates, and all financial variables – we also shut down the policy rate of advanced economies, as it is informative about the reaction of the monetary authority. This allows to assess the relative importance of the policy response, commodity prices, the exchange rate channel, and the financial channel in the transmission of the US monetary policy shock.

Figure 6 shows the median responses (without bands) for our set of experiments on 15 advanced economies.[33] Interestingly, as in the global economy case, industrial production and stock prices revert to equilibrium quickly and overshoot when the transmission via variables proxying for the financial channel – i.e. financial conditions, risk appetite, and cross-border flows – is shut. Conversely, headline CPI shows a mild contraction when oil and commodity prices are not allowed to propagate the shock. Interestingly, core CPI, which does not contain energy prices, shows a mild and not significant re-

[33] A full set of responses can be found in Figure B.10, in the online appendix.

sponse with weaker dependence on commodity prices. The response of core CPI is largely explained by the financial variables and hence correlates with the output contraction. Absent that, there is an expansion of core prices possibly due to pass-through effects.

Financial variables and cross-border flows seem to be key in the transmission of the US shock to the stock market and real economy. Oil and commodity prices provide deflationary pressures on headline prices in advanced economies. The effects of central bank actions and exchange rates appear to be relatively small, possibly due to the movements in risk premia discussed above. The broad picture seems to indicate that the transmission of the US monetary policy shock activates financial channels that limit the action of central banks in advanced economies. However, the overall effect of the financial channel is mild and monetary policy can still operate via traditional inflation targeting and by easing economic conditions in response to adverse external shocks – this would correspond to the case of intermediate financial spillovers, in the classification proposed by Gourinchas (2018).

5 Transmission to Emerging Economies

Since the wave of financial crises in the emerging markets in the late 1990s there has been a step change in macroeconomic policy, with most central banks embracing floating exchange rates, the build up of large foreign exchange reserves, and a shift in government borrowing from foreign to national currencies.[34] Despite an improved resilience to external shocks, emerging markets are still thought to be more vulnerable to US monetary policy spillovers and deterioration of global financial conditions (see for example Carstens and Shin, 2019).

In this section, we try to provide an empirical assessment of the vulnerability of emerging markets to changes in US monetary policy. Emerging, developing and frontier economies are potentially a largely heterogeneous set of countries. Indeed, they can differ along several dimensions such as the monetary policy framework adopted, the

[34] Emerging economies in our analysis have less flexible exchange rate regimes than the AEs. None of our EMEs is classified as a pure floater according to the classification of Ilzetzki et al. (2019) – we treat Czech Republic, Hungary, and Poland as floaters, since their currencies are anchored to the Euro. However, very few of them have hard pegs. We discuss this dimension in detail in Section 7.

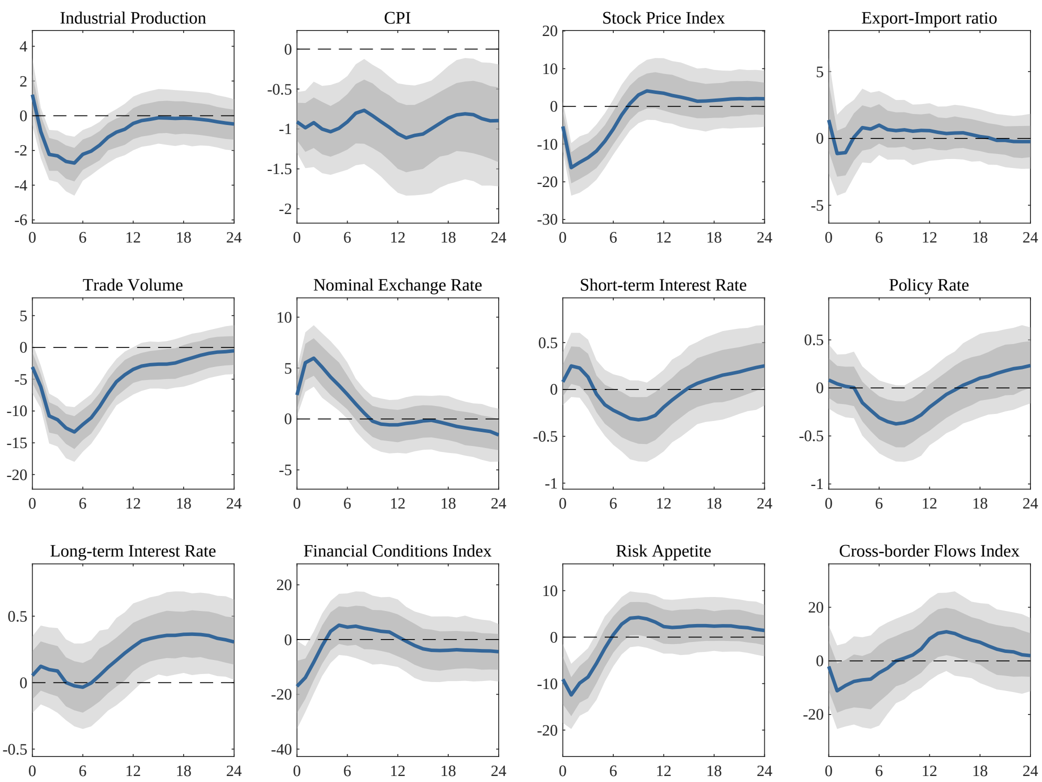
dependence on dollar denominated funds, the degree of invoicing in dollars, the size of their internal markets, and the degree of openness to capital flows. We explore these dimensions in steps. First, in this section, we discuss median responses to US monetary policy actions and contrast them with the advanced economies. As in the previous section, we present median IRFs, aggregated across countries, to a contractionary monetary policy shock. We also provide a first assessment of responses at a country level. Then in Section 6 we look at some of the largest emerging markets that are likely to display very different policy frameworks, and contrast them to the Euro Area. Finally, in Section 7 we look at the role of different policy regimes by grouping countries by their (i) degree of capital market openness and (ii) exchange rate regimes. Our online appendix reports additional exercises along other structural dimensions such as (iii) dollar trade invoicing and (iv) dollar gross exposure. It is important to stress that in this section and in the following two, since the system is linear, estimated responses to expansionary and contractionary shocks are symmetric. Bear in mind that when studying EMEs the quality and reliability of data may be a serious concern. In the light of this observation the use of a relatively recent sample and the median response is helpful in averaging out and alleviating potential data issues.

5.1 Median Responses of Emerging Economies

In the wake of an unexpected tightening of the US monetary policy stance, the economy of the median emerging country contracts, as shown in Figure 7. The national currency depreciates, indicating that the median emerging economy was adopting flexible exchange rates in the time-sample of interest. Yet, movement in the exchange rate is not enough to insulate the economy from strong spillover effects. The expenditure-switching channel is largely dominated by the other channels – demand and financial – and output, prices, and the stock market contract.

Interestingly, the effect of higher prices of imports is dominated by the contraction in demand and possibly subdued commodity prices. Headline inflation responds negatively, immediately, and sharply. The trough response of output in the median emerging economy is around -2.5% and in line with the US economy, while prices react even more strongly than in the US, with a very persistent drop of 1%. It is worth noticing that sev-

Figure 7: Median Response of Emerging Economies



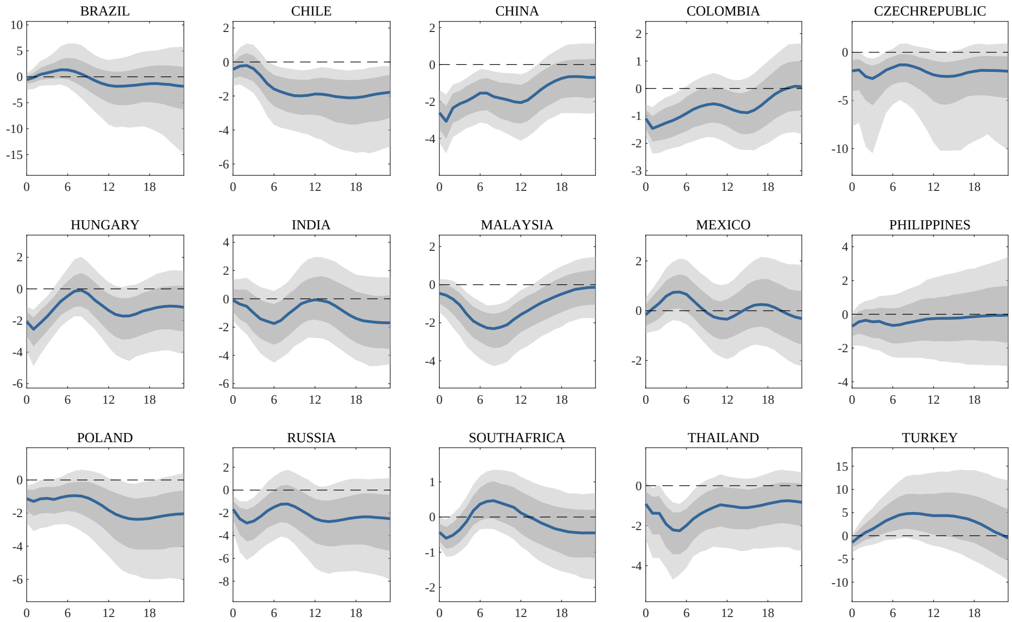
Note: Median responses of 15 emerging economies to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample reported in Table 1. BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

eral countries in this sample are commodity exporters, and hence in aggregate the joint effect of lower commodity prices and lower aggregated demand puts downward pressure on the economy. These results are consistent with the findings in the literature, e.g. Mackowiak (2007) and Iacoviello and Navarro (2018), that emerging markets are more vulnerable to external shocks.

The joint contraction of output and prices, in line with the effect of a large demand shock, allows the central bank to lower its policy rate – potentially putting more downward pressure on the domestic currency. Yet, the policy easing is marginally transmitted to short rates but not long rates, suggesting that risk premia are limiting the effectiveness of the policy action. This evidence chimes with Kalemli-Özcan (2019), who argues that capital flows in and out of EMEs are sensitive to fluctuations in global investors' risk perceptions, induced by changes in the US monetary policy.

Financial conditions and risk appetite deteriorate, while the stock market contracts.

FIGURE 8: RESPONSE OF CPI IN EMERGING ECONOMIES



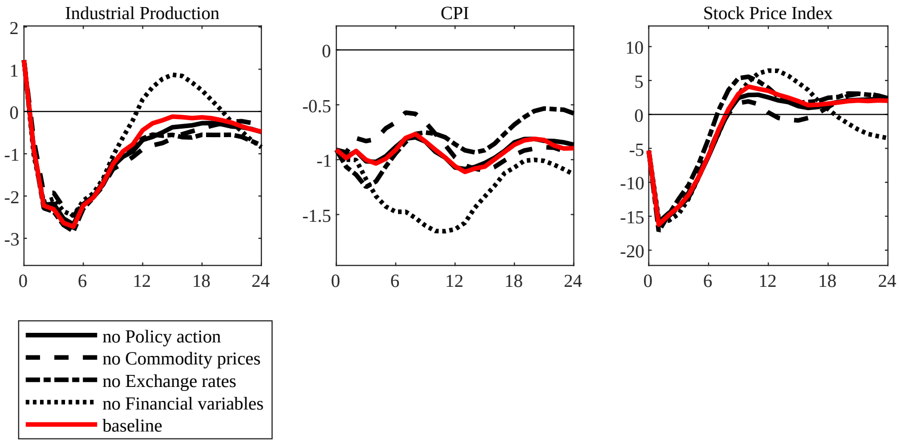
Note: Responses of CPI in 15 emerging economies to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample reported in Table 1. BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

The response of cross-border flows indicates capital outflows, although this is not significant in the aggregate.[35] Importantly, exchange-rate and interest-rate changes move in the same direction: the currency depreciates against the dollar, while long-term yields rise and bond prices fall. This co-movement suggests that sovereign bonds have higher durations in dollar terms than in local currency terms, and hence are riskier to international investors (see discussion in Carstens and Shin, 2019).

Unlike the case of advanced economies, the median responses mask a larger degree of heterogeneity in some of the key variables. The response of CPI to a contractionary shock induces a price decline for 11 out of 15 economies (see Figure 8). Responses of Brazil, Mexico, Philippines, and Turkey are not significant at any levels. Industrial production generally shrinks, and stock prices tumble in all countries except Brazil and Malaysia (Figure B.11, in the online appendix). Interestingly, exchange rates, interest rates and cross-border flows show heterogeneity across countries. Long-term government

[35]In general, emerging economies in our analysis have stricter capital controls than the advanced ones. The median value of Chinn-Ito index for AEs is 0.965, while it is only 0.338 for EMEs. It roughly indicates that the degree of openness to capital for the former is above top 5% in the world, while the latter is only 34%. Table A.8 in the online appendix reports average values of the index for all countries.

Figure 9: Channels of Propagation



Note: Lines correspond to impulse responses obtained with the baseline specification (solid red); assuming the policy rate do not react (solid black); the Brent crude and commodity prices do not react (dashed black); exchange rates do not react (dashed-dotted black); financial conditions, risk appetite, cross-border flows , the excess bond premium and VIX do not react (dotted black). Shock is normalised to induce a 100 basis point increase in the 1-year rate. High-frequency identification. Sample reported in Table 1. BVAR(12).

bond yields tend to move upwards, but responses are not significant in some cases (Figure B.12, in the online appendix). Cross-border flows are rather heterogeneous and country-specific risks seem to play a role among EMEs (Figure B.13, in the online appendix).

To disentangle the role of various transmission channels, we repeat the 'zeroing-out' experiment for the median EME. As with the AEs, we study the channels of transmissions of the US monetary policy shock by selectively zeroing-out the cross-coefficients of key variables: the policy rate, commodity and oil prices, exchange rates, and all financial variables. This provides evidence on the relative importance of the central bank's policy reaction, commodity prices, the exchange rate channel, and the financial channel in the transmission of the US shock.[36] While not in contradiction with what we found for AEs, the counterfactual results reveal a limited differential role for each group of variables (Figure 9).[37] Output still bounces back more when the financial variables do not react, but now it happens only after 9 months. Shutting down oil and commodity prices reduces the extent of the fall in headline inflation, but only marginally. No channel seems to be predominant in the transmission to stock prices. Our interpretation

[36]As discussed in section 3.3, we use the estimated coefficients on the model presented in this section, but set all coefficients on variables of interest in all equations to zero, including their impact responses.

[37]The full set of responses can be found in the online appendix, Figure B.14.

is that the shock transmits rather evenly across the economy and different groups of variables capture similar mechanisms (or are rather ineffective, as the policy stance). It is worth observing that several of our economies are commodity exporters: hence, effects on price, production, and the stock market are likely to be transmitted via several variables in a similar way.

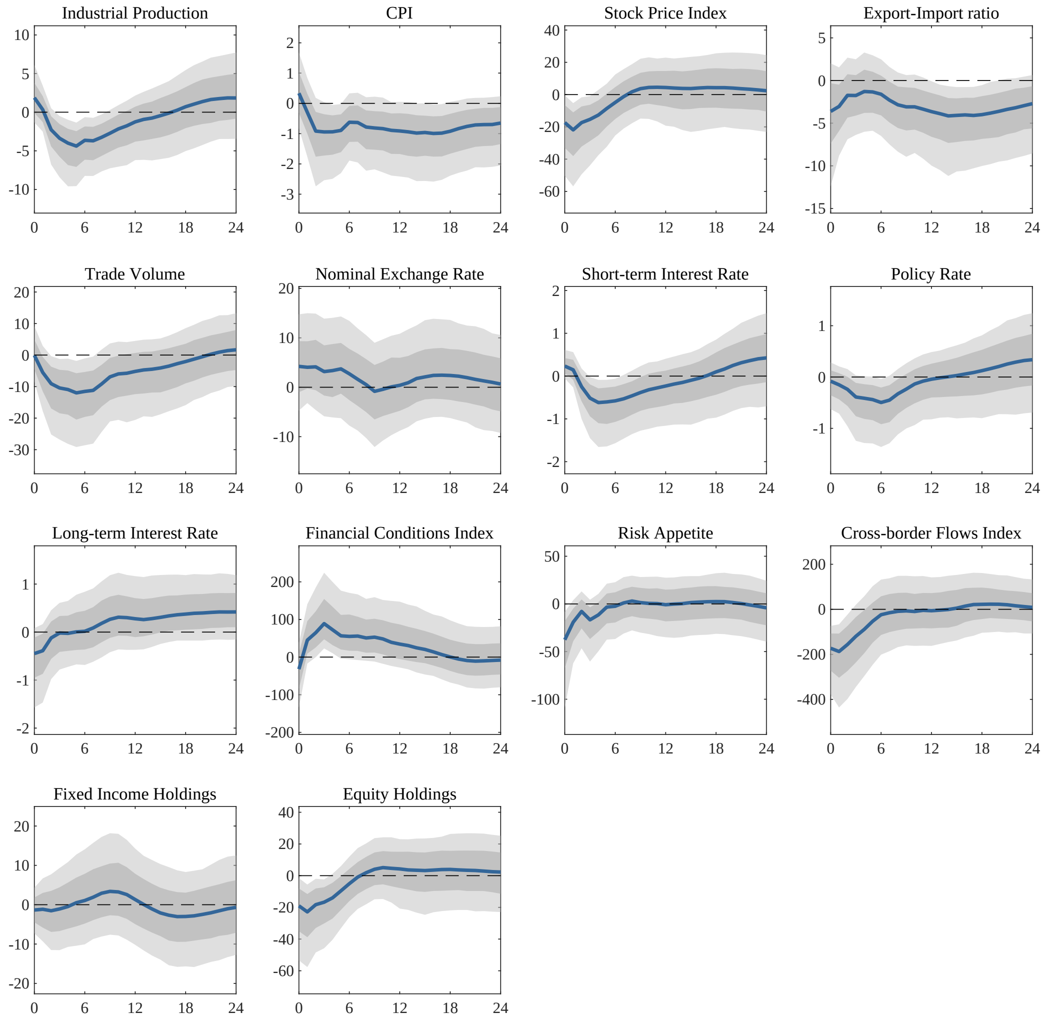
To summarise, emerging markets contract in response to a US monetary tightening. Stock prices, exchange rate, financial conditions, and risk appetite strongly co-move in the US, advanced, and emerging economies. Spillover effects are stronger for EMEs than AEs, with trough responses now almost one-to-one-with the US counterparts. As for advanced economies, prices fall in the median responses and across most of the EMEs in our sample. It suggests that the increase in imported prices is dominated by recessionary pressures at home. At least in the median country, as in the case of AEs, the overall effect of the financial channel is modest and monetary policy can operate by easing economic conditions in response to adverse external shocks (see discussion in Gourinchas, 2018). Importantly, responses of cross-border flows, policy rates, interest rates, and exchange rates are more heterogeneous than for AEs. This reflects more diverse structural characteristics, policy regimes, and the role of country-specific risks among EMEs. In the following sections, we explore some of these features.

6 Transmission to the Euro Area and Major EMEs

Are different policy regimes responsible for the heterogeneity we observe in the responses presented in the previous section? As a first step to test this hypothesis, we focus on the responses of some of the largest emerging economies with different policy regimes – Mexico, China, and India – and benchmark them against the Euro Area, a large economy with a flexible exchange rate and open capital markets. This exercise is helpful in analysing three different policy regimes: open capital markets and a floating rate (Mexico), closed capital markets and a crawling exchange rate (India), closed capital markets and a pegged exchange rate (China).

Figure 10 displays the responses of Euro Area aggregates to a contractionary US monetary policy shock. Similarly to the median advanced and emerging economies, the

Figure 10: Euro Area



Note: Responses of Euro Area to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample 1999:01 – 2018:09. BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

Euro Area also suffers recessionary effects. Output, prices, and the stock market all contract. Trade volume drops by more than in the US at the trough, and the export-import ratio also falls, indicating the prominence of the demand-reducing effect over the expenditure-switching one. The ECB's policy rate responds to deteriorating internal conditions consistently with a Taylor rule and the easing is transmitted through the yield curve to longer maturities. The role of risk premia is marginally visible at longer horizons in the response of the long-term rate. The policy easing improves financial conditions, but it is not enough to stabilise the economy: CPI does not fully revert at all horizons. Capital outflows and devaluation of equities are more severe for the EA than the median AE. The negative responses in capital flows, risk appetite, and equity holdings not only co-move but also display the same dynamics of the global economy. Overall, results suggest that the Euro Area experiences a substantial decline in economic activity due to reduced foreign demand and deteriorating internal conditions.

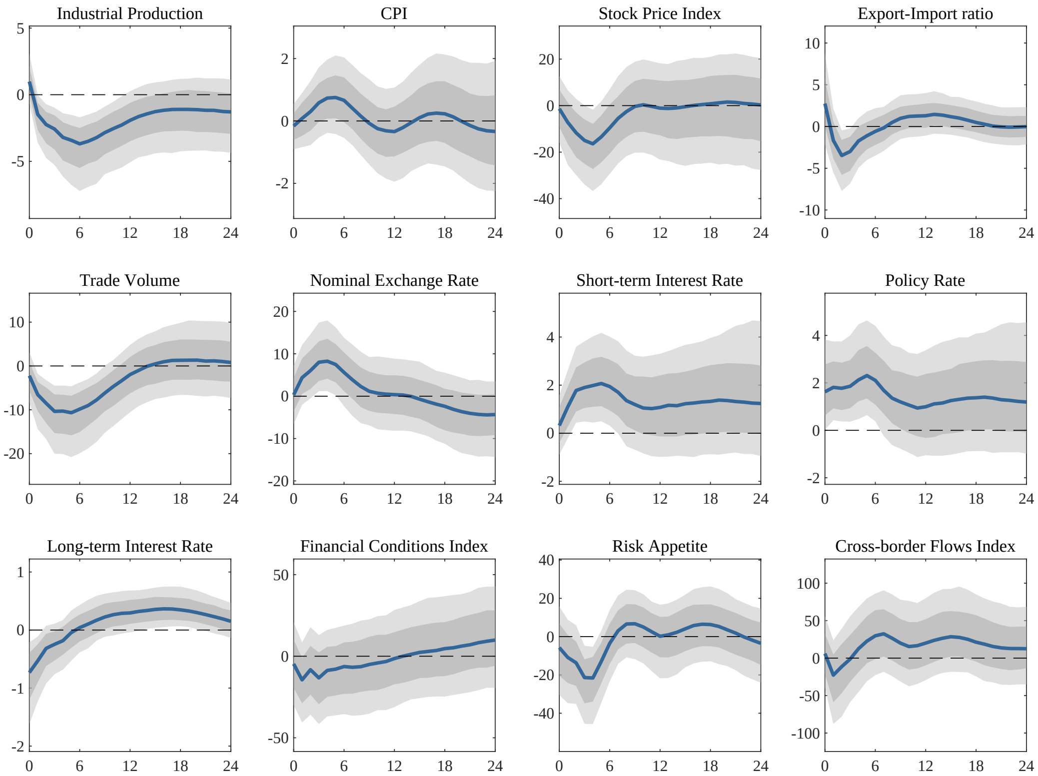
Now we focus on the responses of three major EMEs – Mexico, China, and India. Mexico is a managed floater and has one of the most flexible exchange rate regimes among EMEs, according to the classification of Ilzetzki et al. (2019). On average, across the sample, its Chinn-Ito index puts the country among the top third economies in terms of capital mobility. It is the most open capital market among non-European EMEs in our sample.[38] China on average employs a pre-announced crawling peg with strictly controlled capital markets and it has close ties to the US market in terms of trade and finance. In India, capital controls are as restrictive as in China, but the exchange rate regime is more flexible. India is relatively less connected to the US economy than the former two.[39]

Figure 11 shows the response of Mexico to a US tightening. As the Peso depreciates, Mexico's policy rate, followed by the short-term rate, rises. This is consistent with the 'fear of floating' argument: the Bank of Mexico is trying to shield its economy from excessive capital outflows. It appears successful: cross-border flows are steady and the contraction in risk appetite is short-lived. Financial conditions remain fairly stable as the monetary policy tightening contains credit spreads. However, with financial stability comes the cost of pushing the domestic economy into a recession: industrial production and stock prices contract. The response of headline inflation is insignificant, suggesting that the downward pressure on prices coming from the internal deflation offsets the upward pressure coming from the exchange rate pass-through. Mexico, similarly to the Euro Area, experiences a decline in exports due to lower foreign demand. Yet the very stark policy response is indicative of the extent to which the exposure to the US and to

[38]Table A.8 in the online appendix reports the degree of openness to capital for the countries in our sample.

[39]Ilzetzki et al. (2019) classifies both China and India as crawling peggers: their sample median values are 5 and 7, respectively. The sample average value of the Chinn and Ito (2006) index is 0.166 for both countries. Though roughly 86% of India's exports and imports are invoiced in dollars, its gross dollar exposure is the second lowest among our sample of 15 EMEs. Gopinath (2015) and Bénétrix et al. (2015) for details.

Figure 11: Mexico

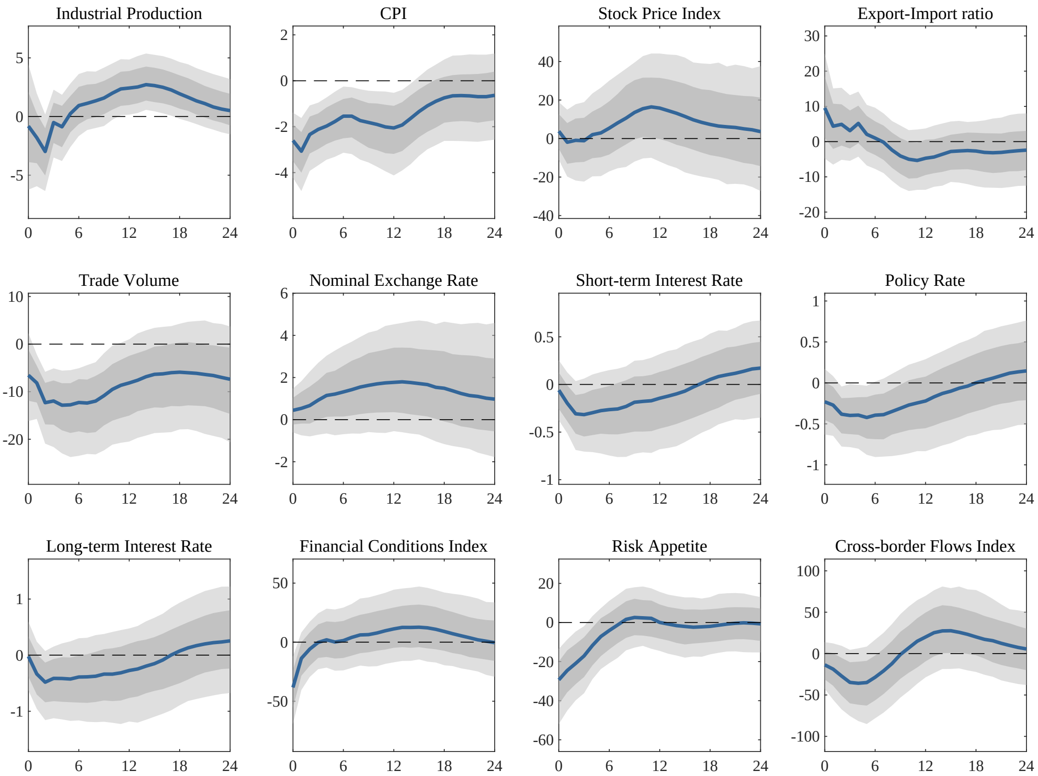


Note: Responses of Mexico to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample 1998:11 – 2018:02. BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

capital flows limits the policy space of the central bank.

Next, we report China's responses in Figure 12. Consistently with the crawling peg adopted by the People's Bank of China (PBC), the exchange rate depreciates slowly and only slightly. Noticeably, it does not revert at all horizons, suggesting a potential 'fear of appreciation' due to concerns about the trade balance. The policy rate shows a loosening of the policy stance that is transmitted through the yield curve. In the absence of open capital markets, the policy stance is fully effective. However, cross-border flows denote an outflow of capital from China – potentially reflecting unsterilised market interventions from the PBC. The policy response insulates the economy: contraction in output is short-lived and followed by some expansion possibly due to the combined internal easing and the currency devaluation. Stock prices do not react on impact. Yet risk appetite and financial conditions deteriorate. Prices decline significantly on impact and remain below trend for over 16 months.

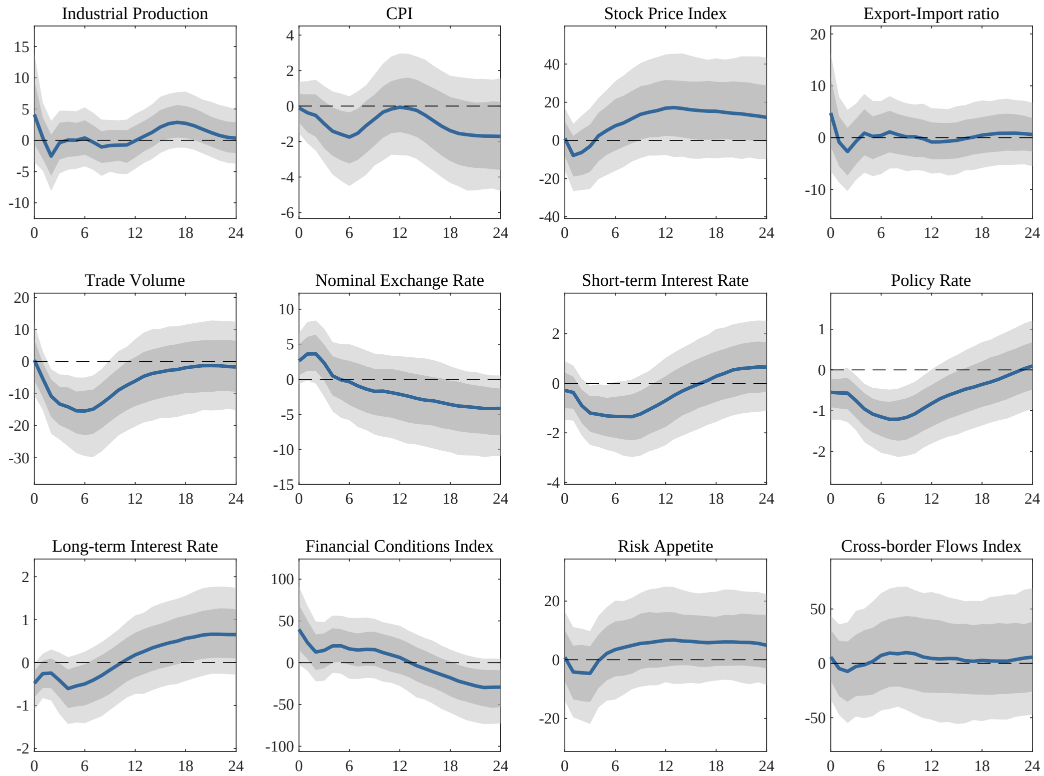
FIGURE 12: CHINA



Note: Responses of China to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample 1994:08 – 2018:08. BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

Finally, in India policy spillovers to a contractionary US shock are limited (see Figure 13): industrial production, CPI and the stock market do not react significantly to the shock at any horizons. The Reserve Bank of India (RBI) loosens its monetary policy stance and cross-border flows remain stable. The lack of movement in capital flows may not be surprising, since India strictly controls its capital market. The policy loosening transmits to short and long rates. The exchange rate first depreciates but quickly reverts to equilibrium. Trade volume contracts significantly, but the overall effect on output seems to be offset by an increasing internal demand, driven by the policy stimulus. India seems to be able to set an autonomous monetary policy and fully sterilise the shock. This result suggests that other structural dimensions might also play a role in the transmission of the US shock: for instance, India's gross dollar exposure is the second lowest among our sample of EMEs, according to Bénétrix et al. (2015). Thanks to a modest economic and financial integration between its economy and the US, the

Figure 13: India



Note: Responses of India to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample 1994:05 – 2018:04. BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

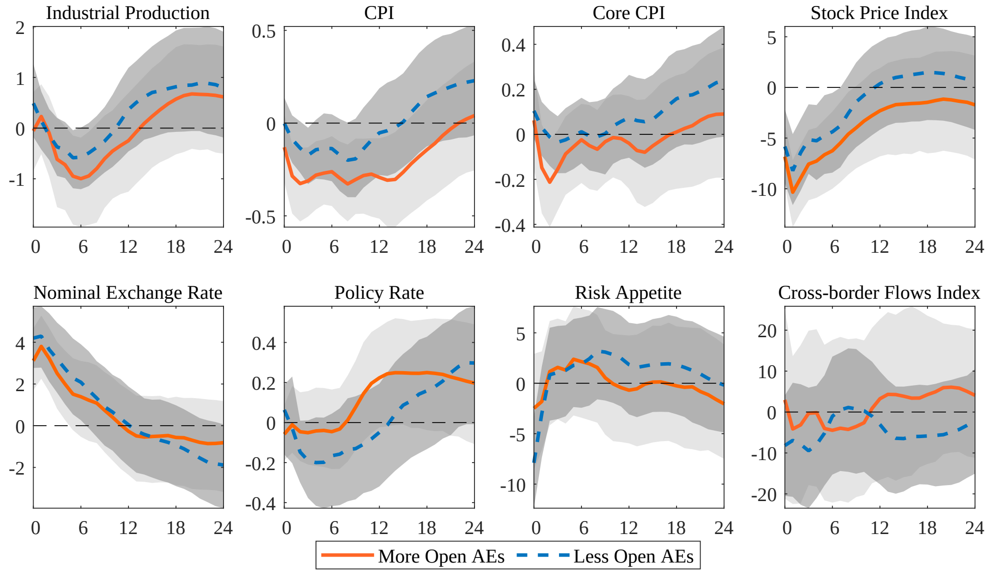
RBI might be facing a weaker trade-off compared to Mexico and China.

Our country-level analyses provide evidence of the role of different policy regimes in the transmission of the shock. Spillover effects are more severe in a relatively open capital market (Mexico) than in more closed ones (China and India). Differences in responses of the latter two EMEs point out that other dimensions, e.g. gross dollar exposure and trade linkages, might also play an important role.

7 Capital Controls and FX regimes

In this section, we further explore the role of different policy regimes by grouping countries by their (i) degree of openness to capital and (ii) exchange rate regimes, the two key dimensions of the classical trilemma. First, we compare open to less-open capital markets by grouping them on the basis of Chinn and Ito (2006)'s index and by studying

Figure 14: Advanced Economies with more v. less Openness to Capital



Note: Orange line – median responses of 5 AEs (Canada, Denmark, Germany, Netherlands, and UK), whose overall capital restriction corresponds to the bottom 1/3 among 15 advanced economies. Dotted blue line – median responses of 6 AEs (Australia, France, Italy, Norway, Spain, and Sweden), whose overall capital restriction corresponds to the top 1/3. Data on capital restrictions are from the Chinn-Ito index. Shock is normalised to induce a 100 basis point increase in the 1-year rate. BVAR (12). Shaded areas are 90% posterior coverage bands.

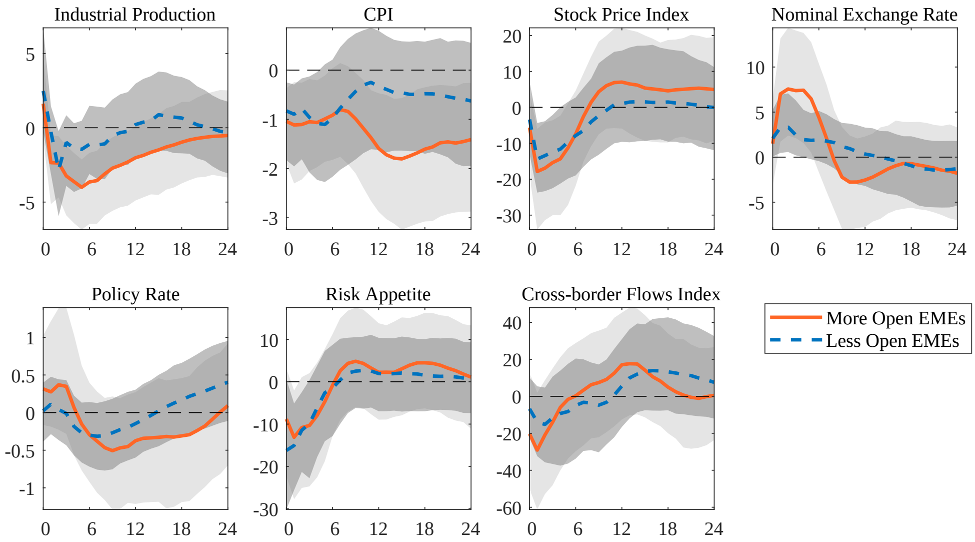
advanced and emerging markets separately.[40] Then, we compare median responses of relative peggers, managed floaters, and free floaters by adopting the classification of Ilzetzki et al. (2019). We also briefly discuss the role of dollar trade invoicing and gross dollar exposure in the transmission of US monetary policy.

In Figure 14, we report the median responses of AEs with more and less openness to capital, based on the Chinn-Ito index, which measures the degree of de jure capital market openness of a country. To construct open and less-open country groups, we calculate the arithmetic average of the Chinn-Ito index over the sample period for each country.[41] Then, we classify countries in the top tercile as more open capital markets and countries in the bottom tercile as less open ones. The group of more open capital markets consists of 5 AEs: Canada, Denmark, Germany, Netherlands and the UK; while the relatively less open markets are Australia, France, Italy, Norway, Spain, and

[40] Pooling all countries and constructing groups based on average values of Chinn and Ito (2006)'s index would simply return the division between AEs and EMEs.

[41] We use the *ka_open* index, which is a continuous measure and ranges between 0 and 1. The higher the number is, the more open a country's capital market is.

Figure 15: Emerging Economies with more v. less Openness to Capital



Note: Orange line – median responses of 5 EMEs (Chile, Czech Republic, Hungary, Mexico, and Poland), whose overall capital restriction corresponds to the bottom 1/3 among 15 advanced economies. Dotted blue line – median responses of 5 EMEs (Brazil, India, South Africa, Thailand and Turkey), whose overall capital restriction corresponds to the top 1/3. Data on capital restrictions are from the Chinn-Ito index. Shock is normalised to induce a 100 basis point increase in the 1-year rate. BVAR (12). Shaded areas are 90% posterior coverage bands.

Sweden.[42] Importantly, all countries in both groups adopt a flexible exchange rate regime during our sample period, 1990 – 2018. We obtain median responses of each group by aggregating the IRFs from the countries' bilateral models as described in Section 2.4.

Figure 14 shows that spillover effects from the US are relatively stronger for economies that have more open capital markets. Responses of output and CPI are (marginally) more negative, significant, and persistent if the capital markets are more globally integrated. Responses of other variables are mostly identical: co-movements among stock prices, exchange rates, and the risk-appetite are in line with results shown in the previous sections. It is important to stress that all the AEs have a high degree of openness to capital, so the difference between the two groups is only marginal.[43]

Next, we compare the median responses of EMEs with more and less openness to capital. Focusing on EMEs is more informative about the role of capital openness since countries are more heterogeneous in this respect. Indeed, the difference between the two groups is now significantly larger: the average value of the Chinn-Ito index for more and

[42]Table A.8 in the online appendix contains more information about the classification.

[43]The average value of the Chinn-Ito index for more and less open AEs is 0.998 and 0.897 respectively.

less open EMEs is 0.469 and 0.354 respectively.[44] Chile, the Czech Republic, Hungary, Mexico, and Poland have more open capital markets, while Brazil, India, South Africa, Thailand, and Turkey have relatively closed capital markets.[45] Importantly, the two groups do not only differ in terms of capital openness but also in terms other structural features: for example, we find a prevalence of floaters among more open markets and a prevalence of peggers among less open ones.

Differences in spillover effects between EMEs with open and closed capital markets are stark (see Figure 15). Output turns significantly negative for the open markets and the median response stays below trend for almost two years. The output response of less open countries, however, is mostly not significant and reverts quickly. CPI responses of the two groups overlap for 6 months, but only open markets experience a significant fall afterwards. Importantly, cross-border flows contract on impact for more open markets, while they are mostly unresponsive for the other group. Also, even though the nominal exchange rate depreciates for both groups, it depreciates more for the open markets. Responses of cross-border flows and the exchange rates validate our classification. Finally, we find almost no difference in the responses of stock prices, policy rates, and risk appetite.

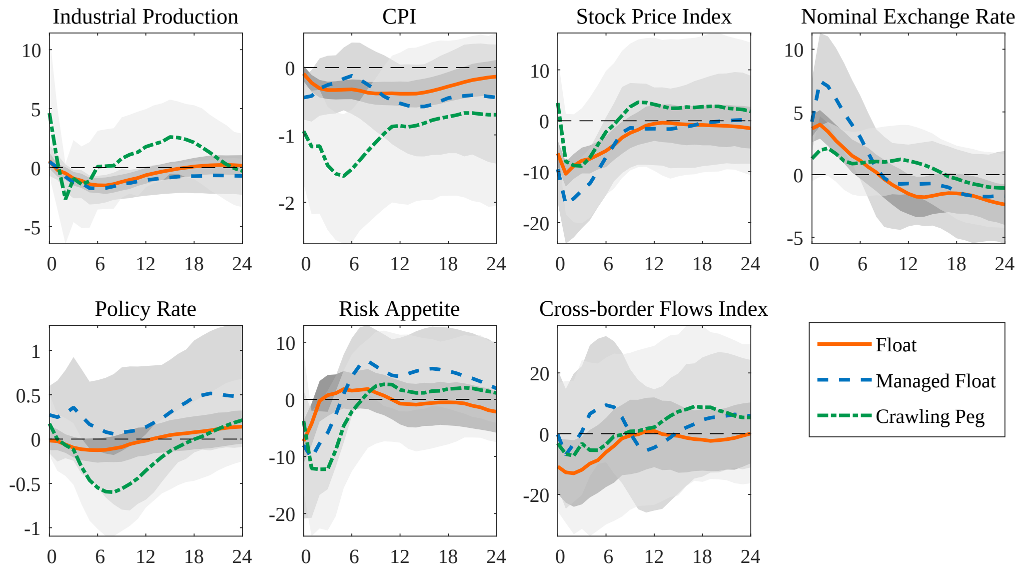
To explore the role of exchange rate regimes, we classify countries into three different groups: (i) floaters, (ii) managed floaters, and (iii) crawling peggers. We assign each country to the regime corresponding to its sample median value of Ilzetzki et al. (2019)'s classification.[46] In our sample, there are 17 floaters (all AEs except Canada, plus the Czech Republic, Hungary, and Poland), 6 managed floaters (Brazil, Canada, Chile, Colombia, Mexico, and South Africa), and 4 crawling peggers (China, India, the Philippines, and Thailand). As before, we obtain median group responses by aggregating IRFs from the countries' bilateral models. Note that unlike the previous exercise on capital controls, here we use all 30 countries in our sample.

[44]To classify countries, we follow the same approach as the AEs – i.e. we take countries whose sample average of the Chinn-Ito index falls into the top and bottom tercile as more and less open capital markets respectively.

[45]Table A.8 in the online appendix provides additional details.

[46]We use Ilzetzki et al. (2019)'s 'fine' classification to construct the three exchange rate regimes. If a country's sample median value of the index is 14, we treat it as a floater. If the value is 12, it is classified as the managed floater. All values below 12 fall into the crawling peg category. Table A.9 in the online appendix contains more information about our criteria.

Figure 16: Exchange rate regimes



Note: Orange line – median responses of 17 floaters (15 advanced economies except Canada, plus Czech Republic, Hungary, and Poland), Dotted blue line – median responses of 6 managed floaters (Brazil, Canada, Chile, Colombia, Mexico, and South Africa), Green dash-dotted line – median responses of 4 crawling peggers (China, India, Philippines, and Thailand). Data on exchange rate regimes are from Ilzetzki et al. (2019). Shock is normalised to induce a 100 basis point increase in the 1-year rate. BVAR (12). Shaded areas are 90% posterior coverage bands.

We compare the median responses of the three different exchange rate groups in Figure 16. First, the exchange rate response validates our classification: it depreciates for the first two groups but does not react for the crawling pegs. A stronger depreciation in the managed float group as compared to the free floaters further corroborates our sample composition. Indeed, managed floaters consist of EMEs, while the majority of free floaters are AEs. Second, the US monetary policy spillover affects all regimes – output, CPI, stock prices, and risk appetite contract in all three groups, but recessionary effects are minimal for the floaters. Crawling peggers seem to suffer the most severe deflation by fully importing the US monetary policy shock. The trough response of output is also the strongest for peggers, although bands are large. The policy response reveals that while floaters (marginally) and peggers (strongly) loosen their policy rates, the managed floaters have to hike them, possibly to avoid capital outflows. This group is indeed formed by countries that combine managed but flexible exchange rates with relatively more open capital markets. Interestingly, the policy rate seems to stabilise capital flows: cross-border flows remain steady for this group. Conversely, floaters experience significant capital outflows in the absence of the capital controls that shield the peggers.

We conclude this section by conducting two other group analyses based on other measures that are closely related to the exchange rate regime: (i) share of trade invoiced in dollars and (ii) gross dollar exposure. We use data from Gopinath (2015) to classify countries between high and low dollar trade invoicing. We follow Bénétrix et al. (2015) to divide countries between high and low exposure to the dollar.[47] Here we focus on EMEs, as this is an important dimension for those economies only. As we did for the degree of capital openness, we select countries that are in the top and bottom tercile in terms of the sample average of the two measures, then we compare their median responses.[48] Figures B.15 and B.16 in the online appendix echo our results in Figure 16: countries with a high degree of dollar trade invoicing/gross dollar exposure display responses that are similar to those of crawling peggers, while economies that are less dependent on the dollar behave similarly to managed floaters. Finally, we conduct a robustness check on capital controls by using a different index, constructed by Fernández et al. (2016b). Results in Figure B.17 in the online appendix are consistent with those in Figure 15 reported above.

To summarise, our results suggest that the degree of openness to capital flows and the exchange rate regime are two important dimensions for understanding the global transmission of US monetary policy. The responses of industrial production and CPI are stronger and more negative for economies that have more open capital markets. Neither flexible nor the 'middle-ground' exchange rate regimes can fully insulate economies from US monetary policy shocks that transmit through both financial and classic channels. Importantly, different policy dimensions and country characteristics – exchange rate regime, openness of capital markets, dollar trade invoicing, and gross dollar exposure – appear to be related, and the choice of the regime might be endogenous and determined by country-specific deeper structural features.

[47] Gopinath (2015) reports the fraction of a country's exports/imports invoiced in a foreign currency. We construct a measure of gross dollar exposure for each country by taking the sum of USD total assets and liabilities as a percentage of GDP from the dataset of Bénétrix et al. (2015).

[48] See Tables A.10 and A.11 in the online appendix for details about the classifications.

8 Asymmetric Effects of US Monetary Policy Shocks

A question that has important policy implications is whether there are asymmetries in the transmission of contractionary and expansionary monetary policy shocks. In the case of US monetary loosenings, financial conditions in third countries ease and capital flows into local bonds and risky assets. When these favourable conditions are reversed abruptly, the foreign economy may be exposed to rapid capital outflows with powerful destabilising effects. Such a mechanism may induce 'fear of floating', asymmetries in the policy response of foreign monetary authorities to positive and negative US monetary policy shocks, and foreign exchange market interventions to avoid sudden and large depreciations of the currency.

A different argument recently advanced is that when a peripheral country has positive net assets denominated in dollars, a loosening in the US causes the local currency to appreciate vis-à-vis the dollar, making the value of foreign assets fall. The total wealth in the economy shrinks, potentially leading to a contraction in local consumption and investment. This mechanism – often mentioned with reference to China – would explain why we might observe asymmetric responses such as 'fear of appreciation' (see discussion in Georgiadis and Mehl, 2016; Han and Wei, 2018).

While these narratives may match the pattern of some crises in the emerging markets and popularly reported facts, the empirical evidence is still relatively thin. This section provides novel evidence about asymmetry in the macroeconomic responses to US monetary policy tightenings and loosenings.

We proceed in two steps. First, we divide our monetary policy instrument into positive (tightening) and negative (loosening) parts. Then we identify the shock in the models presented in the above sections using these two different external instruments. We run this exercise for the US, at the global level, and for advanced and emerging economies. This amounts to assuming that while the system is still linear, tightenings and loosenings are two different types of shock with distinct transmissions.[49] For ease

[49] This has to be seen as a reduced form stylised way to gauge the extent of the different impacts of tightenings and loosenings while maintaining large information sets. Alternatively, one could explore the same effects using a Local Projections approach. However, the gain in flexibility in the IRFs could be offset by the increase in the uncertainty of the estimates and the reduction in data points used for the estimation.

of comparison, we flip the loosening response and normalise both shocks to induce a 100 basis point increase in the US 1-year rate. Hence, for instance, a negative response of US production to the loosening shock in the chart means that the actual response is expansionary.

A note of caution is needed here. An important part of our analysis concerns emerging markets. Yet, in looking at emerging countries and splitting the sample of our IV, data issues are likely to be amplified and a few episodes in a few countries can end up driving the results. To mitigate this issue, we narrow the cross-section of countries and extend the sample by dropping variables for which the time series were shorter. This allows us to include the monetary tightening episodes of the 1990s (and their effects) in our estimation.[50]

8.1 Asymmetries in the US responses

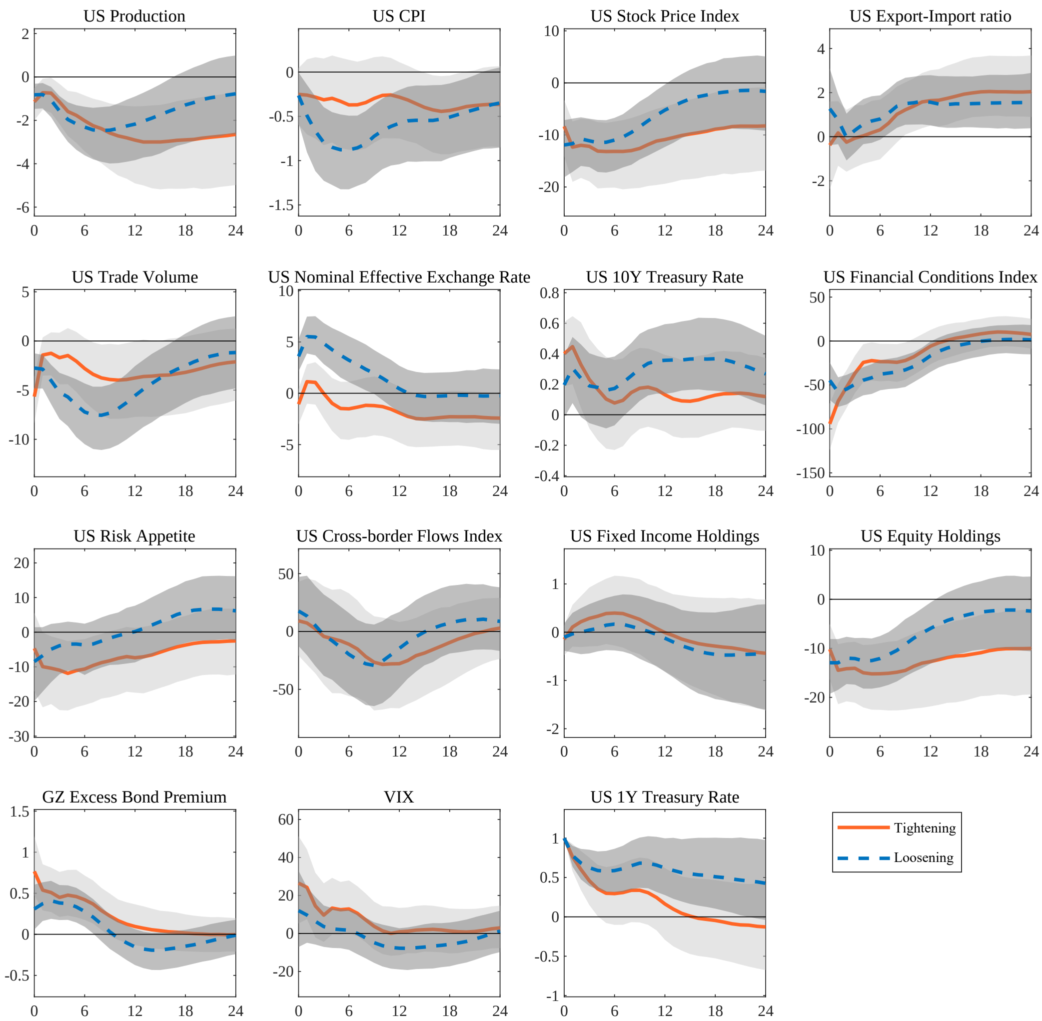
The domestic effects of monetary policy tightenings and loosenings are relatively symmetric, with marginally stronger real effects in tightenings as shown by the response of industrial production (in Figure 17).[51] The interesting exception is the response of CPI, which is remarkably asymmetric: it decreases marginally but not significantly in case of a tightening, while expanding significantly in a loosening. This is an indication of downward rigidity in prices to the monetary policy shock. Trade volume also reacts slightly less to tightenings than to loosenings, possibly indicating a difference in the monetary responses in third countries and hence in the exchange rates.

Marginal differences are also evident in the variables capturing financial channels – risk appetite, excess bond premium, and the VIX – that respond more to contractionary monetary policy. This is matched by the deeper rebalancing of risky assets in contractions. Interestingly the responses of the policy indicator, the U.S. 1-year treasury rate,

[50]To obtain samples starting from the early 1990s, we implement the following modifications in our sample of EMEs: first, we drop two countries, Thailand and Russia, where all the available output series start from the late 1990s. Second, we interpolate backwards a few important indicators, namely output and stock prices, for some of EMEs. This would have otherwise greatly reduced our sample. The endogenous set includes industrial production, CPI, stock prices, export/import ratio, trade volume, nominal exchange rate, short-term and policy rates, financial conditions, risk appetite and cross-border flows.

[51]The stronger effects of a contractionary monetary policy shock compared to an expansionary one are in line with the recent literature on asymmetric responses to MP shocks (see, for example, Cover, 1992; Tenreyro and Thwaites, 2016; Barnichon and Matthes, 2018; Angrist et al., 2018)

FIGURE 17: ASYMMETRIC SHOCKS TO THE US ECONOMY



Note: Orange line – domestic responses to a contractionary US monetary policy shock. Dotted blue line – domestic responses to an expansionary US monetary policy shock. Shocks are normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample 1990:01 – 2018:09. BVAR(12) with asymmetric conjugate priors. Shaded areas are 90% posterior coverage bands.

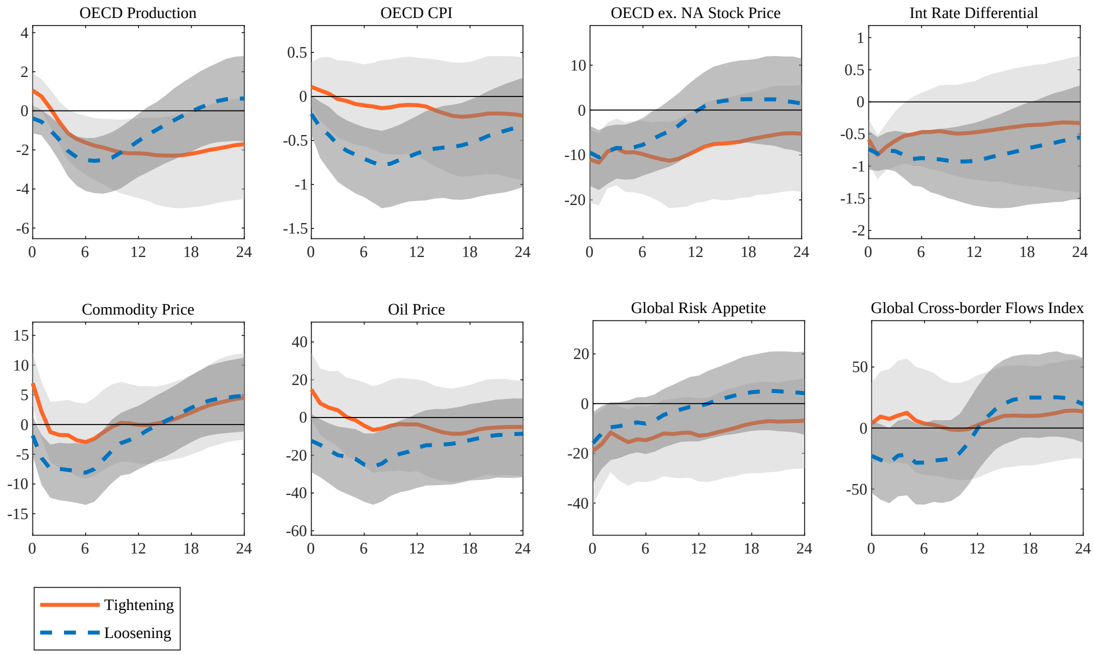
highlight differences in the duration of tightening and loosening cycles.

8.2 Asymmetries in the Global Transmission and AEs

The global economy responds to the shocks in an asymmetric manner (Figure 18).[52] Industrial production contracts slightly more and for longer during contractions, but the difference is not statistically significant. The price responses are strongly asymmetric.

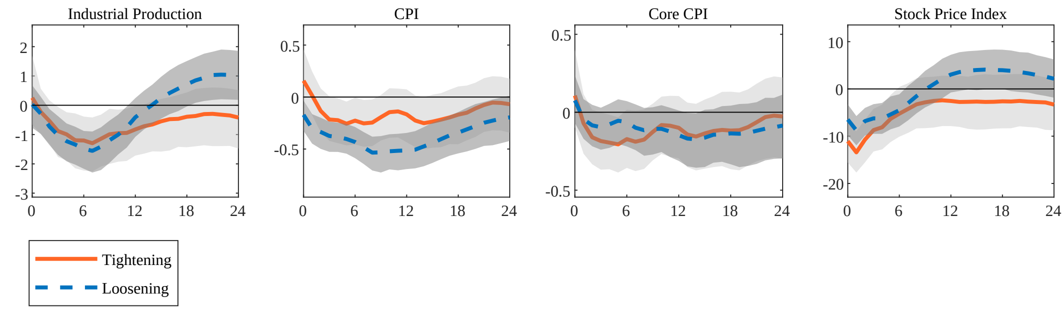
[52] A full set of responses can be found in the online appendix, Figure B.2 for the global economy and Figure B.9 for advanced economies.

Figure 18: Asymmetric shocks to the Global economy



Note: Orange line – global responses to a contractionary US monetary policy shock. Dotted blue line – global responses to an expansionary US monetary policy shock. Shocks are normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample 1990:01 – 2018:09. BVAR(12) with asymmetric conjugate priors. Shaded areas are 90% posterior coverage bands.

Figure 19: Asymmetric shocks to the median advanced economy

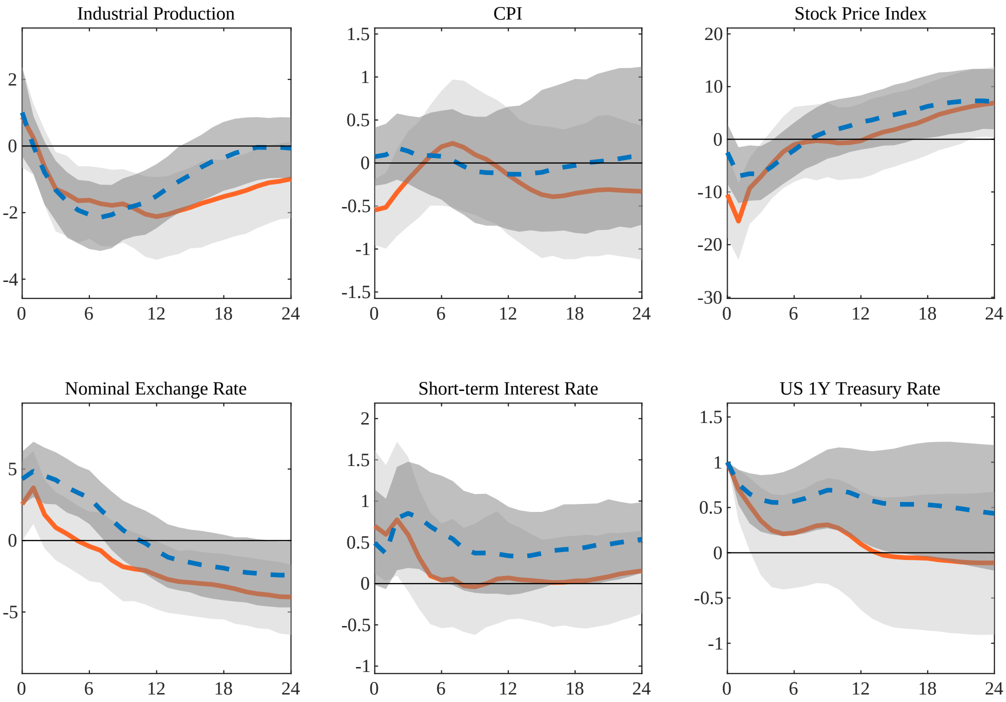


Note: Orange line – median responses of 15 advanced economies to a contractionary US monetary policy shock. Dotted blue line – median responses of 15 advanced economies to an expansionary US monetary policy shock. Shocks are normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample 1990:01 – 2018:09. BVAR(12) with asymmetric conjugate priors. Shaded areas are 90% posterior coverage bands.

Commodity prices and the oil price do not experience meaningful changes after tightenings while they adjust upward in a loosening. This is reflected in the lack of reaction of OECD CPI after a tightening relative to its expansion in a loosening.

A similar pattern is visible in the median responses of our 15 advanced economies to

FIGURE 20: ASYMMETRIC SHOCKS TO THE MEDIAN EMERGING ECONOMY



Note: Orange line – median responses of 13 emerging economies to a contractionary US monetary policy shock. Dashed blue line – median responses of 13 emerging economies to an expansionary US monetary policy shock. Shocks are normalised to induce a 100 basis point increase in the US 1-year rate. High frequency identification. Sample varies from between 1990:01 and 1993:11 to between 2017:12 and 2018:09. BVAR(12) with asymmetric conjugate priors. Shaded areas are 90% posterior coverage bands.

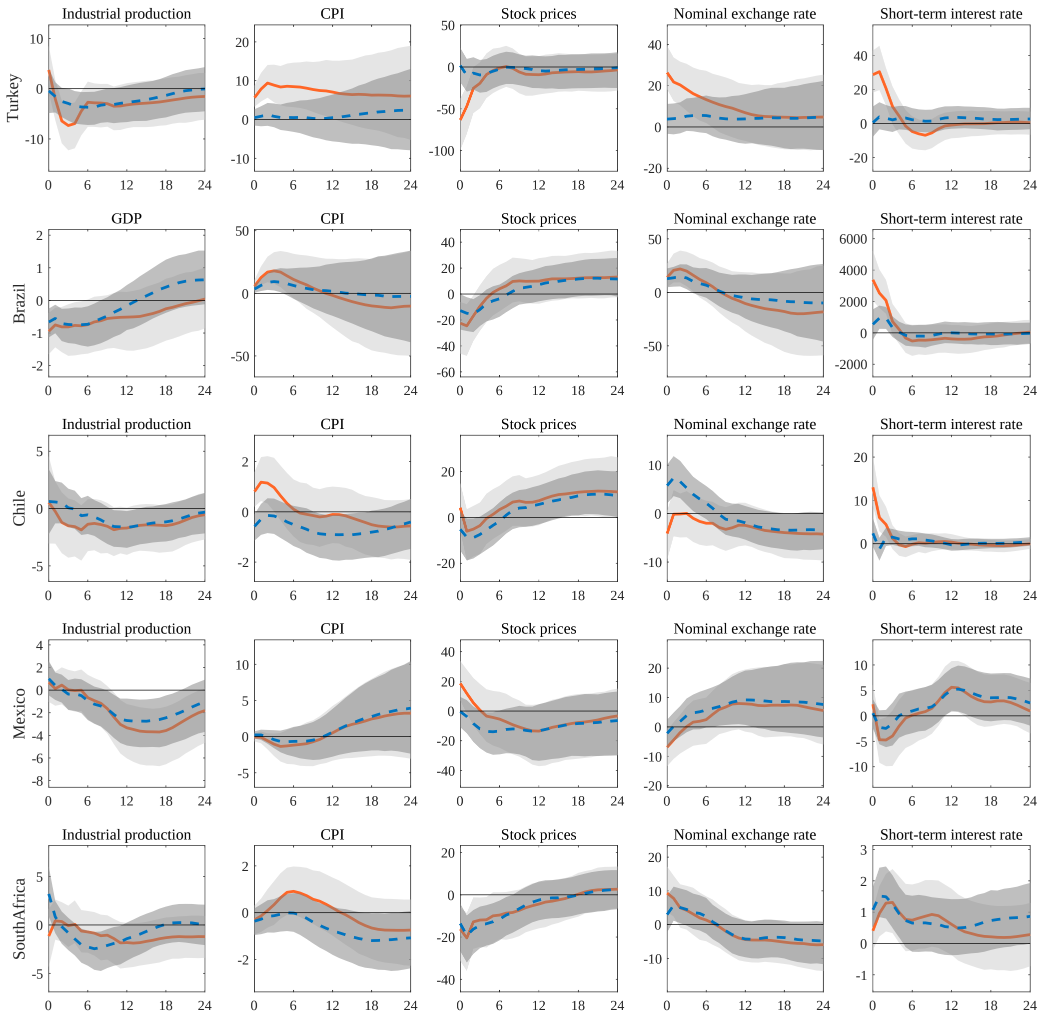
contractionary and expansionary shocks (Figure 19). Here, the asymmetry is marked, with a deeper and longer contraction in output and the stock market in a tightening. CPI contracts in tightenings and expands in loosenings but the downward rigidity of prices is very visible.[53]

8.3 Asymmetries in Emerging Economies

Following a tightening in the US, the median emerging economy displayed in Figure 20 experiences a larger drop in the stock market and a more prolonged recession when compared to a loosening. The domestic policy response can be assessed by observing the response of the short-term interest rate and the asymmetries in the response of the

[53]One interesting result from this chart is that patterns of the '2.5–lemma' are not clear, in contrast to Han and Wei (2018): real spillover effects are evident in both tightenings and loosenings. Their findings might be capturing a downward rigidity in CPI, not a lack of monetary autonomy. As Rey (2016) pointed out, measuring monetary autonomy via the metric of correlation among short-term rates does not fully take into account the financial spillover channels.

Figure 21: Asymmetric shocks: 5 EMEs



Note: Orange line – median responses of each EME to a contractionary US monetary policy shock. Dashed blue line – median responses of each EME to an expansionary shock. Shocks are normalised to induce a 100 bp rise in the US 1-year rate. High frequency identification. Sample as in Table A.12 (online appendix). For Brazil, we replace IP by monthly GDP interpolated backwards from 1996:01 to 1990:01. BVAR(12) with asymmetric priors. Shaded areas are 90% posterior coverage bands.

nominal exchange rate. The depreciation of the currency in a tightening is limited when compared to the appreciation in a loosening. In the aggregate the fear of depreciation trumps the fear of appreciation.[54]

Policy responses and country structural features are a large part of the story. We zoom in on single countries – Turkey, Brazil, Chile, Mexico, and South Africa – to provide a more granular view of how policy regimes and country-specific fragilities interact

[54]These results are in line with those displayed in Figure 7, with the notable exception of short-term rates. It is important to remember that the sample length and pool of countries are different.

in shaping asymmetric responses to US policy shocks. This is an interesting pool of countries that either experiences currency crises (Mexico in 1994, Brazil in 1999, and Turkey in 2001) or conducted particularly prudent monetary policy (Chile, South Africa) for fear of exposing themselves to global shocks.[55]

The responses show remarkable differences when compared to the median aggregated ones. Following a tightening, global financial conditions worsen and capital starts flowing out of an economy; this is visible in the responses of the domestic currencies that fall in all countries but Chile. Interestingly, the Chilean peso only reacts to a loosening, which would be consistent with 'fear of depreciation'. Inflation tends to rise due to imported goods becoming more expensive. The price responses are now very different from the aggregate ones. All the 5 EMEs experience a price hike following the US tightening. We observe particularly dramatic rises in Turkey and Brazil. For instance, Turkey's CPI increases by 5% on impact for a tightening and the effect persists for 12 months. For a loosening the response of prices is not significant, as there is no effect on the exchange rate.

Central banks react to the exchange rates plummeting by hiking rates in the attempt of steadying the economy. In fact, in all cases except Mexico, we observe an increase in the short-term rate response upon a US tightening and a decrease in the case of a loosening. This in turn exacerbates the contraction of the national economy. In particular, we observe a dramatic surge in the short-term rate on impact for Turkey, Brazil, and Chile. This may bear the pattern of the crises experienced by these countries, and is an indication of strong financial spillovers as discussed in Gourinchas (2018). Indeed, if investors have limited trust in the central bank, expectations can become self-fulfilling with the currency falling, interest rates and inflation rising, and the economy deteriorating. Overall, the responses show a pattern of an emerging market crisis similar to what described by Carstens and Shin (2019).[56]

[55]For Brazil, we replace industrial production by monthly GDP interpolated backward from 1996:01 to 1990:01. The results we obtain by using industrial production are qualitatively similar.

[56]Hoek et al. (2020) provide evidence that while the signalling channel of US monetary policy (good macro news - higher policy rates) generates only modest spillovers, contractionary MP shocks can lead to a significant tightening of EME financial conditions.

9 Conclusion

We studied how US monetary policy is transmitted across the globe by employing a high-frequency identification of policy shocks and large VAR techniques. Our identification controls for the information effects of monetary policy while allowing for the separate analysis of tightenings and loosenings of the policy stance. Incorporating a large dataset of macroeconomic and financial indicators at a monthly frequency, we study the effects of US monetary policy shocks on the global economy, the Euro Area, 15 AEs and 15 EMEs. We also provide median responses for selected groups of countries based on their income levels, the degree of openness to capital, exchange rate regimes, dollar trade invoicing, and gross dollar exposure. Our study provides evidence on the channels of propagation of US monetary policy shocks overseas, as well as documenting asymmetries in the responses of peripheral economies to expansionary and contractionary US shocks.

We report a set of novel findings. First, we find that a US monetary tightening induces macro and financial contractionary responses in the US and across the globe. This testifies to the role of dollar as a global currency. Second, US monetary policy spillovers affect both advanced economies and emerging markets, irrespectively of their monetary policy regime. The country-level responses are much less heterogeneous than previously reported. Third, AEs and EMEs that are more open to capital experience stronger real and nominal effects compared to less-open ones. This highlights a potential role for capital controls as an additional policy dimension. Fourth, by disentangling the channels of transmission, we observe that contractionary responses of commodity prices and financial variables are important determinants of negative spillover effects on output and prices. Finally, we find that the responses of output and stock prices of the US, the global economy, and third countries are more persistent in a tightening than in a loosening. CPI instead shows downward rigidity, that is accounted for by the downward rigidity of oil and commodity prices. Importantly, the policy responses of countries that have been affected by currency crises are remarkably asymmetric.

References

Akıncı, Özge, "Global financial conditions, country spreads and macroeconomic fluctuations in emerging countries," *Journal of International Economics*, 2013, *91* (2), 358–371.

Angrist, Joshua D., Òscar Jordà, and Guido M. Kuersteiner, "Semiparametric Estimates of Monetary Policy Effects: String Theory Revisited," *Journal of Business & Economic Statistics*, 2018, *36* (3), 371–387.

Argimon, Isabel, Clemens Bonner, Ricardo Correa, Patty Duijm, Jon Frost, Jakob de Haan, Leo de Haan, and Viktors Stebunovs, "Financial institutions? business models and the global transmission of monetary policy," *Journal of International Money and Finance*, 2019, *90* (C), 99–117.

Banbura, Marta, Domenico Giannone, and Lucrezia Reichlin, "Large Bayesian vector auto regressions," *Journal of Applied Econometrics*, 2010, *25* (1), 71–92.

Barnichon, Regis and Christian Matthes, "Functional Approximation of Impulse Responses," *Journal of Monetary Economics*, 2018, *99* (C), 41–55.

Bénétrix, Agustin S., Philip R. Lane, and Jay C. Shambaugh, "International currency exposures, valuation effects and the global financial crisis," *Journal of International Economics*, 2015, *96* (S1), 98–109.

Bernanke, Ben S, "Federal Reserve Policy in an International Context," *IMF Economic Review*, April 2017, *65* (1), 1–32.

Bernanke, Ben S. and Mark Gertler, "Inside the Black Box: The Credit Channel of Monetary Policy Transmission," *The Journal of Economic Perspectives*, 1995, *9* (4), 27–48.

Bhattarai, Saroj, Arpita Chatterjee, and Woong Yong Park, "Global Spillover Effects of US Uncertainty," Globalization Institute Working Papers 331, Federal Reserve Bank of Dallas November 2017.

Bianchi, Ambrogio Cesa and Andrej Sokol, "Financial shocks, credit spreads and the international credit channel," Bank of England working papers 693, Bank of England November 2017.

Bluedorn, John C. and Christopher Bowdler, "The open economy consequences of U.S. monetary policy," *Journal of International Money and Finance*, March 2011, *30* (2), 309–336.

Bremus, Franziska and Marcel Fratzscher, "Drivers of structural change in cross-border banking since the global financial crisis," *Journal of International Money and Finance*, 2015, *52* (C), 32–59.

Bruno, Valentina and Hyun Song Shin, "Capital flows and the risk-taking channel of monetary policy," *Journal of Monetary Economics*, 2015, *71*, 119 – 132.

_ **and** _ , "Cross-Border Banking and Global Liquidity," *Review of Economic Studies*, 2015, *82* (2), 535–564.

Buch, Claudia M and Linda S Goldberg, "International Banking and Liquidity Risk Transmission: Lessons from Across Countries," *IMF Economic Review*, November 2015, *63* (3), 377–410.

Buch, Claudia M., Matthieu Bussierè, Linda Goldberg, and Robert Hills, "The international transmission of monetary policy," *Journal of International Money and Finance*, 2019, *91* (C), 29–48.

Canova, Fabio, "The transmission of US shocks to Latin America," *Journal of Applied Econometrics*, 2005, *20* (2), 229–251.

— **and Matteo Ciccarelli**, "Panel vector autoregressive models: a survey," Working Paper Series 1507, European Central Bank January 2013.

Carriero, Andrea, Todd E. Clark, and Massimiliano Marcellino, "Large Bayesian vector autoregressions with stochastic volatility and non-conjugate priors," *Journal of Econometrics*, 2019, *212* (1), 137–154.

Carstens, Agustín and Hyun Song Shin, "Emerging Markets Aren't Out of the Woods Yet. How They Can Manage the Risks," *Foreign Affairs*, March 2019.

Cetorelli, Nicola and Linda S. Goldberg, "Banking Globalization and Monetary Transmission," *The Journal of Finance*, 2012, *67* (5), 1811–1843.

Chan, Joshua C. C., "Asymmetric conjugate priors for large Bayesian VARs," CAMA Working Papers 2019-51, Centre for Applied Macroeconomic Analysis, Crawford School of Public Policy, The Australian National University July 2019.

Chinn, Menzie and Hiro Ito, "What matters for financial development? Capital controls, institutions, and interactions," *Journal of Development Economics*, 2006, *81* (1), 163–192.

Ciccarelli, Matteo, Eva Ortega, and Maria Teresa Valderrama, "Heterogeneity and cross-country spillovers in macroeconomic-financial linkages," Working Paper Series 1498, European Central Bank November 2012.

Coibion, Olivier and Yuriy Gorodnichenko, "Information Rigidity and the Expectations Formation Process: A Simple Framework and New Facts," *American Economic Review*, 2015, *105* (8), 2644–78.

Cover, James Peery, "Asymmetric Effects of Positive and Negative Money-Supply Shocks," *The Quarterly Journal of Economics*, 1992, *107* (4), 1261–1282.

Cuaresma, Jesus Crespo, Gernot Doppelhofer, Martin Feldkircher, and Florian Huber, "Spillovers from US monetary policy: Evidence from a time-varying parameter GVAR model," Working Papers in Economics 2018-6, University of Salzburg November 2018.

Dedola, Luca, Giulia Rivolta, and Livio Stracca, "If the Fed sneezes, who catches a cold?," *Journal of International Economics*, 2017, *108* (S1), 23–41.

Dées, Stéphane and Alessandro Galesi, "The global financial cycle and us monetary policy in an interconnected world," Working Papers 1942, Banco de España, Working Papers December 2019.

Ehrmann, Michael and Marcel Fratzscher, "Global Financial Transmission of Monetary Policy Shocks," *Oxford Bulletin of Economics and Statistics*, December 2009, *71* (6), 739–759.

Farhi, Emmanuel and Iván Werning, "Dilemma Not Trilemma? Capital Controls and Exchange Rates with Volatile Capital Flows," *IMF Economic Review*, November 2014, *62* (4), 569–605.

Feldkircher, Martin and Florian Huber, "The international transmission of US shocks? Evidence from Bayesian global vector autoregressions," *European Economic Review*, 2016, *81* (C), 167–188.

Fernández, Andrés, Michael W. Klein, Alessandro Rebucci, Martin Schindler, and Martín Uribe, "Capital control measures: A new dataset," *IMF Economic Review*, 2016, *64* (3), 548–574.

Fernández, Martin Andrés, Michael Klein, Alessandro Rebucci, Martin Schindler, and Martin Uribe, "Capital Control Measures: A New Dataset," *IMF Economic Review*, 2016, *64* (3), 548–574.

Georgiadis, Georgios, "Determinants of global spillovers from US monetary policy," *Journal of International Money and Finance*, 2016, *67* (C), 41–61.

_ , "To bi, or not to bi? Differences between spillover estimates from bilateral and multilateral multi-country models," *Journal of International Economics*, 2017, *107* (C), 1–18.

_ **and Arnaud Mehl**, "Financial globalisation and monetary policy effectiveness," *Journal of International Economics*, 2016, *103* (C), 200–212.

Gerko, Elena and Hélène Rey, "Monetary Policy in the Capitals of Capital," *Journal of the European Economic Association*, 2017, *15* (4), 721–745.

Gertler, Mark and Peter Karadi, "Monetary Policy Surprises, Credit Costs, and Economic Activity," *American Economic Journal: Macroeconomics*, 2015, *7* (1), 44–76.

Giannone, Domenico, Michele Lenza, and Giorgio E. Primiceri, "Prior Selection for Vector Autoregressions," *The Review of Economics and Statistics*, May 2015, *2* (97), 436–451.

Gilchrist, Simon and Egon Zakrajšek, "Credit Spreads and Business Cycle Fluctuations," *American Economic Review*, 2012, *102* (4), 1692–1720.

_ **, Vivian Yue, and Egon Zakrajšek**, "U.S. Monetary Policy and International Bond Markets," *Journal of Money, Credit and Banking*, December 2019, *51* (S1), 127–161.

Gopinath, Gita, "The International Price System," NBER Working Papers 21646, National Bureau of Economic Research, Inc October 2015.

_ **, Emine Boz, Camila Casas, Federico J. Díez, Pierre-Olivier Gourinchas, and Mikkel Plagborg-Moller**, "Dominant Currency Paradigm," NBER Working Papers 22943, National Bureau of Economic Research, Inc December 2016.

Gourinchas, Pierre-Olivier, "Monetary Policy Transmission in Emerging Markets: An Application to Chile," in Enrique G. Mendoza, Ernesto Pastén, and Diego Saravia, eds., *Monetary Policy and Global Spillovers: Mechanisms, Effects and Policy Measures*, Vol. 25 of *Central Banking, Analysis, and Economic Policies Book Series*, Central Bank of Chile, August 2018, chapter 8, pp. 279–324.

_ **and Hélène Rey**, "From World Banker to World Venture Capitalist: U.S. External Adjustment and the Exorbitant Privilege," in "G7 Current Account Imbalances: Sustainability and Adjustment" NBER Chapters, National Bureau of Economic Research, Inc, 2007, pp. 11–66.

_ **,** _ **, and Maxime Sauzet**, "The International Monetary and Financial System," CEPR Discussion Papers 13714, C.E.P.R. Discussion Papers May 2019.

Gürkaynak, Refet S, Brian Sack, and Eric Swanson, "Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements," *International Journal of Central Banking*, May 2005, *1* (1).

Hamilton, James D., "Measuring global economic activity," *Journal of Applied Econometrics*, 2019.

Han, Xuehui and Shang-Jin Wei, "International transmissions of monetary shocks: Between a trilemma and a dilemma," *Journal of International Economics*, 2018, *110* (C), 205–219.

Hoek, Jasper, Steve Kamin, and Emre Yoldas, "When is Bad News Good News? U.S. Monetary Policy, Macroeconomic News, and Financial Conditions in Emerging Markets," International Finance Discussion Papers 1269, Board of Governors of the Federal Reserve System 2020.

Iacoviello, Matteo and Gaston Navarro, "Foreign Effects of Higher U.S. Interest Rates," International Finance Discussion Papers 1227, Board of Governors of the Federal Reserve System (U.S.) 2018.

Ilzetzki, Ethan, Carmen M Reinhart, and Kenneth S Rogoff, "Exchange Arrangements Entering the Twenty-First Century: Which Anchor will Hold?," *The Quarterly Journal of Economics*, 2019, *134* (2), 599–646.

Jarociński, Marek and Peter Karadi, "Deconstructing monetary policy surprises: the role of information shocks," *American Economic Journal: Macroeconomics*, forthcoming.

Kalemli-Özcan, Sebnem, "U.S. Monetary Policy and International Risk Spillovers," NBER Working Papers 26297, National Bureau of Economic Research, Inc September 2019.

Kilian, Lutz, "Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market," *American Economic Review*, 2009, *99* (3), 1053–1069.

_ , "Measuring global real economic activity: Do recent critiques hold up to scrutiny?," 2019.

Kim, Soyoung, "International transmission of U.S. monetary policy shocks: Evidence from VAR's," *Journal of Monetary Economics*, October 2001, *48* (2), 339–372.

Litterman, Robert B, "Forecasting with Bayesian Vector Autoregressions-Five Years of Experience," *Journal of Business & Economic Statistics*, January 1986, *4* (1), 25–38.

Mackowiak, Bartosz, "External shocks, U.S. monetary policy and macroeconomic fluctuations in emerging markets," *Journal of Monetary Economics*, November 2007, *54* (8), 2512–2520.

Melosi, Leonardo, "Signaling Effects of Monetary Policy," *Review of Economic Studies*, 2017, *forthcoming.*

Mertens, Karel and Morten O. Ravn, "The Dynamic Effects of Personal and Corporate Income Tax Changes in the United States," *American Economic Review*, 2013, *103* (4), 1212–47.

Miranda-Agrippino, Silvia and Giovanni Ricco, "The Transmission of Monetary Policy Shocks," Economic Research Papers 269310, University of Warwick - Department of Economics February 2017.

_ **and Hélène Rey**, "World Asset Markets and the Global Financial Cycle," NBER Working Papers 21722, National Bureau of Economic Research, Inc November 2015.

Passari, Evgenia and Hélène Rey, "Financial Flows and the International Monetary System," *Economic Journal*, May 2015, *0* (584), 675–698.

Ramey, Valerie, "How important is the credit channel in the transmission of monetary policy?," *Carnegie-Rochester Conference Series on Public Policy*, 1993, *39*, 1 – 45.

Ramey, Valerie A., "Macroeconomic Shocks and Their Propagation," Working Paper 21978, National Bureau of Economic Research February 2016.

Reinhardt, Dennis and Steven J Riddiough, "The Two Faces of Cross-Border Banking Flows," *IMF Economic Review*, November 2015, *63* (4), 751–791.

Rey, Hélène, "Dilemma not trilemma: the global cycle and monetary policy independence," *Proceedings - Economic Policy Symposium - Jackson Hole*, 2013, pp. 1–2.

_ , "International Channels of Transmission of Monetary Policy and the Mundellian Trilemma," *IMF Economic Review*, May 2016, *64* (1), 6–35.

Rogers, John H., Chiara Scotti, and Jonathan H. Wright, "Evaluating asset-market effects of unconventional monetary policy: a multi-country review," *Economic Policy*, October 2014, *29* (80), 749–799.

— , — , and — , “Unconventional Monetary Policy and International Risk Premia,” *Journal of Money, Credit and Banking*, 2018, *50* (8), 1827–1850.

Romer, Christina D. and David H. Romer, “Federal Reserve Information and the Behavior of Interest Rates,” *American Economic Review*, 2000, *90* (3), 429–457.

Sims, Christopher A. and Tao Zha, “Bayesian Methods for Dynamic Multivariate Models,” *International Economic Review*, November 1998, *39* (4), 949–68.

Stavrakeva, Vania and Jenny Tang, “Exchange rates and monetary policy,” Working Papers 15-16, Federal Reserve Bank of Boston October 2015.

Stock, James H. and Mark Watson, “Disentangling the Channels of the 2007-09 Recession,” *Brookings Papers on Economic Activity*, 2012, *43* (1 (Spring)), 81–156.

Temesvary, Judit, Steven Ongena, and Ann L. Owen, “A global lending channel unplugged? Does U.S. monetary policy affect cross-border and affiliate lending by global U.S. banks?,” *Journal of International Economics*, 2018, *112* (C), 50–69.

Tenreyro, Silvana and Gregory Thwaites, “Pushing on a String: US Monetary Policy Is Less Powerful in Recessions,” *American Economic Journal: Macroeconomics*, October 2016, *8* (4), 43–74.

Uribe, Martin and Vivian Z Yue, “Country spreads and emerging countries: Who drives whom?,” *Journal of international Economics*, 2006, *69* (1), 6–36.

Vicondoa, Alejandro, “Monetary news in the United States and business cycles in emerging economies,” *Journal of International Economics*, 2019, *117* (C), 79–90.

Online Appendix to
The Global Transmission of U.S. Monetary Policy

Riccardo Degasperi* Seokki Simon Hong†

University of Warwick University of Warwick

Giovanni Ricco‡

University of Warwick, CEPR, OFCE-SciencesPo and Now-Casting Economics

First Version: 31 May 2019

This version: 24 March 2020

Abstract

This Online Appendix provides additional tables and charts.

Keywords: Monetary policy, Trilemma, Exchange Rates, Foreign Spillovers.

JEL Classification: E5, F3, F4, C3.

*Department of Economics, The University of Warwick. Email: R.Degasperi@warwick.ac.uk

†Department of Economics, The University of Warwick. Email: S.Hong.3@warwick.ac.uk

‡Department of Economics, The University of Warwick, The Social Sciences Building, Coventry, West Midlands CV4 7AL, UK. Email: G.Ricco@warwick.ac.uk Web: www.giovanni-ricco.com

A Data Appendix

List of Tables in Appendix

A.1 Global variables . . . III
A.2 Endogenous set for the 'median economy' exercises . . . IV
A.3 Data coverage . . . V
A.4 Data coverage (cont'd) . . . VI
A.5 Data sources for endogenous variables . . . VII
A.6 Data sources for endogenous variables (cont'd) . . . VIII
A.7 Sources of short term interest rates . . . IX
A.8 Classification of countries by Financial Market Openness . . . X
A.9 Classification of countries by Exchange Rate Regimes . . . XI
A.10 Classification of EMEs by Trade Invoicing in Dollars . . . XI
A.11 Classification of EMEs by Gross Dollar Exposure . . . XII
A.12 Country coverage for EME asymmetric responses . . . XIII
A.13 Variables Used . . . XIV

Table A.1: Global variables

Variable Name	Description	Source	Code	Start date	End date	Logs	RW
OECD Production	OECD production, total industry excl. construction, SA	Datastream	OCOPRI35G	1975:01	2019:06	•	•
OECD CPI	OECD CPI, All items, NSA	Datastream	OCOCP009F	1975:01	2019:07	•	•
OECD Stock Price	OECD Stock price index (excl. North America), EoM	Datastream	TOTMKEF(PI) U$	1975:01	2019:09	•	•
Interest Rate Differential	Average of 15 advanced economies minus US, short term	IMF, OECD, FRED		1989:06	2019:01		
Euro per USD	Exchange rate, National currency per US dollar, EoM	BIS		1975:01	2019:01	•	
GBP per USD	Exchange rate, National currency per US dollar, EoM	IMF		1975:01	2019:02	•	
JPY per USD	Exchange rate, National currency per US dollar, EoM	IMF		1975:01	2019:02	•	
Global Financial Conditions Index	Short-term credit spreads, weighted average	CrossBorder Capital	CBCFCI	1975:01	2019:03	•	
Global Risk Appetite	Composite index, Equity minus Bond exposure index, weighted average	CrossBorder Capital	CBCRA	1978:05	2019:03		
Global Cross-border Flows Index	Net, all financial flows into a currency, weighted average	CrossBorder Capital	CBCXFI	1976:01	2019:03	•	
Global Fixed Income Holdings	Holdings of government and corporate fixed income, weighted average	CrossBorder Capital	CBCFIHUSD	1975:01	2019:10	•	•
Global Equity Holdings	Holdings of listed equities, weighted average	CrossBorder Capital	CBCEHUSD	1975:01	2019:10	•	•
Global Economic Activity	Kilian (2018) Global Economic Activity Index	Lutz Kilian		1975:01	2018:12		
Commodity Price	CRB commodity price index	Datastream	T80440 U$	1975:01	2019:09	•	•
Oil Price	Crude oil dated Brent U$/BBL, EoM	Datastream	S219FD U$	1975:01	2019:01	•	•
US Production	Production of total industry, SA	OECD MEI		1975:01	2018:12	•	•
US CPI	US CPI, All items, NSA	OECD		1975:01	2018:12	•	•
US Stock Price	US Stock price index, EoM	Datastream	TOTMKUS(PI) U$	1975:01	2019:09	•	•
US Export-Import ratio	US Exports as a percentage of imports	OECD		1975:01	2019:03		•
US Trade Volume	US Exports plus imports	OECD		1975:01	2019:03	•	•
US Nominal Effective Exchange Rate	BIS Nominal effective exchange rate, narrow basket	BIS		1975:01	2019:01	•	•
US 10Y Treasury Rate	US 10-year treasury constant maturity rate, EoM	FRED	DGS10	1975:01	2019:01		
US Financial Conditions Index	Short-term credit spreads	CrossBorder Capital	CBCFCI	1975:01	2019:03	•	
US Risk Appetite	Composite index, Equity exposure index minus Bond exposure index	CrossBorder Capital	CBCRA	1978:05	2019:03		
US Cross-border Flows Index	Net, all financial flows into a currency	CrossBorder Capital	CBCXFI	1976:01	2019:03	•	
US Fixed Income Holdings	Holdings of government and corporate fixed income	CrossBorder Capital	CBCFIHUSD	1975:01	2019:10	•	•
US Equity Holdings	Holdings of listed equities	CrossBorder Capital	CBCEHUSD	1975:01	2019:10	•	•
Excess Bond Premium	Gilchrist and Zakrajšek excess bond premium	FRED		1975:01	2019:08		
VIX	Chicago Board Options Exchange, CBOE volatility index	FRED	VIXCLS	1990:01	2018:09	•	
1Y Treasury Rate	US 1-year treasury constant maturity rate, EoM	FRED	DGS1	1975:01	2019:01		

Notes: The table lists all variables included in the analysis of the reaction of global aggregates to a US monetary policy shock (Chapter 3). The first part of the table contains the global aggregates, and the second part contains the US variables included. *Log* indicates logarithmic transformations. *RW Prior* indicates assignment of a random walk prior vis-à-vis a white noise prior. The monetary policy variable used is the US one-year treasury constant maturity rate. Estimation sample: 1990:01 – 2018:09.

TABLE A.2: Endogenous set for the ‘median economy’ exercises

Foreign set	Logs	RW Prior	U.S. set	Logs	RW Prior
Industrial Production Index	•	•	US Industrial Production Index	•	•
Consumer Price Index	•	•	US Consumer Price Index	•	•
Core CPI Index	•	•	US Core CPI Index	•	•
Nominal Stock Price Index	•	•	US Nominal Stock Price Index	•	•
Export/Import ratio		•	US Export/Import ratio		•
Trade Volume	•	•	US Trade Volume	•	•
Nominal USD Exchange Rate	•	•	US Nominal Effective Exchange Rate	•	•
Short-term Interest Rate			US 10-Year Treasury Constant Maturity Rate		
Policy Rate			US Financial Conditions Index, CBC	•	
Long-term Interest Rate			US Risk Appetite, CBC		
Financial Conditions Index, CBC	•		US Cross-Border Flows Index, CBC	•	
Risk Appetite, CBC			US Fixed Income Holdings, CBC	•	•
Cross-Border Flows Index, CBC	•		US Equity Holdings, CBC	•	•
Fixed Income Holdings, CBC	•	•	US Excess Bond Premium		
Equity Holdings, CBC	•	•	CBOE VIX	•	
	•	•	US 1-year Treasury constant maturity rate		
Global price of Brent Crude	•	•			
Kilian (2019) Global Economic Activity Index					

Notes: The table lists all variables used in the ‘median country’ exercises (Chapters 4 and 5). Due to data availability, Core CPI, Fixed Income and Equity Holdings are used only in the endogenous set of AEs. The left part of the table displays the endogenous variables of the foreign economy, while the right part contains US endogenous variables. The bottom contains global controls that are part of the endogenous set. *Log* indicates logarithmic transformations. *RW Prior* indicates assignment of a random walk prior vis-à-vis a white noise prior. The monetary policy variable used is the US one-year treasury constant maturity rate.

Table A.3: Data coverage

	Industrial Prod.	CPI	Core CPI	Stock Price	Export	Import	Exchange Rate	Short-term Rate
Australia	1975:01 - 2019:05	1986:11 - 2018:12	1975:01 - 2019:06	1975:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1975:01 - 2019:01
Austria	1975:01 - 2018:10	1975:01 - 2018:12	1975:01 - 2019:06	1975:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1989:06 - 2019:01
Belgium	1975:01 - 2018:11	1975:01 - 2019:01	1976:06 - 2019:07	1975:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1975:01 - 2019:01
Brazil	1975:01 - 2018:11	1979:12 - 2018:12	1991:01 - 2018:12	1994:07 - 2019:09	1975:01 - 2019:04	1975:01 - 2019:04	1975:01 - 2019:02	1982:12 - 2019:01
Canada	1975:01 - 2018:10	1975:01 - 2018:12	1975:01 - 2019:06	1975:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1975:01 - 2019:04
Chile	1991:01 - 2018:06	1975:01 - 2018:08	1978:12 - 2018:12	1989:07 - 2019:09	1975:01 - 2018:05	1975:01 - 2018:05	1975:01 - 2019:02	1985:01 - 2018:12
China	1990:01 - 2019:08	1986:01 - 2018:08	2008:01 - 2019:07	1994:05 - 2019:09	1992:01 - 2019:03	1992:01 - 2019:03	1975:01 - 2019:02	1990:01 - 2019:01
Colombia	1990:01 - 2018:11	1975:01 - 2018:12	1995:01 - 2019:07	1992:01 - 2019:09	1991:01 - 2019:03	1991:01 - 2019:03	1975:01 - 2019:02	1986:01 - 2019:01
Czech Rep.	1990:01 - 2018:11	1991:01 - 2018:11	1995:01 - 2019:06	1993:11 - 2019:09	1991:01 - 2019:03	1991:01 - 2019:03	1993:01 - 2019:02	1993:01 - 2018:12
Denmark	1975:01 - 2018:11	1975:01 - 2018:12	1975:01 - 2019:06	1975:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1987:01 - 2019:01
Finland	1975:01 - 2018:11	1975:01 - 2018:12	1976:06 - 2019:06	1975:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1975:01 - 2019:01
France	1975:01 - 2018:11	1975:01 - 2019:01	1975:01 - 2019:06	1975:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1989:02 - 2019:03
Germany	1975:01 - 2018:11	1975:01 - 2018:12	1975:01 - 2019:06	1975:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1975:01 - 2019:01
Hungary	1985:01 - 2018:11	1980:01 - 2018:12	1990:01 - 2019:07	1991:06 - 2019:09	1991:01 - 2019:02	1991:01 - 2019:02	1975:01 - 2019:02	1988:12 - 2019:01
India	1975:01 - 2018:08	1975:01 - 2018:04	NA	1990:01 - 2019:09	1990:01 - 2019:03	1990:01 - 2019:03	1975:01 - 2019:02	1993:01 - 2019:01
Italy	1975:01 - 2018:11	1975:01 - 2018:12	1975:01 - 2019:07	1975:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1978:10 - 2019:01
Japan	1975:01 - 2018:11	1975:01 - 2018:12	1975:01 - 2019:06	1975:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1986:07 - 2019:03
Malaysia	1975:01 - 2017:12	1975:01 - 2018:08	NA	1986:01 - 2019:09	1975:01 - 2018:03	1975:01 - 2018:03	1975:01 - 2019:02	1986:01 - 2019:09
Mexico	1980:01 - 2018:02	1975:01 - 2018:12	1980:01 - 2019:07	1988:01 - 2019:09	1980:01 - 2019:03	1980:01 - 2019:03	1975:01 - 2019:02	1978:01 - 2019:01
Netherlands	1975:01 - 2018:11	1975:01 - 2018:12	1975:01 - 2019:07	1975:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1982:01 - 2019:01
Norway	1975:01 - 2018:11	1975:01 - 2018:12	1979:01 - 2019:07	1980:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1979:01 - 2019:01
Philippines	1996:01 - 2018:07	1975:01 - 2018:07	2000:01 - 2019:07	1987:09 - 2019:09	1975:01 - 2018:02	1975:01 - 2018:02	1975:01 - 2019:02	1976:01 - 2018:12
Poland	1985:01 - 2018:12	1989:01 - 2018:12	1995:01 - 2019:06	1994:03 - 2019:09	1991:01 - 2019:02	1991:01 - 2019:02	1975:01 - 2019:01	1991:06 - 2019:01
Russia	1993:01 - 2018:11	1992:01 - 2018:12	2003:01 - 2019:07	1998:01 - 2019:09	1991:01 - 2019:03	1991:01 - 2019:03	1992:06 - 2018:08	1997:01 - 2018:12
South Africa	1975:01 - 2019:07	1975:01 - 2018:12	2002:01 - 2019:06	1975:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1975:01 - 2019:01
Spain	1975:01 - 2018:11	1975:01 - 2018:12	1976:01 - 2019:06	1987:03 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1977:01 - 2019:01
Sweden	1975:01 - 2018:11	1975:01 - 2018:12	1975:01 - 2019:06	1982:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1982:01 - 2019:01
Thailand	1999:01 - 2018:07	1975:01 - 2018:08	1984:12 - 2019:08	1987:01 - 2019:09	1975:01 - 2018:05	1975:01 - 2018:05	1975:01 - 2019:02	1992:01 - 2019:01
Turkey	1985:01 - 2018:10	1975:01 - 2018:12	1994:01 - 2019:06	1988:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1978:12 - 2019:01
UK	1975:01 - 2018:11	1975:01 - 2018:12	1975:01 - 2019:06	1975:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1985:02 - 2019:03
US	1975:01 - 2018:12	1975:01 - 2018:12	1975:01 - 2019:06	1975:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:01	1975:01 - 2019:01
Euro Area	1975:07 - 2019:08	1990:01 - 2019:09	1996:01 - 2019:09	1994:01 - 2019:09	1990:01 - 2019:08	1990:01 - 2019:08	1975:01 - 2019:01	1994:01 - 2019:01
Greece	1975:01 - 2018:11	1975:01 - 2018:12	2009:05 - 2019:05	1988:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1994:03 - 2019:01
Korea	1989:01 - 2018:11	1975:01 - 2018:12	1975:01 - 2019:08	1987:09 - 2019:09	1975:01 - 2019:04	1975:01 - 2019:04	1975:01 - 2019:02	1991:01 - 2018:12
Portugal	1975:01 - 2018:11	1975:01 - 2018:12	1977:01 - 2019:07	1990:01 - 2019:09	1975:01 - 2019:03	1975:01 - 2019:03	1975:01 - 2019:02	1985:08 - 2019:01

Notes: Greece, Korea and Portugal are not included in the analysis.

Table A.4: Data coverage (cont'd)

	Policy Rate	Long-term Rate	Fin. Conditions	Risk Appetite	Cross-Border Flows	Fixed Income Hold.	Equity Holdings
Australia	1976:04 - 2018:08	1975:01 - 2019:01	1975:01 - 2019:03	1978:05 - 2019:03	1975:01 - 2019:03	1988:04 - 2019:10	1975:01 - 2019:10
Austria	1975:01 - 2018:08	1975:01 - 2019:01	1975:01 - 2019:03	1978:05 - 2019:03	1976:01 - 2019:03	1989:10 - 2019:10	1975:01 - 2019:10
Belgium	1975:01 - 2019:01	1975:01 - 2019:01	1975:01 - 2019:03	1978:05 - 2019:03	1976:01 - 2019:03	1989:10 - 2019:10	1975:01 - 2019:10
Brazil	1986:06 - 2018:11	1999:12 - 2019:02	1976:02 - 2019:03	1991:12 - 2019:03	1980:01 - 2019:03	2002:01 - 2019:10	1993:10 - 2019:10
Canada	1975:01 - 2018:08	1975:01 - 2019:08	1975:01 - 2019:03	1978:05 - 2019:03	1976:01 - 2019:03	1989:01 - 2019:10	1975:01 - 2019:10
Chile	1995:05 - 2018:12	1994:08 - 2013:11	1976:04 - 2019:03	1978:05 - 2019:03	1980:01 - 2019:03	2002:10 - 2019:10	1975:12 - 2019:10
China	1990:03 - 2018:11	1990:01 - 2019:02	1982:01 - 2019:03	1994:08 - 2019:03	1982:10 - 2019:03	2000:10 - 2019:10	1993:07 - 2019:10
Colombia	1995:04 - 2018:12	2002:09 - 2019:02	1975:02 - 2019:03	1988:04 - 2019:03	1977:01 - 2019:03	1989:10 - 2019:10	1984:12 - 2019:10
Czech Rep.	1995:12 - 2018:12	2000:04 - 2019:01	1992:05 - 2019:03	1996:12 - 2019:03	1994:02 - 2019:03	2006:01 - 2019:10	1993:08 - 2019:10
Denmark	1975:01 - 2018:12	1983:05 - 2019:01	1975:01 - 2019:03	1978:05 - 2019:03	1976:01 - 2019:03	1999:10 - 2019:10	1975:01 - 2019:10
Finland	1975:01 - 2019:01	1975:01 - 2019:01	1975:01 - 2019:03	1978:05 - 2019:03	1976:01 - 2019:03	1989:10 - 2019:10	1975:01 - 2019:10
France	1975:01 - 2019:01	1975:01 - 2018:12	1975:01 - 2019:03	1978:05 - 2019:03	1976:01 - 2019:03	1989:10 - 2019:10	1975:01 - 2019:10
Germany	1975:01 - 2019:01	1975:01 - 2019:02	1975:01 - 2019:03	1978:05 - 2019:03	1976:01 - 2019:03	1989:10 - 2019:10	1975:01 - 2019:10
Hungary	1987:01 - 2018:12	1999:02 - 2019:01	1977:02 - 2019:02	1994:10 - 2019:02	1977:01 - 2019:02	1997:10 - 2019:10	1991:06 - 2019:10
India	1975:01 - 2018:11	1994:05 - 2019:02	1975:02 - 2019:03	1978:05 - 2019:03	1977:01 - 2019:03	1998:10 - 2019:10	1975:01 - 2019:10
Italy	1975:01 - 2019:01	1980:01 - 2019:01	1975:01 - 2019:03	1978:05 - 2019:03	1976:01 - 2019:03	1989:10 - 2019:10	1975:01 - 2019:10
Japan	1975:01 - 2019:01	1975:01 - 2019:01	1975:01 - 2019:03	1978:05 - 2019:03	1976:03 - 2019:03	1997:10 - 2019:10	1975:01 - 2019:10
Malaysia	1995:11 - 2018:12	1996:01 - 2019:02	1975:02 - 2019:03	1983:05 - 2019:03	1977:01 - 2019:03	2005:01 - 2019:10	1980:01 - 2019:10
Mexico	1998:11 - 2018:12	1980:01 - 2019:02	1975:02 - 2019:03	1981:04 - 2019:03	1978:01 - 2019:03	2005:10 - 2019:10	1975:01 - 2019:10
Netherlands	1985:06 - 2019:01	1975:01 - 2018:12	1975:01 - 2019:03	1978:05 - 2019:03	1976:01 - 2019:03	1989:10 - 2019:10	1975:01 - 2019:10
Norway	1982:04 - 2018:12	1985:01 - 2019:01	1975:01 - 2019:03	1983:05 - 2019:03	1976:01 - 2019:03	1995:10 - 2019:10	1980:01 - 2019:10
Philippines	1986:01 - 2018:12	1999:02 - 2019:02	1975:02 - 2019:03	1978:05 - 2019:03	1976:04 - 2019:03	2015:01 - 2019:10	1975:01 - 2019:10
Poland	1993:01 - 2018:12	2001:10 - 2019:02	1975:02 - 2019:02	1994:08 - 2019:02	1989:03 - 2019:02	2003:10 - 2019:10	1991:04 - 2019:10
Russia	1992:01 - 2018:11	1999:01 - 2018:06	1993:02 - 2019:03	1997:10 - 2019:03	1995:02 - 2019:03	2004:01 - 2019:10	1994:06 - 2019:10
South Africa	1980:12 - 2018:12	1975:01 - 2019:01	1975:02 - 2019:03	1978:05 - 2019:03	1976:03 - 2019:03	1975:01 - 2019:10	1975:01 - 2019:10
Spain	1975:01 - 2019:01	1978:03 - 2019:01	1975:01 - 2019:03	1978:05 - 2019:03	1976:01 - 2019:03	1989:10 - 2019:10	1975:01 - 2019:10
Sweden	1975:01 - 2019:01	1975:01 - 2019:01	1975:01 - 2019:03	1978:05 - 2019:03	1976:01 - 2019:03	2001:10 - 2019:10	1975:01 - 2019:10
Thailand	1994:01 - 2019:01	1979:12 - 2019:02	1975:02 - 2019:03	1979:10 - 2019:03	1976:04 - 2019:03	1989:10 - 2019:10	1976:06 - 2019:10
Turkey	1986:04 - 2019:01	2000:06 - 2019:01	1975:02 - 2019:03	1991:05 - 2019:03	1980:01 - 2019:03	2003:10 - 2019:10	1995:12 - 2019:10
UK	1975:01 - 2018:12	1975:01 - 2018:08	1975:01 - 2019:03	1978:05 - 2019:03	1976:05 - 2019:03	1987:01 - 2019:10	1975:01 - 2019:10
US	1975:01 - 2019:01	1975:01 - 2019:01	1975:01 - 2019:03	1978:05 - 2019:03	1976:01 - 2019:03	1975:01 - 2019:10	1975:01 - 2019:10
Euro Area	1999:01 - 2019:01	1975:01 - 2019:09	1975:01 - 2019:03	1978:05 - 2019:03	1976:01 - 2019:03	1989:10 - 2019:10	1975:01 - 2019:10
Greece	1975:01 - 2019:01	1997:06 - 2018:12	1975:02 - 2019:03	1979:04 - 2019:03	1976:10 - 2019:03	1995:01 - 2019:10	1975:01 - 2019:10
Korea	1975:01 - 2018:12	2000:10 - 2018:12	1975:02 - 2019:03	1978:05 - 2019:03	1976:04 - 2019:03	2002:04 - 2019:10	1975:01 - 2019:10
Portugal	1975:01 - 2019:03	1993:07 - 2019:01	1975:02 - 2019:03	1984:05 - 2019:03	1977:01 - 2019:03	1989:10 - 2019:10	1981:01 - 2019:10

Notes: Greece, Korea and Portugal are not included in the analysis.

Table A.5: Data sources for endogenous variables

	Industrial Prod.	CPI	Core CPI	Stock Price	Export	Import	Exchange Rate	Short-term Rate
Australia	Datastream	Datastream	Datastream	Datastream	OECD MEI	OECD MEI	IMF IFS	OECD MEI
Austria	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	OECD MEI
Belgium	OECD MEI	OECD MEI	Datastream	Datastream	OECD MEI	OECD MEI	IMF IFS	Datastream
Brazil	OECD MEI	OECD MEI	Datastream	Datastream	OECD MEI	OECD MEI	IMF IFS	IMF IFS
Canada	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	IMF IFS
Chile	Datastream	IMF IFS	Datastream	Datastream	IMF IFS	IMF IFS	IMF IFS	IMF IFS
China	Datastream	IMF IFS	Datastream	Datastream	OECD MEI	OECD MEI	IMF IFS	Datastream
Colombia	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	OECD MEI
Czech Rep.	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	OECD MEI
Denmark	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	OECD MEI
Finland	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	IMF IFS
France	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	IMF IFS
Germany	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	OECD MEI
Hungary	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	IMF IFS
India	IMF IFS	IMF IFS	NA	Datastream	IMF IFS	IMF IFS	IMF IFS	Datastream
Italy	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	OECD MEI
Japan	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	IMF IFS
Malaysia	IMF IFS	IMF IFS	NA	Datastream	IMF IFS	IMF IFS	IMF IFS	IMF IFS
Mexico	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	OECD MEI
Netherlands	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	OECD MEI
Norway	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	OECD MEI
Philippines	Datastream	IMF IFS	Datastream	Datastream	IMF IFS	IMF IFS	IMF IFS	IMF IFS
Poland	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	OECD MEI
Russia	OECD MEI	OECD MEI	Datastream	Datastream	OECD MEI	OECD MEI	IMF IFS	OECD MEI
South Africa	Datastream	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	IMF IFS
Spain	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	OECD MEI
Sweden	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	IMF IFS
Thailand	Datastream	IMF IFS	Datastream	Datastream	IMF IFS	IMF IFS	IMF IFS	Datastream
Turkey	Datastream	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	IMF IFS
UK	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	IMF IFS	BOE
US	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	BIS	OECD MEI
Euro Area	OECD MEI	OECD MEI	OECD MEI	Datastream	OECD MEI	OECD MEI	BIS	OECD MEI

Notes: acronyms correspond to the following sources. IMF IFS: IMF International Financial Statistics database; OECD MEI: OECD Main Economic Indicators database; Datastream: Thomson-Reuters Datastream database; BIS: Bank of International Settlements Statistics warehouse; CBC: CrossBorder Capital.

TABLE A.6: Data sources for endogenous variables (cont'd)

	Policy Rate	Long-term Rate	Fin. Conditions	Risk Appetite	Cross-Border Flows	Fixed Income Hold.	Equity Holdings
Australia	BIS	IMF IFS	CBC	CBC	CBC	CBC	CBC
Austria	ECB	IMF IFS	CBC	CBC	CBC	CBC	CBC
Belgium	ECB	Datastream	CBC	CBC	CBC	CBC	CBC
Brazil	BIS	IMF IFS	CBC	CBC	CBC	CBC	CBC
Canada	BIS	IMF IFS	CBC	CBC	CBC	CBC	CBC
Chile	IMF IFS	Datastream	CBC	CBC	CBC	CBC	CBC
China	OECD MEI	Datastream	CBC	CBC	CBC	CBC	CBC
Colombia	BIS	Datastream	CBC	CBC	CBC	CBC	CBC
Czech Rep.	BIS	IMF IFS	CBC	CBC	CBC	CBC	CBC
Denmark	BIS	IMF IFS	CBC	CBC	CBC	CBC	CBC
Finland	OECD MEI	IMF IFS	CBC	CBC	CBC	CBC	CBC
France	ECB	IMF IFS	CBC	CBC	CBC	CBC	CBC
Germany	IMF IFS	OECD MEI	CBC	CBC	CBC	CBC	CBC
Hungary	BIS	OECD MEI	CBC	CBC	CBC	CBC	CBC
India	BIS	Datastream	CBC	CBC	CBC	CBC	CBC
Italy	ECB	IMF IFS	CBC	CBC	CBC	CBC	CBC
Japan	OECD MEI	Datastream	CBC	CBC	CBC	CBC	CBC
Malaysia	BIS	Datastream	CBC	CBC	CBC	CBC	CBC
Mexico	BIS	Datastream	CBC	CBC	CBC	CBC	CBC
Netherlands	ECB	IMF IFS	CBC	CBC	CBC	CBC	CBC
Norway	Norges Bank	OECD MEI	CBC	CBC	CBC	CBC	CBC
Philippines	BIS	Datastream	CBC	CBC	CBC	CBC	CBC
Poland	BIS	OECD MEI	CBC	CBC	CBC	CBC	CBC
Russia	BIS	OECD MEI	CBC	CBC	CBC	CBC	CBC
South Africa	BIS	IMF IFS	CBC	CBC	CBC	CBC	CBC
Spain	ECB	IMF IFS	CBC	CBC	CBC	CBC	CBC
Sweden	Riksbank	IMF IFS	CBC	CBC	CBC	CBC	CBC
Thailand	Datastream	IMF IFS	CBC	CBC	CBC	CBC	CBC
Turkey	IMF IFS	IMF IFS	CBC	CBC	CBC	CBC	CBC
UK	BIS	IMF IFS	CBC	CBC	CBC	CBC	CBC
US	FRED	OECD MEI	CBC	CBC	CBC	CBC	CBC
Euro Area	BIS	OECD MEI	CBC	CBC	CBC	CBC	CBC

Notes: acronyms correspond to the following sources. IMF IFS: IMF International Financial Statistics database; OECD MEI: OECD Main Economic Indicators database; Datastream: Thomson-Reuters Datastream database; BIS: Bank of International Settlements Statistics warehouse; CBC: CrossBorder Capital.

Table A.7: Sources of short term interest rates

	Short-term interest rate	Source
Australia	Interbank 3 Month	OECD MEI
Austria	VIBOR 3 month	OECD MEI
Belgium	T-bill Rate (3 months)	Datastream
Brazil	Deposit Rate (90 day)	IMF IFS
Canada	T-bill Rate (3 months)	IMF IFS
Chile	Deposit Rate (90 day)	IMF IFS
China	Deposit Rate (90 day)	Datastream
Colombia	Deposit Rate (90 day)	OECD MEI
Czech Rep.	PRIBOR 3 Month	OECD MEI
Denmark	CIBOR 3 Month	OECD MEI
Finland	HELIBOR 3 Month	IMF IFS
France	T-bill Rate (3 months)	IMF IFS
Germany	FIBOR 3 Month	OECD MEI
Hungary	T-bill Rate (3 months)	IMF IFS
India	Lending Rate	Datastream
Italy	T-bill Rate (3 months)	OECD MEI
Japan	T-bill Rate (3 months)	IMF IFS
Malaysia	T-bill Rate (3 months)	IMF IFS
Mexico	T-bill Rate (3 months)	OECD MEI
Netherlands	AIBOR 3 month	OECD MEI
Norway	NIBOR 3 month	OECD MEI
Philippines	Deposit Rate (90 day)	IMF IFS
Poland	WIBOR 3 month	OECD MEI
Russia	Interbank 1-3 Month	OECD MEI
South Africa	T-bill Rate (3 months)	IMF IFS
Spain	Interbank 3 Month	OECD MEI
Sweden	T-bill Rate (3 months)	IMF IFS
Thailand	Interbank 1 Month	Datastream
Turkey	Deposit Rate (90 day)	IMF IFS
UK	T-bill Rate (3 months)	Bank of England

Table A.8: Classification of countries by Financial Market Openness

Chinn-Ito Index, the Sample Average					
ADVANCED	Australia	0.828	EMERGING	Brazil	0.369
	Austria	0.968		Chile	0.635
	Belgium	0.968		China	0.166
	Canada	1		Colombia	0.403
	Denmark	0.994		Czech Rep.	0.951
	Finland	0.968		Hungary	0.907
	France	0.948		India	0.166
	Germany	1		Malaysia	0.411
	Italy	0.948		Mexico	0.674
	Japan	0.989		Philippines	0.389
	Netherlands	0.990		Poland	0.476
	Norway	0.895		Russia	0.465
	Spain	0.905		South Africa	0.169
	Sweden	0.946		Thailand	0.284
	UK	1		Turkey	0.323
ADVANCED	MEDIAN	0.968	EMERGING	MEDIAN	0.403
	TOP 33%	0.989		TOP 33%	0.469
	BOTTOM 33%	0.948		BOTTOM 33%	0.354
	ST.DEV	0.048		ST.DEV	0.245

	Advanced		Emerging	
	Open (Top 33%)	Less Open (Bottom 33%)	Open (Top 33%)	Less Open (Bottom 33%)
	Canada	Australia	Chile	Brazil
	Denmark	France	Czech Rep.	India
	Germany	Italy	Hungary	South Africa
	Netherlands	Norway	Mexico	Thailand
	UK	Spain	Poland	Turkey
		Sweden		
Sample Average	0.997	0.912	0.729	0.222

Notes: The measure of financial openness is the arithmetic mean of the *ka_ open* index from Chinn and Ito (2006), which has the value from 0 (mostly closed) to 1 (mostly open). The sample is 1990 – 2017 for AEs, but it varies among EMEs: from 1990:01 - 2019:09 for the longest (South Africa) to 2002:09 - 2018:09 for the shortest (Colombia).

Table A.9: Classification of countries by Exchange Rate Regimes

Ilzetzki-Reinhart-Rogoff (2019) Fine Classification				
Floats	Managed floats	Median IRR	Crawling pegs	Median IRR
14 AEs*	Brazil	12	China	5
Czech Republic	Canada	12	India	7
Hungary	Chile	12	Philippines	10
Poland	Colombia	12	Thailand	11
	Mexico	12		
	South Africa	12		

Notes: Medians across sample period of each country. 12: +/- 5% moving band; 11: +/- 2% moving band; 10: crawling band +/- 5%; 7: de facto crawling peg; 5: pre-announced crawling peg. Czech Republic, Hungary, and Poland are classified as floaters, since their currencies are anchored to Euro.
* 14 AEs are all of the AEs in our sample minus Canada. The median value of all 14 countries is 14, which corresponds to a freely floating regime in the Ilzetzki et al. (2019) classification.

Table A.10: Classification of EMEs by Trade Invoicing in Dollars

	Exports			Imports		
Country	Avg. shares	High	Low	Avg. shares	Top 1/3	Bottom 1/3
Brazil	0.943	•		0.844	•	
Chile	NA			NA		
China	NA			NA		
Colombia	0.990	•		0.990	•	
Czech Rep.	0.136		•	0.192		•
Hungary	0.181		•	0.265		•
India	0.864	•		0.855	•	
Malaysia	0.9	•		0.9*	•	
Mexico	NA			NA		
Philippines	NA			NA		
Poland	0.305		•	0.303		•
Russia	NA			NA		
South Africa	0.52			0.52*		•
Thailand	0.821			0.789		
Turkey	0.461		•	0.591		
MEDIAN	0.670			0.690		
TOP 33%	0.864			0.844		
BOTTOM 33%	0.461			0.52		

Notes: Data from Gopinath (2015). Numbers in the second and fourth columns represent the average share of exports/imports into a country invoiced in US dollars, averaged across all years starting from 1999. We calculate the average, top and bottom tertile values excluding 5 countries with no data available (indicated as 'NA'). A country belongs to the 'High' group if its share of exports/imports invoiced in the USD corresponds to the top tertile and the 'low' group if it falls below the bottom tertile among 10 EMEs listed above.
* Only exports invoicing data are available for Malaysia and South Africa. We assume that import USD invoicing shares are roughly the same as the export ones for these two countries.

Table A.11: Classification of EMEs by Gross Dollar Exposure

Country	Total USD Assets + Liabilities	High Exposure	Low Exposure
Brazil	35.443		
Chile	80.519	•	
China	38.887		
Colombia	44.310		
Czech Rep.	30.494		•
Hungary	28.121		•
India	24.684		•
Malaysia	78.865	•	
Mexico	45.227		
Philippines	55.743	•	
Poland	20.216		•
Russia	61.570	•	
South Africa	30.956		•
Thailand	47.550	•	
Turkey	38.548		
MEDIAN	38.887		
TOP 33%	46.001		
BOTTOM 33%	33.947		

Notes: We construct a measure of gross dollar exposure for each country by taking the sum of total USD assets and liabilities as a share of domestic GDP, from the dataset of Bénétrix et al. (2015). Numbers in the second column represent the average of this measure over the sample, which varies from 1990:01 – 2019:09 for the longest (South Africa) to 2002:09 – 2018:09 for the shortest (Colombia). A country belongs to the 'High exposure' group if its gross dollar exposure corresponds to the top tertile and the 'Low exposure' group if it falls below the bottom tertile among 15 EMEs listed above.

Table A.12: Country coverage for EME asymmetric responses

Countries	Estimation Sample	Countries	Estimation Sample
Brazil	1990:01 - 2018:09	Malaysia	1990:01 - 2017:12
Chile	1991:01 - 2018:06	Mexico	1990:01 - 2018:02
China	1990:12 - 2018:08	Philippines	1990:01 - 2018:07
Colombia	1992:01 - 2018:09	Poland	1991:06 - 2018:09
Czech Rep.	1993:11 - 2018:09	South Africa	1990:01 - 2018:09
Hungary	1991:06 - 2018:09	Turkey	1990:01 - 2018:09
India	1993:01 - 2018:04		

Notes: The set of endogenous variables includes five main local indicators: industrial production, CPI, stock prices, exchange rate, and short-term interest rate. It also includes all US variables detailed in Table A.2, the global controls and CRB commodity price index. The end-of-month stock price series is interpolated backwards by regressing it on the monthly average stock prices by simple OLS regression and obtaining the fitted values for Brazil (from 1994:07 to 1990:01), China (from 1994:05 to 1990:12), and Poland (from 1994:03 to 1991:05). For the Philippines, we interpolate backwards industrial production from 1996:01 to 1990:01 by using Kalman filter techniques and exploiting the correlations obtained from a BVAR(12) estimated on all indicators for the Philippines.

Table A.13: Variables Used

Variable	Source	Transformation: log	Transformation: RW Prior	Model (1)	Model (2)	Model (3)	Model (4)
Industrial Production Index	OECD	•	•	√	√	√	√
CPI	OECD	•	•	√	√	√	√
Core CPI	OECD	•	•	√	√		
Nominal Stock Price Index	Datastream	•	•	√	√	√	√
Export/Import ratio	OECD		•	√	√	√	√
Trade Volume	OECD	•	•	√	√	√	√
Nominal USD Exchange Rate	BIS	•	•	√	√	√	√
Short-term Interest Rate	OECD			√	√	√	√
Policy Rate	BIS			√	√	√	
Long-term Interest Rate	IMF			√	√	√	
Financial Conditions Index, CBC	CBC	•		√	√	√	
Risk Appetite, CBC	CBC			√	√	√	
Cross-Border Flows Index, CBC	CBC	•		√	√	√	√
Fixed Income Holdings, CBC	CBC	•	•	√			
Equity Holdings, CBC	CBC	•	•	√			
Global price of Brent Crude	FRED	•	•	√	√	√	√
Global Economic Activity Index	Kilian (2019)			√	√	√	√
CRB Commodity Price Index	Datastream	•	•				√
US Industrial Production Index	OECD	•	•	√	√	√	√
US CPI	OECD	•	•	√	√	√	√
US Core CPI	OECD	•	•	√	√		
US Nominal Stock Price Index	Datastream	•	•	√	√	√	√
US Export/Import ratio	OECD		•	√	√	√	√
US Trade Volume	OECD	•	•	√	√	√	√
US Nominal Effective Exchange Rate	BIS	•	•	√	√	√	√
US 10-Year Treasury Constant Maturity Rate	FRED			√	√	√	
US Financial Conditions Index, CBC	CBC	•		√	√	√	
US Risk Appetite, CBC	CBC			√	√	√	
US Cross-Border Flows Index, CBC	CBC	•		√	√	√	√
US Fixed Income Holdings, CBC	CBC	•	•	√			
US Equity Holdings, CBC	CBC	•	•	√			
US Excess Bond Premium	FRED			√	√	√	√
CBOE VIX	FRED	•		√	√	√	√
US 1-Year Treasury Constant Maturity Rate	FRED			√	√	√	√

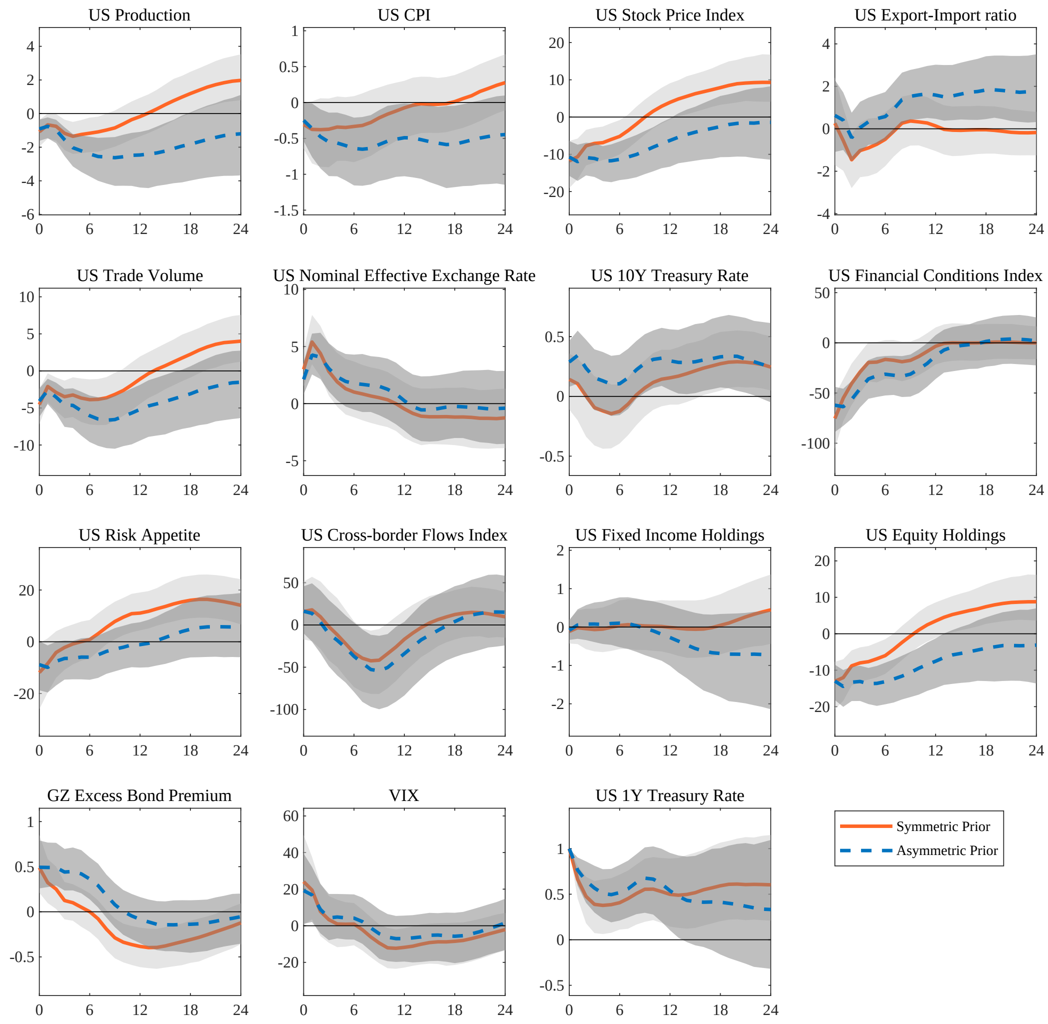
Models: (1) Bilateral BVAR specification for AEs in Section 4, Euro Area in Section 6, AE groups based on capital openness measures in Section 7, and asymmetric effects of the shocks in AEs in Section 8; (2) specification for the study of transmission channels in AEs in Section 4; (3) specification for EMEs in Section 5 (the same specification is used for the analysis of transmission channels), for Mexico, China, and India in Section 6, and all other group exercises in Section 7; (4) specification for the analysis of asymmetric effects of the shocks across EMEs in Section 8.

B Additional Charts

List of Figures in Appendix

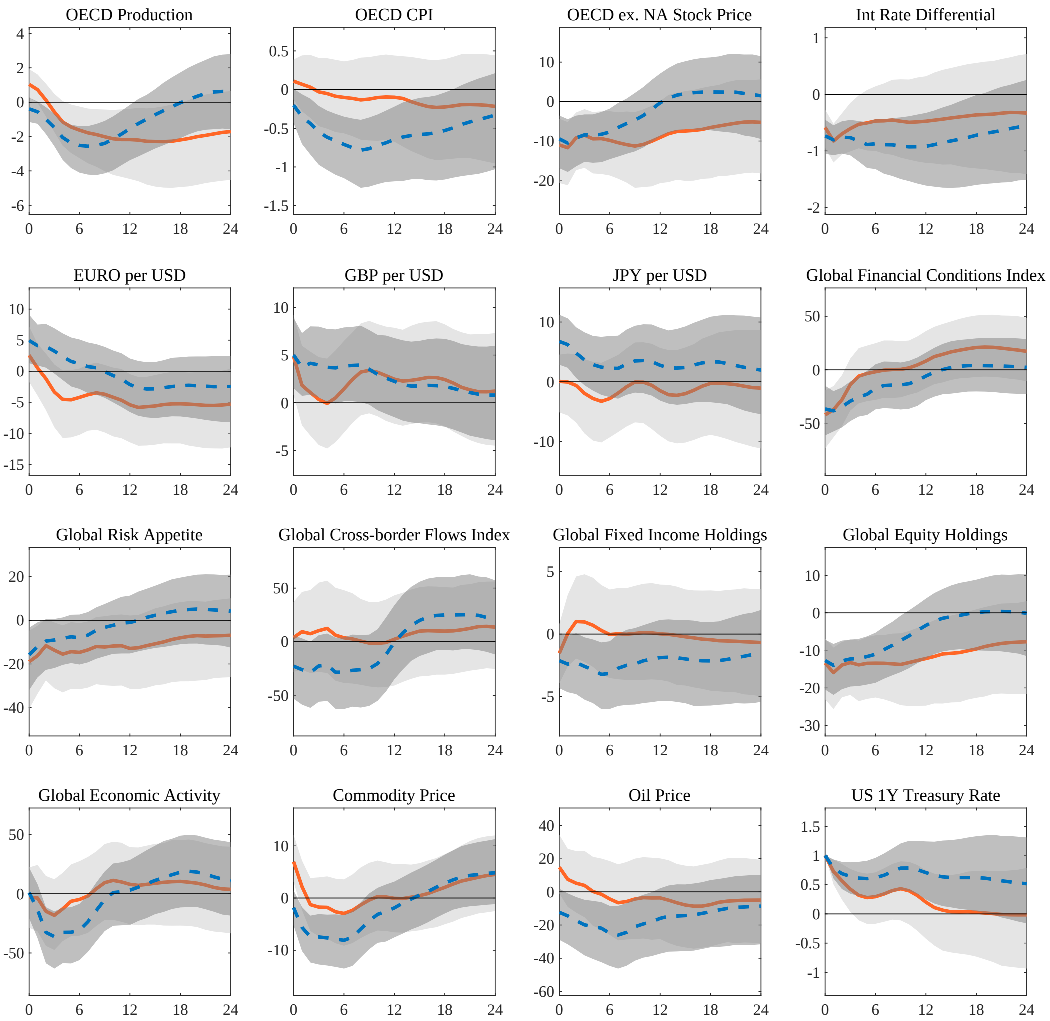
B.1 NIW v. Asymmetric Prior comparison, US XVI
B.2 Asymmetric shocks, the Global economy XVII
B.3 Channels, the Global economy XVIII
B.4 Nominal exchange rate, local currency/USD, Advanced Economies XIX
B.5 Stock Prices, Advanced Economies XIX
B.6 Long-term rates, Advanced Economies XX
B.7 Cross-border Flows, Advanced Economies XX
B.8 Trade volume, Advanced Economies XXI
B.9 Asymmetric shocks, Advanced Economies XXII
B.10 Channels, Advanced Economies XXIII
B.11 Stock Prices, Emerging Economies XXIV
B.12 Long-term rates, Emerging Economies XXIV
B.13 Cross-border Flows, Emerging Economies XXV
B.14 Channels, Emerging Economies XXVI
B.15 Emerging Economies by USD Trade Invoicing XXVII
B.16 Emerging Economies by Gross USD Exposures XXVIII
B.17 EMEs by capital control, Fernandez et al. (2016) XXIX

FIGURE B.1: NIW v. ASYMMETRIC PRIOR COMPARISON, US



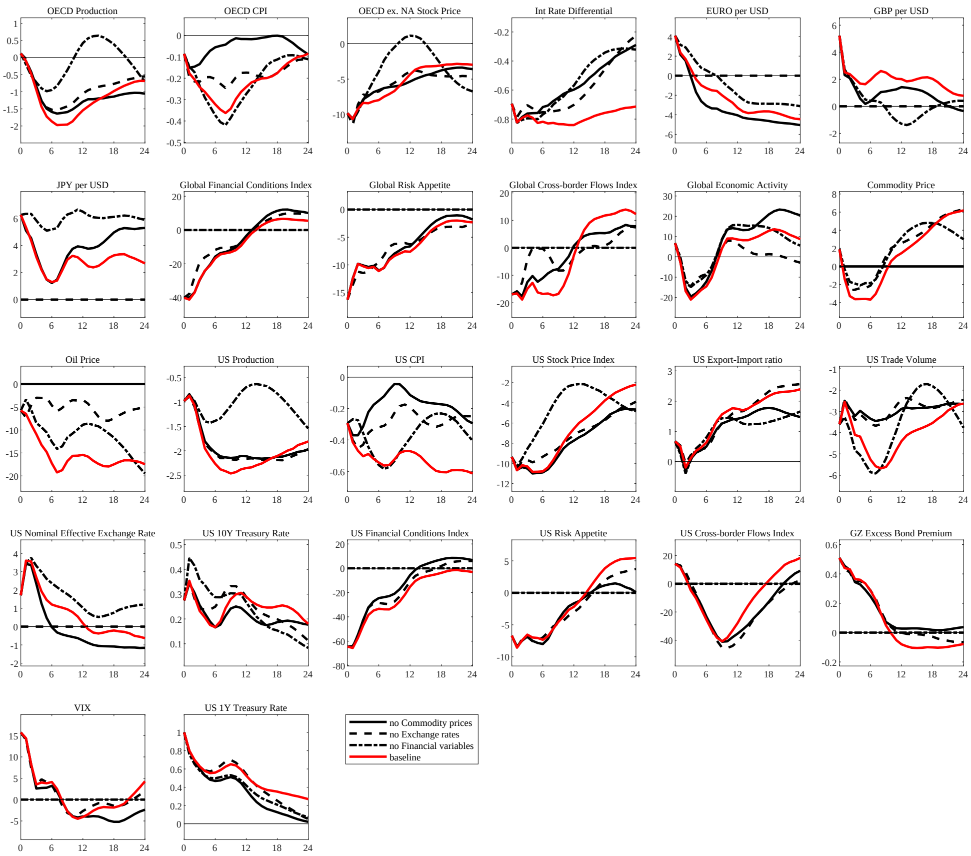
Note: Solid orange line – BVAR(12) with optimal tightness hyperparameter computed as in Giannone et al. (2015). Dashed blue line – with asymmetric priors, following Chan (2019). Domestic responses to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. Sample 1990:01 – 2018:09. Shaded areas are 90% posterior coverage bands.

Figure B.2: Asymmetric shocks, the Global economy



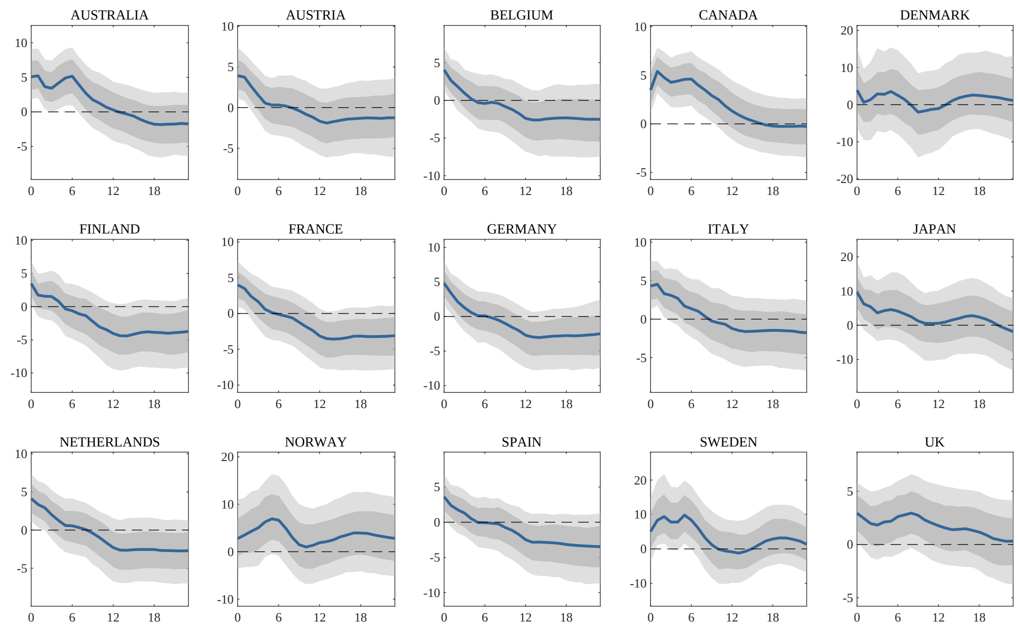
Note: Solid orange line – global responses to a contractionary US monetary policy shock. Dashed blue line – global responses to an expansionary US monetary policy shock. Shocks are normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample 1990:01 – 2018:09. BVAR(12) with asymmetric conjugate priors. Shaded areas are 90% posterior coverage bands.

Figure B.3: Channels, the Global economy



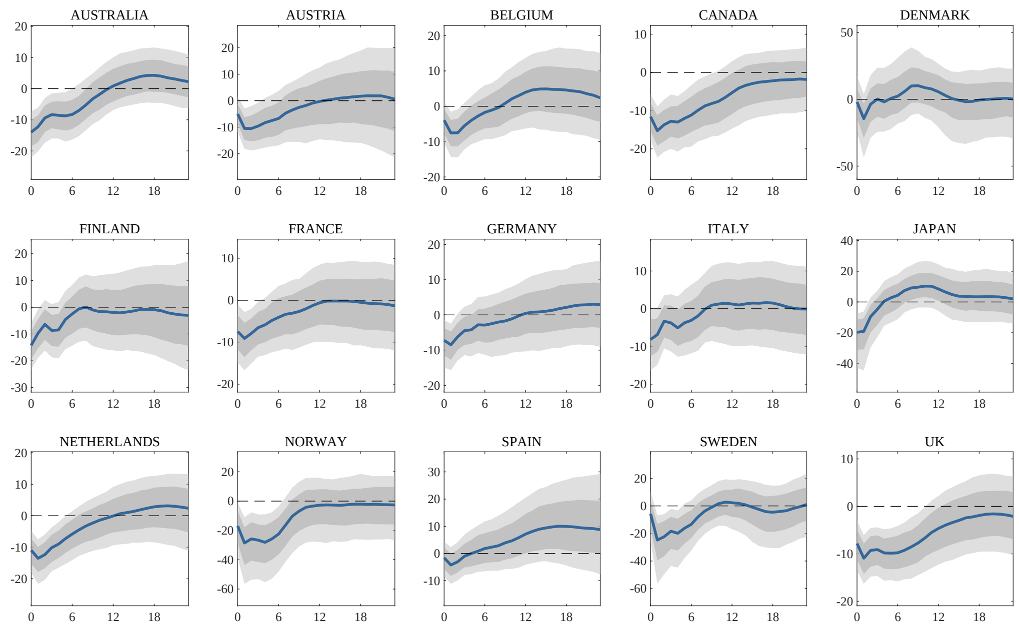
Note: Lines correspond to impulse responses obtained with the baseline specification (solid red); assuming the Brent crude and commodity prices do not react (solid black); assuming the nominal exchange rates do not react (dashed black); finally, assuming financial conditions, risk appetite cross-border flows, the excess bond premium, and VIX do not react (dash-dotted black). Shock is normalised to induce a 100 basis point increase in the 1-year rate. High-frequency identification. Sample 1990:01 - 2018:09. BVAR(12).

Figure B.4: Nominal exchange rate, local currency/USD, Advanced Economies



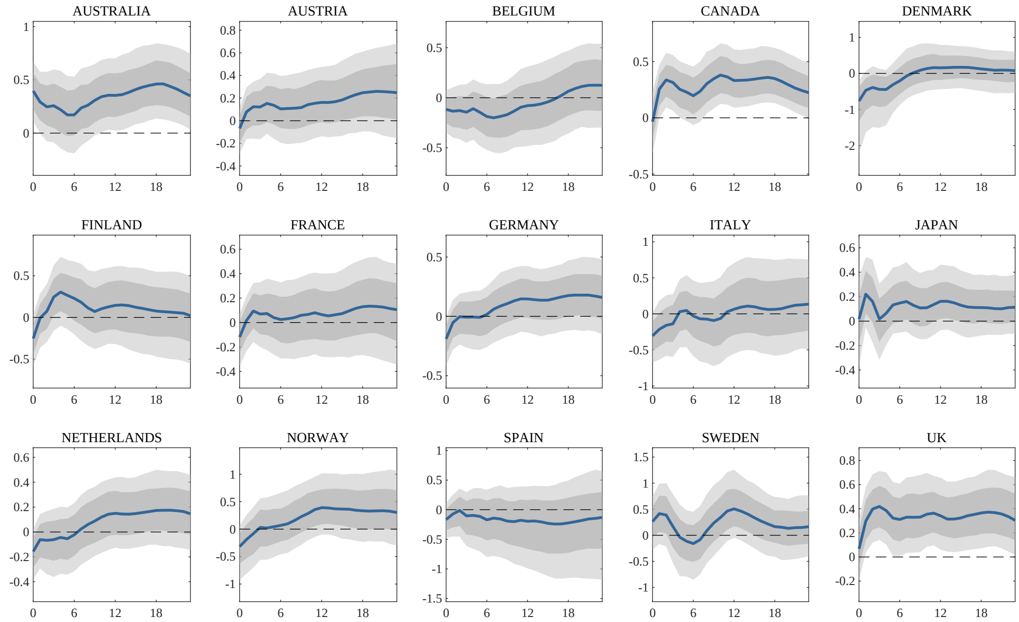
Note: Responses of nominal exchange rate in 15 advanced economies to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample reported in Table 1 (in the paper). BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

Figure B.5: Stock Prices, Advanced Economies



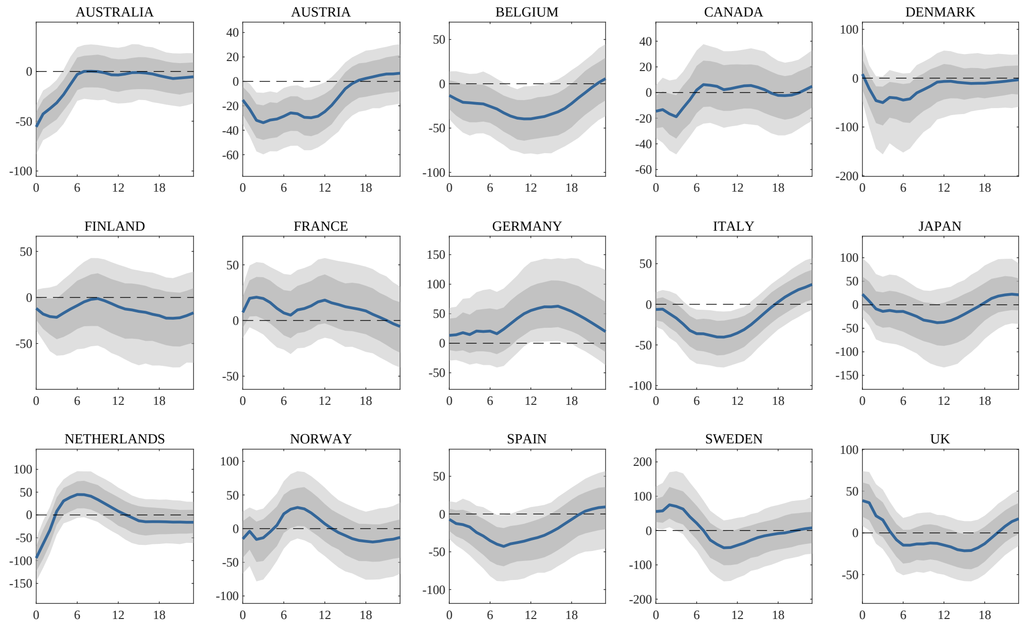
Note: Responses of stock price indices in 15 advanced economies to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample reported in Table 1 (in the paper). BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

Figure B.6: Long-term rates, Advanced Economies



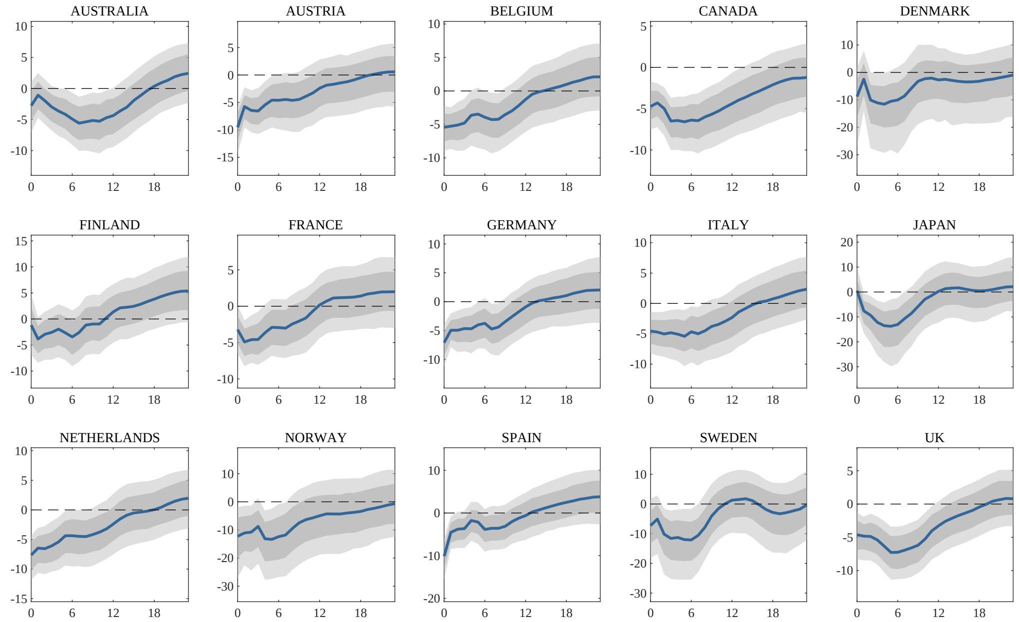
Note: Responses of long-term government bond yields in 15 advanced economies to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample reported in Table 1 (in the paper). BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

Figure B.7: Cross-border Flows, Advanced Economies



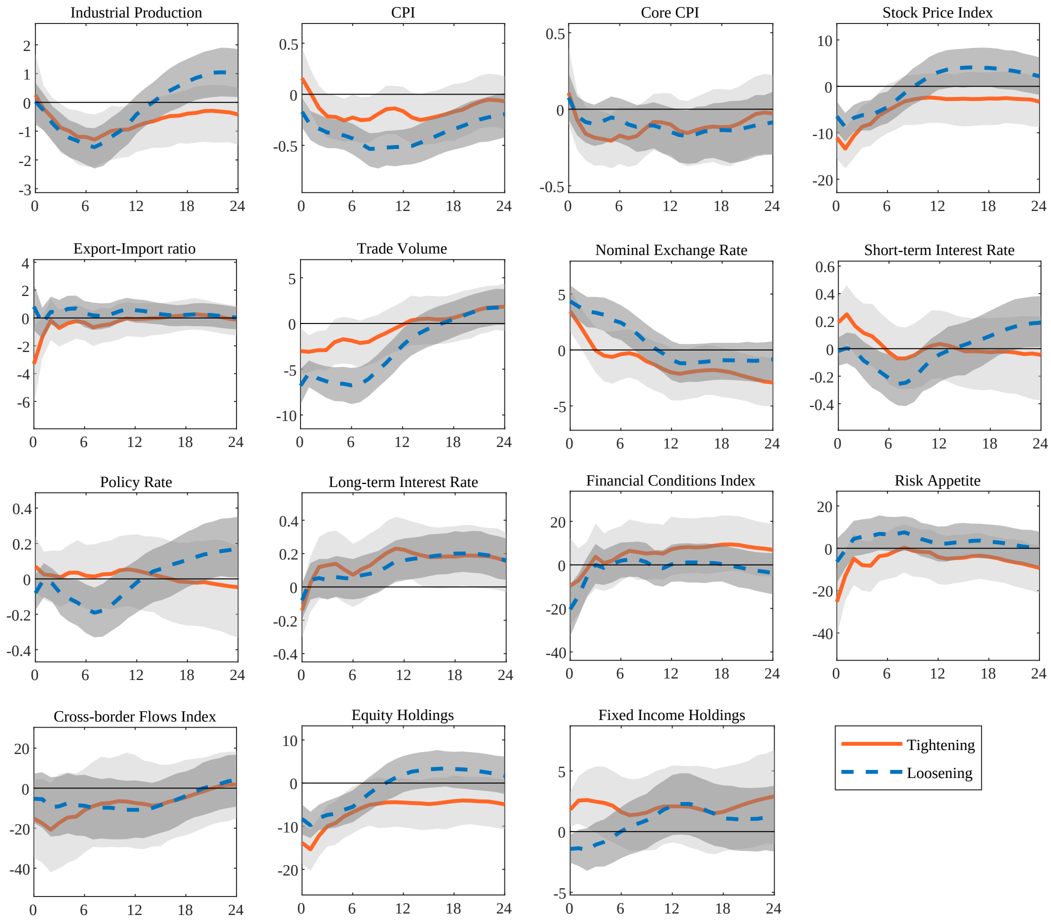
Note: Responses of cross-border flows in 15 advanced economies to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample reported in Table 1 (in the paper). BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

FIGURE B.8: TRADE VOLUME, ADVANCED ECONOMIES



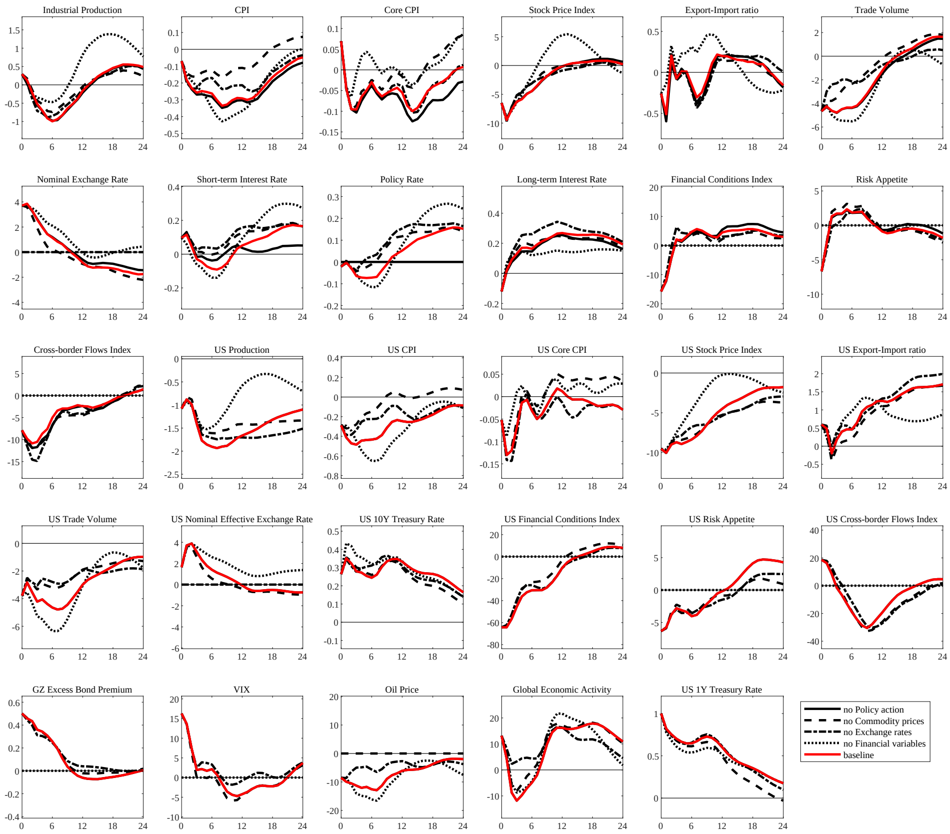
Note: Responses of trade volume in 15 advanced economies to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample reported in Table 1 (in the paper). BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

Figure B.9: Asymmetric shocks, Advanced Economies



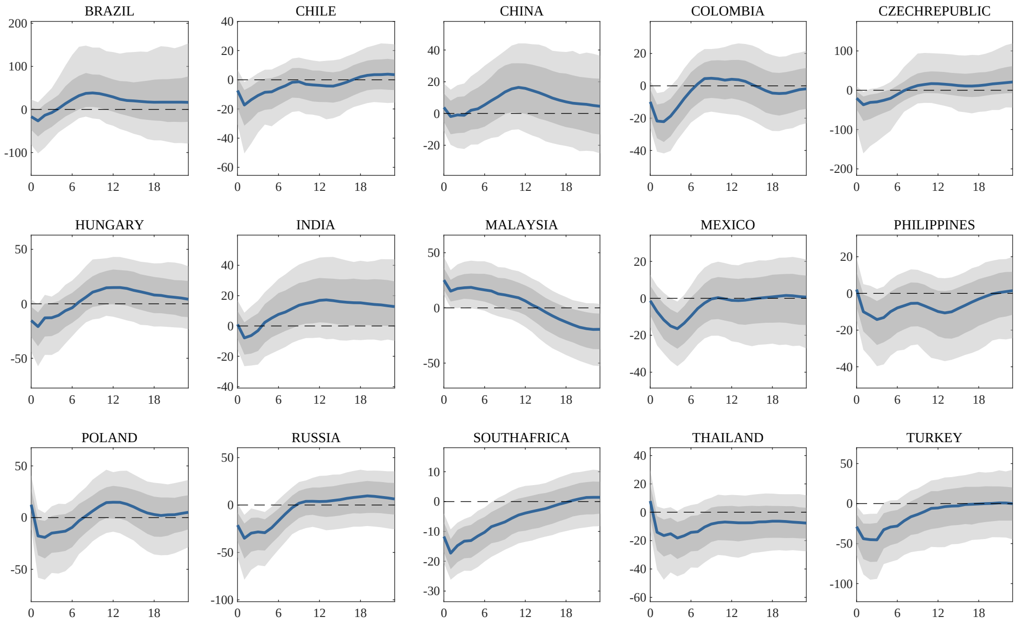
Note: Solid orange line – median responses of 15 advanced economies to a contractionary US monetary policy shock. Dashed blue line – median responses of 15 advanced economies to an expansionary US monetary policy shock. Shocks are normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample reported in Table 1 (in the paper). BVAR(12) with asymmetric conjugate priors. Shaded areas are 90% posterior coverage bands.

Figure B.10: Channels, Advanced Economies



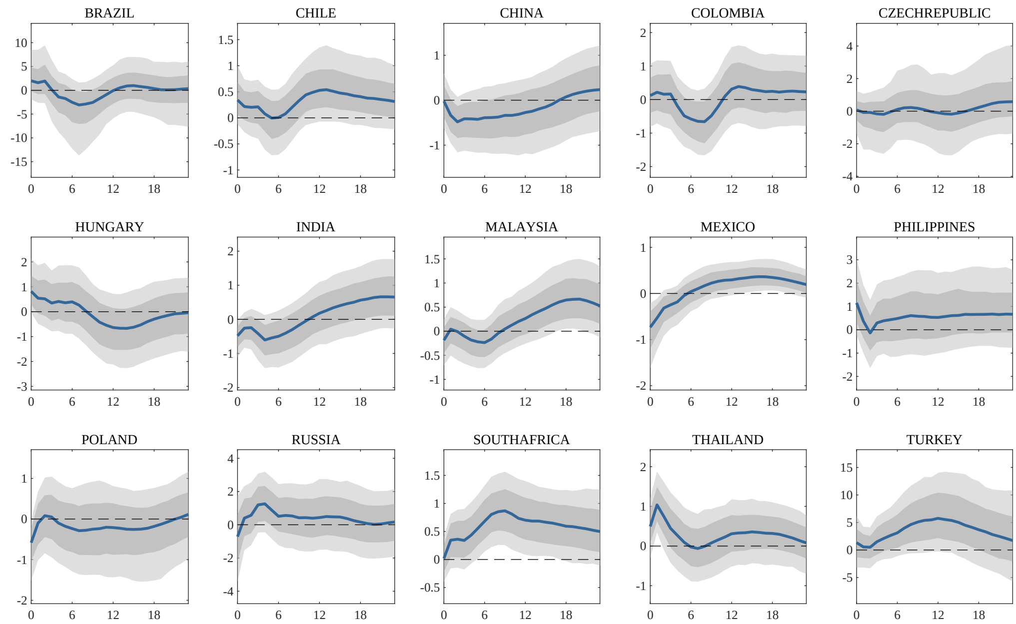
Note: Lines correspond to impulse responses obtained with the baseline specification (solid red); assuming the policy rate does not react (solid black); the Brent crude and commodity prices do not react (dashed black); exchange rates do not react (dashed-dotted black); financial conditions, risk appetite, cross-border flows, the excess bond premium, and VIX do not react (dotted black). Shock is normalised to induce a 100 basis point increase in the 1-year rate. High-frequency identification. Sample reported in Table 1 (in the paper). BVAR(12).

Figure B.11: Stock Prices, Emerging Economies



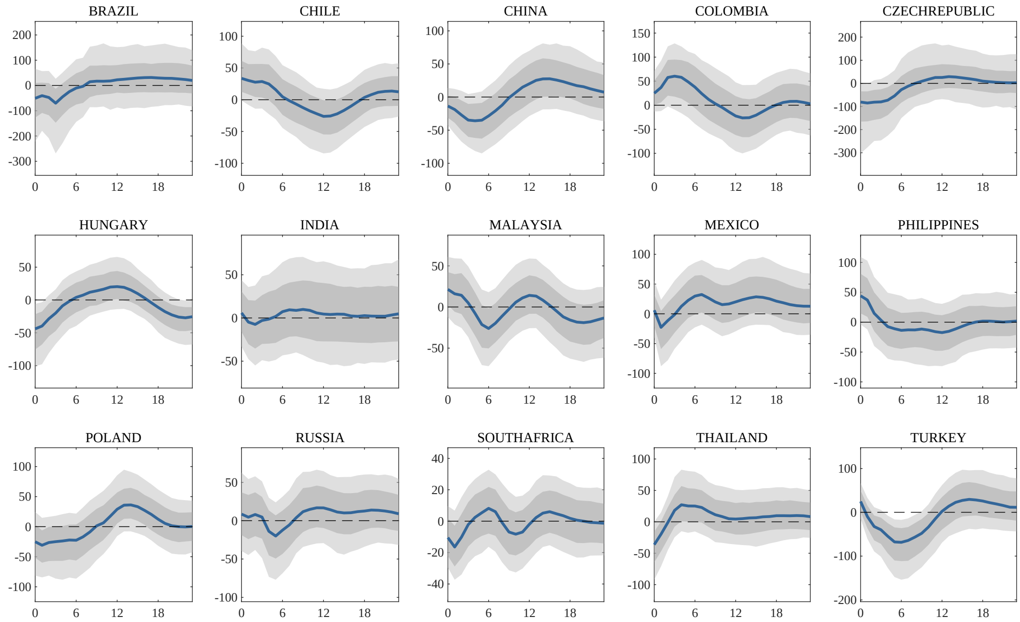
Note: Responses of stock price indices in 15 emerging economies to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample reported in Table 1 (in the paper). BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

Figure B.12: Long-term rates, Emerging Economies



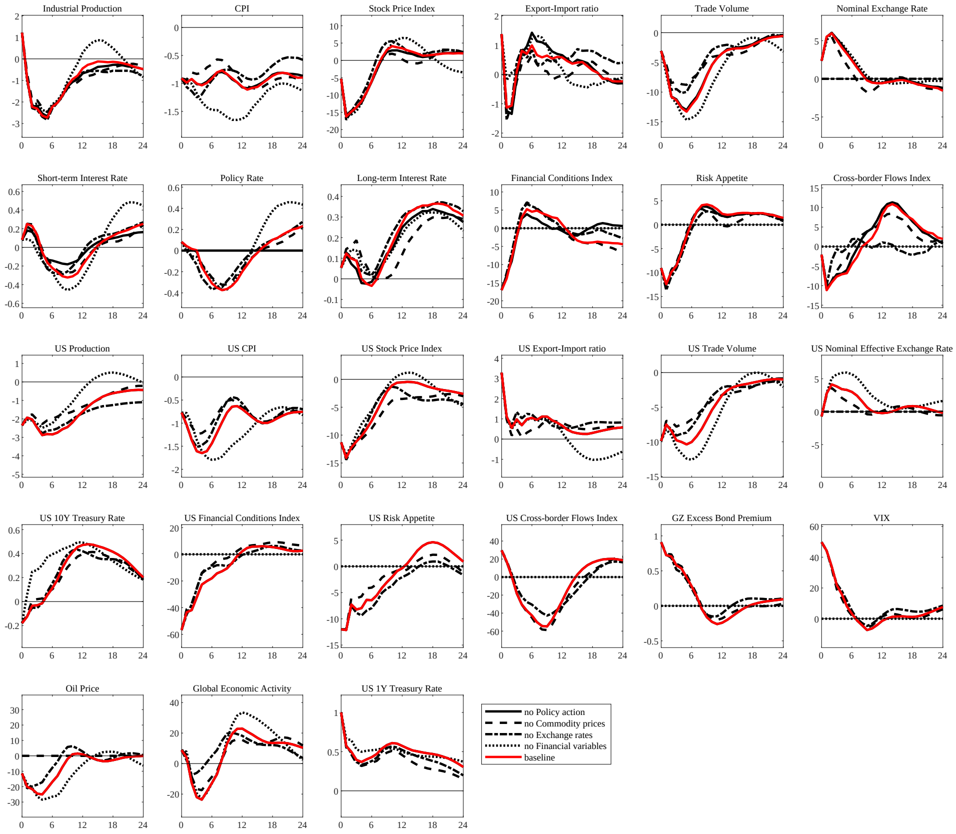
Note: Responses of long-term government bond yields in 15 emerging economies to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification.Sample reported in Table 1 (in the paper). BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

Figure B.13: Cross-border Flows, Emerging Economies



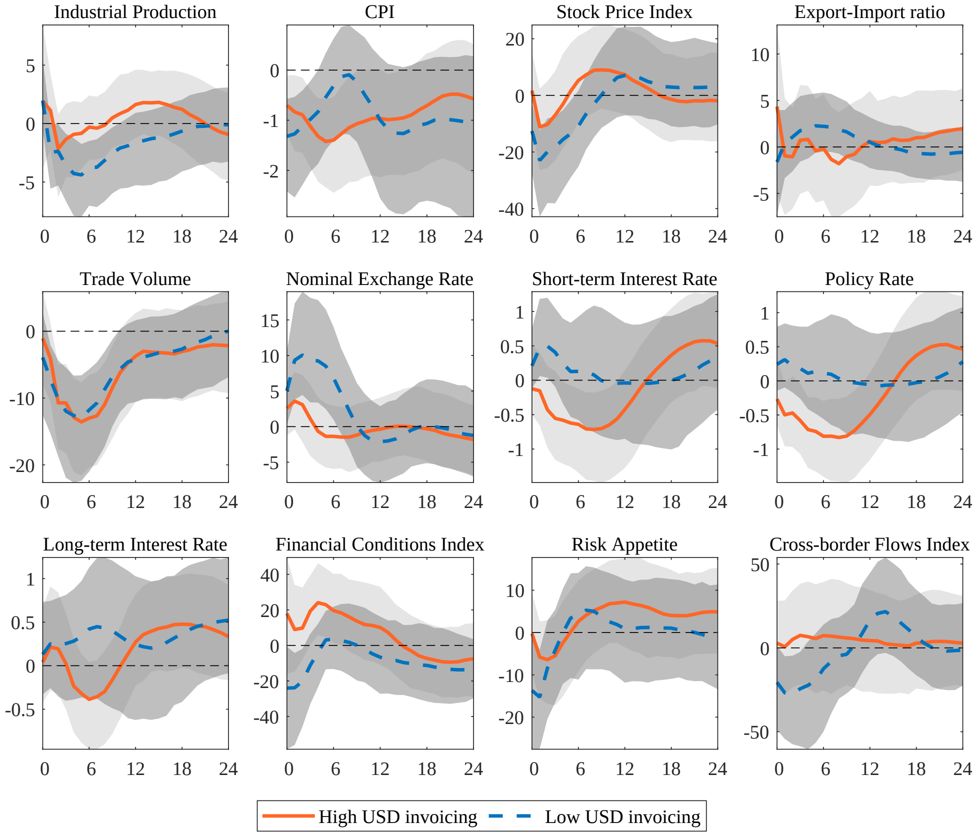
Note: Responses of cross-border flows in 15 emerging economies to a contractionary US monetary policy shock, normalised to induce a 100 basis point increase in the 1-year rate. High frequency identification. Sample reported in Table 1 (in the paper). BVAR(12) with asymmetric conjugate priors. Shaded areas are 68% and 90% posterior coverage bands.

Figure B.14: Channels, Emerging Economies



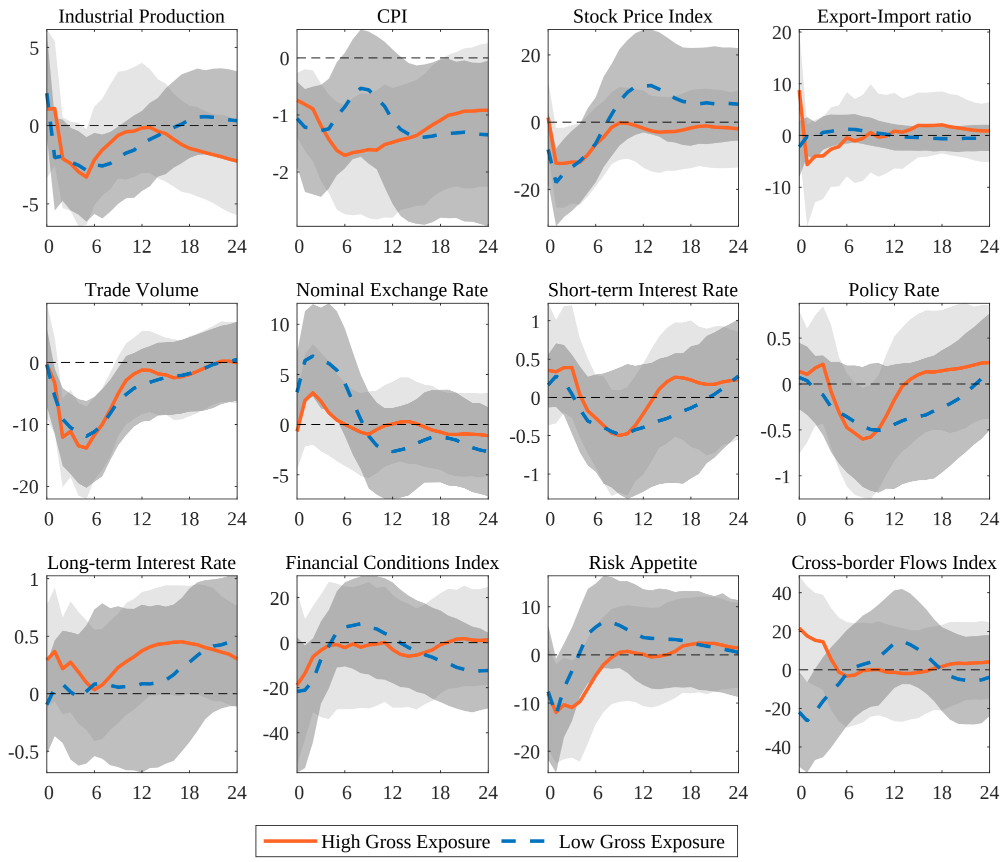
Note: Lines correspond to impulse responses obtained with the baseline specification (solid red); assuming the policy rate does not react (solid black); the Brent crude and commodity prices do not react (dashed black); exchange rates do not react (dashed-dotted black); financial conditions, risk appetite, cross-border flows, the excess bond premium, and VIX do not react (dotted black). Shock is normalised to induce a 100 basis point increase in the 1-year rate. High-frequency identification. Sample reported in Table 1 (in the paper). BVAR(12).

Figure B.15: Emerging Economies by USD Trade Invoicing



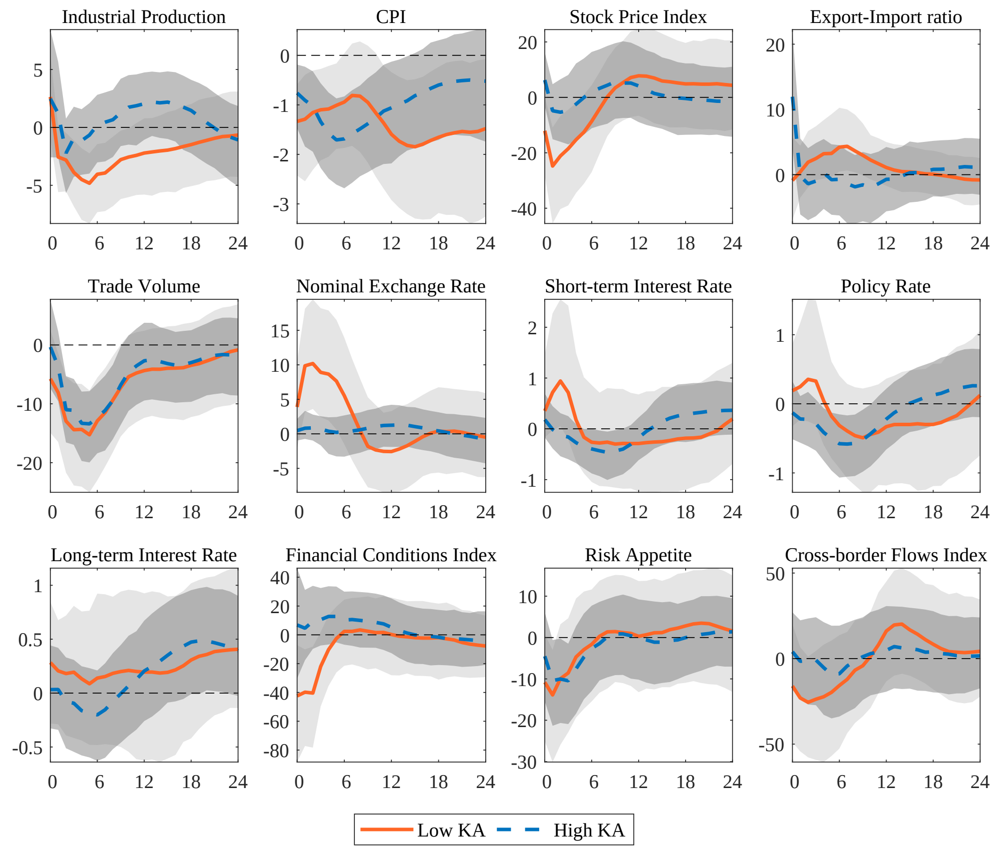
Note: Solid orange line – median responses of 5 emerging economies (Brazil, Colombia, Thailand, India, and Malaysia), whose USD trade invoicing both in terms of exports and imports corresponds to the top 1/3 among 15 EMEs. Dashed blue line – median responses of 5 emerging economies (Czech Republic, Hungary, Poland, Turkey and South Africa), whose USD trade invoicing both in terms of exports and imports corresponds to the bottom 1/3. Data on trade invoices in USD are from Gopinath (2015). Shock is normalised to induce a 100 basis point increase in the 1-year rate. BVAR (12). Shaded areas are 90% posterior coverage bands.

Figure B.16: Emerging Economies by Gross USD Exposures



Note: Solid orange line – median responses of 5 emerging economies (Chile, Malaysia, Philippines, Russia, and Thailand), whose gross USD exposure corresponds to the top 1/3 among 15 EMEs. Dashed blue line – median responses of 5 emerging economies (Czech Republic, Hungary, India, Poland, and South Africa), whose gross USD exposure corresponds to the bottom 1/3. Data on gross USD exposure are from Bénétrix et al. (2015). Shock is normalised to induce a 100 basis point increase in the 1-year rate. BVAR (12). Shaded areas are 90% posterior coverage bands.

FIGURE B.17: EMEs BY CAPITAL CONTROL, FERNANDEZ ET AL. (2016)



Note: Solid orange line – median responses of 5 emerging economies (Chile, Czech Republic, Hungary, Poland, and Turkey), whose overall capital restriction corresponds to the bottom 1/3 among 15 EMEs. Dashed blue line – median responses of 5 emerging economies (China, India, Malaysia, Philippines, and Thailand), whose overall capital restriction corresponds to the top 1/3. Data on overall capital restriction are from Fernández et al. (2016b). Shock is normalised to induce a 100 basis point increase in the 1-year rate. BVAR (12). Shaded areas are 90% posterior coverage bands.

References

Bénétrix, Agustin S., Philip R. Lane, and Jay C. Shambaugh, "International currency exposures, valuation effects and the global financial crisis," *Journal of International Economics*, 2015, *96* (S1), 98–109.

Chan, Joshua C. C., "Asymmetric conjugate priors for large Bayesian VARs," CAMA Working Papers 2019-51, Centre for Applied Macroeconomic Analysis, Crawford School of Public Policy, The Australian National University July 2019.

Chinn, Menzie and Hiro Ito, "What matters for financial development? Capital controls, institutions, and interactions," *Journal of Development Economics*, 2006, *81* (1), 163–192.

Fernández, Martin Andrés, Michael Klein, Alessandro Rebucci, Martin Schindler, and Martin Uribe, "Capital Control Measures: A New Dataset," *IMF Economic Review*, 2016, *64* (3), 548–574.

Giannone, Domenico, Michele Lenza, and Giorgio E. Primiceri, "Prior Selection for Vector Autoregressions," *The Review of Economics and Statistics*, May 2015, *2* (97), 436–451.

Gopinath, Gita, "The International Price System," NBER Working Papers 21646, National Bureau of Economic Research, Inc October 2015.

Ilzetzki, Ethan, Carmen M Reinhart, and Kenneth S Rogoff, "Exchange Arrangements Entering the Twenty-First Century: Which Anchor will Hold?," *The Quarterly Journal of Economics*, 2019, *134* (2), 599–646.