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What Explains International Interest Rate Co-Movement?

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Abstract

We show that global supply and demand shocks are important drivers of interest rate co-movement across seven advanced economies. Beyond that, local structural shocks transmit internationally via aggregate demand channels, and central banks react predominantly to domestic macroeconomic developments: unexpected monetary policy tightening decreases most foreign interest rates, while expansionary local supply and demand shocks increase them. To disentangle determinants of international interest rate co-movement, we use a Bayesian structural panel vector autoregressive model accounting for latent global supply and demand shocks. We identify country-specific structural shocks via informative prior distributions based on a standard theoretical multi-country open economy model.

Keywords: informative priors, panel vector autoregressions, spillovers, structural vector autoregressions

JEL classification: C11, C30, E52, F42

1 Introduction

A large literature reports strong international interest rate co-movement. There are several possible sources behind this. On the one hand, common real economic developments could lead to synchronized actions by monetary policy authorities. These common real economic developments could be caused by global shocks, shifting structural relationships simultaneously in all countries. They might also be due to real cross-border spillovers, for example due to shifts of domestic aggregate demand with foreign output. Even if monetary policy only reacts to domestic developments, interest rates in several countries might move in a seemingly coordinated fashion in such cases. On the other hand, interest rate changes in one country might spill over directly to other countries, for example via exchange rate movements. Under such a mechanism, monetary policy would be an active driver of international interest rate developments. While the literature focuses on these sources individually, we disentangle different determinants of international interest rate reactions with a Bayesian structural panel VAR and quantify their respective importance.

Our results are twofold. First, we show that interest rate co-movement is predominantly driven by global demand and supply shocks. Domestic and global shocks together explain between 70% and 100% of the forecast error variance decomposition of interest rates. Second, if shocks transmit internationally, they do so mainly via an aggregate demand channel. This channel is relevant for expansionary global supply shocks, which thereby cause a delayed increase in interest rates. For country-specific shocks, we find that contractionary monetary policy shocks cause modest negative reactions in the majority of foreign interest rates, while expansionary supply and demand shocks raise foreign interest rates with a time lag. In comparison to spillovers via aggregate demand, the exchange rate channel is rather unimportant according to our results. Our findings support that monetary policy authorities in our sample mainly react endogenously to domestic rather than foreign economic developments.

We derive our results from a Bayesian structural panel vector autoregressive (BSPVAR) model including Australia (AU), Canada (CA), the Euro area (EA), Japan (JP), South Korea (KO), the United Kingdom (UK), and the United States (US).[1] We use data on the output gap, inflation, shadow rates and real effective exchange rates between 1980:Q3 and

[1]For simplicity, we use *currency area* and *country* interchangeably in the following.

2019:Q4. In our setup, it is possible to jointly identify country-specific structural monetary policy, supply and demand equations, which allows us to quantify international endogenous reactions of monetary policy, and exogenous monetary policy shocks. Specifically, we develop an open-economy version of the model of Baumeister and Hamilton (2018) and extend it to a multi-country framework. The Bayesian SVAR approach of Baumeister and Hamilton (2015, 2018) relies on informative priors on structural contemporaneous relationships; i.e., (semi-)elasticities of structural economic equations. To derive these priors, we make use of the open economy model of Lubik and Schorfheide (2007) and its closed economy version of Lubik and Schorfheide (2004) as main sources of information (the latter one is used in Baumeister and Hamilton, 2018).

Next to country-specific monetary policy, supply and demand shocks, we identify latent global supply and demand shocks in our model. We show that our global supply shocks are linked to both oil-related and -unrelated global supply changes, such as China joining the WTO. Global demand shocks are related to global disturbances in the financial sector and the so-called global financial cycle, which explains co-movements in risky assets (Rey, 2015; Miranda-Agrippino and Rey, 2020, 2022). That is, the mechanisms through which the global demand shock work are similar to those of the global financial cycle. However, even though the literature emphasizes the importance of US developments for the global financial cycle (Rogers et al., 2023), we provide evidence that the global shocks are not only driven by US developments. While these explain part of the global shocks, robustness specifications allowing for a special role of the US support that the US can be treated similar to the remaining countries in our sample.

Our PVAR model generates direct insights into all country-specific and global drivers of interest-rate co-movement. This distinguishes our paper from a large part of the literature where many studies limit their analysis to setups with two countries (e.g., Kim and Roubini, 2000; Kim, 2001; Maćkowiak, 2007) or cross-country effects of a single country's structural shocks (e.g. Dees et al., 2007; Georgiadis, 2015; Feldkircher and Huber, 2016; Burriel and Galesi, 2018; Crespo Cuaresma et al., 2019). Similar to our paper, Gerko and Rey (2017), Rogers et al. (2018), and Liu et al. (2022) analyze international spillovers of monetary policy shocks of multiple countries, paying no attention though to cross-border effects of global and country-specific supply and demand shocks which we find to be the most important drivers. While Mumtaz and Surico (2009) and Charnavoki and Dolado (2014) show in a structural factor model that global supply and demand shocks have similar effects on global activity and inflation as we find on local measures, they do not allow for local foreign shocks. In terms of country-specific results, we can compare our paper to a large literature on the international effects of US monetary policy shocks. Our finding of the importance of the aggregate demand channel implies a negative co-movement of foreign interest rates in reaction to domestic monetary policy shocks. This is in line with Feldkircher and Huber (2016); Dedola et al. (2017); Crespo Cuaresma et al. (2019), but contrasts with findings of no (Gerko and Rey, 2017; Liu et al., 2022) or even positive co-movement (Rogers et al., 2018; De Santis and Zimic, 2022).

In general, structural multi-country VAR models such as ours face an identification and estimation challenge. The identification challenge results from the presence of multiple country-specific structural and global shocks. The estimation challenge comes from the large number of free parameters as the model includes variables of all countries jointly. We tackle those challenges by working directly on the structural form of the VAR model. To facilitate this, we rely on two types of prior knowledge. First, consistent with the literature we use trade-weighted averages of foreign variables (instead of each foreign country separately) in each structural equation. This approach implies homogeneity restrictions on structural contemporaneous and autoregressive coefficients associated with foreign terms, and thereby effectively removes the curse-of-dimensionality that usually arises from extending the panel dimension of the model. While the restrictions are in the spirit of those imposed on the reduced form in global VAR (GVAR) models (see, e.g., Pesaran et al., 2009; Crespo Cuaresma et al., 2016), they are in our opinion easier to defend since homogeneity restrictions on structural model parameters do in general not imply similar restrictions on reduced form coefficients (and vice versa). Second, we use prior information from theoretical open-economy models to identify the structural equations in our PVAR as country-specific open-economy Phillips curves, IS curves, monetary policy rules, and exchange rate equations. This prior knowledge implies economically meaningful exclusion restrictions on some contemporaneous structural coefficients. Moreover, it allows us to formulate informative prior distributions on the remaining contemporaneous structural coefficients. Thereby, we incorporate identification uncertainty around restrictions accounting for a lack of conclusive theoretical evidence. Thus, we avoid unjustifiable recursive structures (as used in, for example, Chen et al., 2016; Bluwstein and Canova, 2016, where the order of countries matters) or block-exogeneity (as in Kim and Roubini, 2000; Kim, 2001; Maćkowiak, 2007). Compared to studies applying sign and/or magnitude restrictions in multi-country models (Gambacorta et al., 2014; Liu et al., 2022; De Santis and Zimic, 2022), we clearly acknowledge the uncertainty around those restrictions. To the best of our knowledge, we are the first who draw inference on a fully identified structural PVAR model (i.e., a model where all country-specific structural equations are identified) without imposing restrictions on the reduced form.

2 Bayesian structural PVAR model

We use a structural PVAR model including Australia, Canada, the Euro Area, Japan, South Korea, the United Kingdom and the United States; this set of countries represents around 54% of the world's economic activity as of 2019. For each country $c \in \{1, \ldots, C\}$, we include the output gap (y_{ct}) as a measure of economic activity, year-on-year inflation rates (π_{ct}), Krippner-shadow interest rates (r_{ct}) – which capture both conventional and unconventional monetary policy actions (Krippner, 2013) – and year-on-year growth rates of the real effective exchange rates (σ_{ct}). The real effective exchange rates are defined such that an increase in σ_{ct} indicates an increase in competitiveness. Our sample spans from 1980:Q3 to 2019:Q4 using quarterly observations.[2]

To fully specify the contemporaneous relations among our included variables, we rely on structural relations derived in theoretical open-economy models such as Lubik and Schorfheide (2007). Specifically, we formulate an empirical open economy Phillips curve (labeled "AS"), IS curve ("AD"), monetary policy rule ("MP"), and an exchange rate

[2] Online Appendix A explains the data in more detail. Two country selections deserve note. First, we rely on constructed data (provided by Eurostat, the ECB and Oxford Economics) for a counterfactual Euro Area between 1980 and 1999. We show that including the EA as an aggregate before the introduction of the Euro – by estimating a model with data starting in 1999:Q1 – does not alter the results, Figures E.22 and E.41. Second, we exclude China because, especially for the first part of our sample, there are issues with the availability and quality of Chinese data.

equation ("ER") for every country c, which we index by superscript $j \in \{s, d, m, \sigma\}$:

$$y_{ct} = \alpha^{c,\pi}\pi_{ct} + \alpha^{c,\sigma}\sigma_{ct} + \text{lag terms} + \chi_c^s u_{gt}^s + u_{ct}^s \tag{AS}$$

$$y_{ct} = \beta^{c,r} r_{ct} + \beta^{c,\pi}\pi_{ct} + \beta^{c,\sigma}\sigma_{ct} + \beta^{c,y^*} y_{ct}^* + \text{lag terms} + \chi_c^d u_{gt}^d + u_{ct}^d \tag{AD}$$

$$r_{ct} = (1 - \rho^c)\left(\psi^{c,\pi}\pi_{ct} + \psi^{c,y} y_{ct} + \psi^{c,\sigma}(\sigma_{ct} - \pi_{ct}^*)\right) + \text{lag terms} + u_{ct}^m \tag{MP}$$

$$\sigma_{ct} = \theta^{c,y}(y_{ct} - y_{ct}^*) + \theta^{c,\sigma^*}\sigma_{ct}^* + \text{lag terms} + u_{ct}^\sigma. \tag{ER}$$

Each of our structural equations shift with a structural domestic shock u_{ct}^j. Moreover, the supply and demand equations are subject to a structural global shock u_{gt}^j with a country- and shock-specific loading χ_c^j. Structural global shocks u_{gt}^j potentially imply shock correlations across countries c, but not across economic equations j. We model them as latent static factors. Even though the global shocks are fairly general, we show below, that they are related to some important determinants of global business cycle developments such as oil supply shocks (global supply) and the global financial cycle (global demand). We argue that monetary policy is largely conducted by independent central banks, which precludes the use of a global monetary policy shock. We also exclude a global exchange rate shock, since the currencies in our analysis are the overwhelmingly dominant currencies in the world during the time of our analysis.

The $\alpha, \beta, \psi, \theta$-coefficients are the (semi-)elasticities of the structural equations (AS) to (ER). Note that we aggregate foreign terms into a single variable and coefficient as in the term "$\beta^{c,y^*} y_{ct}^*$" in the aggregate demand equation. This aggregation is possible under homogeneity restrictions discussed in subsection 2.1. All aggregated foreign variables $(y_{ct}^*, \pi_{ct}^*, \sigma_{ct}^*)$ are understood to be trade-weighted averages of country-specific terms.[3]

Stacking the $J = 4$ structural equations of each country results in the full structural PVAR model with $n = CJ = 28$ equations. In compact matrix notation, it reads:

$$\mathbf{A}\mathbf{y}_t = \mathbf{B}\mathbf{x}_{t-1} + \chi\mathbf{u}_{gt} + \mathbf{u}_t \tag{1}$$
$$\mathbf{u}_t \sim \mathcal{N}(\mathbf{0}, \mathbf{D}), \qquad \mathbf{u}_{gt} \sim \mathcal{N}(\mathbf{0}, \mathbf{I}_J).$$

[3]Since we use real effective exchange rates and not real exchange rates with respect to the US$ for a limited number of countries, the exchange rates included in our model do not form a closed system (Bussière et al., 2009; Feldkircher and Huber, 2016). Thus we can include σ_{ct}^* in the set of foreign variables for all countries without concerns about multicollinearity.

The endogenous variables are captured in the $n \times 1$ vector $\mathbf{y}_t = (\mathbf{y}_{1t}, \ldots, \mathbf{y}_{Ct})'$ with $\mathbf{y}_{ct} = (y_{ct}, \pi_{ct}, r_{ct}, \sigma_{ct})'$. The right-hand-side variables include $p = 4$ lags, a constant and trend, the latter to counter the trending behavior of (mostly) shadow rates in our comparatively short sample, collected in the $k \times 1$ vector $\mathbf{x}_{t-1}$, with $k = CJp + 2 = 114$. We show that the main results also hold for models with $p = 8$ lags, Figures E.20 and E.39, and without a trend, Figures E.21 and E.40.

The $n \times 1$ vector $\mathbf{u}_t$ contains the structural domestic shocks, which jointly follow a normal distribution with mean zero and diagonal variance matrix $\mathbf{D}$. The $G = 2$ structural global shocks $\mathbf{u}_{gt} = (u^s_{gt}, u^d_{gt})$ independently follow a $\mathcal{N}(0,1)$ distribution and load onto each country according to the $n \times G$-dimensional loading matrix χ, which collects the country- and shock-specific loadings χ^j_c. In the stacked model the (semi-)elasticities are collected in the $n \times n$-matrix $\mathbf{A}$ of structural contemporaneous parameters. The $n \times k$-matrix $\mathbf{B}$ contains the structural lag coefficients.

Let us denote the $T \times J$ matrix of structural global shocks $\mathbf{U}_{gT} = \left[\mathbf{u}'_{g1}, \ldots, \mathbf{u}'_{gT}\right]'$. Similar to Baumeister and Hamilton (2015), the joint prior distribution of the structural model parameters is

$$p(\mathbf{A}, \mathbf{B}, \mathbf{D}, \chi, \mathbf{U}_{gT}) = p(\mathbf{A})p(\mathbf{D}|\mathbf{A})p(\mathbf{B}, \chi|\mathbf{A}, \mathbf{D})p(\mathbf{U}_{gT}). \tag{2}$$

To facilitate direct inference on the structural VAR model, we rely on informative prior knowledge on the structural contemporaneous coefficients in $\mathbf{A}$. The approach of Baumeister and Hamilton (2015) offers two distinct advantages in this regard. First, using prior distributions on (semi-)elasticities in $\mathbf{A}$ transparently shows the full information set imposed by us. Second, we choose each of our priors with a specified degree of uncertainty (albeit never "uninformative"). Modeling the uncertainty around the prior knowledge is especially appealing in multi-country models because typically a larger number of identifying restrictions is necessary while at the same time precise prior information from theoretical models is lacking.

In this paper, we rely on two types of prior knowledge derived from theoretical open economy models. First, we describe the above-mentioned homogeneity restrictions on all structural coefficients on foreign variables in section 2.1. Second, we explain in section 2.2 how we derive the informative prior distributions in $\mathbf{A}$ (including some exclusion restrictions) using theoretical models and empirical estimates from the literature. In section 2.3, we discuss the prior distributions on the remaining model coefficients $(\mathbf{B}, \mathbf{D}, \chi, \mathbf{U}_{gT})$ and sketch the Gibbs sampler adaptation used to derive the posterior distributions. Further details are given in Online Appendix C.

2.1 Homogeneity restrictions

We impose homogeneity restrictions on all structural contemporaneous and lag parameters in $\mathbf{A}$ and $\mathbf{B}$ that correspond to foreign variables. As an example, let us consider the role of foreign output gaps for aggregate demand (AD). A standard open economy model usually combines a single elasticity, say β^{c,y^*}, with an aggregate measure of output gaps from the rest of the world. For the latter, we use the (trade-weighted) sum of foreign output gaps, $y^*_{ct} = \sum_{c^* \neq c} w_{cc^*} y_{c^*t}$. That is, our aggregate demand curve contains the term

$$\beta^{c,y^*} y^*_{ct} = \beta^{c,y^*} \sum_{c^* \neq c} w_{cc^*} y_{c^*t} = \sum_{c^* \neq c} \underbrace{(w_{cc^*} \beta^{c,y^*})}_{=\beta^{c,y_{c^*}}} y_{c^*t}. \tag{3}$$

In our baseline model, weights w_{cc^*} are the average of BIS bilateral trade weights used to calculate real effective exchange rates for a narrow "basket" of 27 economies.

The assumption $\beta^{c,y_{c^*}} = w_{cc^*} \beta^{c,y^*}$ allows us to identify a single parameter β^{c,y^*}, distributed to each foreign country c^* according to its weight, instead of $C - 1$ separate foreign coefficients $\beta^{c,y_{c^*}}$. Thus, homogeneity assumptions effectively remove the curse of dimensionality arising from the panel dimension of the model, reducing the number of free parameters in every row of $\mathbf{A}$ from $n = 28$ to $2n_c = 8$ and the number of lagged structural coefficients in each row of $\mathbf{B}$ from $k = 114$ to $2n_c p + 2 = 34$ coefficients.

While our homogeneity restrictions are comparable to those imposed in GVAR models, there are important differences. First, homogeneity restrictions are more convincingly put on the structural than reduced form of the VAR, since the former match theoretical considerations. The two alternatives are not equivalent, since homogeneity restrictions on the reduced form put the restrictions on the inverse of $\mathbf{A}$. That is, while our structural model fulfills the homogeneity restrictions, the reduced-form counterpart does not. Second, the covariance matrix in GVAR models only captures the relations among one country and the weighted sum of all other countries. Thus, GVAR models commonly rely on generalized impulse response functions since identifying all structural shocks is infeasible (see, e.g., Dees et al., 2007; Feldkircher and Huber, 2016; Crespo Cuaresma et al., 2019). Opposed to this, we can investigate dynamic responses of each country's variable to all domestic, foreign and global shocks easily because we identify the parameters of the full model $\mathbf{A}, \mathbf{B}$, χ and $\mathbf{D}$.

Notwithstanding their advantages, one might have three main concerns regarding the homogeneity restrictions based on time-invariant trade weights.[4] First, global supply chains vary over time, with some countries rising to global importance while others become less central. We think that this argument is less of a concern in our sample which does not encompass China. Second, trade weights may be suboptimal if cross-border capital flows rather than trade are related to foreign interest rates (Feldkircher and Huber, 2016). We show that our results are robust to three alternative banking weights for foreign interest rates while the remaining foreign variables enter trade-weighted (Feldkircher and Huber, 2016, use similar weights), Figures E.24 to E.26 and E.43 to E.45. Third, the US may have a special role, both as an originator and transmitter of international shocks – an argument underlying the often used block-exogeneity assumption in the literature. We discuss the role of the US in section 3.3.3.

2.2 Informative priors on contemporaneous parameters

Theoretical models offer convincing arguments that the structural equations are (contemporaneously) independent of some of the variables in our model. We can interpret the zero restrictions as prior knowledge imposed by very informative prior distributions with zero variance and which are not updated by the data. The exclusion restrictions are uncontroversial, as they apply mostly to the role of foreign variables, or to domestic interest rates in the aggregate supply curve.

Despite the exclusion of many foreign terms, the country-specific blocks are not fully isolated from foreign contemporaneous developments (such as the US block under block-exogeneity assumptions) because of the potential role of foreign output gaps for aggregate demand and the exchange rate equation. Moreover, we allow monetary policy to react to

[4] Canova and Ciccarelli (2004); Koop and Korobilis (2016); Korobilis (2016); Koop and Korobilis (2019); Camehl (2022), for example, develop alternative ways to estimate *reduced form* PVAR models albeit without addressing structural identification.

Table 1: Prior on contemporaneous parameters for country c

parameter	distribution	prior mode	prior scale	restrictions
$\alpha^{c,\pi}$	$t(3)$	2	0.4	≥ 0
$\alpha^{c,\sigma}$	$t(3)$	-0.5	0.4	
$\beta^{c,r}$	$t(3)$	-1	0.4	≤ 0
$\beta^{c,\pi}$	$t(3)$	0.75	0.4	
$\beta^{c,\sigma}$	$t(3)$	0.2	0.4	
β^{c,y^*}	$t(3)$	0.5	0.4	≥ 0
$\psi^{c,\pi}$	$t(3)$	1.5	0.4	≥ 0
$\psi^{c,y}$	$t(3)$	0.5	0.4	≥ 0
$\psi^{c,\sigma}$	$t(3)$	0	0.4	
$\theta^{c,y}$	$t(3)$	1	0.4	
ρ^{c}	*Beta*(2.6,2.6)	0.5	0.2	$0 \leq \rho^c \leq 1$
θ^{c,σ^*}	*Gen-Beta*(2.6,2.6,-1,0)	-0.5	0.2	$-1 \leq \theta^{c,\sigma^*} \leq 0$

movements in the nominal exchange rate. We show further below that results are robust if we deviate from some of the exclusion restrictions, notably on foreign terms.

In order to derive prior distributions on the remaining structural contemporaneous coefficients (the coefficients explicitly introduced in equations (AS) to (ER)), we mainly build on the New-Keynesian small open economy model of Lubik and Schorfheide (2007). Based on theoretical insights, we formulate prior beliefs in the form of informative prior distributions and – in some cases – sign restrictions on the remaining structural parameters in **A**. Online Appendix B documents in detail the derivation of structural contemporaneous parameters.

Our prior beliefs on $(\alpha^{c,\pi}, \alpha^{c,\sigma}, \beta^{c,r}, \beta^{c,\pi}, \beta^{c,\sigma}, \beta^{c,y^*}, \psi^{c,\pi}, \psi^{c,y}, \psi^{c,\sigma}, \theta^{c,y}, \theta^{c,\sigma^*}, \rho^c)_{c=1}^{C}$ are summarized in Table 1. We report distribution class, mode and scale, and potentially additional sign restrictions for a generic country c since we do not differentiate priors across countries. As in Baumeister and Hamilton (2018), we set a t-distribution with three degrees of freedom (and scale of 0.4) for the majority of parameters, allowing for larger tails compared to a normal distribution. We follow Baumeister and Hamilton (2018) in the prior specifications for the parameters of their closed-economy model, $(\alpha^{c,\pi}, \beta^{c,r}, \beta^{c,\pi}, \psi^{c,\pi}, \psi^{c,y}, \rho^c)_{c=1}^{C}$. We refer the reader to their paper for a detailed discussion on these prior beliefs. Notable among the coefficients is ρ^c, which captures potential interest rate smoothing by monetary authorities.

In an open economy, supply depends on exchange rate changes, measured by $\alpha^{c,\sigma}$. The parameter relates to the import share, intertemporal substitution elasticity, discount factor and the slope coefficient of the Phillips curve of the theoretical model. Online Appendix B provides the exact relations of the coefficients in the SVAR model and the theoretical model of Lubik and Schorfheide (2007). To avoid singularities in the theoretical model, intertemporal substitution elasticity are commonly restricted to be larger than zero and smaller than one (Lubik and Schorfheide, 2007; Justiniano and Preston, 2010). We follow Lubik and Schorfheide (2007) and settle for a mean of 0.5. As in Baumeister and Hamilton (2018) we assume a discount factor of zero and a slope coefficient of 0.25. Similarly, Lubik and Schorfheide (2004) set a prior for the slope coefficients allowing for a wide rage between 0 and 1. We substitute expectations with autoregressive processes of order one with an autoregressive parameter equal to 0.75. Based on these values we set the prior mode for $\alpha^{c,\sigma}$ to -0.5.

In the open economy IS curve, we set a positive prior mode of 0.5 for β^{c,y^*}. We follow standard models where the Marshall-Learner condition implies a positive impact of foreign output on domestic output. Note that this transmission channel qualitatively creates a very similar effect to a global demand shock with positive loadings on all countries. Indeed, by allowing for global shocks, we intentionally weaken shock transmission via the aggregate demand channel described by β^{c,y^*}. To limit this weakening effect, we introduce a sign restriction on $\beta^{c,y*}$. We show in a robustness check without global shocks and no sign restriction that the full posterior distribution of β^{c,y^*} is positive. Next, we assume a prior mode of 0.2 for $\beta^{c,\sigma}$, i.e. a slightly positive dependence of aggregate demand on competitiveness.

The monetary policy authority can set interest rates according to a generalized Taylor rule in line with the specification in Lubik and Schorfheide (2007), Adolfson et al. (2007), and Justiniano and Preston (2010). Since we include shadow rates in our model, we assume that we can model monetary policy behavior via such an interest rate rule for both conventional and unconventional actions. In a robustness analysis, we challenge this assumption by re-estimating our model based on data until 2007:Q3 only. Our main findings hold in the sub-sample, Figures E.23 and E.42. We apply the negative of $\psi^{c,\sigma}$ to foreign inflation to incorporate our prior belief that central banks (if at all) are influenced in their policy by nominal rather than real exchange rate fluctuations. Moreover, we set the prior mode of $\psi^{c,\sigma}$ to zero (as in Adolfson et al., 2007), as the countries in our sample are characterized by flexible exchange rate regimes.

Equation (ER) determines exchange rates as a function of contemporaneous domestic and foreign output as well as foreign exchange rates. We assume that purchasing power parity holds, which implies that σ_{ct} directly relates to the terms of trade. As in Lubik and Schorfheide (2007), the difference in domestic and foreign demand growth thus determines the terms of trades endogenously, such that growth in domestic and foreign demand balances out. We thus apply $\theta^{c,y}$ to the difference between domestic and foreign output gaps. A prior mode of one is based on the relation of import shares and intertemporal substitution elasticity.

By definition, real effective exchange rates are highly correlated, as a relative appreciation of one country implies a relative depreciation of (most of) its trading partners. If unaccounted for, this feature can lead to estimation difficulties and implausible estimates (Lubik and Schorfheide, 2007). To deal with this issue, we allow for contemporaneous relations of domestic to foreign exchange rates through θ^{c,σ^*}, for which we formulate a generalized Beta distribution between the boundaries -1 and 0.

Following Baumeister and Hamilton (2018), we impose prior beliefs on two types of impact responses to economic shocks. For these priors, we use asymmetric t-distributions with location parameter μ, scale parameter σ, degrees of freedom ν, and shape parameter λ, the latter one controlling the degree of asymmetry. First, we assume for every country that the output response to a contractionary monetary policy shock is smaller than the interest rate response ($\mu = -0.3; \sigma = 0.5; \nu = 3; \lambda = -2$). Second, we assume a positive output response to aggregate supply shocks ($\mu = 0.3; \sigma = 0.5; \nu = 3; \lambda = 2$). Finally, we impose a fairly uninformative prior distribution on $\det(\mathbf{A})$ to avoid sign changing of the determinate ($\mu = 2; \sigma = 40; \nu = 3; \lambda = 10$).

2.3 Remaining priors, and posterior inference

We choose the same prior distributions and hyperparameter settings for $\mathbf{B}$ and $\mathbf{D}$ conditional on $\mathbf{A}$ as Baumeister and Hamilton (2018). The variances of individual structural shocks (i.e., the diagonal elements of $\mathbf{D}$) follow conditional inverse-gamma prior distributions. The prior distribution of $\mathbf{B}$, conditional on $\mathbf{A}$ and $\mathbf{D}$, follows a Minnesota prior describing the belief that each data series follows an AR(1)-process with coefficient 0.75, with prior confidence increasing with the lag length. We use fairly uninformative priors on the constant terms and deterministic trend using a tightness of 100. We account for interest rate smoothing in the monetary policy equation by adding an additional prior on the lagged coefficients of the monetary policy equation of country c. This prior is a multivariate normal distribution with mean zero with the exception of the coefficient on $r_{c,t-1}$, for which we set a mean of ρ^c, and variance matrix $0.1I_k$.

Each global shock u_{gt}^j is a latent factor of country-specific correlated shocks $\breve{u}_{ct}^j = \chi_c^j u_{gt}^j + u_{ct}^j$. To solve the common identification problem in factor models, we impose for scale identification that $\mathbf{U}_{gT}$ are mutually uncorrelated and follow (unconditionally) a standard-normal distribution. To identify the sign, we assume that each global shock loads positively on the first country in our sample, i.e. $\chi_{AU}^j > 0$. To limit the influence of global shocks, we use a normal prior for the nonzero elements of χ with mean zero and variance 0.1, conditional on $\mathbf{A}$ and $\mathbf{D}$.

The structure of the model is such that, conditional on $\mathbf{A}$ and $\mathbf{U}_{gT}$, the shock variances $\mathbf{D}$, lagged structural coefficients $\mathbf{B}$ and loadings χ can be drawn from a normal-inverse gamma distribution (Baumeister and Hamilton, 2015). However, because global shocks are unobserved, their distribution depends on the current draw of all other model parameters. Therefore, we implement a Gibbs sampler described in Online Appendix C.3 to obtain the joint posterior distribution

$$p(\mathbf{A}, \mathbf{B}, \mathbf{D}, \chi, \mathbf{U}_{gT} | \mathbf{Y}_T), \tag{4}$$

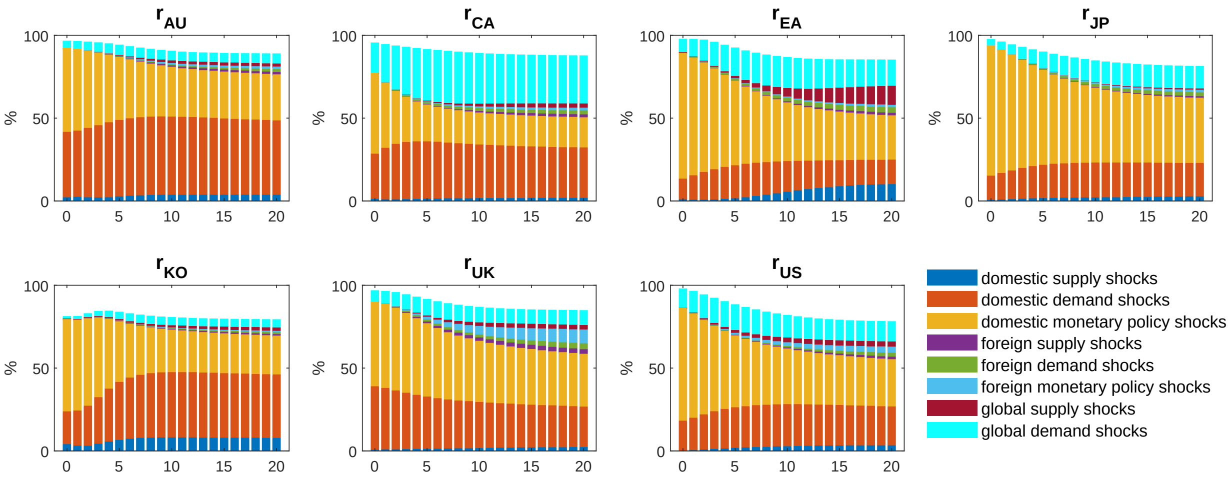
where we draw on the fact that the conditional posterior distribution $p(\mathbf{A}|\mathbf{U}_{gT}, \mathbf{Y}_T)$ directly follows from Baumeister and Hamilton (2015), while all other distributions are as in a common static factor model, see for example Geweke and Zhou (1996).

3 Results

3.1 Drivers of interest rates

In our model, interest rate co-movements across countries can materialize via real economic global shocks, via real cross-border effects or via exchange rate movements. If spillovers emerge via the first two mechanisms, the domestic central bank reacts directly to changes in the domestic economic environment caused by international developments. That is,

Figure 1: Forecast error variance decomposition of interest rates



NOTES: The figure shows the forecast error variance decomposition of country-specific interest rates (in subplots) to domestic, foreign and global shocks over 20 quarters. Foreign shocks are grouped for convenience of presentation. Unlabeled shares are explained by the residual shock to the exchange rate equation.

international macroeconomic developments cause interest rates to co-move rather than the other way around.

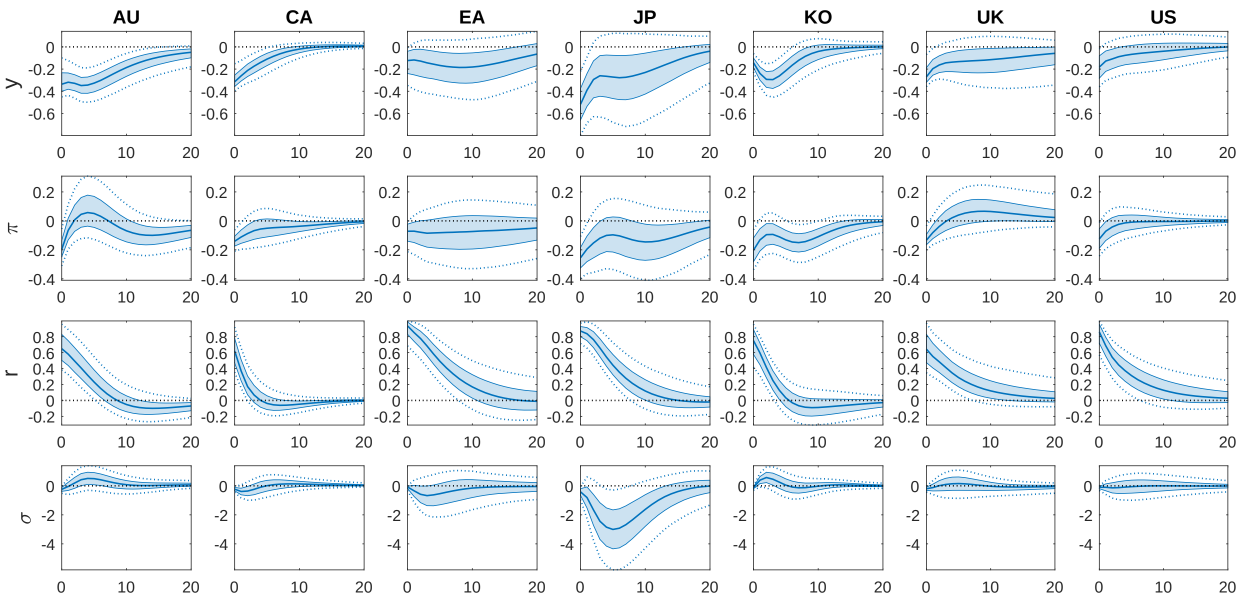
First, we quantify the importance of international factors in explaining interest rate movements. To that end, we compute forecast error variance decomposition for interest rates to domestic, foreign, and global shocks over 20 quarters, shown in Figure 1. We find that domestic and global shocks vastly drive variation in interest rates, explaining – for all countries and horizons – between 70% and 100% of the forecast error variance of interest rates. Foreign shocks and the residual shocks to the exchange rate equations are comparatively unimportant. The contribution of domestic monetary policy shocks decreases over time, while domestic and global demand shocks become more important. This result on shocks is consistent with previous findings by De Santis and Zimic (2022) and Baumeister and Hamilton (2018). The decomposition of the remaining endogenous variables are in Figure D.17. The relative importance of domestic, global and foreign shocks is similar for output and inflation, but differs across variables and countries for individual supply, demand and monetary policy shocks.

Next, we analyze in more detail the mechanisms through which structural shocks affect interest rates. To that end, we first show that the dynamic responses of interest rates to domestic monetary policy shocks are as expected. Second, we document that interest rate movements following domestic and global supply and demand shocks are consistent with the endogenous reaction of monetary policy to real economic fluctuations as described by the posterior distributions of structural coefficients from the different monetary policy rules. We show in a third part that even the relatively unimportant country-specific foreign shocks impact domestic interest rates mostly via an aggregate demand channel.

3.2 Effects of domestic monetary policy shocks

Figure 2 shows median impulse responses of country-specific variables (in rows) to country-specific one unit contractionary monetary policy shocks (in columns) for 20 quarters together with the 68% and 95% posterior credibility sets (shaded area and dotted lines, respectively). Unexpected tightening in monetary policy raises interest rates, lowers output gaps and inflation domestically. Exchange rates react differently across countries, for some exchange rates increase after a few quarters (AU, CA, KP, UK), while for others they decrease (EA, JP) or barely move (US).

Figure 2: Impulse responses of domestic variables to country-specific monetary policy shocks



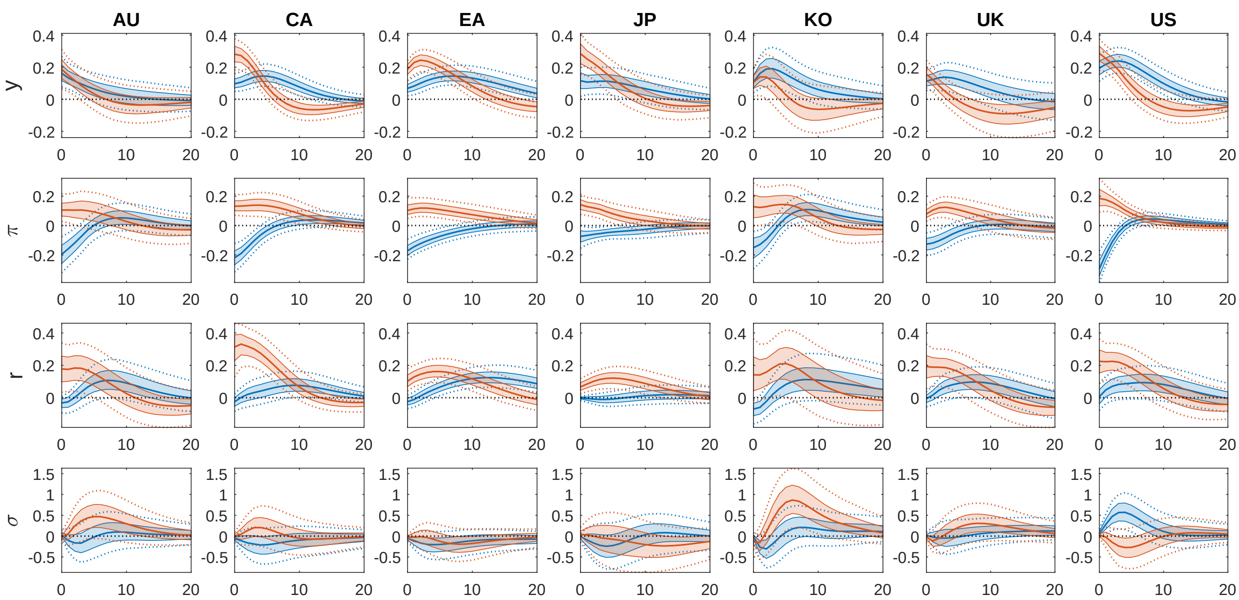
NOTES: The solid lines in the figure show median impulse responses of country-specific variables (in rows) to country-specific monetary policy shocks (in columns) over 20 quarters. The shaded areas (dotted lines) show the 68% (95%) posterior credibility sets. The shocks have size of one unit (i.e., one percentage point).

The domestic interest rate reaction peaks on impact, but is smaller than the initial shock size because of the direct endogenous response of monetary policy to lower output gaps and inflation caused by the contractionary monetary policy shock. After impact, the posterior credibility bands associated with the impulse responses do not contain zero for several quarters, in part because of the significant degree of interest rate smoothing in all countries.

3.3 Effects of domestic and global supply and demand shocks

Domestic supply shocks lead to an expansion in output, a sharp drop in inflation and a delayed increase in exchange rates. They initially cause a small decrease or no effect in interest rates, see diagonal elements in Figures D.9 to D.12. For most economies a rebouncing effect is visible after a few quarters. Demand shocks increase domestic interest rates on impact with the peak effect for the countries within one year, see diagonal elements in Figures D.13 to D.16. The shocks raise output gap and inflation. Exchange rates decrease with a trough after on average around a year. The associated posterior credibility sets for the domestic responses exclude zero for several quarters.

Figure 3: Impulse responses to global supply (blue) and global demand (red) shocks



NOTES: The solid lines in the figure show median impulse responses of country-specific variables (in rows) to global supply shocks (in columns) in blue and to global demand shocks in red over 20 quarters. The shaded areas (dotted lines) show the respective 68% (95%) posterior credibility sets. The shocks have size of one unit (i.e., one percentage point).

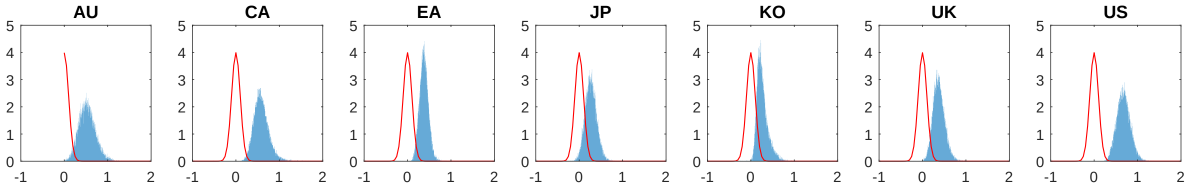
The effects of global supply and demand shocks are in line with the responses to domestic shocks. Figure 3 shows the median responses to global supply and demand shocks in blue and red, respectively, together with the posterior credibility sets. Global supply and demand shocks cause strong reactions. Output gaps increase on impact. This response is slightly stronger, but also more short-lived for global demand shocks than for global supply shocks. Inflation rates decline in response to global supply shocks, while they increase on impact following a demand shock – for many countries the size and duration of the effects is similar for both shocks. Our findings are in line with Mumtaz and Surico (2009) and Charnavoki and Dolado (2014) who use structural factor models to study the effect of global supply and demand shocks (identified via sign or exclusion restrictions) on global activity, inflation, and commodity prices. For real effective exchange rates, we see a difference between the US – which increase after a supply shock and decrease following a demand shock – and the other countries in our sample, which mostly show opposite reactions, albeit with zero often included in the credibility sets. This difference can be explained by the magnitude of price responses, which are slightly larger in the US than in the other countries in our sample. This indicates that the US might become relatively more competitive after a global supply shock, and relatively less competitive after a global demand shock.

The peak response of interest rates is positive for both shocks. Global demand shocks lead to a large immediate reaction (see also Mumtaz and Surico, 2009). Medium-term responses to global supply shocks are positive due to spillovers via aggregate demand: as output increases in all countries after a global supply shock, so does *foreign* output, which shifts domestic aggregate demand endogenously outward, see also Figure 9. However, on impact the exogenous shift in supply curves dominates, which explains the visible delay in interest rate responses.

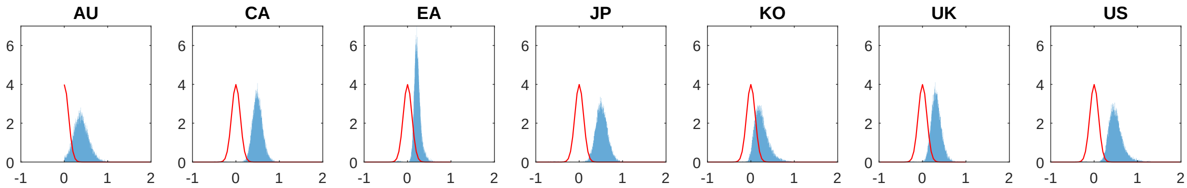
We see some heterogeneity across countries regarding the size of impact effects. This is due to different loadings, see Figure 4. The majority of the posterior draws is positive and distinct from zero for nearly all countries. The exception is Japan and to some extent the EA. Notably, Japan reacts least to global supply shocks compared to all other countries, visible by relatively more posterior mass of χ^s_{JP} close to zero compared to the other countries. Especially, global supply shocks cause no considerable reaction in Japanese interest rates. The global shocks load slightly stronger on the US than on other countries, as already indicated by the exchange rate responses.

Figure 4: Posterior distributions of loadings χ_c^s and χ_c^d

(a) supply loading χ_c^s



(b) demand loading χ_c^d



NOTES: The histograms show the posterior distribution of χ_c^s and χ_c^d together with the prior distribution (red line).

3.3.1 What are global supply and demand shocks?

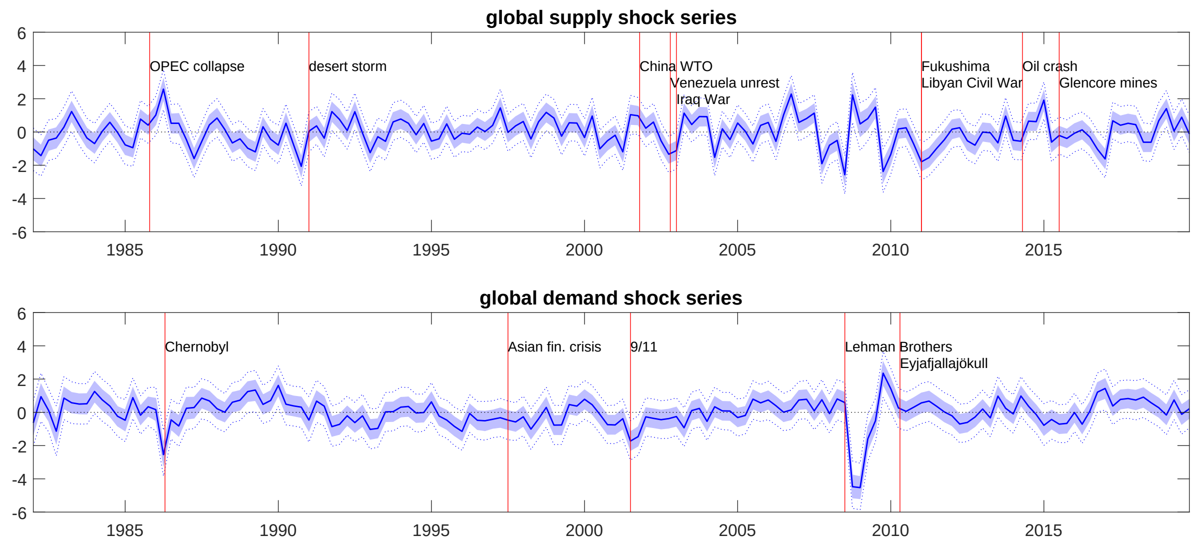
The global shocks are essential drivers of economic developments. To underline their crucial role, we evaluate whether the data support including global shocks. To that end, we compare the model fit of the model with global shocks to an alternative excluding global shocks via the Savage-Dickey density ratio (Verdinelli and Wasserman, 1995). A model without global shocks is a restricted version of the model with global shocks. Integrating out the global shocks, the restrictions imply that $\chi_c^j = 0$ for all countries and equations (except for Australia given the sign restriction imposed on those parameters). The ratio is interpreted as the Bayes factor for the two models and is defined as the marginal posterior density relative to the marginal prior density evaluated at the restriction:

$$SDDR = \frac{p\left(\{\chi_c^j = 0\}_{c \neq AU, j}\right)}{p\left(\{\chi_c^j = 0\}_{c \neq AU, j} | \mathbf{Y}_T\right)}.$$

We obtain a value of 146, clearly supporting the inclusion of global shocks.

But how can we interpret these shocks? In our model, global shocks are defined as the idiosyncratic part of country-specific supply and demand curves which is correlated across countries. Two observationally equivalent sources can drive the shocks. First, they reflect unanticipated current or future changes in exogenous variables, i.e. global developments outside our model. For example, they can be driven by so-called "primitive" shocks (as defined in e.g., Ramey, 2016) such as natural disasters or geopolitical events having a worldwide effect. Second, they also reflect joint shifts of structural relationships to domestic events. For example, the great financial crisis can be interpreted as a global demand shock. Without allowing for global shocks, direct links across countries (like the elasticity of aggregated demand with respect to foreign output, $\beta^{c,y*}$) risk misidentification of shocks and transmission channels because it forces all domestic shocks to be transmitted globally via the same endogenous variable.

Figure 5: Estimated time series of global shocks



NOTES: The solid lines in the figure show median global shock series. The shaded areas (dotted lines) show the respective 68% (95%) posterior credibility sets. Oil supply events are drawn from (Antolín-Díaz and Rubio-Ramírez, 2018; Känzig, 2021, and reference therein).

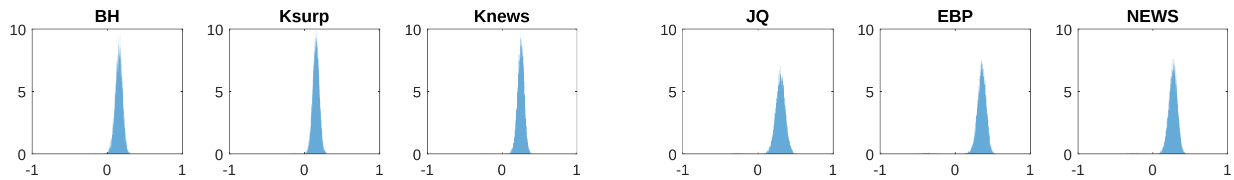
Figure 5 shows the identified global shock series. Our global supply shocks are linked to oil supply shocks but also capture global supply changes unrelated to oil. For example, the Venezuela oil strike (December 2002), the start of the Iraq War (March 2003), and the Libyan Civil War (February 2011) are associated with negative global supply shocks. Some other important oil supply events occur at times where the credibility set of global supply shocks includes zero. Among important other shocks, we see that the accession of China to the WTO and the Fukushima nuclear disaster with the associated disruption of global supply chains coincide with supply shocks that are clearly different from zero.

The nuclear disaster in Chernobyl (April 1986) and the terrorist attacks on 9 September

2001 coincide with strong negative demand shocks. A series of large negative global demand shocks start with the collapse of Lehman Brothers (September 2008). The largest negative global demand shock is timed at the peak of the global financial crisis in 2009. Hence, we think that large shocks to uncertainty and credit supply shocks causing disruptions to worldwide financial markets may be interpreted in our model as a negative global demand shock. This finding remains across all robustness checks.

Figure 6: Correlation of global supply and demand shocks with oil supply and credit supply shock proxies

(a) correlation with global supply shocks **(b)** correlation with global demand shocks



NOTES: The histograms show the correlation of the posterior draws of the global shocks with various shock proxies from the literature, always multiplied such that the proxy is expansionary. BH: oil supply shocks of Baumeister and Hamilton (2019); Ksurp: oil supply expectation shocks of Känzig (2021); Knews: oil supply news instrument of Känzig (2021) based on high-frequency changes in oil futures prices around OPEC production announcements; JQ: innovations to the financial conditions index of Jermann and Quadrini (2012); EBP: excess bond premium of Gilchrist and Zakrajšek (2012); NEWS: textual proxy series of Mumtaz et al. (2018) counting the words “credit crunch” and “tight credit”in nine US newspapers.

To investigate these anecdotal links further, we calculate the correlation (at each posterior draw) of global supply and demand shocks to prominent shock and instrument series for oil supply shocks and credit supply shocks, respectively, see Figure 6. We find a positive correlation of our global supply shocks to exogenous expansions of oil supply. Likewise, our global demand shock is positively correlated to proxies of expansionary credit supply shocks. Overall, the correlations with our global shocks do not exceed 0.5 for all measures, which indicates that our global shocks also capture additional worldwide developments.

The strong link of the global demand shock to disruption in financial conditions might imply that co-movements in financial variables are shifted in our model to the global demand shock. These co-movements are usually interpreted as the “global financial cycle”, which is strongly connected to financial conditions in the US (Rey, 2015; Rogers et al., 2023). We investigate the role of the global financial cycle and the US economy for our model in the following subsections.

In a robustness check we also allow for a global monetary policy shock in the model despite the difficulty of interpreting such a shock economically. We find that the shock is (statistically) relevant with a SDDR of 214 over our baseline model. However, since it is not clear which exogenous events could be associated which such a shock, the global monetary policy shock must be (mainly) explained by country-specific developments. Indeed, we show in Figure E.61 that the "global" monetary policy shocks are strongly correlated to many common instruments for US monetary policy shocks.

3.3.2 The role of the global financial cycle

Our global demand shocks are related to worldwide disturbances in the financial sector. Rey (2015), Miranda-Agrippino and Rey (2020), and Miranda-Agrippino and Rey (2022), among others, stress that the same type of shocks could be the reason for co-movements in risky assets, called the global financial cycle. We find that, indeed, our global demand shocks are not only correlated to the credit supply instruments mentioned above, but also to residuals from an AR(4) model of Miranda-Agrippino and Rey (2020)'s GFC factor.

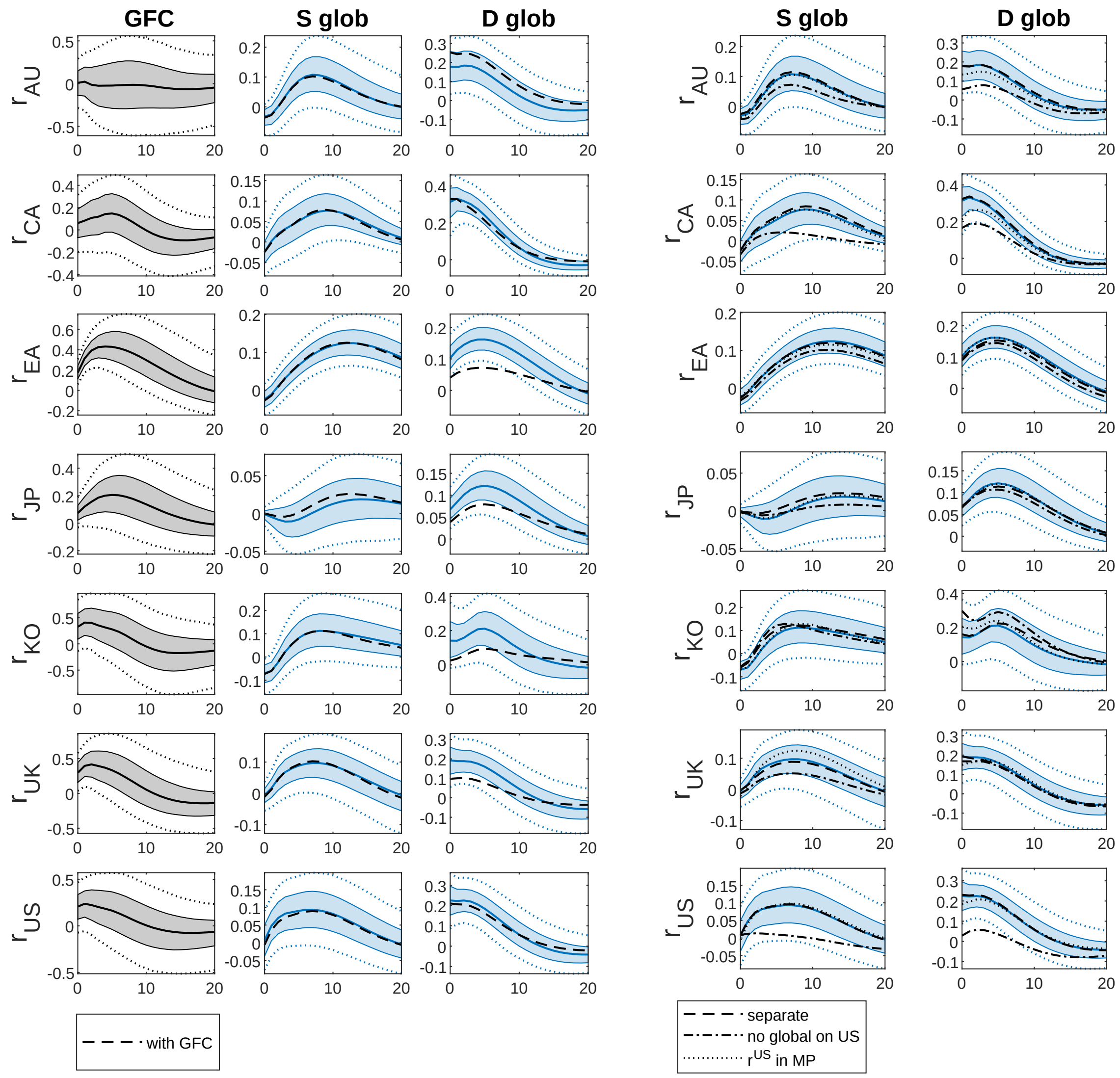
Augmenting our baseline model with the GFC factor of Miranda-Agrippino and Rey (2020) as an additional endogenous variable isolates the influence of the global financial cycle on country-specific developments.[5] Three pieces of evidence indicate that the influence of the GFC works through the same channels as aggregate demand. First, our posterior estimates show that the GFC factor enters the country-specific demand equations positively in all countries, while it is contemporaneously irrelevant for nearly all other structural equations. Exceptions are aggregate supply in Korea and exchange rate equations in Australia and Canada. Hence, loose global financial conditions stimulate aggregated demand. Second, country-specific loadings of the global demand shock, χ_c^d, decrease in comparison to Figure 4, Panel (b). Third, the impulse-response functions to innovations to the GFC factor are very similar to usual (global) demand shocks, increasing output gaps and inflation in all countries bar Australia. Panel (a) of Figure 7 shows median interest rate reactions from the GFC-extended version to GFC shocks and compares responses to global shocks of the extended model (black dashed line) to the baseline model (blue). The reaction to

[5]We use the quarterly average of the GFC factor updated to 2019Q1, as provided on http://silviamirandaagrippino.com/code-data [accessed 26 June 2023]. The GFC factor is contemporaneously included in all baseline equations, and all variables contribute contemporaneously to the development of the GFC factor in the additional equation. We set relatively wide priors on the additional contemporaneous parameters, Student t priors with mode zero and scale one.

a GFC shock is qualitatively similar to that of a global demand shock. Compared to the baseline, the response to global demand shocks is somewhat muted for more than half of the countries, while the reaction to global supply shocks is identical.

Figure 7: Impulse responses of interest rates to GFC shocks and global shocks for alternative specifications

(a) role of GFC **(b)** role of US



NOTES: Figure shows country-specific impulse responses of interest rates to GFC shocks (GFC), global supply shocks (S glob) and demand shocks (D glob) over 20 quarters. The posterior mean responses (black lines) of the different models are plotted together with the 68% (shaded areas) and 95% (blue dotted lines) credibility set of our baseline model. In case of the GFC shock credibility sets (dark shaded areas and dotted lines) from the extended model with the GFC variable are plotted. The shocks have size of one unit.

3.3.3 The role of the US

The positive correlations between global demand shocks and (US-centered) shock proxies for credit supply, and the relation between this shock and the global financial cycle, which is strongly driven by US developments, begs the question whether our global shocks are only observationally indistinguishable US shocks. To investigate this, we consider three alternative specifications where we attribute a special role to the US.

First, we relax the homogeneity assumption and allow structural coefficients (**A** and **B**) on US variables to be different from other foreign variables. Panel (b) of Figure 7 plots median interest rate responses to global shocks of the model with separate US coefficients (dark dashed lines), labeled *separate*, along with the posterior credibility sets of the baseline model. We find that allowing for a greater role of direct spillovers from the US to other countries does not change the importance of and responses to global shocks. Moreover, a Bayes factor of 1'247 against the baseline model supports the full set of homogeneity assumptions.

Second, we assume that global shocks do not directly influence US developments, by setting US loadings to zero. Thereby, we isolate unexpected US developments from driving global shocks. We find that interest rate reactions of the US, CA, and AU to global supply and demand shocks is somewhat lower compared to the baseline model, see the dark dashed-dotted lines in panel (b) of Figure 7, labeled *no global on US*. While the US response is smaller by definition, the difference in Australian and Canadian responses points into the direction that, indeed, part of the global shocks is explained by US developments with global consequences affecting in particular small open economies. However, removing US loadings does not nullify the importance of global shocks, as the posterior distributions of other loadings are all positive, bar the demand loading for Australia. As the newly identified global demand shocks are unimportant for Australia, we changed the normalizing country to the Euro Area in this case.

Third, we allow for a dominant US central bank by including US interest rates directly in the policy rules of other countries, thus allowing for an additional direct spillover channel. The prior distribution of the new structural parameter $\psi^{c,r^{US}}$ follows a t-distribution with mean zero, scale 0.4 and 3 degrees of freedom. The posterior distributions is negative for the EA, consistent with monetary policy anticipating a cooling of the economy after an interest rate increase in the US. It is positive for CA, KO and UK, implying a central bank reaction more in-line with capital flow pressures. For AU and JP, the coefficient is centered around zero. The international interest rate reactions to global supply and demand shocks are nearly identical, indicating robustness of our model in that regard, see dark dotted lines of panel (b) of Figure 7 labeled r^{US} *in MP*.

Overall, our tests indicate that US developments are important parts of identified global shocks due to its sheer size, but that the US is not "special" enough to be treated differently from the other countries in our sample.

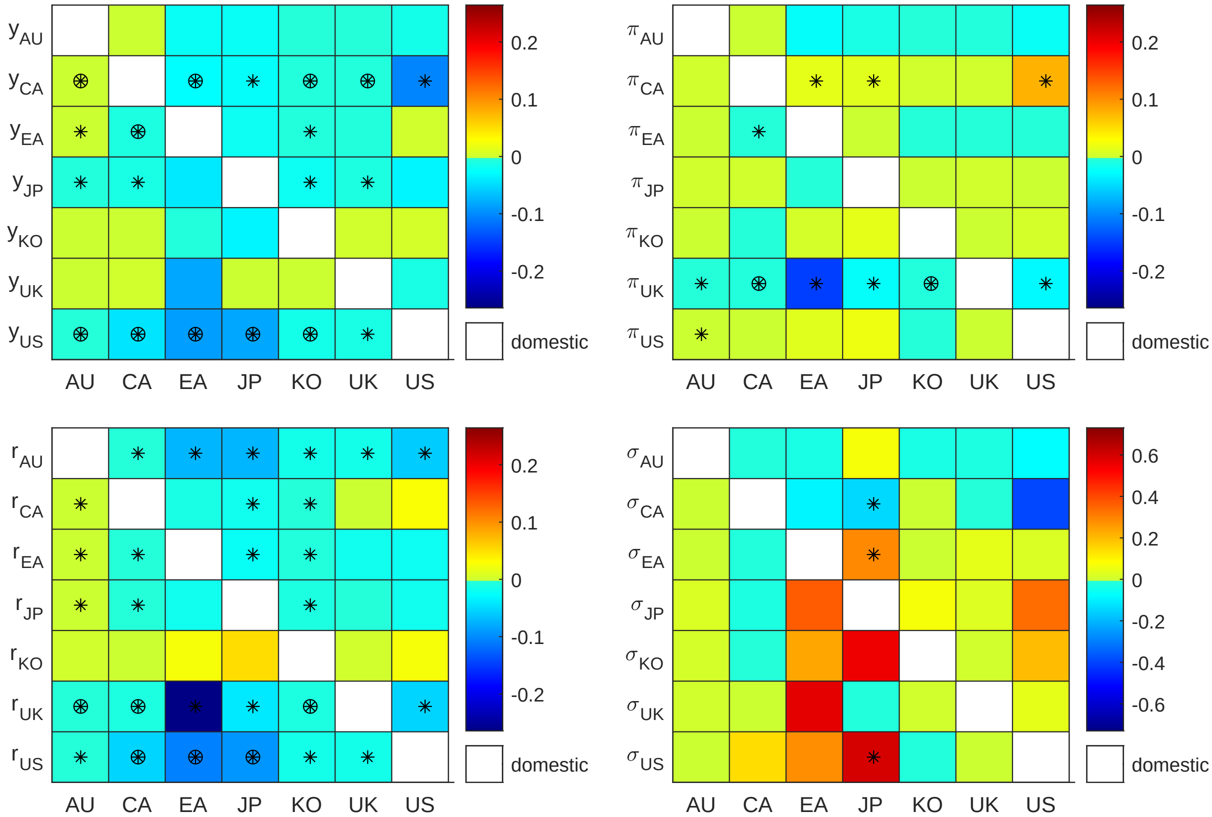
3.4 Effects of foreign shocks

3.4.1 Responses to foreign monetary policy shocks

Next to global shocks, our model allows (contemporaneously) for international transmission of local monetary policy shocks via exchange rates and via aggregate demand (see also Jones et al., 2022). In case of exchange rate targeting, foreign central banks should increase their interest rates in reaction to a contractionary domestic monetary policy shock in an effort to keep their exchange rates stable. Thus, we might expect a positive co-movement of international interest rates after monetary policy shocks, especially for countries in which the exchange rate coefficient in the monetary policy rule, $\psi^{c,\sigma}$, is positive. Transmission channels via aggregate demand, on the other hand, would imply a negative co-movement in a textbook model: as contractionary monetary policy shocks lower domestic output gaps, net foreign exports and therefore foreign aggregate demand falls. This "beggar-thy-neighbour"-effect should result in endogenous expansionary monetary policy by foreign central banks.

Just like theoretical predictions, the empirical findings on signs of monetary policy spillovers in the literature are mixed. The majority of papers, focusing on different sets of (advanced) economies and different shock origins, finds mostly negative co-movements (Feldkircher and Huber, 2016; Dedola et al., 2017; Crespo Cuaresma et al., 2019). However, especially with respect to US monetary policy shocks, there exists conflicting evidence in the sense that there could be either no co-movement (Liu et al., 2022; Degasperi et al., 2021) or even positive co-movement (Rogers et al., 2018; Ha, 2021; Ilzetzki and Jin, 2021; De Santis and Zimic, 2022), especially when the "receiving" country is a small open economy with strong trade connections to the US like Canada.

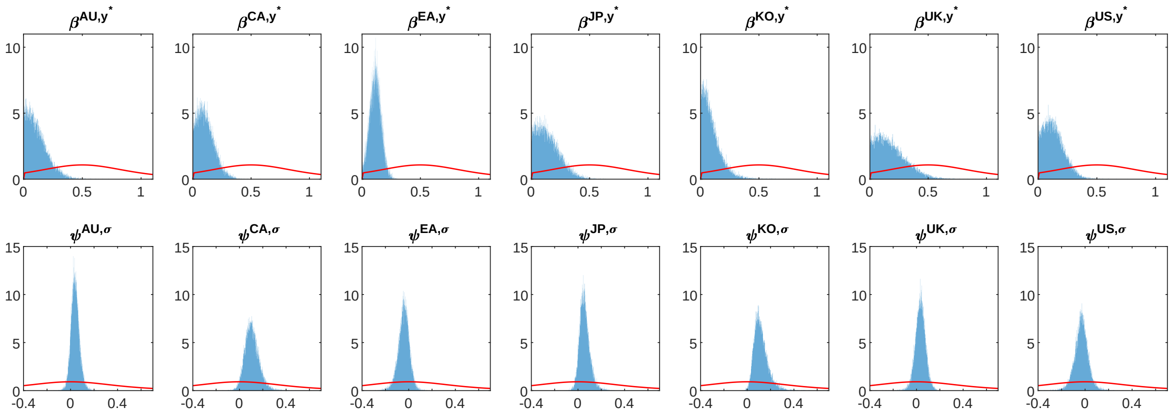
Figure 8: Impulse responses at horizon four of foreign variables to country-specific monetary policy shocks



NOTES: Heat map of median impulse responses of country-specific variables (in rows) to country-specific monetary policy shocks (in columns) at horizon four. The asterisk (asterisk with circle) indicates that zero is not contained in the 68% (95%) posterior credibility sets. The color scales for the response of output gap, inflation, and interest rates are aligned.

Our baseline results fit to the above literature. Figure 8 shows – in colored cells – the median impulse responses of country-specific variables (in rows) to country-specific contractionary monetary policy shocks (in columns) at horizon four, with one subplot for each of the four macroeconomic variables. We add an asterisk (with circle) if zero is not contained in the 68% (95%) posterior credibility sets, respectively. The color scales are aligned for the response of output gap, inflation, and interest rates but not for exchange rate responses. Figures D.5 to D.8 depict the full impulse responses over all horizons. The interest responses (lower left subplot) show that, in general, we find negative international co-movement after monetary policy shocks. However, the reactions are weaker for countries where monetary policy rules also focus on exchange rates, notably Korea. Moreover, credibility sets are wider for shocks originating in countries that are important global financial centers, namely US, UK and EU (Miranda-Agrippino and Rey, 2020).

Figure 9: Structural contemporaneous parameters β^{c,y^*} and $\psi^{c,\sigma}$



NOTES: The solid red lines in the Figure show the prior distribution of the structural contemporaneous parameters (columns: countries; rows: parameters). The histograms show posterior distributions.

The negative co-movement can be explained by real spillovers across borders via foreign aggregate demand (see also Georgiadis, 2015; Feldkircher and Huber, 2016; Dedola et al., 2017; Crespo Cuaresma et al., 2019). The output and inflation reaction to domestic monetary policy shocks are negative on average, see the first two suplots in Figure 8. Thus, the shock transmission seems to work mostly via output gaps rather than inflation, as the posterior credibility sets of the former usually exclude zero, while they mostly include zero for the latter. Notably, the countries with the strongest output and inflation reactions are also the ones with the strongest interest rate responses. Canada is an exception because they react with decreasing output gaps and increasing inflation, creating a trade-off for monetary policy. Last, the lower right subplot of the figure shows that foreign real effective exchange rates react weakly and the 68% credibility sets contain zero. That is, the cross-border transmission of monetary policy shocks is dominated by the aggregate demand channel rather than the exchange rate transmission channel.

To investigate these findings further, we turn to the posterior distributions of the elasticities of foreign variables (blue histograms in Figure 9) together with their prior distributions (solid red lines). The aggregate demand channel predicts a positive effect of higher foreign output gaps on domestic inflation. At the same time, allowing for global demand shocks might weaken the strength of aggregate demand transmission channel. We see this in the posterior distribution of the coefficient β^{c,y^*}, first row in Figure 9, which is positive, but pushed towards zero for many countries. As expected, the aggregate demand channel becomes much more important in our robustness test excluding global shocks: posterior distributions of β^{c,y^*} are much more positive, and foreign shocks are more important in forecast-error variance decompositions, Figures E.18 and E.37. Only Korea remains the exception, which indicates that they indeed have a particularly weak aggregated demand channel.

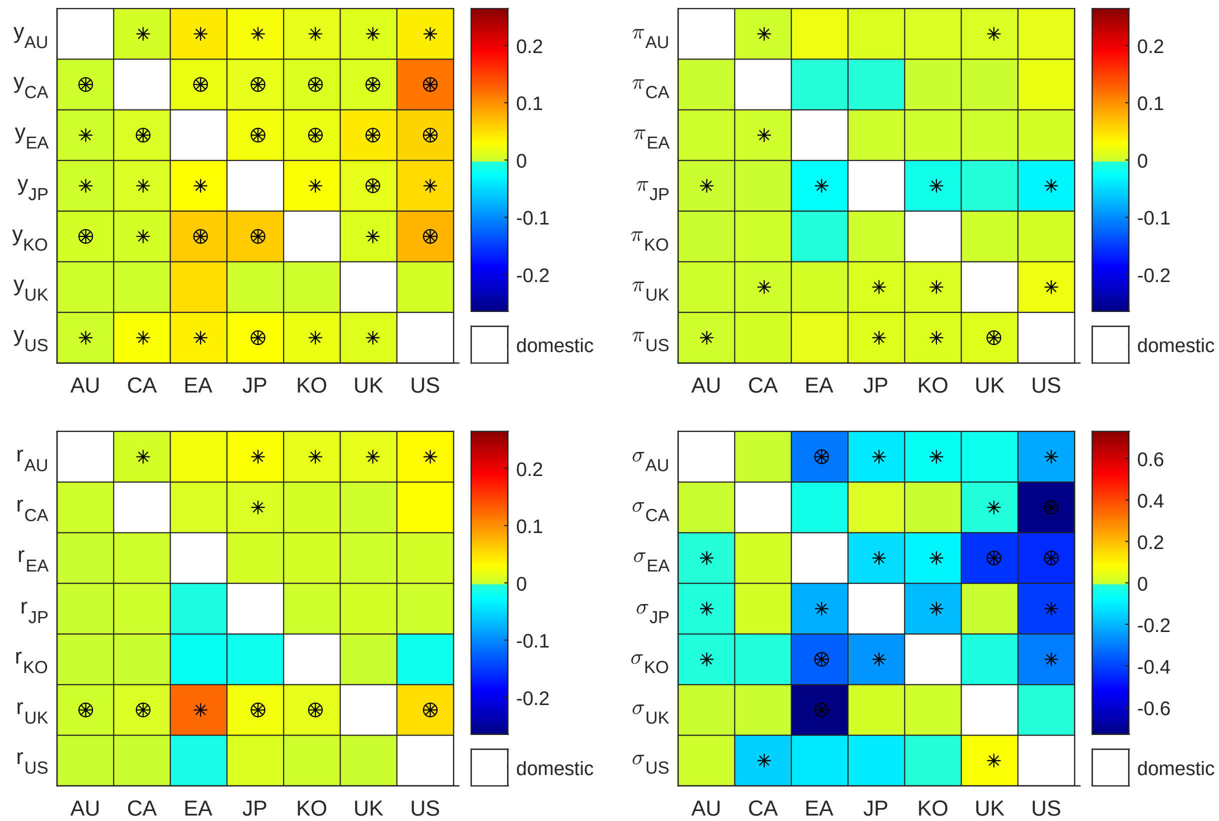
The exchange rate channel is captured by the endogenous reaction of domestic monetary policy to (nominal) exchange rate fluctuations, $\psi^{c,\sigma}$, second row in Figure 9. Exchange rates play a role for the conduct of monetary policy in all countries bar EA and US. They are particularly important for Canada and Korea, similar to Justiniano and Preston (2010). Overall, however, we find the exchange rate channel to be less important than the aggregate demand, because of the weak reaction of real effective exchange rates to monetary policy shocks (last row of Figure 2 and lower right subplot of Figure 8).

While a dominant transmitter role of the US is stressed in the literature (such as Miranda-Agrippino and Rey, 2020; Rey, 2016; De Santis and Zimic, 2022), our results give a more diverse picture, as they highlight the similarity of responses to shocks originating in other countries, and also the response of US variables to foreign shocks. These reactions should caution against block-exogeneity assumptions in VAR models. Moreover, our findings relate to studies reporting similarities in spillover effects and mutual reactions caused by unconventional monetary policy shocks of the Fed and ECB (such as Curcuru et al., 2018; Miranda-Agrippino and Nenova, 2022; Jarociński, 2022). However, it should be noted that a generalization of our results towards other currency areas might not be possible. Especially for the case of emerging economies, one would need to pay extra attention to the role of exchange rate arrangements and capital controls, which could dominate aggregate demand channels.

3.4.2 Responses to foreign supply and demand shocks

The international transmission of local supply and demand shocks also materializes via the aggregate demand channel. Figures 10 and 11 show the median foreign responses to supply and demand shocks, respectively, at horizon four. In both cases and for many shock-country pairs, we observe that foreign output gaps expand, albeit not to the same degree as domestic output. Inflation and interest rates also go up on average. These findings are consistent with those reported by Feldkircher and Huber (2016) for US shocks. The impulse response functions for all horizons are reported in Figures D.9 to D.16.

Figure 10: Impulse responses at horizon four of foreign variables to country-specific supply shocks

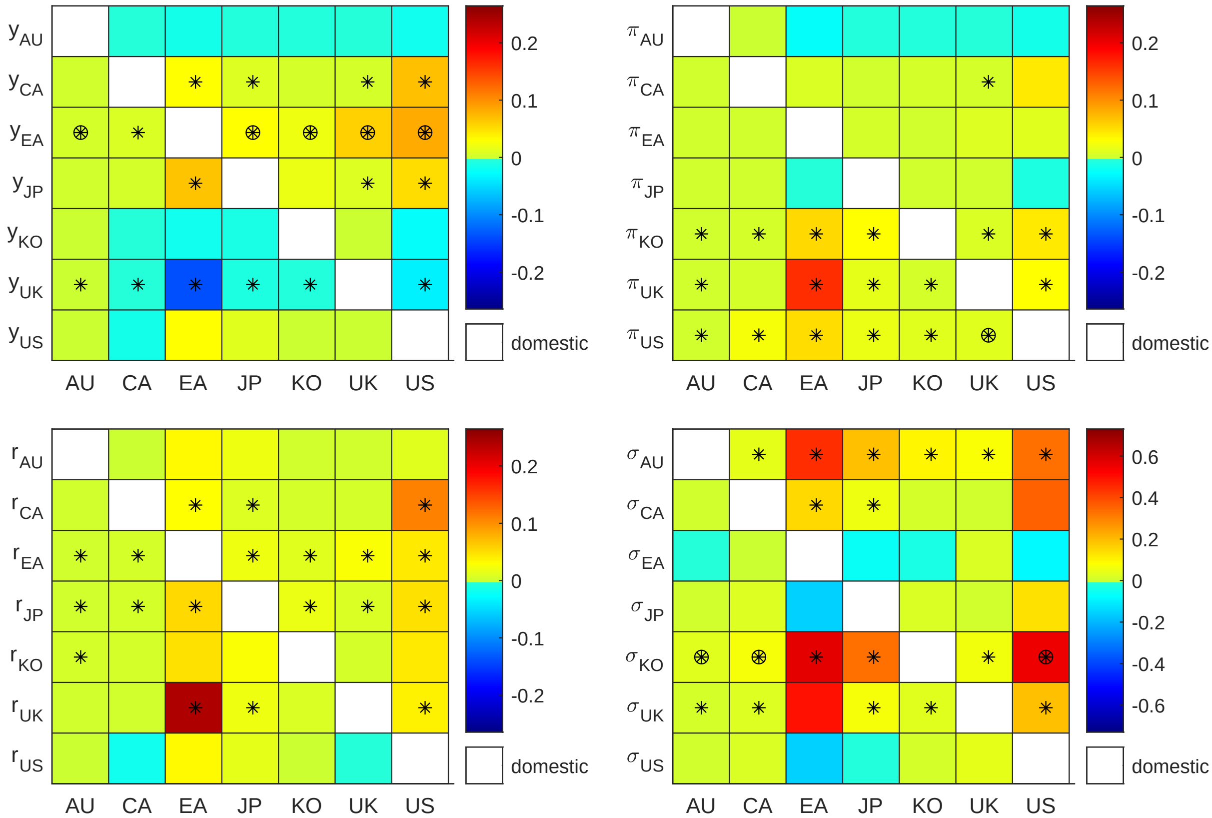


NOTES: Heat map of median impulse responses of country-specific variables (in rows) to country-specific supply shocks (in columns) at horizon four. The asterisk (asterisk with circle) show the 68% (95%) posterior credibility sets. The color scales for the response of output gap, inflation, and interest rates are aligned.

The increase of domestic output in reaction to the two shocks shifts foreign aggregate demand outwards, resulting in the economic expansion and increase in inflation. Endogenous foreign monetary policy (the increase in interest rates) mutes the outward shift in aggregate demand: For many shock-country pairs, the 68% or even 95% credibility sets of these responses, denoted by an asterisk and asterisk with circle, do not contain zero. With respect to the relative strength of responses across shocks (the colors in the Figures), we see the importance of country sizes and trade weights. US and Euro Area shocks in general create the largest responses. Moreover, the Euro Area economy is, for example, affected stronger by shocks from the United Kingdom than by Japanese shocks.

Last, we observe that foreign real effective exchange rate growth is negatively affected by supply shocks and positively by demand shocks. The reason for this is the opposite domestic development, which is an increase (decrease) in competitiveness after a supply

Figure 11: Impulse responses at horizon four of foreign variables to country-specific demand shocks



NOTES: Heat map of median impulse responses of country-specific variables (in rows) to country-specific demand shocks (in columns) at horizon four. The asterisk (asterisk with circle) show the 68% (95%) posterior credibility sets. The color scales for the response of output gap, inflation, and interest rates are aligned.

(demand) shock. As before, shocks from the US and EA usually create stronger reactions.

3.5 Further analysis

In this section, we establish that our main results, namely the importance of global shocks and the dominance of the aggregate demand channel in the transmission of foreign shocks, also hold under alternative model setups.

3.5.1 Changing the monetary policy rule

Next to the discussed channels, domestic monetary policy could directly react to changes in foreign interest rates, output and inflation. We check this by extending the monetary policy rules to contain coefficients on (a) foreign interest rates, (b) foreign inflation and (c) foreign output gaps, inflation and interest rates. Generalizing the monetary policy equation does not alter the importance of global shocks, Figures E.27 to E.29, and of the aggregate demand channel notably, Figures E.46 to E.48. The reason for this is that the posterior distributions of the additional contemporaneous coefficients are mostly centered around zero.

3.5.2 Further changes to foreign variables in structural equations

We check robustness to alternative specifications of aggregate supply and the exchange rate equations. To that end, we first add foreign output gaps in the supply equation, restricting the coefficient to be positive. Second, we adjust the exchange rate equation such that interest rate differential enter. Hence, we model directly the uncovered interest rates parity such that differences in interest rates between the countries should equalize relative changes in exchange rates, potentially strengthening the exchange rate channel for the transmission of monetary policy shocks. Results do not change considerably, Figures E.30 to E.31 and E.49 to E.50.

3.5.3 Model extensions to fifth variable

Monetary policy shocks might be transmitted internationally via financial channels, such as the wealth and credit channel (for a description of different financial channels see, for example, Bauer and Neely, 2014; Neely, 2015; Fratzscher et al., 2018). The central banks' actions can alter asset prices by stimulating or dampening the demand for assets. Changes in asset prices impact the wealth of households and companies leading to adjusted spending (wealth channel). The monetary authority actions can affect the availability of credit in the market which in turn alters spending and investments (credit channel).

We augment our model by growth in stock prices (wealth channel) or term spreads (credit channel), measured as 5-year yields minus shadow interest rates.[6] We find mixed evidence for the existence of a wealth channel in response to monetary policy shocks,

[6]We include the additional channel variable (domestic and foreign) contemporaneously in all baseline equations and allow all variables to contribute contemporaneously to the development of the channel variable, with the exception of foreign exchange rates and foreign channel variables. We set Student t priors with mode zero and scale one on the additional contemporaneous parameters. We add prior beliefs that contractionary monetary policy raises domestic interest rates, lowers domestic output gaps and inflation, and decreases competitiveness, by setting asymmetric t distributions with $\mu = 0$, $\sigma = 1$, $v = 3$, and $\lambda = 20$ on the impact effects of monetary policy shocks. We restrict the impact response of the stock prices or term spreads to a domestic monetary policy shock to be negative.

Figure E.56. However, our results show that the credit channel domestically is active since term spreads respond negatively to monetary policy shocks from the same country, Figure E.57. Adding stock prices does not alter the main results substantially, see Figures E.32 and E.51. In the model with term spreads, however, the aggregate demand channel is strengthened substantially, which also increases the contribution of foreign shocks to forecast error variances, see Figures E.33 and E.52.

We also augment our model by total trade, exports or imports, respectively. We observe that the median responses of the additional channel variable to a monetary policy shock are often negative (albeit with credibility sets including zero, Figures E.58 to E.60). Exports and imports show very similar responses. This supports the aggregate demand channel, whereby trade should decrease when domestic and foreign output gaps go down. As for the model with term spreads, including the respective channel variable intensifies the aggregated demand channel and increases the share of the forecast error variance of interest rates explained by foreign shocks, Figures E.34 to E.36 and E.53 to E.55.

4 Conclusions

In this paper, we investigate the structural economic causes of international co-movement of interest rates. To draw inference on structural equations, we extend the Bayesian structural VAR of Baumeister and Hamilton (2018) to a multi-country framework accounting for domestic and global shocks. The approach has three advantages over the literature. First, by using informative priors on structural contemporaneous coefficients we achieve full identification of the model equations, allowing us to differentiate between aggregate supply, aggregate demand, a monetary policy rule and an exchange-rate equation for each country in our sample. Second, separating unexpected shifts of structural equations into local and global shock components sharpens inference and thereby facilitates the economic interpretation of our results. Third, we are the first to show how homogeneity restrictions on *structural* foreign coefficients can remove the curse of dimensionality which usually arises from extending the panel dimension. Our restrictions – for the same variable, equation and lag, foreign coefficients are equal up to a constant weight – are applied in the literature on reduced form global VAR models. However, we argue that they are much more convincing if imposed on the structural form of the model.

We show that global supply and demand shocks are an important source of international economic fluctuations. As output and inflation move in sync across the countries of our sample, so do interest rates due to the endogenous monetary policy reaction to *domestic* economic developments. Domestic and global shocks account for 70% to 100% of the variation of interest rates. However, local shocks from a foreign country can cause additional spillovers. We show that these transmissions mostly arise through an aggregate demand channel. Thus, an exogenous shift in the behavior of monetary authorities leads to a decline in foreign interest rates. Demand and supply shocks cause positively correlated responses in interest rates internationally. The strongest international reactions are found for shocks originating in the EA and US, which are the two largest trading partners for the majority of the countries in our sample. We show that our main findings hold when changing prior beliefs on contemporaneous relations and the model set-up.

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References

Adolfson, M., Laseen, S., Linde, J., Villani, M., 2007. Bayesian estimation of an open economy DSGE model with incomplete pass-through. Journal of International Economics 72, 481–511.

Antolín-Díaz, J., Rubio-Ramírez, J.F., 2018. Narrative Sign Restrictions for SVARs. American Economic Review 108, 2802–29.

Bauer, M., Neely, C., 2014. International channels of the Fed's unconventional monetary policy. Journal of International Money and Finance 44, 24–46.

Baumeister, C., Hamilton, J.D., 2015. Sign restrictions, structural vector autoregressions, and useful prior information. Econometrica 83, 1963–1999.

Baumeister, C., Hamilton, J.D., 2018. Inference in structural vector autoregressions when the identifying assumptions are not fully believed: Re-evaluating the role of monetary policy in economic fluctuations. Journal of Monetary Economics 100, 48–65.

Baumeister, C., Hamilton, J.D., 2019. Structural Interpretation of Vector Autoregressions with Incomplete Identification: Revisiting the Role of Oil Supply and Demand Shocks. American Economic Review 109, 1873–1910.

Bluwstein, K., Canova, F., 2016. Beggar-Thy-Neighbor? The International Effects of ECB Unconventional Monetary Policy Measures. International Journal of Central Banking 12, 69–120.

Burriel, P., Galesi, A., 2018. Uncovering the heterogeneous effects of ECB unconventional monetary policies across euro area countries. European Economic Review 101, 210–229.

Bussière, M., Chudik, A., Sestieri, G., 2009. Modelling global trade flows: results from a GVAR model. Working Paper Series 1087. European Central Bank.

Camehl, A., 2022. Penalized estimation of panel vector autoregressive models: A panel LASSO approach. International Journal of Forecasting .

Canova, F., Ciccarelli, M., 2004. Forecasting and turning point predictions in a Bayesian panel VAR model. Journal of Econometrics 120, 327–359.

Charnavoki, V., Dolado, J.J., 2014. The Effects of Global Shocks on Small Commodity-Exporting Economies: Lessons from Canada. American Economic Journal: Macroeconomics 6, 207–37.

Chen, Q., Filardo, A., He, D., Zhu, F., 2016. Financial crisis, US unconventional monetary policy and international spillovers. Journal of International Money and Finance 67, 62–81.

Crespo Cuaresma, J., Doppelhofer, G., Feldkircher, M., Huber, F., 2019. Spillovers from US monetary policy: evidence from a time varying parameter global vector auto-regressive model. Journal of the Royal Statistical Society Series A: Statistics in Society 182, 831–861.

Crespo Cuaresma, J., Feldkircher, M., Huber, F., 2016. Forecasting with Global Vector Autoregressive Models: A Bayesian Approach. Journal of Applied Econometrics 31, 1371–1391.

Curcuru, S.E., Pooter, M.D., Eckerd, G., 2018. Measuring Monetary Policy Spillovers between U.S. and German Bond Yields. International Finance Discussion Papers 1226. Board of Governors of the Federal Reserve System (U.S.).

De Santis, R.A., Zimic, S., 2022. Interest rates and foreign spillovers. European Economic Review 144, 104043.

Dedola, L., Rivolta, G., Stracca, L., 2017. If the Fed sneezes, who catches a cold? Journal of International Economics 108, S23–S41.

Dees, S., di Mauro, F., Smith, L.V., Pesaran, M.H., 2007. Exploring the international linkages of the euro area: a global VAR analysis. Journal of Applied Econometrics 22, 1–38.

Degasperi, R., Hong, S.S., Ricco, G., 2021. The global transmission of U.S. monetary policy. Working Papers hal-03373749. HAL.

Feldkircher, M., Huber, F., 2016. The international transmission of US shocks - Evidence from Bayesian global vector autoregressions. European Economic Review 81, 167 – 188. Model Uncertainty in Economics.

Fratzscher, M., Duca, M.L., Straub, R., 2018. On the International Spillovers of US Quantitative Easing. The Economic Journal 128, 330–377.

Gambacorta, L., Hofmann, B., Peersman, G., 2014. The Effectiveness of Unconventional Monetary Policy at the Zero Lower Bound: A Cross-Country Analysis. Journal of Money, Credit and Banking 46, 615–642.

Georgiadis, G., 2015. Examining asymmetries in the transmission of monetary policy in the euro area: Evidence from a mixed cross-section global VAR model. European Economic Review 75, 195–215.

Gerko, E., Rey, H., 2017. Monetary policy in the capitals of capital. Journal of the European Economic Association 15, 721–745.

Geweke, J., Zhou, G., 1996. Measuring the pricing error of the arbitrage pricing theory. The Review of Financial Studies 9, 557–587.

Gilchrist, S., Zakrajšek, E., 2012. Credit spreads and business cycle fluctuations. American Economic Review 102, 1692–1720.

Ha, J., 2021. Financial market spillovers of U.S. monetary policy shocks. Review of International Economics 29, 1221–1274.

Ilzetzki, E., Jin, K., 2021. The puzzling change in the international transmission of US macroeconomic policy shocks. Journal of international economics 130, 103444.

Jarociński, M., 2022. Central bank information effects and transatlantic spillovers. Journal of International Economics 139, 103683.

Jermann, U., Quadrini, V., 2012. Macroeconomic effects of financial shocks. American Economic Review 102, 238–71.

Jones, C., Kulish, M., Rees, D.M., 2022. International spillovers of forward guidance shocks. Journal of Applied Econometrics 37, 131–160.

Justiniano, A., Preston, B., 2010. Monetary policy and uncertainty in an empirical small open-economy model. Journal of Applied Econometrics 25, 93–128.

Känzig, D.R., 2021. The Macroeconomic Effects of Oil Supply News: Evidence from OPEC Announcements. American Economic Review 111, 1092–1125.

Kim, S., 2001. International transmission of U.S. monetary policy shocks: Evidence from VAR's. Journal of Monetary Economics 48, 339–372.

Kim, S., Roubini, N., 2000. Exchange rate anomalies in the industrial countries: A solution with a structural VAR approach. Journal of Monetary Economics 45, 561–586.

Koop, G., Korobilis, D., 2016. Model Uncertainty in Panel Vector Autoregressive Models. European Economic Review 81, 115–131.

Koop, G., Korobilis, D., 2019. Forecasting with High-Dimensional Panel VARs. Oxford Bulletin of Economics and Statistics 81, 937–959.

Korobilis, D., 2016. Prior selection for panel vector autoregressions. Computational Statistics and Data Analysis 101, 110–120.

Krippner, L., 2013. Measuring the stance of monetary policy in zero lower bound environments. Economics Letters 118, 135–138.

Liu, L., Matthes, C., Petrova, K., 2022. Monetary policy across space and time, in: Essays in Honour of Fabio Canova. Emerald Publishing Limited. volume 44, pp. 37–64.

Lubik, T.A., Schorfheide, F., 2004. Testing for Indeterminacy: An Application to U.S. Monetary Policy. American Economic Review 94, 190–217.

Lubik, T.A., Schorfheide, F., 2007. Do central banks respond to exchange rate movements? A structural investigation. Journal of Monetary Economics 54, 1069–1087.

Maćkowiak, B., 2007. External shocks, U.S. monetary policy and macroeconomic fluctuations in emerging markets. Journal of Monetary Economics 54, 2512–2520.

Miranda-Agrippino, S., Nenova, T., 2022. A tale of two global monetary policies. Journal of International Economics 136, 103606.

Miranda-Agrippino, S., Rey, H., 2020. US monetary policy and the global financial cycle. The Review of Economic Studies 87, 2754–2776.

Miranda-Agrippino, S., Rey, H., 2022. The global financial cycle, in: Handbook of international economics. Elsevier. volume 6, pp. 1–43.

Mumtaz, H., Pinter, G., Theodoridis, K., 2018. What do VARs tell us about the impact of a credit supply shock? International Economic Review 59, 625–646.

Mumtaz, H., Surico, P., 2009. The Transmission of International Shocks: A Factor-Augmented VAR Approach. Journal of Money, Credit and Banking 41, 71–100.

Neely, C.J., 2015. Unconventional monetary policy had large international effects. Journal of Banking & Finance 52, 101–111.

Pesaran, M.H., Schuermann, T., Smith, L.V., 2009. Forecasting economic and financial variables with global VARs. International Journal of Forecasting 25, 642–675.

Ramey, V.A., 2016. Macroeconomic shocks and their propagation. Handbook of Macroeconomics 2, 71–162.

Rey, H., 2015. Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence. NBER Working Papers 21162. National Bureau of Economic Research, Inc.

Rey, H., 2016. International channels of transmission of monetary policy and the mundellian trilemma. IMF Economic Review 64, 6–35.

Rogers, J.H., Scotti, C., Wright, J.H., 2018. Unconventional Monetary Policy and International Risk Premia. Journal of Money, Credit and Banking 50, 1827–1850.

Rogers, J.H., Sun, B., Wu, W., 2023. Drivers of the Global Financial Cycle. SSRN 4397119.

Verdinelli, I., Wasserman, L., 1995. Computing bayes factors using a generalization of the savage-dickey density ratio. Journal of the American Statistical Association 90, 614–618.

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