universität innsbruck

Research Platform
Empirical and Experimental Economics

What goes around comes around: How large are spillbacks from US monetary policy?

Max Breitenlechner, Georgios Georgiadis, Ben Schumann

Working Papers in Economics and Statistics

2021-05

University of Innsbruck
https://www.uibk.ac.at/eeecon/

University of Innsbruck
Working Papers in Economics and Statistics

The series is jointly edited and published by

- Department of Banking and Finance
- Department of Economics
- Department of Public Finance
- Department of Statistics

Contact address of the editor:
research platform "Empirical and Experimental Economics"
University of Innsbruck
Universitaetsstrasse 15
A-6020 Innsbruck
Austria
Tel: + 43 512 507 71022
Fax: + 43 512 507 2970
E-mail: eeecon@uibk.ac.at

The most recent version of all working papers can be downloaded at
https://www.uibk.ac.at/eeecon/wopec/

For a list of recent papers see the backpages of this paper.

What goes around comes around: How large are spillbacks from US monetary policy?*

Max Breitenlechner† *University of Innsbruck*

Georgios Georgiadis‡ *European Central Bank*

Ben Schumann§ *Free University of Berlin*

August 2, 2021

Abstract

We quantify spillbacks from US monetary policy based on structural scenario analysis and minimum relative entropy methods applied in a Bayesian proxy structural vector-autoregressive model estimated on data for the time period from 1990 to 2019. We find that spillbacks account for a non-trivial share of the overall slowdown in domestic real activity in response to a contractionary US monetary policy shock. Our analysis suggests that spillbacks materialise as Tobin's q/cash flow and stock market wealth effects impinge on US investment and consumption. Contractionary US monetary policy depresses foreign sales of US firms, which reduces their valuations/cash flows and thereby induces cutbacks in investment. Similarly, as contractionary US monetary policy depresses US and foreign equity prices, the value of US households' portfolios is reduced, which triggers a drop in consumption. Net trade does not contribute to spillbacks because US monetary policy affects exports and imports similarly. Finally, spillbacks materialise through advanced rather than emerging market economies, consistent with their relative importance in US firms' foreign demand and US foreign equity holdings.

Keywords: US monetary policy, spillovers, spillbacks, Bayesian proxy structural VAR models.
JEL-Classification: F42, E52, C50.

*We would like to thank, without implying endorsement, Dimitris Georgarakos, Marek Jarocinski, Silvia Miranda-Agrippino, Gernot Müller, Ivan Petrella, Michele Piffer, Martin Schmitz, Andrej Sokol, and Fabrizio Venditti, seminar participants at the ECB, Bank of Lithuania, University of Innsbruck, University of Tübingen, and Hong Kong Institute for Monetary and Financial Research as well as conference participants at the 28^{th} European Summer Symposium in International Macroeconomics (ESSIM), the 2021 BoE/BIS/ECB/IMF Spillover Conference, the 21^{st} IWH-CIREQ-GW Macroeconometric Workshop, the 13^{th} FIW Research Conference on International Economics, the 25^{th} ICMAIF, the 11^{th} RCEA Money-Macro-Finance Conference, the 27^{th} International Conference on Computing in Economics and Finance, and the 2021 Conference on Economic Measurement. Helena Le Mezo provided excellent research assistance. Georgios Georgiadis gratefully acknowledges financial support from Hong Kong Institute for Monetary and Financial Research. This paper represents the views of the authors, which are not necessarily the views of the Hong Kong Monetary Authority, Hong Kong Institute for Monetary and Financial Research, or its Board of Directors or Council of Advisers. The above-mentioned entities except the authors take no responsibility for any inaccuracies or omissions contained in the paper. The views expressed in the paper do also not reflect those of the ECB, the Eurosystem and should not be reported as such.

†E-mail address: max.breitenlechner@uibk.ac.at.

‡E-mail address: georgios.georgiadis@ecb.int.

§E-mail address: benschumann91@gmail.com.

1 Introduction

Much empirical work as well as prominent policy debates suggest that US monetary policy spillovers are large and an important driver of business cycles and financial conditions in the global economy (Banerjee et al., 2016; Dedola et al., 2017; Bräuning and Sheremirov, 2019; Iacoviello and Navarro, 2019; Vicondoa, 2019; Degasperi et al., 2020). At the same time, it has been argued that the Federal Reserve has exhibited "benign neglect" regarding its international effects (Eichengreen, 2013, p. 87). For example, after the Global Financial Crisis some policymakers complained that US monetary policy measures aimed at stabilising the domestic economy elicited waves of capital flows and accentuated financial market volatility in the rest of the world (Rajan, 2013). Some have even argued that the global effects of US monetary policy inhibit control of fundamentals by monetary policy in small open and emerging market economies and jeopardise local financial stability (Rey, 2016; Miranda-Agrippino and Rey, 2020).

Against this background, some policymakers have argued that the Federal Reserve should take into account its effects on the rest of the world in the calibration of its monetary policy (Rajan, 2016a,b). The Federal Reserve has responded that it already does so implicitly, as spillovers spill back to the US economy: "Actions taken by the Federal Reserve influence economic conditions abroad. Because these international effects in turn spill back on the evolution of the US economy, we cannot make sensible monetary policy choices without taking them into account" (Fischer, 2014); similarly: "The Fed recognizes that its own policies do have international spillovers, and, in turn because they affect global performance, they are going to have spillbacks to US economic performance" (Yellen, 2019). Carney (2019) exemplifies the view that large monetary policy spillbacks are not confined to the Federal Reserve: "Advanced economies' monetary policies will increasingly need to take account of spillbacks". Similarly, Shin (2015) notes: "There is much talk of 'headwinds' from emerging markets buffeting advanced economies, [which] are the result of monetary policy actions taken some time ago (...) by precisely those advanced economies". However, to the best of our knowledge, no rigorous analysis of spillbacks from US monetary policy exists in the literature. In this paper we fill this gap.

We define spillbacks from US monetary policy as the difference between the actual domestic effects of US monetary policy and a counterfactual in which the spillovers to rest-of-the-world real activity are nil. Our analysis suggests that spillbacks are large: When spillovers to the rest of the world in response to a contractionary US monetary policy shock are precluded, the slowdown in domestic real activity and the drop in domestic consumer prices is substantially smaller.

Regarding economic transmission channels our analysis suggests that spillbacks materialise through Tobin's q/cash flow and stock market wealth effects. In particular, contractionary US monetary policy depresses US firms' valuations/cash flows as their foreign sales decline, inducing them to cut back investment. Similarly, as contractionary US monetary policy depresses US and also foreign equity prices, the value of US households' portfolios is reduced, which triggers a drop in consumption; that wealth effects contribute to the domestic effects of monetary policy is consistent with recent work on heterogeneous-agent New Keynesian models (Kaplan et al., 2018; Alves et al., 2020). In contrast to consumption and investment, net exports do not contribute to spillbacks because US monetary policy affects exports and imports to a similar degree. Finally, spillbacks to US consumer prices materialise primarily as a US monetary policy contraction puts downward pressure on global commodity prices and thereby reduces US import prices.

Regarding geographic transmission channels our analysis suggests that spillbacks materialise through advanced economies (AEs) rather than through emerging market economies (EMEs). Specifically, we find that we can replicate the counterfactual in which US monetary policy spillovers to real activity in the entire rest of the world are nil by precluding spillovers only to AEs. In contrast, when only spillovers to EMEs are precluded we replicate the baseline under which spillovers are unconstrained. We argue this finding is consistent with the relative exposure of US firms' sales and US holdings' of foreign equity across AEs and EMEs. An important caveat to this finding is that it reflects the average properties of the data over our sample period from 1990 to 2019. As the importance of EMEs has been growing over time, their contribution to spillbacks from US monetary policy may be larger at the current juncture. We leave the assessment of time variation in spillbacks to future research.

Our finding that spillbacks from US monetary policy are large but that these materialise primarily through AEs and not EMEs suggests there may be a case for international monetary policy coordination (Engel, 2016; Ostry and Ghosh, 2016; Egorov and Mukhin, 2020). In particular, we find that while real activity spillovers from US monetary policy are contractionary in both AEs and EMEs, consumer prices fall in AEs but rise in EMEs. Thus, while US monetary policy spillovers do not induce welfare-reducing trade-offs between output and inflation stabilisation in AEs, they do so in EMEs. This implies that global welfare could benefit if spillovers to EMEs were internalised by playing a role in the calibration of US monetary policy that is independent from spillbacks. Interestingly, there is evidence that the Federal Reserve is doing precisely that already. Ferrara and Teuf (2018) construct an indicator that measures the number of references to the international environment in FOMC minutes. They then estimate a Taylor-rule with domestic variables augmented with their international environment indicator, and find that the Federal Reserve responds to global developments even conditional on US real activity and inflation. Hence, our finding that spillbacks from US monetary policy hardly materialise through EMEs may be a rationalisation for the observed behaviour of the Federal Reserve.

It should be noted upfront that quantifying spillbacks from US monetary policy is not straightforward even conceptually.[1] On the one hand, it is unlikely that any existing structural model in the literature can be expected to encompass all empirically relevant monetary policy spillover transmission channels (see for example Bräuning and Sheremirov, 2019; Degasperi et al., 2020, for opposing views regarding the relative importance of trade vs. financial channels). As a result, a structural model is likely to impose a dogmatic prior that unduly constrains the range of possible spillback assessments (for a similar argument see Bachmann and Sims, 2012; Rostagno et al., 2021). Moreover, as spillovers can be shut down in various ways there is not a unique 'no-spillovers' counterfactual structural model; and in general, precluding spillovers in a structural model in different ways results in different spillback assessments. On the other hand, an empirical approach that defines the counterfactual benchmark in terms of the outcome that spillovers are absent without being explicit about the transmission channels that are being shut down may be more difficult to interpret economically. Notwithstanding these conceptual challenges, the lack of existing analysis coupled with the prominence spillbacks from US monetary policy have assumed (Fischer, 2014; Shin, 2015; Yellen, 2019; Carney, 2019) dictate an urgency for study. It is against this background that we attempt to inject more rigour in the debate about spillbacks with this paper.

Considering these conceptual challenges, we opt for an empirical instead of a structural approach. This avoids imposing dogmatic priors and frees us from taking a stand on the specification of the 'no-spillovers' counterfactual structural model. In particular, we carry out counterfactual analyses in two-country vector-autoregressive (VAR) models for the US and the rest of the world. We adopt the Bayesian proxy structural VAR framework of Arias et al. (2018, forthcoming). We identify a US monetary policy shock using the high-frequency interest rate surprises on FOMC meeting dates of Gürkaynak et al. (2005) as in Gertler and Karadi (2015) as well as Caldara and Herbst (2019), additionally cleansed from central bank information effects as in Jarocinski and Karadi (2020). We consider two approaches to construct counterfactual impulse responses in which the real activity spillovers from US monetary policy to the rest of the world are nil: (i) Structural scenario analysis (SSA) and (ii) minimum relative entropy (MRE).

In SSA we identify two additional shocks that represent a convolution—but together capture the universe—of rest-of-the-world structural shocks by combinations of zero, sign and magnitude restrictions. We use combinations of these two rest-of-the-world shocks to offset the real

[1] We discuss these issues in more detail in Section 2.

activity spillovers from US monetary policy to obtain the counterfactual. Technically, SSA indicates how US variables would evolve if current and future shocks materialised along the impulse response horizon that happened to offset the effect of the US monetary policy shock on rest-of-the-world real activity. Intuitively, SSA is similar to the assessment of direct and indirect effects in mediation analysis, in which simulated interventions are invoked in order to keep the value of the mediating variable at its baseline (Pearl et al., 2016). SSA is a point of contact with existing literature and provides a natural methodological benchmark (Kilian and Lewis, 2011; Bachmann and Sims, 2012; Wong, 2015; Epstein et al., 2019; Rostagno et al., 2021). We also consider a more general version of SSA in which we do not restrict the set of structural shocks we use to undo the real activity spillovers from US monetary policy to obtain the counterfactual (Antolin-Diaz et al., 2021).

In MRE we determine the minimum 'tilt' of the posterior distribution of the baseline impulse responses to a US monetary policy shock that satisfies the counterfactual constraint that the mean real activity spillovers are nil. Intuitively, MRE indicates how US variables would evolve in a counterfactual world in which the spillovers from US monetary policy to rest-of-the-world real activity are nil but which is otherwise minimally different from the actual world in an information-theoretic sense (Cogley et al., 2005; Robertson et al., 2005; Giacomini and Ragusa, 2014). We argue SSA and MRE are conceptually complementary, which strengthens our analysis given the challenges involved in defining the counterfactual benchmark.

The rest of the paper is organised as follows. Section 2 provides a brief discussion of the conceptual challenges in the analysis of spillbacks. Section 3 provides a short description of the Bayesian proxy SVAR model. Section 4 lays out our specification of the Bayesian proxy SVAR model. Section 5 explains how we construct counterfactuals and presents our results. Section 6 concludes.

2 Monetary policy spillbacks: conceptual considerations

Consider a two-country New Keynesian dynamic stochastic general equilibrium (NK DSGE) model for the US and the rest of the world. To illustrate the conceptional challenges in the analysis of spillbacks, we consider a model that incorporates multiple transmission channels for spillovers from US monetary policy. Specifically, the model features cross-border bank lending as in Akinci and Queralto (2019) as well as trade in final goods under producer-currency pricing.[2] The black solid lines with circles in Figure 1 depict the impulse responses to a contractionary US monetary policy shock: Rest-of-the-world output rises on impact as depreciation against the dollar stimulates net exports through expenditure switching; the

[2]A detailed model description is available upon request.

output spillover turns negative with some delay when the deterioration of the net worth of rest-of-the-world banks that, given their stock of US dollar liabilities, results from the appreciation of the dollar induces a contraction in local lending.

In the spirit of Fischer (2014) and Yellen (2019) we define spillbacks as the part of the overall domestic effect of US monetary policy that arises because of spillovers to the rest of the world. Intuitively, if the rest of the world was not affected by US monetary policy, nothing would spill back to the US economy. Based on this definition, spillbacks are given by the difference between the domestic effects of US monetary policy in the 'true' model in Figure 1 and in some counterfactual model in which there are no spillovers to the rest of the world.

An intuitive 'no-spillover' counterfactual model is a version of the 'true' model in which cross-border bank lending and trade are shut down. The impulse responses for this counterfactual model are shown by the orange lines with squares in Figure 1. As a result of the absence of spillovers, the domestic output effects of US monetary policy are weaker. Based on this 'no-spillover' counterfactual model we conclude that in the 'true' model spillbacks—the difference between the black lines with circles and the orange lines with squares—amplify the domestic output effects of US monetary policy.[3]

However, in practice it is unlikely that the 'true' model and all spillover transmission channels are known. Arguably, any existing model studied in the literature incorporates only a subset of all empirically relevant spillover transmission channels and is thereby mis-specified. For example, the impulse responses shown by the blue lines with triangles in Figure 1 show the effects of a US monetary policy shock when the model does not feature cross-border bank lending but still features trade.[4] It is not surprising that in this mis-specified model the effects of US monetary policy are different from those in the 'true' model. Accordingly, the spillback assessment we obtain when we use this mis-specified model as baseline does not recover the one we obtain when we use the 'true' model as baseline: The difference between the blue lines with triangles and the orange lines with squares (the spillbacks assessed using the mis-specified model as baseline) differs from the difference between the black lines with circles and the orange lines with squares (the 'true' spillbacks). The bias in the assessment of

[3]There also exist counterfactual models in which there are no spillbacks while spillovers from US monetary policy are *not* precluded. For example, we could assume the US is large relative to the rest of the world. However, especially against the background of the debate about the implications of spillovers from US monetary policy discussed in the Introduction it seems more natural and intuitive to benchmark spillbacks based on counterfactual models in which spillovers are absent. Furthermore, the absence of spillovers constitutes a sufficient condition for the absence of spillbacks.

[4]The parametrisation in this model coincides with that in the 'true' model, which could be interpreted as reflecting the researcher's tight priors centred around the true values of the corresponding deep parameters. Of course, when the mis-specified model is confronted with the data with looser priors the estimated parameters in general do not recover their true values and thereby lose their structural interpretation (Fernandez-Villaverde and Rubio-Ramirez, 2008). This is an additional practical challenge when structural models are used to assess spillbacks.

the spillbacks results from a dogmatic prior imposed on the structure of the model in terms of the spillover transmission channels the researcher decides to consider.

Another conceptual challenge in the analysis of spillbacks is that even if the 'true' model was known, the 'no-spillover' counterfactual benchmark model is not unique. For example, the green lines with crosses show that specifying the US as a small open economy mutes spillovers to rest-of-the-world domestic variables, even when cross-border bank lending and trade are not shut down. However, it can also be seen that the spillback assessment implied by using this small open economy counterfactual model as the 'no-spillover' benchmark (black lines with circles vs. green lines with crosses) is different from the one implied by using the 'true' model with cross-border bank lending and trade shut down as 'no-spillover' benchmark (black lines with circles vs. orange lines with squares). Unfortunately, there is no metric that could be used to determine which of these two 'no-spillover' counterfactual benchmarks—shutting down cross-border bank lending and trade or assuming the US is a small open economy—is conceptually more appropriate or intuitive for assessing spillbacks.

In sum, two conceptual challenges afflict the analysis of spillbacks from US monetary policy based on a structural model: (i) the risk of imposing a dogmatic prior that biases the range of possible spillback assessments; (ii) the lack of a unique structural 'no-spillover' counterfactual benchmark. Against this background, we adopt an empirical approach that avoids imposing dogmatic priors and considers an entire class of counterfactual models in which spillovers from US monetary policy to rest-of-the-world output are nil as 'no-spillover' benchmark. The disadvantage of an empirical approach is that it is not straightforward to disentangle the transmission channels through which spillbacks materialise. To address this shortcoming, we later extend our analysis and explore the behaviour of variables that reflect a range of possible transmission channels of spillbacks in the counterfactual.

3 The Bayesian proxy SVAR framework

We provide a description of the Bayesian proxy SVAR (BPSVAR) framework of Arias et al. (forthcoming) before discussing our model specification and identifying assumptions. Because we identify a global uncertainty shock in addition to a US monetary policy shock using proxy variables, we discuss the BPSVAR model for the general case with k proxy variables.

Following the notation of Rubio-Ramirez et al. (2010), consider without loss of generality the structural VAR model with one lag and without deterministic terms

$$\boldsymbol{y}_t'\boldsymbol{A}_0 = \boldsymbol{y}_{t-1}'\boldsymbol{A}_1 + \boldsymbol{\epsilon}_t', \qquad \boldsymbol{\epsilon} \sim N(\boldsymbol{0}, \boldsymbol{I}_n), \tag{1}$$

where $\boldsymbol{y}_t$ is an $n \times 1$ vector of endogenous variables and $\boldsymbol{\epsilon}_t$ an $n \times 1$ vector of structural shocks. The BPSVAR framework builds on the following assumptions in order to identify k structural shocks of interest: There exists a $k \times 1$ vector of proxy variables $\boldsymbol{m}_t$ that are (i) correlated with the k structural shocks of interest $\boldsymbol{\epsilon}_t^*$, and (ii) orthogonal to the remaining structural shocks $\boldsymbol{\epsilon}_t^o$. Formally, the identifying assumptions are

$$E[\boldsymbol{\epsilon}_t^* \boldsymbol{m}_t'] = \underset{(k \times k)}{\boldsymbol{V}}, \tag{2a}$$

$$E[\boldsymbol{\epsilon}_t^o \boldsymbol{m}_t'] = \underset{((n-k) \times k)}{\boldsymbol{0}}, \tag{2b}$$

and represent the relevance and the exogeneity condition, respectively.

Denote by $\tilde{\boldsymbol{y}}_t' \equiv (\boldsymbol{y}_t', \boldsymbol{m}_t')$ the vector of endogenous variables augmented with the $k \times 1$ vector of proxy variables, by $\tilde{\boldsymbol{A}}_\ell$ the corresponding coefficient matrices of dimension $\tilde{n} \times \tilde{n}$ with $\tilde{n} = n + k$, by $\tilde{\boldsymbol{\epsilon}} \equiv (\boldsymbol{\epsilon}_t', \boldsymbol{v}_t')' \sim N(\boldsymbol{0}, \boldsymbol{I}_{n+k})$, where $\boldsymbol{v}_t$ is a $k \times 1$ vector of measurement errors (see below). The augmented model is then given by

$$\tilde{\boldsymbol{y}}_t' \tilde{\boldsymbol{A}}_0 = \tilde{\boldsymbol{y}}_{t-1}' \tilde{\boldsymbol{A}}_1 + \tilde{\boldsymbol{\epsilon}}_t'. \tag{3}$$

To ensure that augmenting the model with these equations does not affect the dynamics of the endogenous variables, restrictions are imposed on the matrices $\tilde{\boldsymbol{A}}_\ell$ such that

$$\tilde{\boldsymbol{A}}_\ell = \begin{pmatrix} \underset{(n \times n)}{\boldsymbol{A}_\ell} & \underset{(n \times k)}{\boldsymbol{\Gamma}_{\ell,1}} \\ \underset{(k \times n)}{\boldsymbol{0}} & \underset{(k \times k)}{\boldsymbol{\Gamma}_{\ell,2}} \end{pmatrix}, \qquad \ell = 0, 1. \tag{4}$$

The zero restrictions on the lower left-hand side block imply that the proxy variables do not enter the equations of the endogenous variables. The reduced form of the model is

$$\tilde{\boldsymbol{y}}_t' = \tilde{\boldsymbol{y}}_{t-1}' \tilde{\boldsymbol{A}}_1 \tilde{\boldsymbol{A}}_0^{-1} + \tilde{\boldsymbol{\epsilon}}_t{}' \tilde{\boldsymbol{A}}_0^{-1}. \tag{5}$$

Because the inverse of $\tilde{\boldsymbol{A}}_0$ is given by

$$\tilde{\boldsymbol{A}}_0^{-1} = \begin{pmatrix} \boldsymbol{A}_0^{-1} & -\boldsymbol{A}_0^{-1} \boldsymbol{\Gamma}_{0,1} \boldsymbol{\Gamma}_{0,2}^{-1} \\ 0 & \boldsymbol{\Gamma}_{0,2}^{-1} \end{pmatrix}, \tag{6}$$

the last k equations of the augmented model in Equation (5) read as

$$\boldsymbol{m}_t' = \tilde{\boldsymbol{y}}_{t-1}' \tilde{\boldsymbol{A}}_1 \begin{pmatrix} -\boldsymbol{A}_0^{-1} \boldsymbol{\Gamma}_{0,1} \boldsymbol{\Gamma}_{0,2}^{-1} \\ \boldsymbol{\Gamma}_{0,2}^{-1} \end{pmatrix} - \boldsymbol{\epsilon}_t' \boldsymbol{A}_0^{-1} \boldsymbol{\Gamma}_{0,1} \boldsymbol{\Gamma}_{0,2}^{-1} + \boldsymbol{v}_t' \boldsymbol{\Gamma}_{0,2}^{-1}, \tag{7}$$

which shows that the proxy variables may be serially correlated and affected by past values of the endogenous variables, and measurement error.

Ordering the structural shocks so that $\boldsymbol{\epsilon}_t = (\boldsymbol{\epsilon}_t^{o\prime}, \boldsymbol{\epsilon}_t^{*\prime})'$ we have

$$E\left[\boldsymbol{\epsilon}_t \boldsymbol{m}_t'\right] = -\boldsymbol{A}_0^{-1}\boldsymbol{\Gamma}_{0,1}\boldsymbol{\Gamma}_{0,2}^{-1} = \begin{pmatrix} \underset{((n-k)\times k)}{\mathbf{0}} \\ \underset{(k\times k)}{\boldsymbol{V}} \end{pmatrix}, \tag{8}$$

where the first equality is obtained using Equation (7) and because the structural shocks $\boldsymbol{\epsilon}_t$ are by assumption orthogonal to $\boldsymbol{y}_{t-1}$ and $\boldsymbol{v}_t$, and the second equality is due to the exogeneity and relevance conditions in Equations (2a) and (2b). Equation (8) shows that the identifying assumptions imply restrictions on the last k columns of the contemporaneous structural impact coefficients in $\tilde{\boldsymbol{A}}_0^{-1}$. In particular, if the exogeneity condition in Equation (2b) holds, the first $n-k$ columns of the upper right-hand side sub-matrix $\boldsymbol{A}_0^{-1}\boldsymbol{\Gamma}_{0,1}\boldsymbol{\Gamma}_{0,2}^{-1}$ of $\tilde{\boldsymbol{A}}_0^{-1}$ in Equation (6) are zero. From Equation (5) it can be seen that this implies that the first $n-k$ structural shocks do not impact contemporaneously the proxy variables. In turn, if the relevance condition in Equation (2a) holds, the last k columns of the upper right-hand side sub-matrix $\boldsymbol{A}_0^{-1}\boldsymbol{\Gamma}_{0,1}\boldsymbol{\Gamma}_{0,2}^{-1}$ of $\tilde{\boldsymbol{A}}_0^{-1}$ are different from zero. From Equation (5) it can be seen that this implies that the last k structural shocks impact the proxy variables contemporaneously. The Bayesian estimation algorithm of Arias et al. (forthcoming) determines the estimates of $\boldsymbol{A}_0$ and $\boldsymbol{\Gamma}_{0,\ell}$ such that the restrictions on $\tilde{\boldsymbol{A}}_0^{-1}$ implied by Equations (2a) and (2b) as well as on $\tilde{\boldsymbol{A}}_\ell$ in Equation (4) are simultaneously satisfied, and hence the estimation identifies the structural shocks $\boldsymbol{\epsilon}_t^*$.

If the number of structural shocks identified by the proxy variables is larger than one, the BPSVAR model is set identified, as rotations of the structural shocks $\boldsymbol{Q}\boldsymbol{\epsilon}_t^*$ satisfy the exogeneity and relevance conditions in Equations (2a) and (2b). In this case, additional restrictions are needed in order to point-identify the structural shocks in $\boldsymbol{\epsilon}_t^*$. An important advantage of the BPSVAR over the traditional frequentist proxy SVAR framework is that the additional identifying assumptions can be imposed on the relevance condition in Equation (2a) reflected in the matrix $\boldsymbol{V}$ rather than on the contemporaneous relationships between the endogenous variables in the structural impact matrix $\boldsymbol{A}_0^{-1}$. One may, for example, impose the restriction that a particular structural shock in $\boldsymbol{\epsilon}_t^*$ does not affect a particular proxy variable in $\boldsymbol{m}_t$. Restrictions on the relationship between structural shocks and proxy variables are arguably less controversial than exogeneity restrictions between the endogenous variables in $\boldsymbol{A}_0^{-1}$, such as for example those imposed in Mertens and Ravn (2013).

Another appealing feature of the BPSVAR model is that it allows to incorporate a prior belief about the strength of the proxy variables as instruments are based on the notion that "researchers construct proxies to be relevant" (Caldara and Herbst, 2019, p. 165). A convenient metric is the 'reliability matrix' $\boldsymbol{R}$ derived in Mertens and Ravn (2013) given by

$$\boldsymbol{R} = \left(\boldsymbol{\Gamma}_{0,2}^{-1\prime}\boldsymbol{\Gamma}_{0,2} + \boldsymbol{V}\boldsymbol{V}'\right)^{-1}\boldsymbol{V}\boldsymbol{V}'. \tag{9}$$

Intuitively, $\boldsymbol{R}$ indicates the share of variance of the proxy variables that is accounted for by the structural shocks $\boldsymbol{\epsilon}_t^*$ (see Equation (7)). Specifically, the minimum eigenvalues of $\boldsymbol{R}$ can be interpreted as the share of the variance of (any linear combination of) the proxy variables explained by the structural shocks $\boldsymbol{\epsilon}_t^*$ (Gleser, 1992).

Yet another appealing feature of the BPSVAR model is that it allows to additionally identify some of the structural shocks in $\boldsymbol{\epsilon}_t^o$ using zero, sign and magnitude restrictions. These additional restrictions are imposed on the contemporaneous structural impact matrix $\boldsymbol{A}_0^{-1}$. Importantly, the BPSVAR framework of Arias et al. (forthcoming) allows coherent inference for specifications in which identification is achieved using zero, sign, and magnitude restrictions as well as proxy variables.

Finally, a last appealing feature of the BPSVAR framework—especially relative to the traditional frequentist proxy SVAR framework—is that it allows exact finite sample inference, even in settings in which the proxy variables are weak instruments and only set rather than point identification is achieved with a combination of sign, magnitude and zero restrictions (see Moon and Schorfheide, 2012; Caldara and Herbst, 2019; Arias et al., forthcoming). In particular, note that traditional proxy SVAR models are typically estimated following a three-step procedure (Mertens and Ravn, 2013; Gertler and Karadi, 2015): (i) estimate the reduced-form VAR model by least squares; (ii) regress the reduced-form residuals on the proxy; and (iii) impose the restrictions derived in (ii) to identify the structural parameters. This three-stage procedure makes only limited use of the information contained in the proxy. For example, the estimation of the reduced-form VAR model is not informed by the proxy variable. In contrast, the joint likelihood of the endogenous variables and the proxy variables based on Equation (3) allows the proxy to inform the estimation of both reduced form and structural parameters in the BPSVAR model and therefore entails a coherent modelling of all sources of uncertainty. Furthermore, in a Bayesian setting, weak identification does not pose a problem *per se*; as long as the prior distribution is proper, inference is possible (Poirier, 1998). By contrast, traditional frequentist proxy SVAR models require an explicit theory to deal with weakly informative instruments (Olea et al., forthcoming), either to derive the asymptotic distributions of estimators or to ensure satisfactory coverage in bootstrap procedures.[5]

[5]To the best of our knowledge, there is no clear consensus yet on how to conduct inference in frequentist proxy SVAR models, even in a setting with only a single proxy variable (Jentsch and Lunsford, 2016, 2019).

4 Empirical framework

4.1 VAR model specification

Our point of departure is the closed-economy US VAR model in Gertler and Karadi (2015), which includes as endogenous variables monthly (log) US industrial production (IP), the (log) US consumer-price index (CPI), the excess bond premium (EBP) and the one-year US Treasury Bill (TB) rate as a monetary policy indicator. We augment the model with the VXO, (log) rest-of-the-world (non-US) real industrial production, and the (log) nominal effective exchange rate (NEER) of the US dollar. Variable descriptions and data sources are provided in Table 1. The sample spans the time period from February 1990 to June 2019.

4.2 Identifying assumptions

We identify a US monetary policy shock using a proxy variable and—for the purpose of SSA counterfactuals—two rest-of-the-world shocks using a mixture of sign, magnitude and zero restrictions. In addition, we identify a global uncertainty shock to preclude that the two rest-of-the-world shocks are contaminated by shocks that are common to the US and the rest of the world. We identify the global uncertainty shock using a second proxy variable.

4.2.1 US monetary policy and global uncertainty shocks

As in Gertler and Karadi (2015) as well as Caldara and Herbst (2019) we consider the intra-daily interest rate surprises around narrow time windows on FOMC meeting days of Gürkaynak et al. (2005) as proxy variable for the US monetary policy shock. We cleanse these surprises from central bank information effects using the 'poor-man's' approach of Jarocinski and Karadi (2020): When the interest rate surprise has the same sign as the equity price surprise, we classify it as a central bank information effect; when the interest rate and the equity price surprises have opposite signs, we classify it as a 'pure' monetary policy surprise.

We consider the intra-daily gold price surprises of Piffer and Podstawski (2018) around narrow time windows on narratively selected days as proxy variable for the global uncertainty shock. Specifically, Piffer and Podstawski (2018) first extend the list of dates selected by Bloom (2009) on which the VXO increased arguably due to exogenous uncertainty shocks. Then, they calculate the change in the price of gold between the last auction before and the first auction after the news about the event representing the uncertainty shock became available to markets. The original data on gold price surprises of Piffer and Podstawski (2018) cover the time period until 2015; we use the update of Bobasu et al. (2020) that spans until 2019.

Consider the notation from Section 3 and define $\boldsymbol{\epsilon}_t^* \equiv (\epsilon_t^{mp}, \epsilon_t^u)'$, where ϵ_t^{mp} denotes the US monetary policy shock and ϵ_t^u the global uncertainty shock. Furthermore, define $\boldsymbol{m}_t \equiv (p_t^{\epsilon,mp}, p_t^{\epsilon,u})'$ as the vector containing the proxy variables for the US monetary policy and the global uncertainty shocks. Our identifying assumptions are

$$E[\boldsymbol{\epsilon}_t^* \boldsymbol{m}_t'] = \begin{pmatrix} E[p_t^{\epsilon,mp}\epsilon_t^{mp}] & E[p_t^{\epsilon,u}\epsilon_t^{mp}] \\ E[p_t^{\epsilon,mp}\epsilon_t^{u}] & E[p_t^{\epsilon,u}\epsilon_t^{u}] \end{pmatrix} = \underset{(2\times 2)}{\boldsymbol{V}}, \tag{10a}$$

$$E[\boldsymbol{\epsilon}_t^o \boldsymbol{m}_t'] = \begin{pmatrix} E[p_t^{\epsilon,mp}\boldsymbol{\epsilon}_t^{o}] & E[p_t^{\epsilon,u}\boldsymbol{\epsilon}_t^{o}] \end{pmatrix} = \underset{((n-2)\times 2)}{\boldsymbol{0}}. \tag{10b}$$

First, in the relevance condition in Equation (10a) we assume that US monetary policy shocks drive the interest rate surprises on FOMC meeting days, $E[p_t^{\epsilon,mp}\epsilon_t^{mp}] \neq 0$. This is the standard instrument relevance assumption maintained in the literature (Gertler and Karadi, 2015; Caldara and Herbst, 2019). The exogeneity condition $E[p_t^{\epsilon,mp}\boldsymbol{\epsilon}_t^{o}] = 0$ in Equation (10b) cannot be tested as none of the other structural shocks $\boldsymbol{\epsilon}_t^o$ is observed, but it seems plausible that in a narrow time window around FOMC meetings monetary policy shocks are the only systematic drivers of interest rate surprises purged from central bank information effects.

Second, in the relevance condition in Equation (10a) we assume that global uncertainty shocks drive the gold price surprises on the narratively selected dates, $E[p_t^{\epsilon,u}\epsilon_t^{u}] \neq 0$. Intuitively, as gold is widely seen as a safe haven asset, demand increases when uncertainty rises (Baur and McDermott, 2010, 2016). Piffer and Podstawski (2018) provide evidence that gold price surprises are relevant instruments for uncertainty shocks based on F-tests and Granger causality tests with the VXO and the macroeconomic uncertainty measure constructed in Jurado et al. (2015). Ludvigson et al. (forthcoming) also use gold price changes as a proxy variable for uncertainty shocks. Regarding the exogeneity condition $E[p_t^{\epsilon,u}\boldsymbol{\epsilon}_t^{o}] = 0$ in Equation (10b), Piffer and Podstawski (2018) document that gold price surprises are uncorrelated with a range of non-uncertainty shocks.

As discussed in Section 3, when multiple proxy variables are used to identify multiple structural shocks, the relevance and exogeneity conditions are not sufficient for point identification. In this case, additional restrictions need to be imposed on the structural impact matrix $\boldsymbol{A}_0^{-1}$ that reflects the contemporaneous relationships between the endogenous variables $\boldsymbol{y}_t$ or—arguably less restrictive and an important advantage of the BPSVAR over the traditional frequentist proxy SVAR framework—on $\boldsymbol{V}$ in Equation (10a). A natural idea is to impose that $\boldsymbol{V}$ is a diagonal matrix, implying that US interest rate surprises on FOMC meeting days purged from central bank information effects are not driven by global uncertainty shocks, and that gold price surprises on days with prominent global economic, political or natural events are not systematically driven by US monetary policy shocks. Technically, these additional restrictions imply an over-identified system, which cannot be handled by the algorithm of

Arias et al. (forthcoming). We therefore impose a weaker set of additional restrictions on $\boldsymbol{V}$, namely only that US interest rate surprises on FOMC meeting days are not driven by global uncertainty shocks, $E[p_t^{\epsilon,mp}\epsilon_t^u] = 0$. Note that this assumption is implicitly maintained and crucial for the validity of much work in the literature. For example, if this assumption was not satisfied then the prominent analyses of Gertler and Karadi (2015), Caldara and Herbst (2019) as well as Jarocinski and Karadi (2020) would be invalid as the identified US monetary policy shocks would be contaminated by global uncertainty shocks.

Finally, it is worthwhile pointing out that when two proxy variables are used to identify two structural shocks, a single additional zero restriction imposed on $\boldsymbol{V}$ is sufficient for point-identification (Giacomini et al., forthcoming).[6]

4.2.2 Rest-of-the-world shocks

Existing literature using SSA has considered offsetting shocks that are as 'close' as possible to the transmission channel being evaluated (Kilian and Lewis, 2011; Bachmann and Sims, 2012; Wong, 2015; Epstein et al., 2019; Rostagno et al., 2021). For example, Bachmann and Sims (2012) assess the role of the confidence channel in the transmission of fiscal policy shocks. To do so, in the counterfactual they use a confidence shock to offset the effect of a fiscal policy shock on the confidence measure in the VAR model.

To establish a point of contact with this literature, we use rest-of-the-world shocks to offset the real activity spillovers from US monetary policy. In particular, we 'identify' two rest-of-the-world 'depreciating' and 'appreciating' shocks. Our identification implies these two shocks only have a reduced-form interpretation. However, this is sufficient for our purposes as the two rest-of-the-world 'depreciating' and 'appreciating' shocks nest the universe of rest-of-the-world structural shocks.

While using specific offsetting shocks that are as 'close' as possible to the transmission channel of interest may seem intuitive and a useful point of contact with existing literature, we argue below in Section 5.1 that it is not compelling from a conceptual point of view. We therefore also consider a more general version of SSA in which we do not restrict the set of structural shocks we use to offset the real activity spillovers from US monetary policy.

Table 2 presents the sign and relative magnitude restrictions we impose in order to identify the two rest-of-the-world shocks. We normalise both shocks so that rest-of-the-world real activity decelerates on impact. We impose the restriction that real activity slows down more

[6] This is appealing also because under set-identification results may depend on the choice of the prior distribution for the construction of the rotation matrices in the estimation (Baumeister and Hamilton, 2015).

at home than abroad in order to distinguish US and rest-of-the-world shocks.[7]

For the 'depreciating' rest-of-the-world shock we assume that it appreciates the US dollar NEER and that it slows down rest-of-the-world and US real activity. We assume US real activity slows down as expenditure reducing and expenditure switching effects in the US point in the same direction: In response to a rest-of-the-world 'depreciating'—e.g. a contractionary demand—shock US exports decline as rest-of-the-world real activity slows down. Moreover, because the US dollar NEER appreciates the rest-of-the-world switches away from imports from the US towards domestically produced goods, also slowing down US real activity.

For the 'appreciating' rest-of-the-world shock we assume that it depreciates the US dollar NEER. We do not assume that US real activity slows down, as expenditure reducing and expenditure switching effects in the US move in opposite directions: While demand for US exports declines as rest-of-the-world real activity slows down in response to a rest-of-the-world 'appreciating'—e.g. a contractionary monetary policy—shock, in the US the depreciation of the US dollar NEER induces expenditure switching away from imports towards domestically produced goods; the overall effect on US net exports and hence US real activity is ambiguous.[8]

Finally, note that as we need to offset the effect of a US monetary policy shock on only one variable (rest-of-the-world real activity), we could identify just a single instead of two rest-of-the-world shocks. However, as it offers sharper identification with only negligible additional computational cost we identify two rest-of-the-world shocks.

4.3 Priors

We use flat priors for the VAR parameters. We follow Caldara and Herbst (2019) as well as Arias et al. (forthcoming) and impose a 'relevance threshold' to express our prior belief that the proxy variables are relevant instruments: We require that at least a share $\gamma = 0.1$ of the variance of the proxy variables is accounted for by the US monetary policy and global uncertainty shocks, respectively; this is weaker than the relevance threshold of $\gamma = 0.2$ used by Arias et al. (forthcoming), and—although not directly comparable conceptually—lies below the 'high-relevance prior' of Caldara and Herbst (2019).

[7]Consistent with the exogeneity restriction in Equation (10b) we also assume that the proxy variables are not systematically driven by the rest-of-the-world shocks using zero restrictions.

[8]While we do not take a stand on the response of the exchange rate to rest-of-the-world productivity, financial and fiscal policy shocks, it should be clear that they are subsumed in one of the two rest-of-the-world reduced-form shocks.

4.4 Baseline impulse responses

Figure 2 presents the posterior mean of the baseline impulse responses together with 68% credible sets (as is common when using uninformative priors, see Arias et al., 2018, forthcoming).[9] Our findings are consistent with the literature (see Gertler and Karadi, 2015; Caldara and Herbst, 2019). A contractionary US monetary policy shock is accompanied by a rise in the one-year Treasury Bill rate, tightens financial conditions by raising the excess bond premium, increases the VXO, appreciates the dollar NEER, temporarily reduces US industrial production and persistently US consumer prices. Our findings are also consistent with the literature on the spillovers from US monetary policy (see, e.g., Banerjee et al., 2016; Georgiadis, 2016; Dedola et al., 2017; Iacoviello and Navarro, 2019; Vicondoa, 2019; Degasperi et al., 2020; Dees and Galesi, 2021): Rest-of-the-world real activity slows down considerably, essentially mirroring developments in the US.

The second and third columns in Figure 2 show that the 'depreciating' and 'appreciating' rest-of-the-world—e.g. a contractionary demand and monetary policy—shocks slow down real activity globally. That rest-of-the-world shocks have a non-trivial impact on the US suggests that spillovers from US monetary policy may entail non-trivial spillbacks.

Finally, the last column in Figure 2 shows that the global uncertainty shock appreciates the US dollar NEER, raises the VXO and the excess bond premium, causes a slowdown in global real activity, lowers US consumer prices, and is followed by a fall in the one-year Treasury Bill rate. Overall, the impulse responses of the global uncertainty shock are consistent with the literature on the importance of US safe assets and the implications for the US dollar exchange rate (Bianchi et al., 2020; Jiang et al., 2021) as well as the global economy and financial markets (Epstein et al., 2019).

Before we move to the counterfactual analysis, Figure E.1 documents that our results for the effects of US monetary policy shocks are robust in several important dimensions. First, we consider an alternative specification in which we drop interest rate surprises on non-scheduled FOMC meetings ('intermeetings') when constructing the monetary policy shock proxy variable as suggested by Caldara and Herbst (2019). Second, instead of the approach of Gertler and Karadi (2015) for temporal aggregation of the interest rate and gold price surprises from daily to monthly frequency we take the simple average in a given month as in Jarocinski and Karadi (2020). Third, we do not consider the 'poor-man's' approach of Jarocinski and Karadi (2020) to cleanse the daily interest rate surprises from central bank information effects but instead follow Miranda-Agrippino and Ricco (2021) and purge the

[9] While Caldara and Herbst (2019) show 90% credible sets in a BPSVAR model estimation, it should be noted that they use informative Minnesota-type priors.

surprises from information contained in Greenbook projections. Fourth, we include additional variables in the VAR model, namely rest-of-the-world consumer prices and policy rates, US exports and imports as well as global equity prices; in this case we follow Giannone et al. (2015) and use informative priors in order to deal with the high dimensionality of the model. Fifth, we additionally identify US demand and supply shocks using standard sign restrictions. Sixth, we additionally identify an oil supply shock as a second global shock that is common to the US and the rest of the world using the proxy variable constructed by Känzig (2021). And seventh, we do not impose a 'relevance threshold' for the proxy variables and set γ to zero.

5 Quantifying spillbacks from US monetary policy

The VAR model in Equation (1) can be iterated forward and re-written as

$$\boldsymbol{y}_{T+1,T+h} = \boldsymbol{b}_{T+1,T+h} + \boldsymbol{M}'\boldsymbol{\epsilon}_{T+1,T+h}, \tag{11}$$

where the $nh \times 1$ vector $\boldsymbol{y}_{T+1,T+h} \equiv [\boldsymbol{y}'_{T+1}, \boldsymbol{y}'_{T+2}, \dots, \boldsymbol{y}'_{T+h}]'$ denotes the future values of the endogenous variables, $\boldsymbol{b}_{T+1,T+h}$ an autoregressive component that is due to initial conditions as of period T, and the $nh \times 1$ vector $\boldsymbol{\epsilon}_{T+1,T+h} \equiv [\boldsymbol{\epsilon}'_{T+1}, \boldsymbol{\epsilon}'_{T+2}, \dots, \boldsymbol{\epsilon}'_{T+h}]'$ future values of the structural shocks; the $nh \times nh$ matrix $\boldsymbol{M}$ reflects the impulse responses and is a function of the structural VAR parameters $\boldsymbol{\psi} \equiv vec(\boldsymbol{A}_0, \boldsymbol{A}_1)$.

Assume for simplicity of exposition but without loss of generality that the VAR model in Equation (1)—which does not have deterministic components—is stationary and in steady state in period T so that $\boldsymbol{b}_{T+1,T+h} = \boldsymbol{0}$. In this setting, an impulse response to the i-th structural shock over a horizon of h periods coincides with the forecast $\boldsymbol{y}_{T+1,T+h}$ conditional on $\boldsymbol{\epsilon}_{T+1,T+h} = [\boldsymbol{e}'_i, \boldsymbol{0}_{1\times n(h-1)}]'$, where $\boldsymbol{e}_i$ is an $n \times 1$ vector of zeros with unity at the i-th position. For example, for the impulse response to a US monetary policy shock we have $\epsilon^{mp}_{T+1} = 1$, $\epsilon^{mp}_{T+s} = 0$ for $s > 1$ and $\epsilon^{\ell}_{T+s} = 0$ for $s > 0$, $\ell \neq mp$.

As in Section 2, we define spillbacks as the difference between the impulse responses of domestic variables to a US monetary policy shock in the baseline denoted by $\boldsymbol{y}_{T+1,T+h}$ (displayed in Figure 2) and in a counterfactual denoted by $\widetilde{\boldsymbol{y}}_{T+1,T+h}$. In the counterfactual, the impulse response of rest-of-the-world real activity to a US monetary policy shock is nil. We consider two approaches for constructing the counterfactual impulse response $\widetilde{\boldsymbol{y}}_{T+1,T+h}$: SSA and MRE.

5.1 SSA counterfactuals

5.1.1 Conceptual considerations

In SSA the VAR model is unchanged in the counterfactual in terms of the structural parameters $\boldsymbol{\psi}$ and hence $\boldsymbol{M}$ in Equation (11). Therefore, in order for the impulse response $\widetilde{\boldsymbol{y}}_{T+1,T+h}$ to satisfy counterfactual constraints we must allow for additional shocks in $\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h}$ to materialise over horizons $T+1, T+2, \ldots, T+h$. In our application of SSA these additional shocks and their magnitude are chosen such that they offset the effect of the US monetary policy shock on rest-of-the-world real activity. Intuitively, SSA analyses causal contributions to an overall effect in a similar way as mediation analysis does in structural causal models (see Pearl et al., 2016, chpt. 3): To assess the direct and indirect effects of a variable of interest X on an outcome variable Y a mediating variable Z is held constant by simulated interventions.

Building on Waggoner and Zha (1999), Antolin-Diaz et al. (2021) describe how to obtain $\widetilde{\boldsymbol{y}}_{T+1,T+h}$ subject to constraints on the paths of a subset of the endogenous variables represented by

$$\overline{\boldsymbol{C}}\widetilde{\boldsymbol{y}}_{T+1,T+h} = \overline{\boldsymbol{C}}\boldsymbol{M}'\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h} \sim N(\overline{\boldsymbol{f}}_{T+1,T+h}, \overline{\boldsymbol{\Omega}}_f), \tag{12}$$

where $\overline{\boldsymbol{C}}$ is a $k_o \times nh$ selection matrix, $\overline{\boldsymbol{f}}_{T+1,T+h}$ is a $k_o \times 1$ vector and $\overline{\boldsymbol{\Omega}}_f$ a $k_o \times k_o$ matrix, and subject to constraints on the structural shocks represented by

$$\boldsymbol{\Xi}\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h} \sim N(\boldsymbol{g}_{T+1,T+h}, \boldsymbol{\Omega}_g), \tag{13}$$

where $\boldsymbol{\Xi}$ is a $k_s \times nh$ selection matrix, $\boldsymbol{g}_{T+1,T+h}$ a $k_s \times 1$ vector, and $\boldsymbol{\Omega}_g$ a $k_s \times k_s$ matrix. In our context, Equation (12) imposes the counterfactual constraint that the real activity spillovers from US monetary are nil, and Equation (13) the constraint that some structural shocks may not be in the set of offsetting shocks that enforce the counterfactual constraint. Antolin-Diaz et al. (2021) show how to obtain the SSA solution in terms of $\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h}$ which satisfies both the counterfactual constraint on the endogenous variables in Equation (12) and the constraint on the offsetting shocks in Equation (13). The SSA counterfactual impulse response is then given by $\widetilde{\boldsymbol{y}}_{T+1,T+h} = \boldsymbol{M}'\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h}$.[10,11]

[10]Note that because at every horizon we have two rest-of-the-world shocks to impose one constraint (that rest-of-the-world real activity does not respond to a US monetary policy shock), there is a multiplicity of solutions. Antolin-Diaz et al. (2021) show that the solution chosen minimises the Frobenius norm of the deviation of the distribution of the structural shocks under the counterfactual from the baseline. Intuitively, this means the counterfactual shocks chosen are those that are minimally different in terms of mean and variance from their baseline analogues.

[11]See Appendix C for further technical details and the specification of the matrices $\overline{\boldsymbol{C}}$, $\overline{\boldsymbol{f}}_{T+1,T+h}$, $\boldsymbol{\Xi}$, $\overline{\boldsymbol{g}}_{T+1,T+h}$, $\boldsymbol{\Omega}_g$ and $\overline{\boldsymbol{\Omega}}_f$ under the baseline and the counterfactual conditional forecast for our application.

5.1.2 Results from SSA

The left-hand side panel in Figure 3 presents the baseline impulse response of domestic industrial production to the US monetary policy shock from Figure 2 (black solid line) and the SSA counterfactual in which rest-of-the-world shocks materialise so that real activity spillovers are offset (green line with squares). Because we estimate the unknown VAR parameters by Bayesian methods, we present results in terms of the posterior distribution of the counterfactual impulse responses. In the counterfactual in which real activity spillovers are precluded the drop in US industrial production is reduced substantially compared to the baseline. This implies that spillbacks amplify the domestic effects of US monetary policy. Quantitatively, spillbacks account for almost 50% of the overall domestic effect of US monetary policy on industrial production.

From a conceptual perspective it is intuitive to consider rest-of-the-world shocks to offset real activity spillovers from US monetary policy shocks in line with earlier literature using SSA (Kilian and Lewis, 2011; Bachmann and Sims, 2012; Wong, 2015; Epstein et al., 2019; Rostagno et al., 2021). At the same time, one could argue there should not be any constraint on the set of shocks that may materialise to offset the real activity spillovers in the counterfactual. A collateral benefit of this alternative is that it does not require identifying assumptions for the rest-of-the-world shocks. The middle panel in Figure 3 presents the results for this more general SSA specification. The results are very similar to those based only on rest-of-the-world shocks in the left-hand side panel.

Figure 4 presents the posterior distribution of the difference between the response of domestic industrial production to a US monetary policy shock in the baseline and the SSA counterfactuals from Figure 3. Our estimation assigns a high probability to spillbacks being different from zero. The posterior distribution of the SSA spillback estimates is tighter if the set of offsetting shocks is not constrained. This is because in this case only the US monetary policy shock needs to be identified, and hence uncertainty stemming from the set identification of the rest-of-the-world shocks based on sign restrictions is absent.[12]

The validity of SSA depends on the characteristics of the offsetting shocks, i.e. $\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h}$ in Equation (13). In particular, if these are exceptionally large or persistent, then agents may update their beliefs about the policy regime and the structure of the economy more generally; recall that the rest-of-the-world shocks include—even if we do not disentangle them

[12] As our two rest-of-the-world shocks are set identified inference on the identified set may depend on the choice of our prior over the rotation matrix as we sample from the set of orthonormal matrices using the uniform prior discussed in Rubio-Ramirez et al. (2010). As pointed out by Baumeister and Hamilton (2015) this uniform prior might influence the posterior of the impulse responses, although the practical relevance of this concern is still debated (Inoue and Kilian, 2020).

explicitly—policy shocks. Consequently, SSA might be subject to the Lucas critique. However, the results for the 'modesty statistic' of Leeper and Zha (2003) displayed in the top row in Figure 5 indicate that the offsetting shocks are not unusually large or persistent; the test statistic has a standard normal distribution under the null of 'modest' interventions. Similarly, the q-divergence proposed by Antolin-Diaz et al. (2021) and displayed in the bottom row in Figure 5 does not indicate that the distribution of shocks in the counterfactual is notably different from the baseline; the q-divergence indicates how strongly the distributions of the offsetting shocks in the counterfactual deviate from their baseline distributions expressed in terms of a bias of the 'heads' probability of a coin toss.

One may wonder if our results for the counterfactual in Figure 3 suggest that without the rest of the world and without spillbacks US monetary policy would be ineffective. We return to this important question below in Section 5.5.4 after discussing the transmission channels through which the spillbacks materialise.

5.2 MRE counterfactuals

5.2.1 Conceptual considerations

In the existing literature MRE is used to incorporate restrictions derived from economic theory in order to improve a forecast. For example, Robertson et al. (2005) improve their forecasts of the Federal Funds rate, US inflation and the output gap by imposing the constraint that the mean three-year-ahead inflation forecast must equal 2.5% through MRE.[13] Similar in spirit, we use MRE to generate a counterfactual conditional forecast based on our baseline conditional forecast in Equation (11) that represents the impulse responses to a US monetary policy shock.

As in SSA conceive of an impulse response as—again assuming for simplicity of exposition the VAR model is stationary and in steady state in period T so that $\boldsymbol{b}_{T+1,T+h} = \mathbf{0}$—the conditional forecast $\boldsymbol{y}_{T+1,T+h}$, where in case of a US monetary policy shock we have $\epsilon^{mp}_{T+1} = 1$, $\epsilon^{mp}_{T+s} = 0$ for $s > 1$ and $\epsilon^{\ell}_{T+s} = 0$ for $s > 0$, $\ell \neq mp$. Our posterior belief about the actual effects of a US monetary policy shock after h periods based on the data is given by

$$f(\boldsymbol{y}_{T+h}|\boldsymbol{y}_{1,T}, \mathcal{I}_a, \boldsymbol{\epsilon}_{T+1,T+h}) \propto p(\boldsymbol{\psi}) \times \ell(\boldsymbol{y}_{1,T}|\boldsymbol{\psi}, \mathcal{I}_a) \times \nu, \tag{14}$$

where $p(\boldsymbol{\psi})$ is the prior about the structural VAR parameters, $\mathcal{I}_a$ our identifying assumptions, and ν the volume element of the mapping from the posterior distribution of the structural VAR parameters to the posterior distribution of the impulse response $\boldsymbol{y}_{T+h}$; the mean of f

[13] See Cogley et al. (2005) and Giacomini and Ragusa (2014) for similar applications.

is plotted in the first column in Figure 2. MRE determines the posterior beliefs about the effects of a US monetary policy shock $\widetilde{\boldsymbol{y}}_{T+h}$ in a counterfactual VAR model with structural parameters $\widetilde{\boldsymbol{\psi}}$ by

$$Min_{\widetilde{\boldsymbol{\psi}}} \ \mathcal{D}(f^*||f) \quad s.t.$$
$$\int f^*(\widetilde{\boldsymbol{y}})\widetilde{y}^{ip^*} d\widetilde{\boldsymbol{y}} = E(\widetilde{y}^{ip^*}) = 0, \ \int f^*(\widetilde{\boldsymbol{y}})d\widetilde{\boldsymbol{y}} = 1, \ f^*(\widetilde{\boldsymbol{y}}) \geq 0, \tag{15}$$

where $\mathcal{D}(\cdot)$ is the Kullback-Leibler divergence—the 'relative entropy'—between the counterfactual and baseline posterior beliefs (we drop the subscripts in $\widetilde{y}^{ip*}_{T+h}/\widetilde{\boldsymbol{y}}_{T+h}$ in Equation (15) for simplicity). In general, there is an infinite number of counterfactual beliefs f^* that satisfy the constraint $E(\widetilde{y}^{ip^*}_{T+h}) = 0$. The MRE approach in Equation (15) disciplines the choice of the counterfactual posterior beliefs f^* by requiring that they are *minimally* different from the baseline posterior beliefs f in an information-theoretic sense.[14] Intuitively, MRE determines the counterfactual VAR model in which real activity spillovers from US monetary policy are nil but whose dynamic properties in terms of impulse responses are otherwise minimally different from those of the actual VAR model.[15]

It turns out that in order to determine the posterior beliefs f^* in Equation (15) MRE updates the baseline posterior beliefs f by incorporating the information represented by the constraint that real activity spillovers from US monetary policy are nil in the counterfactual VAR model according to

$$f^*\left(\widetilde{\boldsymbol{y}}_{T+h}|\boldsymbol{y}_{1,T}, \mathcal{I}_a, \boldsymbol{\epsilon}_{T+1,T+h}, \widetilde{y}^{ip^*}_{T+h} = 0\right) \propto$$
$$f(\widetilde{\boldsymbol{y}}_{T+h}|\boldsymbol{y}_{1,T}, \mathcal{I}_a, \boldsymbol{\epsilon}_{T+1,T+h}) \times \tau\left(\widetilde{y}^{ip^*}_{T+h}(\boldsymbol{\psi})\right), \tag{16}$$

where τ is a 'tilt' function (see Robertson et al., 2005). Intuitively, τ down-weights the baseline posterior for values of the VAR parameters $\boldsymbol{\psi}$ that are associated with large deviations from the counterfactual constraint that real activity spillovers from US monetary policy shall be nil. In practice, Robertson et al. (2005) as well as Giacomini and Ragusa (2014) show

[14] The structural parameters $\widetilde{\boldsymbol{\psi}}$ of the counterfactual VAR model could in principle be obtained from the counterfactual impulse responses $\widetilde{\boldsymbol{y}}$ based on the mapping between impulse responses and structural VAR parameters (see Arias et al., 2018, Appendix B).

[15] Brute force alternatives for carrying out counterfactual analysis in VAR models are to set to zero autoregressive parameters after or before estimation (see, for example, Ramey, 1993; Vicondoa, 2019; Degasperi et al., 2020; Dees and Galesi, 2021). However, setting to zero VAR coefficients before estimation implies a mis-specified empirical model and induces biased estimates; in general, the bias is not informative about the strength of the channel that is being shut down (Georgiadis, 2017). In turn, setting to zero VAR coefficients after estimation may be understood similarly as the MRE approach in the sense that it reflects some counterfactual VAR model. However, while the MRE approach determines a counterfactual VAR model that is—roughly speaking—minimally different from the actual VAR model, setting to zero some VAR coefficient does not impose any intuitively plausible discipline on the choice of the counterfactual VAR model (for a discussion see Benati, 2010).

that MRE boils down to adjusting the weights of the draws of the approximated baseline posterior distribution.[16] Once the counterfactual weights are obtained, importance sampling techniques can be used to estimate the mean and percentiles of the counterfactual posterior distribution.[17]

Before turning to the MRE results, it is worthwhile highlighting the conceptual difference between SSA and MRE counterfactuals. In particular, the SSA posterior of the counterfactual impulse response is given by $f(\widetilde{\boldsymbol{y}}_{T+h}|\boldsymbol{y}_{1,T}, \mathcal{I}_a, \widetilde{\boldsymbol{\epsilon}}_{T+1,T+h})$, whereas the MRE posterior is given by $f^*(\widetilde{\boldsymbol{y}}_{T+h}|\boldsymbol{y}_{1,T}, \mathcal{I}_a, \boldsymbol{\epsilon}_{T+1,T+h}, \widetilde{y}^{ip^*}_{T+h} = 0)$. This makes clear that SSA and MRE are conceptually different approaches to counterfactual analysis: While SSA holds the VAR model in terms of structural parameters $\boldsymbol{\psi}$ constant and produces the counterfactual impulse responses by allowing for some of the structural shocks $\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h}$ to be non-zero over horizons $T+1, T+2, \ldots, T+h$, MRE retains the assumption that only the US monetary policy shock in $T+1$ is non-zero but determines beliefs about impulse responses in a counterfactual VAR model with structural parameters $\widetilde{\boldsymbol{\psi}} \neq \boldsymbol{\psi}$.

5.2.2 Results from MRE counterfactuals

The right-hand side column in Figure 3 presents the baseline impulse response of US industrial production to the contractionary US monetary policy shock (black solid line) together with the MRE counterfactual (blue line with triangles). The results are very similar to those from SSA: When real activity spillovers are precluded, US industrial production drops by much less following a contractionary US policy shock.[18]

5.3 Spillbacks to US consumer prices

The first panel in Figure 6 presents results for US consumer prices.[19] Similar to industrial production, in the counterfactual in which real activity spillovers from US monetary policy

[16] See appendix D for details on the implementation of MRE.

[17] Importance sampling is only feasible and efficient if the baseline density—in our case the posterior distribution of the impulse responses—spans the target density. As shown in Arias et al. (2018) the posterior of the impulse responses follows a Normal-Generalized-Normal distribution, which (in theory) has infinite support. Hence, theoretically any counterfactual posterior distribution of impulse responses can be obtained using MRE updating. However, in practice when the posterior distribution is approximated by a finite number of draws and when the target density is very different from the baseline density, importance sampling might perform poorly. In this case, other samplers can be used, for instance the one-block tailored Metropolis–Hastings algorithm of Chib et al. (2018).

[18] While SSA produces a *distribution of differences*, MRE produces a *different distribution*. Therefore, we cannot report a statistic for the MRE counterfactual that corresponds to those for SSA depicted in Figure 4.

[19] Figure E.2 presents the posterior distribution of the spillbacks to US consumer prices as well as the 'modesty statistic' of Leeper and Zha (2003) analogous to Figures 4 and 5 for industrial production. The relevant q-divergence is the same as in Figure 5.

are precluded, US consumer prices fall by less. Hence, spillbacks again account for almost 50% of the overall domestic effect of US monetary policy on consumer prices.

5.4 Placebo tests

As a placebo test for our counterfactual analysis, we check what we obtain when we estimate spillbacks from US monetary policy through some small open economy (SOE) rather than through the entire rest of the world. We expect the counterfactual in which we preclude only spillovers to individual SOEs to be very similar to the baseline, if at all different.

The top row in Figure 7 presents results for estimations in which we constrain real activity spillovers from US monetary policy to some individual SOEs to be nil while those to the rest of the world to be identical to our baseline (dark blue crossed lines). The impulse responses of US industrial production from this alternative counterfactual are very different from the counterfactual in which real activity spillovers to the entire rest of the world are constrained to be nil (light blue lines with triangles). In fact, the impulse responses of US industrial production from this alternative counterfactual in which only spillovers to individual SOEs are precluded are very similar to the unconstrained baseline (black solid lines). SSA and MRE thus indicate that the spillbacks from US monetary policy that materialise through individual SOEs alone are essentially zero. This is plausible.

A related check for the plausibility of SSA and MRE counterfactuals is to explore how large spillbacks from US monetary policy are assessed if we constrain spillovers to the rest of the world to be nil but leave those to individual SOEs unconstrained. The impulse responses of US industrial production for this specification (dark blue crossed lines) in the bottom row in Figure 7 are hardly distinguishable from the counterfactual in which spillovers to the entire rest of the world are precluded (light blue lines with triangles. This suggests that the contribution of individual SOEs to the overall spillbacks from US monetary policy are negligible. Again, this is plausible.

Overall, the results from these exercises bolster the plausibility of our counterfactual analysis based on SSA and MRE.[20]

5.5 Transmission channels

To shed light on the channels through which spillbacks from US monetary policy materialise we first examine the responses of US GDP components. To do so we augment the VAR model by one additional endogenous variable at a time, unless otherwise mentioned.

[20]Figures E.3 and E.4 provide results for SSA with rest-of-the-world shocks and for MRE.

5.5.1 GDP components

Figure 8 displays the responses of US real exports, imports, investment and consumption to a monetary policy shock in the baseline and the counterfactual in which real activity spillovers from US monetary policy are precluded.[21] All GDP components decline in response to a contractionary US monetary policy shock in the baseline. In the counterfactual the decline is weaker for all GDP components. The results in the first two rows suggest that net exports cannot account for spillbacks to the US: Exports and imports decline by less in the counterfactual to roughly the same degree. The panels in the last two rows suggest that spillbacks instead arise through consumption and in particular investment. We next explore the underlying mechanisms in more detail.

5.5.2 Investment

From a theoretical perspective a key determinant of investment is Tobin's q, i.e. the ratio of the market price of capital—a firm's stock market valuation—and its replacement price. A slowdown in rest-of-the-world real activity in response to a contractionary US monetary policy shock might reduce US firms' foreign sales, their profits, and hence their valuations. Moreover, much work has documented that contrary to the prediction from standard Tobin's q theory, firm investment is additionally determined by cash flow (for references and a discussion see Cao et al., 2019).

Indeed, Figure 9 documents that US equity prices fall by less in the counterfactual when spillovers from US monetary policy are precluded. And somewhat more clearly, also US firms' cash flows measured by earnings expectations falls by less in the counterfactual.

That US firms' valuations and cash flows fall by less in the counterfactual in which real activity spillovers are precluded is consistent with their substantial exposure to the rest of the world: More than 40% (30%) of total sales (revenues) of S&P 500 firms are accounted for by the rest of the world (Brzenk, 2018; Silverblatt, 2019). Moreover, Figure 9 documents that valuations of sectors which are more exposed to the rest of the world exhibit greater differences in their responses to a US monetary policy shock across the baseline and the counterfactual than sectors which are less exposed.

Overall, our results are consistent with spillbacks from US monetary policy arising through cutbacks in investment by US firms whose valuations and cash flows fall as they experience

[21] The results for investment are based on quarterly data interpolated to monthly frequency. Figure E.5 documents that results are very similar if we use quarterly data interpolated to monthly frequency also for consumption, exports and imports.

a decline in foreign demand. Figure E.7 documents that other possible channels—through probabilities of default, risk premia and uncertainty—may also contribute to the spillbacks to investment, although their quantitative contributions seems to be marginal.

5.5.3 Consumption

The main channel through which monetary policy affects consumption in the traditional representative-agent NK (RANK) model centres on interest rates and inter-temporal substitution. However, Figure 10 documents that the one-year ahead *ex ante* real interest rate responds very similarly in the baseline and the counterfactual. The evidence thus suggests real interest rates and inter-temporal substitution do not play a role in the transmission of spillbacks from US monetary policy.

Recent research highlights that indirect channels may be quantitatively much more important for monetary transmission than direct channels centred on inter-temporal substitution as laid out in RANK models. Kaplan et al. (2018) propose a heterogeneous-agent NK (HANK) framework in which the effect of monetary policy on consumption that materialises through indirect channels involving labour demand, wages and wealth is large relative to direct channels. Alves et al. (2020) generalise the model of Kaplan et al. (2018) by accounting for aggregate capital adjustment costs and inertia in the monetary policy rule and show that this entails substantial marginal propensities to consume out of illiquid equity wealth; also, these propensities turn out to be rather similar across the income distribution. Alves et al. (2020) show that these wealth effects play a quantitatively important role in the transmission of monetary policy.[22]

Recall that Figure 9 already documents that US equity prices fall by less in the counterfactual, and that this is plausibly related to spillovers and hence spillbacks due to a weaker fall in US firms' drop in foreign sales. Analogously, Figure 10 documents that global equity prices also fall considerably less in response to a US monetary policy shock in the counterfactual. As they are denominated in foreign currency, the smaller drop in foreign equity prices is further cushioned by the somewhat weaker appreciation of the US dollar NEER in the counterfactual (see Figure 6 and Georgiadis and Mehl, 2016). Overall, the responses of domestic and foreign equity prices are qualitatively consistent with stock market wealth effects accounting for the spillbacks to US consumption.

Estimates of the elasticity of US aggregate consumption to equity prices in the literature are

[22]In the 1979 movie "Manhattan" Woody Allen's character laments:
My stocks are down. I'm cash poor or something. I got no cash flow. I'm not liquid, something's not flowing. (...) You know, I gotta cut down. I'll have to give up my apartment. I'm not gonna be able to play tennis, pick checks up at dinner, or take the Southampton house. Plus I'll probably have to give my parents less money.

broadly consistent with the implied stock market wealth effects that account for spillbacks to US consumption. In particular, in the counterfactual consumption declines less by about 0.02pp and US/non-US equity prices decline less by about 0.25pp/0.6pp in US dollar terms given Figures 6, 9, and 10; given that foreign equity accounts for about one third of the overall US equity portfolio (see Figure E.6), the dampening in the drop in the overall portfolio is about 0.37pp. Therefore, for stock market wealth effects to *fully* account for the spillbacks from US monetary policy, we would need an elasticity of aggregate consumption to equity prices of about 5.5% $(0.02/(0.25 \times 2/3 + 0.6 \times 1/3))$. This is not too far from estimates in the literature. For example, using US county-level data Chodorow-Reich et al. (2021) find an elasticity of about 3.2%. Similarly, in the calibrated HANK model of Alves et al. (2020) the implied marginal propensity to consume out of illiquid equity averages around 3% across the income distribution.[23]

Figure E.7 documents that other possible channels—through precautionary savings related to variation in consumer confidence and wealth effects through house price variation—do not appear to account for spillbacks to consumption.

Of course we need to note that our analysis of the channels through which spillbacks materialise is reduced form and thereby remains suggestive. In particular, it does not allow us to perfectly decompose the overall spillbacks into the contributions accounted for by Tobin's q/cash flow and stock market wealth effects, respectively. In practice, these channels interact and amplify each other to produce the overall spillbacks. For example, a decline in US investment due to Tobin's q/cash flow effects induces a slowdown in real activity, which in turn induces a drop in employment and wages, which eventually induces a drop in consumption independently of stock market wealth effects.

5.5.4 Would US monetary policy be ineffective domestically if it wasn't for spillbacks?

In the counterfactual in Figure 3 a non-trivial posterior probability mass of the domestic real activity effects of US monetary policy is not below zero. One might be tempted to interpret this as suggesting that US monetary policy would be ineffective domestically if there were no spillbacks. However, especially given our findings for the role of US foreign equity holdings and US firms' sales/cash flow from the rest of the world for the transmission of spillbacks, this interpretation is not warranted.

[23]Using aggregate data Lettau and Ludvigson (2004) estimate an elasticity of about 5%. In the context of the interaction between US monetary policy and stock prices Bjornland and Leitemo (2009) estimate an elasticity of the output gap to exogenous equity price changes of about 10%.

In particular, in a counterfactual thought experiment in which spillbacks are nil we would have that US holdings of foreign equity were zero as well; but then holdings of domestic equity would be commensurately higher. As a result, stock market wealth effects would not play out through spillbacks on foreign equity holdings, but instead through domestic equity holdings; a similar argument applies to the spillbacks that materialise through the exposure of US firms to the rest of the world through sales/cash flow. In other words, rather than assessing how large the overall domestic effects would be in a counterfactual world without spillbacks, our analysis decomposes the *actual* overall domestic effect of US monetary policy into the components that materialise through domestic channels and spillbacks.

5.5.5 Transmission channels for spillbacks to US consumer prices

Figure 6 documents that in the counterfactual US domestic prices exhibit a reduction in the drop in response to a monetary policy shock that is very similar to that in consumer prices. Hence, spillbacks to US consumer prices are to a large extent accounted for by spillbacks to US real activity, which put downward pressure on domestic prices. At the same time, spillbacks to US consumer prices also materialise in a more direct way. In particular, Figure 6 shows that also US import prices drop by less in the counterfactual.[24] Given that US import prices are largely invoiced and sticky in US dollar (Gopinath et al., 2010), the weaker appreciation of the US dollar NEER in the counterfactual likely only plays a limited role. Instead, the weaker drop in US import prices seems to be primarily due to a weaker fall in oil prices in the counterfactual. Indeed, the reduction in the drop in import prices excluding petroleum in the counterfactual is much smaller than for overall import prices.

5.6 Spillbacks through AEs vs. EMEs

Finally, we explore if spillbacks materialise through spillovers to AEs or EMEs, or both. To this end, we re-estimate the VAR model replacing rest-of-the-world industrial production with the corresponding AE and EME analogues. We then repeat the counterfactual analysis, imposing that the real activity spillovers to AEs and EMEs are nil. In order to assess the contribution of spillovers to AEs and EMEs for the overall spillbacks to the US, we consider two variations of the counterfactual: First we only preclude spillovers from US monetary policy to AEs while constraining spillovers to EMEs to coincide with those in the baseline;

[24] The hump-shaped pattern in the response of import prices contrasts with the predictions from producer-currency pricing (PCP) but is consistent with dominant-currency pricing (DCP; Gopinath et al., 2020): Under PCP import prices fall on impact essentially one-to-one with the exchange rate; under DCP, import prices are stable in the short run, and are adjusted only gradually along with US domestic prices as rest-of-the-world exporters vary their mark-ups in order to preserve market shares due to strategic complementarities.

hence, in this variation we shut down spillbacks through AEs but allow spillbacks through EMEs. Second, we do the reverse.

The left-hand side panel in Figure 11 presents the results for the variation of the counterfactual in which we shut down spillovers to AEs but not to EMEs. The light blue line with triangles depicts the domestic real activity response to a US monetary policy shock when spillovers to the entire rest of the world—i.e. both AEs and EMEs—are precluded, and the dark blue line with crosses when only spillovers to AEs are precluded. The domestic effect of a US monetary policy shock is estimated to be almost identical when spillovers to the entire rest of the world or only to AEs are precluded. This suggests that spillbacks from US monetary policy arise much more through AEs rather than EMEs. Indeed, the right-hand side panel shows that the domestic effect of a US monetary policy shock is almost identical when spillovers to the entire rest of the world are unconstrained (black solid line) and when only spillovers to EMEs are precluded (dark blue line with crosses). An important caveat to this finding is that it reflects the average properties of the data over the entire time period from 1990 to 2019; as the importance of EMEs has been growing over time, their contribution to the overall spillbacks may be larger at the current juncture.

One may wonder if the relative importance of AEs and EMEs is consistent with our findings on the transmission channels in Section 5.5. Recall that the evidence suggests spillbacks materialise through stock market wealth effects and Tobin's q/cash flow effects rooted in the exposure of US firms' to foreign demand and holdings of foreign equity. The top panel in Figure 12 documents that since 2003 the share of US foreign portfolio investment equity accounted for by AEs and EMEs on average amounted to about 63% and 26%, respectively. Because the share accounted for by AEs has been falling over time along with the integration of EMEs in global financial markets, the dominant role of AEs as a destination for US foreign portfolio investment equity over our sample period would stand out even more prominently if data prior to 2003 was available. [25] Finally, using the country composition of exports as a proxy for the share of US firms' revenues/sales accounted for by AEs and EMEs in the bottom panel in Figure 12 again suggests a more important role for AEs. Overall, the country composition of the exposure of US foreign equity holdings and exports in Figure 12 is consistent with our interpretation of Figure 11 that spillbacks from US monetary policy have materialised primarily through AEs over our sample period.

These findings have important implications for the notion that the existence of large spillbacks from US monetary policy weakens the case for more extensive forms of international monetary policy coordination (Fischer, 2014; Yellen, 2019). Figure 13 presents estimates of the spillovers

[25] Figure E.9 documents that differences in spillovers to AEs and EMEs equity prices across the baseline and the counterfactual are very similar.

from US monetary policy to consumer prices and policy rates in AEs and EMEs. While real activity spillovers are negative both in AEs and EMEs, consumer prices fall in AEs but tend to rise in EMEs. The latter is a common finding usually ascribed to greater exchange rate pass-through to consumer prices in EMEs (Hausmann et al., 2001). Indeed, our estimates suggest that consistent with fear-of-floating EME monetary policy is tightened in response to a contractionary US monetary policy shock (Calvo and Reinhart, 2002); the latter could also point to trade-offs between output stabilisation and financial stability due to foreign-currency exposures on EME balance sheets (Georgiadis and Zhu, 2021). The tightening in EME monetary policy may contain exchange rate depreciation and hence prevent spikes in import prices as well as risks to financial stability but comes at the cost of exacerbating the slowdown in real activity.

Thus, while US monetary policy spillovers do not induce welfare-reducing trade-offs between output and inflation stabilisation in AEs, they do so in EMEs. This implies that global welfare could benefit if spillovers to EMEs were internalised by playing a role in the calibration of US monetary policy that is independent from spillbacks.[26] Interestingly, there is evidence that the Federal Reserve is doing precisely that already. Specifically, Ferrara and Teuf (2018) construct an indicator that measures the number of references to the international environment in FOMC minutes. They then estimate a Taylor-rule with standard domestic variables augmented with their international environment indicator and find that the Federal Reserve responds to global developments even conditional on US real activity and inflation. Our finding that spillbacks from US monetary policy hardly materialise through EMEs may be a rationalisation for the observed behaviour of the Federal Reserve.

6 Conclusion

In this paper we quantify spillbacks from US monetary policy using SSA and MRE in a state-of-the-art BPSVAR model. Our results suggest that spillbacks are large as they account for a substantial fraction of the overall domestic effects of US monetary policy. We find that spillbacks materialise through stock market wealth and Tobin's q/cash flow effects. In particular, contractionary US monetary policy depresses valuations and cash flows of US firms through declines in foreign sales, inducing them to cut back investment. Moreover, as contractionary US monetary policy depresses US and global equity prices, stock market wealth effects impinge on consumption. Net trade does not contribute to spillbacks because

[26]It is not clear if AE monetary policy does not offset spillovers from the US due to the presence of trade-offs beyond output and inflation stabilisation or simply due to interest rate smoothing. In any case, given that we find there are spillbacks through AEs it is possible that US monetary policy indeed internalises its spillovers at least to AEs as claimed by (Fischer, 2014).

US monetary policy affects exports and imports similarly.

We also find that spillbacks materialise through AEs rather than through EMEs, consistent with the composition of US foreign equity holdings and exports. This suggests that US monetary policy only internalises a part of the spillovers it emits to the rest of the world through spillbacks. Moreover, our evidence also suggests that while US monetary policy spillovers do not give rise to trade-offs between output stabilisation on the one hand and inflation stabilisation as well as financial stability on the other hand in AEs, they may do so in EMEs. Against this background, our results suggest global welfare could benefit if spillovers to EMEs were internalised by playing an independent role in the calibration of US monetary policy.

A natural extension of this paper would consider spillbacks from monetary policy in other systemic economies such as the euro area (Draghi, 2018; Coeure, 2019) and time variation in spillbacks.

References

Akinci, O., Queralto, A., 2019. Exchange Rate Dynamics and Monetary Spillovers with Imperfect Financial Markets. Federal Reserve Bank of New York Staff Reports 849.

Alves, F., Kaplan, G., Moll, B., Violante, G., 2020. A Further Look at the Propagation of Monetary Policy Shocks in HANK. Journal of Money, Credit and Banking 52 (S2), 521–559.

Antolin-Diaz, J., Petrella, I., Rubio Ramirez, J., 2021. Structural Scenario Analysis with SVARs. Journal of Monetary Economics 117, 798–815.

Arias, J., Rubio-Ramirez, J., Waggoner, D., 2018. Inference Based on Structural Vector Autoregressions Identified with Sign and Zero Restrictions: Theory and Applications. Econometrica 86 (2), 685–720.

Arias, J., Rubio Ramírez, J., Waggoner, D., forthcoming. Inference in Bayesian Proxy-SVARs. Journal of Econometrics.

Bachmann, R., Sims, E., 2012. Confidence and the Transmission of Government Spending Shocks. Journal of Monetary Economics 59 (3), 235–249.

Banerjee, R., Devereux, M., Lombardo, G., 2016. Self-Oriented Monetary Policy, Global Financial Markets and Excess Volatility of International Capital Flows. Journal of International Money and Finance 68, 275–297.

Baumeister, C., Hamilton, J., 2015. Sign Restrictions, Structural Vector Autoregressions, and Useful Prior Information. Econometrica 83 (5), 1963–1999.

Baur, D., McDermott, T., 2010. Is Gold a Safe Haven? International Evidence. Journal of Banking & Finance 34 (8), 1886–1898.

Baur, D., McDermott, T., 2016. Why is Gold a Safe Haven? Journal of Behavioral and Experimental Finance 10, 63–71.

Benati, L., 2010. VAR Policy Counterfactuals Based on Structural VARs Reliable. ECB Working Paper 1188.

Bertaut, C., Bressler, B., Curcuru, S., 2019. Globalization and the Geography of Capital Flows. FEDS Notes September.

Bianchi, J., Bigio, S., Engel, C., 2020. Banks, Dollar Liquidity, and Exchange Rates. mimeo.

Bjornland, H., Leitemo, K., 2009. Identifying the Interdependence Between US Monetary Policy and the Stock Market. Journal of Monetary Economics 56 (2), 275–282.

Bloom, N., 2009. The Impact of Uncertainty Shocks. Econometrica 77 (3), 623–685.

Bobasu, A., Geis, A., Quaglietti, L., Ricci, M., 2020. Tracking Global Economic Uncertainty: Implications for Global Investment and Trade. ECB Economic Bulletin 1.

Brzenk, P., 2018. The Impact of the Global Economy on the S&P 500. S&P Global Equity Research March.

Bräuning, F., Sheremirov, V., 2019. Output Spillovers from U.S. Monetary Policy: The Role of International Trade and Financial Linkages. Federal Reserve Bank of Boston Working Paper 19-15.

Caldara, D., Herbst, E., 2019. Monetary Policy, Real Activity, and Credit Spreads: Evidence from Bayesian Proxy SVARs. American Economic Journal: Macroeconomics 11 (1).

Calvo, G., Reinhart, C., 2002. Fear of Floating. Quarterly Journal of Economics 117 (2), 379–408.

Cao, D., Lorenzoni, G., Walentin, K., 2019. Financial frictions, investment, and Tobin's q. Journal of Monetary Economics 103 (C), 105–122.

Carney, M., 2019. The Growing Challenges for Monetary Policy in the Current International Monetary and Financial System. Speech held at the Federal Reserve Bank of Kansas City Jackson Hole Symposium, 23 August.

Chib, S., Shin, M., Simoni, A., 2018. Bayesian Estimation and Comparison of Moment Condition Models. Journal of the American Statistical Association 113 (524), 1656–1668.

Chodorow-Reich, G., Nenov, P., Simsek, A., 2021. Stock Market Wealth and the Real Economy: A Local Labor Market Approach. American Economic Review 111 (5), 1613–1657.

Coeure, B., 2019. The Euro's Global Role in a Changing World: A Monetary Policy Perspective. Speech held at the Council on Foreign Relations, New York City, 15 February.

Cogley, T., Morozov, S., Sargent, T., 2005. Bayesian Fan Charts for UK Inflation: Forecasting and Sources of Uncertainty in an Evolving Monetary System. Journal of Economic Dynamics and Control 29 (11), 1893–1925.

Dedola, L., Rivolta, G., Stracca, L., 2017. When the Fed Sneezes, Who Gets a Cold? Journal of International Economics S1 (108), S23–S41.

Dees, S., Galesi, A., 2021. The Global Financial Cycle and US Monetary Policy in an Interconnected World. Journal of International Money and Finance 115, 102395.

Degasperi, R., Hong, S. S., Ricco, G., 2020. The Global Transmission of US Monetary Policy. Warwick Economics Research Paper 1257.

Draghi, M., 2018. The International Dimension of the ECB's Asset Purchase Programme: An Update. Speech held at the Conference on "Exiting Unconventional Monetary Policies", organised by the Euro 50 Group, the CF40 forum and CIGI, Paris, 26 October.

Egorov, K., Mukhin, D., 2020. Optimal Policy under Dollar Pricing. CESifo Working Paper 8272.

Eichengreen, B., 2013. Does the Federal Reserve Care about the Rest of the World? Journal of Economic Perspectives 27 (4), 87–104.

Engel, C., 2016. International Coordination of Central Bank Policy. Journal of International Money and Finance 67 (C), 13–24.

Epstein, B., Finkelstein Shapiro, A., Gonzalez Gomez, A., 2019. Global Financial Risk, Aggregate Fluctuations, and Unemployment Dynamics. Journal of International Economics 118 (C), 351–418.

Favara, G., Gilchrist, S., Lewis, K., Zakrajsek, E., 2016. Updating the Recession Risk and the Excess Bond Premium. FEDS Notes October.

Fernandez-Villaverde, J., Rubio-Ramirez, J., September 2008. How Structural Are Structural Parameters? In: NBER Macroeconomics Annual 2007. Vol. 22 of NBER Chapters. National Bureau of Economic Research, pp. 83–137.

Ferrara, L., Teuf, C.-E., 9 2018. International Environment and US Monetary Policy: A Textual Analysis. Banque de France Eco Notepad Blog, posted September 25.

Fischer, S., 2014. The Federal Reserve and the Global Economy. Per Jacobsson Foundation Lecture, Annual Meetings of the IMF and the World Bank Group, Washington D.C., 11 October.

Georgiadis, G., 2016. Determinants of Global Spillovers from US Monetary Policy. Journal of International Money and Finance 67, 41–61.

Georgiadis, G., 2017. To Bi, or Not to Bi? Differences in Spillover Estimates from Bilateral and Multilateral Multi-country Models. Journal of International Economics 107 (C), 1–18.

Georgiadis, G., Mehl, A., 2016. Financial Globalisation and Monetary Policy Effectiveness. Journal of International Economics 103 (C), 200–212.

Georgiadis, G., Zhu, F., 2021. Foreign-currency Exposures and the Financial Channel of Exchange Rates: Eroding Monetary Policy Autonomy in Small Open Economies? Journal of International Money and Finance 110 (C).

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

Giacomini, R., Kitagawa, T., Read, M., forthcoming. Robust Bayesian Inference in Proxy SVARs. Journal of Econometrics.

Giacomini, R., Ragusa, G., 2014. Theory-coherent Forecasting. Journal of Econometrics 182 (1), 145–155.

Giannone, D., Lenza, M., Primiceri, G., 2015. Prior Selection for Vector Autoregressions. Review of Economics and Statistics 97 (2), 436–451.

Gleser, L., 1992. The Importance of Assessing Measurement Reliability in Multivariate Regression. Journal of the American Statistical Association 87 (419), 696–707.

Gopinath, G., Boz, E., Casas, C., Diez, F., Gourinchas, P.-O., Plagborg-Moller, M., 2020. Dominant Currency Paradigm. American Economic Review 110 (3), 677–719.

Gopinath, G., Itskhoki, O., Rigobon, R., 2010. Currency Choice and Exchange Rate Pass-Through. American Economic Review 100 (1), 304–336.

Gürkaynak, R., Sack, B., Swanson, E., 2005. The Sensitivity of Long-Term Interest Rates to Economic News: Evidence and Implications for Macroeconomic Models. American Economic Review 95 (1), 425–436.

Haubrich, J., Pennacchi, G., Ritchken, P., 2012. Inflation Expectations, Real Rates, and Risk Premia: Evidence from Inflation Swaps. Review of Financial Studies 25 (5), 1588–1629.

Hausmann, R., Panizza, U., Stein, E., 2001. Why Do Countries Float the Way They Float? Journal of Development Economics 66 (2), 387–414.

Iacoviello, M., Navarro, G., 2019. Foreign Effects of Higher US Interest Rates. Journal of International Money and Finance 95, 232–250.

Inoue, A., Kilian, L., 2020. The Role of the Prior in Estimating VAR Models with Sign Restrictions. CEPR Discussion Paper 15545.

Jarocinski, M., Karadi, P., 2020. Deconstructing Monetary Policy Surprises: The Role of Information Shocks,. American Economic Journal: Macroeconomics 12 (2), 1–43.

Jentsch, C., Lunsford, K., 2016. Proxy SVARs: Asymptotic Theory, Bootstrap Inference, and the Effects of Income Tax Changes in the United States. Federal Reserve Bank of Cleveland Working Paper 16-19.

Jentsch, C., Lunsford, K. G., July 2019. The Dynamic Effects of Personal and Corporate Income Tax Changes in the United States: Comment. American Economic Review 109 (7), 2655–78.

Jiang, Z., Krishnamurthy, A., Lustig, H., 2021. Foreign Safe Asset Demand and the Dollar Exchange Rate. Journal of Finance 76 (3), 1049–1089.

Jurado, K., Ludvigson, S., Ng, S., 2015. Measuring Uncertainty. American Economic Review 105 (3), 1177–1216.

Känzig, D. R., 2021. The Macroeconomic Effects of Oil Supply News: Evidence from OPEC Announcements. American Economic Review 111 (4), 1092–1125.

Kaplan, G., Moll, B., Violante, G.-L., 2018. Monetary Policy According to HANK. American Economic Review 108 (3), 697–743.

Kilian, L., Lewis, L., 2011. Does the Fed Respond to Oil Price Shocks? Economic Journal 121 (555), 1047–1072.

Leeper, E., Zha, T., 2003. Modest Policy Interventions. Journal of Monetary Economics 50 (8), 1673–1700.

Lettau, M., Ludvigson, S., 2004. Understanding Trend and Cycle in Asset Values: Reevaluating the Wealth Effect on Consumption. American Economic Review 94 (1), 276–299.

Ludvigson, S., Ma, S., Ng, S., forthcoming. Uncertainty and Business Cycles: Exogenous Impulse or Endogenous Response? American Economic Journal: Macroeconomics.

Martinez-Garcia, E., Grossman, V., Mack, A., 2015. A Contribution to the Chronology of Turning Points in Global Economic Activity (1980–2012). Journal of Macroeconomics 46, 170–185.

Mertens, K., Ravn, M., 2013. The Dynamic Effects of Personal and Corporate Income Tax Changes in the United States. American Economic Review 103 (4), 1212–1247.

Miranda-Agrippino, S., Rey, H., 2020. US Monetary Policy and the Global Financial Cycle. Review of Economic Studies 87 (6), 2754–2776.

Miranda-Agrippino, S., Ricco, G., 2021. The Transmission of Monetary Policy Shocks. American Economic Journal: Macroeconomics 13 (3), 74–107.

Moon, H., Schorfheide, F., 2012. Bayesian and Frequentist Inference in Partially Identified Models. Econometrica 80 (2), 755–782.

Olea, M., Stock, J., Watson, M., forthcoming. Inference in Structural Vector Autoregressions Identified with an External Instrument. Journal of Econometrics.

Ostry, J., Ghosh, A., 2016. On the Obstacles to International Policy Coordination. Journal of International Money and Finance 67 (C), 25–40.

Pearl, J., Glymour, M., Jewell, N., 2016. Causal Inference in Statistics - A Primer. John Wiley & Sons.

Piffer, M., Podstawski, M., 2018. Identifying Uncertainty Shocks Using the Price of Gold. Economic Journal 128 (616), 3266–3284.

Poirier, D., 1998. Revising Beliefs In Nonidentified Models. Econometric Theory 14 (4), 483–509.

Rajan, R., 2013. A Step in the Dark: Unconventional Monetary Policy After the Crisis. Speech at The Andrew Crockett Memorial Lecture, Bank for International Settlements, Basel, 23 June.

Rajan, R., 2016a. Rethinking the Global Monetary System. Speech held at the London School of Economics, May 10.

Rajan, R., 2016b. Towards Rules of the Monetary Game. Speech held at the IMF/Government of India Conference on Advancing Asia: Investing for the Future, New Delhi, 12 March.

Ramey, V., 1993. How Important Is the Credit Channel in the Transmission of Monetary Policy? Carnegie-Rochester Conference Series on Public Policy 39 (1), 1–45.

Rey, H., 2016. International Channels of Transmission of Monetary Policy and the Mundellian Trilemma. IMF Economic Review 64 (1), 6–35.

Robertson, J., Tallman, E., Whiteman, C., 2005. Forecasting Using Relative Entropy. Journal of Money, Credit and Banking 37 (3), 383–401.

Rostagno, M., Altavilla, C., Carboni, G., Lemke, W., Motto, R., Saint Guilhem, A., 2021. Combining Negative Rates, Forward Guidance and Asset Purchases: Identification and Impacts of the ECB's Unconventional Policies. ECB Working Paper 2564.

Rubio-Ramirez, J., Waggoner, D., Zha, T., 2010. Structural Vector Autoregressions: Theory of Identification and Algorithms for Inference. Review of Economic Studies 77 (2), 665–696.

Shin, H.-S., 2015. Remarks. Held the Board of Governors of the Federal Reserve System conference "Monetary Policy Implementation and Transmission in the Post-crisis Period", Washington, D.C., 13 November.

Silverblatt, H., 2019. S&P 500 2018: Global Sales. S&P Global Equity Research August.

Vicondoa, A., 2019. Monetary News in the United States and Business Cycles in Emerging Economies. Journal of International Economics 117 (C), 79–90.

Waggoner, D., Zha, T., 1999. Conditional Forecasts in Dynamic Multivariate Models. Review of Economics and Statistics 81 (4), 639–651.

Wong, B., 2015. Do Inflation Expectations Propagate the Inflationary Impact of Real Oil Price Shocks?: Evidence from the Michigan Survey. Journal of Money, Credit and Banking 47 (8), 1673–1689.

Yellen, J., 2019. On Monetary Policy, Currencies, and Manipulation. Podcast recorded for The Brookings Institution, 19 February.

A Tables

Table 1: Data description

Variable	Description	Source	Coverage
US 1-year TB rate	1-year Treasury Bill yield at constant maturity	US Treasury/Haver	1990m1 - 2019m6
US IP	Industrial production excl. construction	FRB/Haver	1990m1 - 2019m6
US CPI	Consumer price index	BLS/Haver	1990m1 - 2019m6
US EBP	Excess bond premium	See Favara et al. (2016)	1990m1 - 2019m6
VXO	CBOE market volatility index VXO	Wall Street Journal/Haver	1990m1 - 2019m6
S&P 500	S&P 500 Composite	S&P/Haver	1990m1 - 2019m6
US PPI	PPI finished goods	BLS/Haver	1990m1 - 2019m6
US import prices	Import price index: All imports	BLS/Haver	1990m1 - 2019m6
US import prices excl. petroleum	Import price index: Non-petroleum imports	BLS/Haver	1990m1 - 2019m6
US consumption	Real personal consumption expenditures (chnd. 2012$)	BEA/Haver	1990m1-2019m6
US investment	Gross private domestic investment (chnd. 2012$)	BEA/Haver	1990q1-2019q2, interpolated to monthly frequency
US exports	Exports of goods and services (chnd. 2012$)	BEA/Census Bureau/Haver	1990m1-2019m6
US imports	Imports of goods and services (chnd. 2012$)	BEA/Census Bureau/Haver	1990m1-2019m6
US dollar NEER	Nominal broad trade-weighted dollar index	FRB/Haver	1990m1-2019m6
CFED-1Y real interest rate	See Haubrich et al. (2012)	Cleveland Fed	1990m1 - 2019m6
Oil prices	European Brent spot price ($ per barrel)	EIA/Haver	1990m1 - 2019m6
Dow Jones World	Dow Jones Global Index	Dow Jones/Haver	1992m1 - 2019m6
Dow Jones excl. US	Dow Jones Global Index excl. US	Dow Jones/Haver	1992m1 - 2019m6
MSCI AEs	MSCI AEFE Index: Developed markets in Europe, Australasia, Israel and the Far East	MSCI/Bloomberg	1990m1 - 2019m6
MSCI EMEs	MSCI MXEF Index: Emerging markets with mid to large cap	MSCI/Bloomberg	1990m1 - 2019m6
S&P 500 earnings expectations	S&P 500 Composite 12-months forward earnings per share	S&P/Bloomberg	1990m1 - 2019m6
S&P 500 low/high RoW exposure	Based on sectoral S&P 500 indices	S&P/Haver	1990m1 - 2019m6
RoW, AE, EME IP	Industrial production, see Martinez-Garcia et al. (2015)	Dallas Fed Global Economic Indicators/Haver	1990m1 - 2019m6
RoW, AE, EME CPI	Consumer price index	Dallas Fed Global Economic Indicators/Haver (Martinez-Garcia et al., 2015)	1990m1 - 2019m6
RoW, AE, EME policy rate	Short-term official/policy rate, see Martinez-Garcia et al. (2015)	Dallas Fed Global Economic Indicators/Haver	1990m1 - 2019m6
Singapore IP	Industrial production: Manufacturing (excl. rubber processing)	Department of Statistics/Haver	1990m1 - 2019m6
Taiwan IP	Industrial production: Manufacturing	Ministry of Economic Affairs/Haver	1990m1 - 2019m6
Israel IP	Industrial production: Manufacturing	Central Bureau of Statistics/Haver	1990m1 - 2019m6

Notes: BLS stands for Bureau of Labour Statistics, FRB for Federal Reserve Board, BEA for Bureau of Economic Analysis, and EIA for Energy Information Administration.

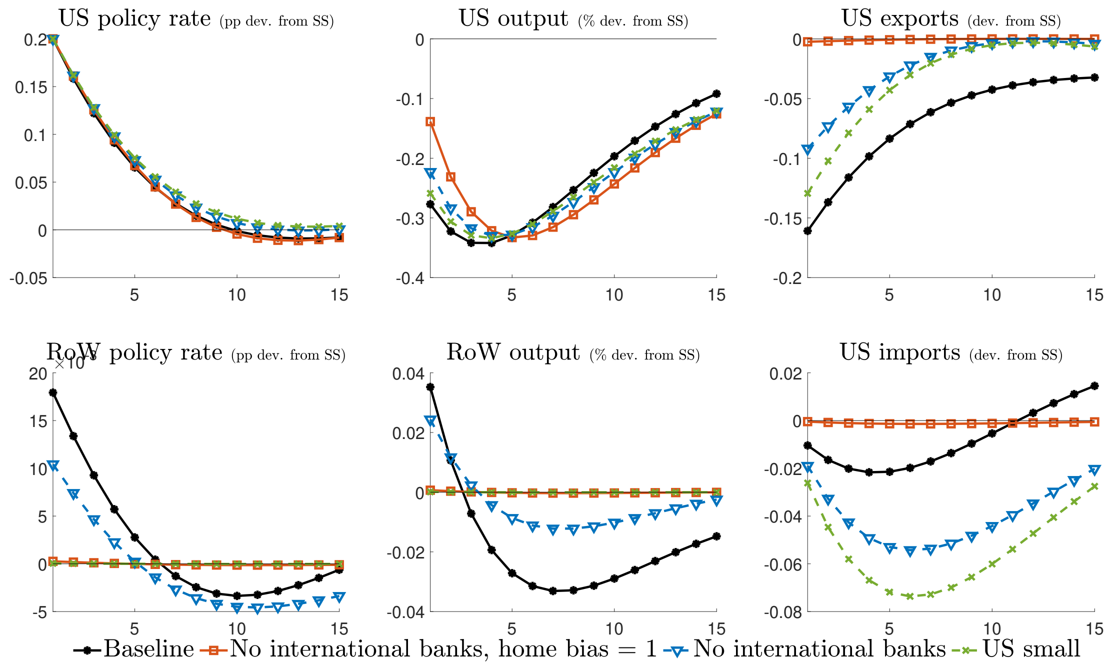
Table 2: Identification restrictions of the rest-of-the-world shocks

Variable / Shock	RoW 'depreciating' shock	RoW 'appreciating' shock
US 1-year T-Bill rate		
US industrial production	$< 0^{\triangle}$	$\Diamond$
US CPI		
US excess bond premium		
US dollar NEER	> 0	< 0
VXO		
RoW industrial production	< 0 & $<^{\triangle}$	< 0 & $<^{\Diamond}$

Notes: The table presents the sign and magnitude restrictions we impose in order to identify the rest-of-the world shocks. We additionally impose the exogeneity restrictions $E[p_t^{\epsilon,mp}\boldsymbol{\epsilon}_t^{o}] = 0$ in Equation (10b) that the proxy variables are not driven by the rest-of-the-world shocks.

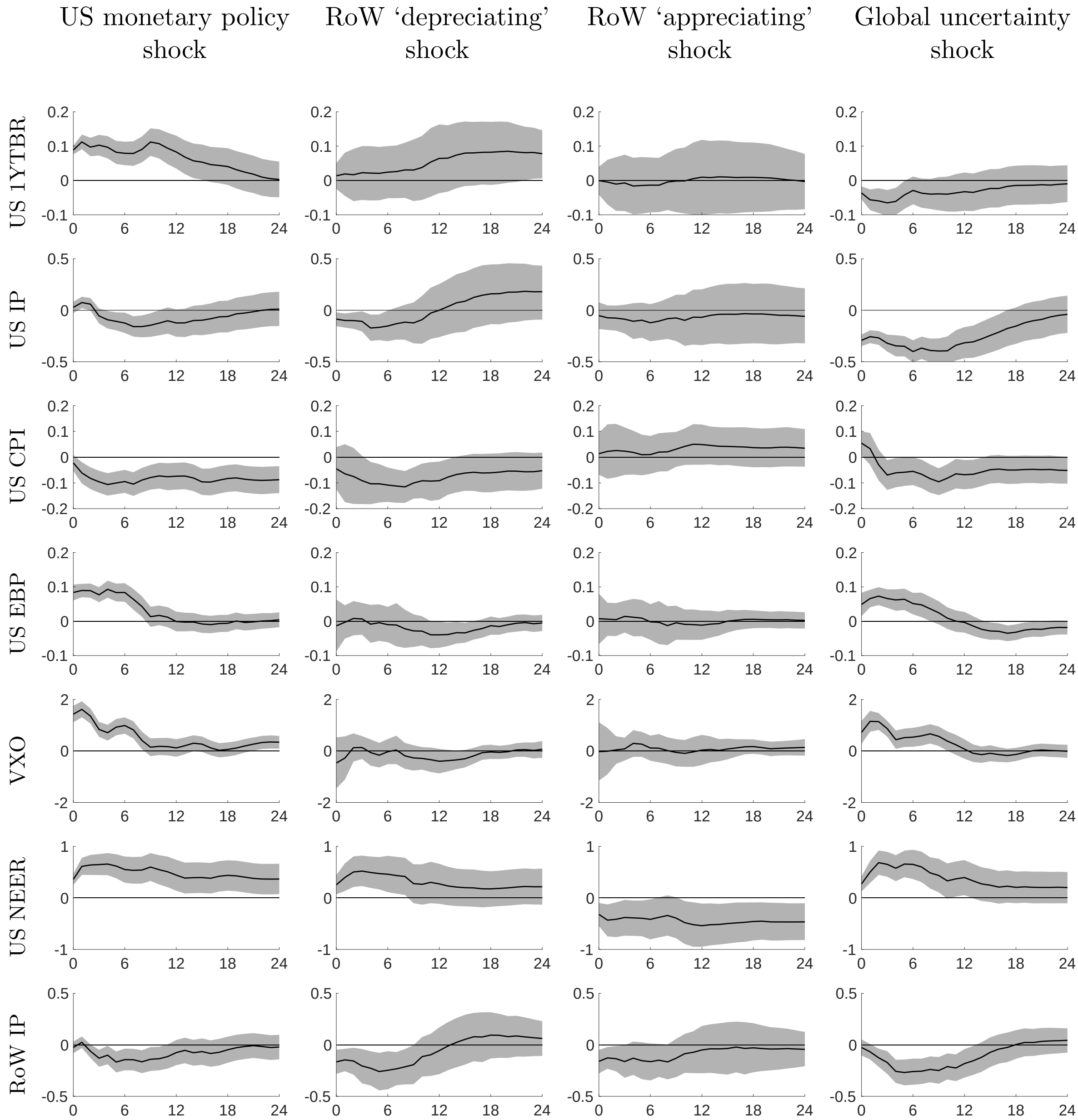
B Figures

Figure 1: Impulse responses to a US monetary policy shock in a structural two-country model



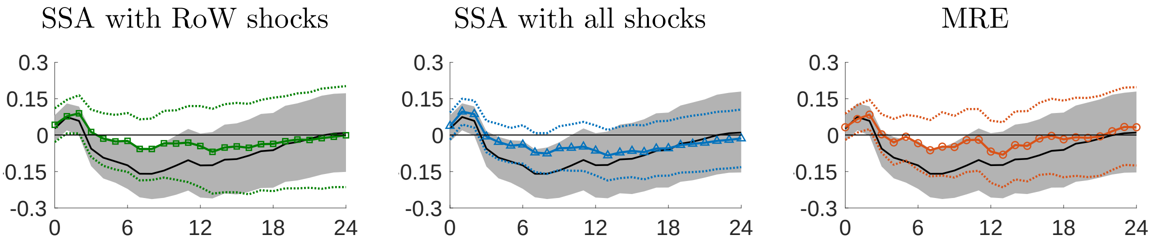
Notes: The figure displays the responses of policy rates and output in the US and the rest of the world as well as US exports and imports to a contractionary US monetary policy shock in the structural two-country model. The black solid lines with circles show the impulse responses for the baseline specification with international banks and home bias below unity, the orange lines with squares for a specification without international banks and with home bias equal to unity, the blue solid lines with triangles for a specification without international banks, and the green lines with crosses for a specification with international banks and home bias below unity but in whic hthe US is assumed to be small relative to the rest of the world. Interest rates are plotted in percentage-point deviations from steady state, output in percent deviations from steady state, and exports/imports in absolute deviations from steady state (in order to avoid complications in specifications in which their steady-state values are zero).

Figure 2: Baseline impulse responses to US monetary policy, rest-of-the-world 'appreciating' and 'depreciating', and global uncertainty shocks



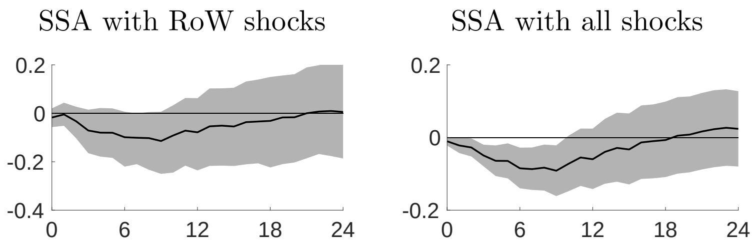
Notes: The figure shows the point-wise posterior means of the impulse responses (black solid lines) and 68% centered point-wise probability bands (grey areas) obtained from the BPSVAR model. '1YTBR' stands for the one-year Treasury Bill rate, 'IP' for industrial production, 'CPI' for the consumer-price index, 'EBP' for excess bond premium, 'VXO' for the S&P 500 stock market volatility index, and 'NEER' for the nominal effective exchange rate.

Figure 3: Baseline and counterfactual impulse responses of US industrial production to a US monetary policy shock



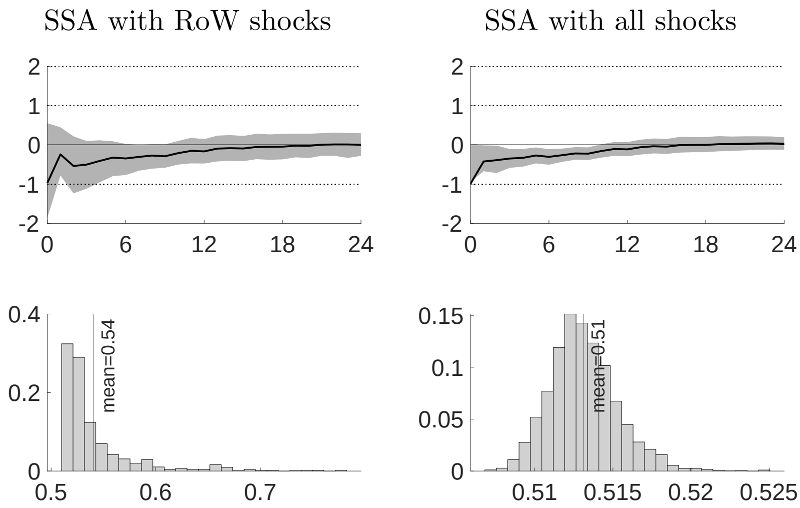
Notes: The black solid lines depict the baseline impulse responses of US industrial production to a US monetary policy shock and the coloured solid lines with markers the counterfactual impulse responses based on point-wise posterior mean SSA with rest-of-the-world shocks (left column, green lines with squares), based on point-wise posterior mean SSA with all shocks (middle column, blue lines with triangles), and based on point-wise posterior mean MRE (right column, red lines with circles). The grey shaded areas represent 68% centered point-wise probability bands for the baseline impulse responses, and the light-coloured dotted lines represent 68% centered point-wise probability bands for the counterfactual impulse responses.

Figure 4: Distribution of SSA spillback estimates



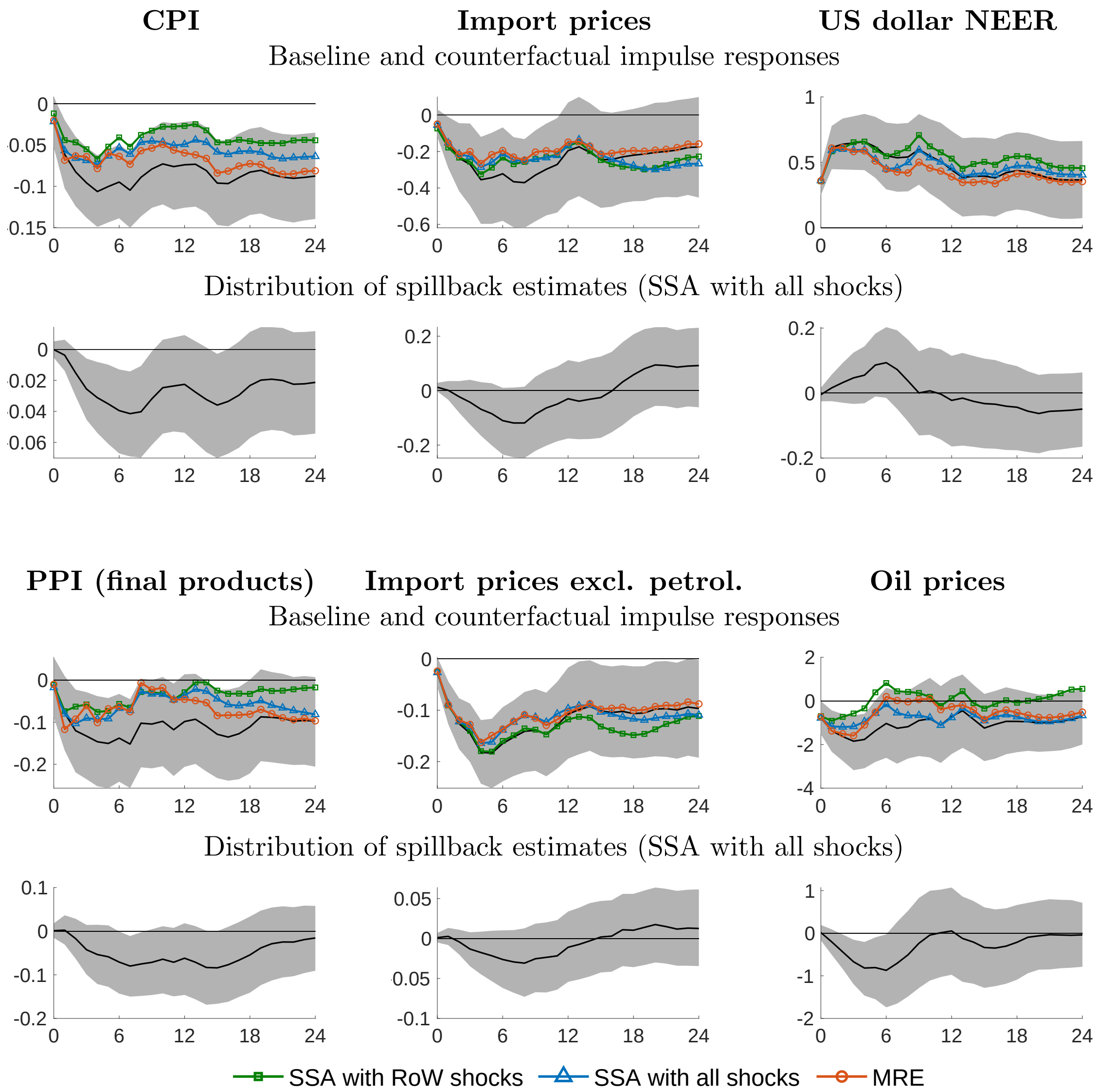
Notes: The figure presents the point-wise mean of the differences between the baseline and the counterfactual effects of US monetary policy on US industrial production together with 68% centered point-wise probability bands.

Figure 5: Modesty statistic of Leeper and Zha (2003) and distribution of the q-divergence of Antolin-Diaz et al. (2021) for SSA counterfactuals



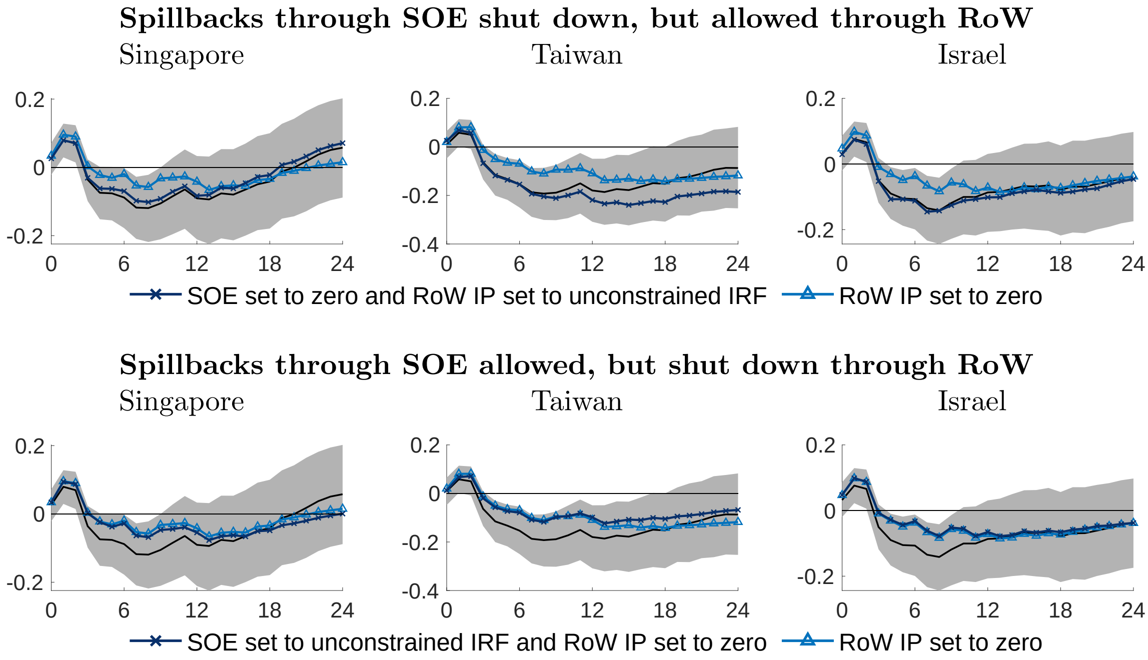
Notes: The top panels show the 'modesty statistic' of Leeper and Zha (2003) for the implied offsetting shocks that impose the counterfactual constraint for rest-of-the-world industrial production; the black solid line depicts the point-wise mean and the grey shaded areas the 68% centered point-wise probability bands. The offsetting shocks are 'modest'—meaning their materialisation is unlikely to induce agents to adjust their expectation formation and beliefs about the structure of the economy—if the statistic is smaller than two in absolute value. The bottom panels show the distribution of the q-divergence of Antolin-Diaz et al. (2021) for the SSA; the left-hand side panel presents results for the case in which only the rest-of-the-world shocks are used as offsetting shocks, while the right-hand side panel for the case in which all shocks are used. The q-divergence indicates how unlikely a conditional forecast is in terms of comparing the implied distributions of shocks with their unconditional distributions, translated into a comparison of the binomial distributions of a fair and a biased coin. See Appendix C.1 for a description how we implement the q-divergence in the context of our paper. We drop SSA counterfactuals when the offsetting shocks increase over time ($\tilde{\epsilon}_{T+1} < \tilde{\epsilon}_{T+h}$) or if the offsetting shocks are particularly large on impact ($\tilde{\epsilon}_{T+1}$ lies above the 99^{th} percentile in absolute terms).

Figure 6: Spillbacks for US consumer prices



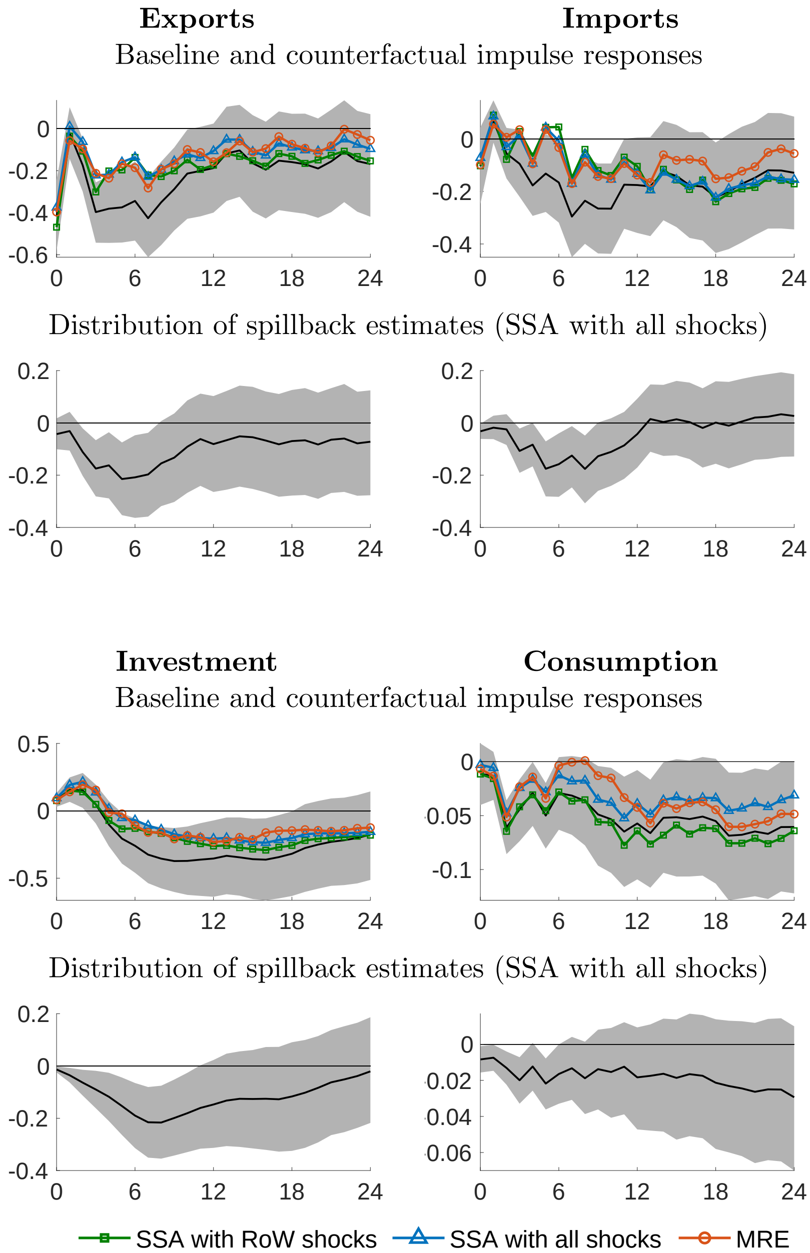
Notes: In the first and third row the figure shows the baseline and counterfactual impulse responses based on SSA with rest-of-the-world shocks (green lines with squares), SSA with all shocks (blue lines with triangles) and MRE (red lines with circles) for US CPI, import prices with and without petroleum, PPI, the US dollar NEER and oil prices to a US monetary policy shock. The grey shaded areas represent 68% centered point-wise probability bands for the baseline impulse responses. In the second and fourth row the figure shows the point-wise mean of the differences between the baseline and the counterfactual effects together with 68% centered point-wise probability bands.

Figure 7: Placebo-test impulse responses of US industrial production



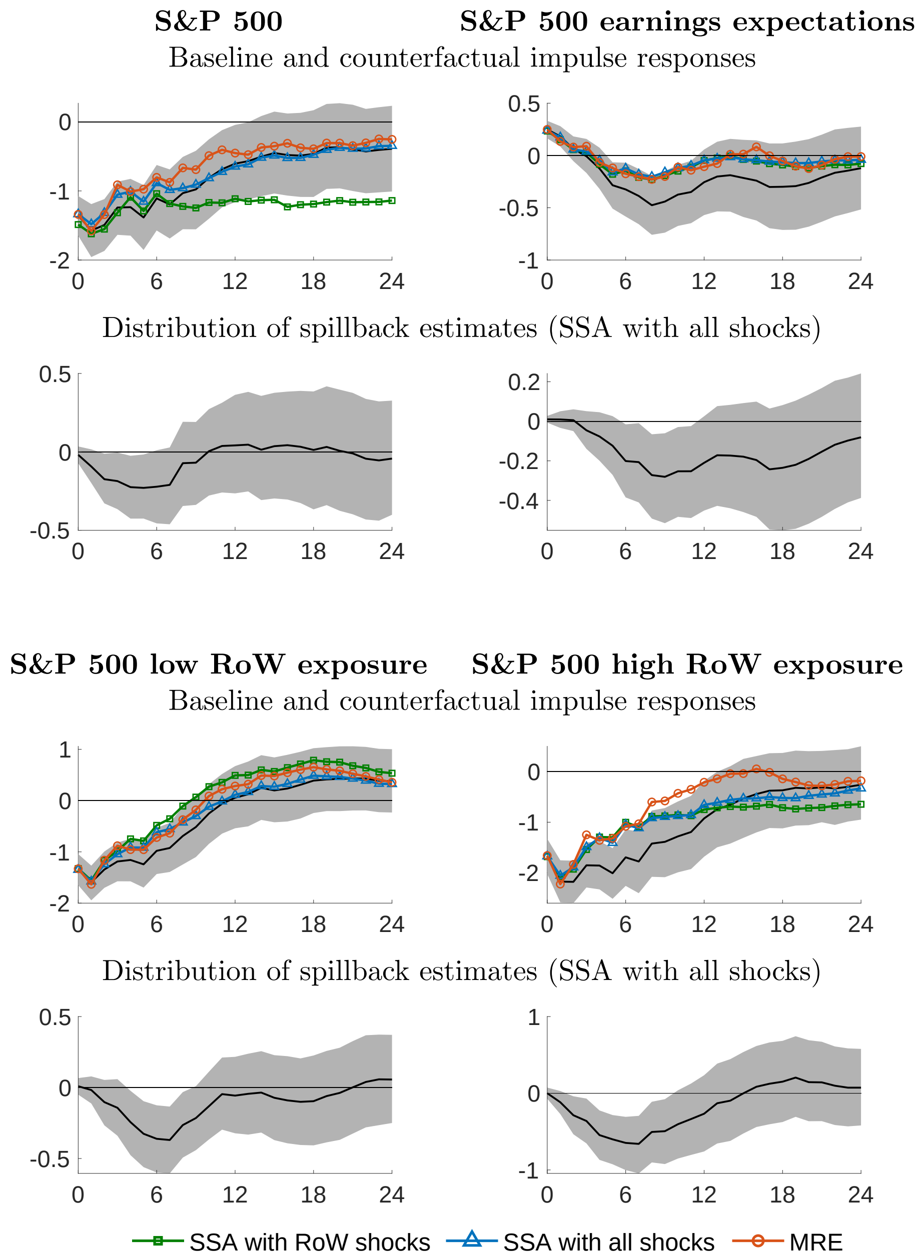
Notes: The black solid lines depict the response of US industrial production from VAR models in which SOE industrial production is added to the vector of observables and their impulse responses to a US monetary policy shock are not constrained, and the grey shaded areas represent the associated 68% centered point-wise probability bands. The light blue lines with triangles depict the counterfactual impulse response in which spillovers to rest-of-the-world and SOE industrial production are precluded. In the top row, the dark blue lines with crosses depict the counterfactual response of US industrial production when SOE industrial production is constrained to not respond to a US monetary policy shock, and rest-of-the-world industrial production is constrained to respond as in the unconstrained case. In the bottom row, the dark blue lines with crosses depict the response of US industrial production when the response of SOE industrial production is constrained to respond as in the unconstrained case, and rest-of-the-world industrial production is constrained to not respond to a US monetary policy shock. Figure E.3 and Figure E.4 document the placebo tests based on SSA with rest-of-the-world shocks and MRE.

Figure 8: Responses of monthly GDP components to US monetary policy shock for the baseline and the counterfactual



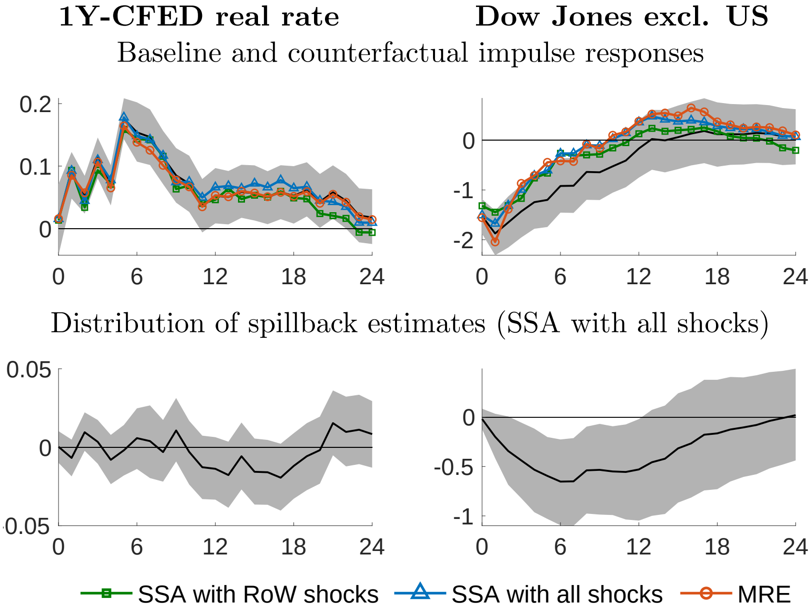
Notes: In the first and third row the figure shows the baseline and counterfactual impulse responses based on SSA with rest-of-the-world shocks (green lines with squares), SSA with all shocks (blue lines with triangles) and MRE (red lines with circles) for real exports, real imports, real private gross fixed capital investment and real private consumption expenditures to a US monetary policy shock. The grey shaded areas represent 68% centered point-wise probability bands for the baseline impulse responses. In the second and fourth row the figure shows the point-wise mean of the differences between the baseline and the counterfactual effects together with 68% centered point-wise probability bands.

Figure 9: Channels of transmission for spillbacks from US monetary policy to investment



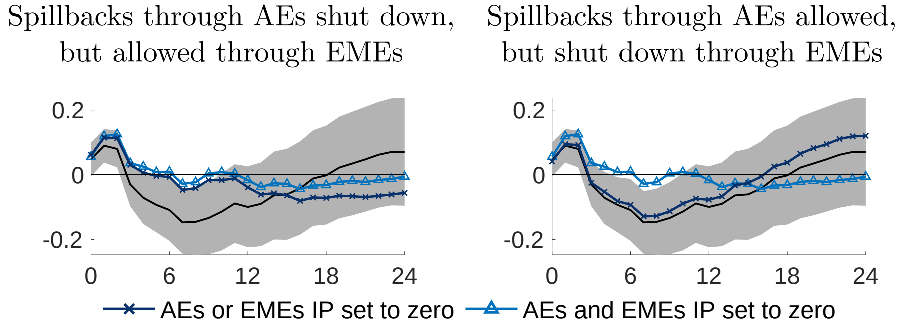
Notes: In the first and third row the figure shows the baseline and counterfactual impulse responses based on SSA with rest-of-the-world shocks (green lines with squares), SSA with all shocks (blue lines with triangles) and MRE (red lines with circles) for the S&P 500 Composite, the 12-months forward S&P 500's earnings per share, and the S&P 500 index for low and high rest-of-the-world exposures. The latter two are constructed as market-capitalisation-weighted averages of sectoral S&P indices. The low rest-of-the-world exposure sectors are utilities, telecommunication services, health care and financials, and the high rest-of-the-world exposure sectors are energy, materials, industrials and information technology; see Brzenk (2018) for data and a discussion of rest-of-the-world exposures in the S&P 500. The grey shaded areas represent 68% centered point-wise probability bands for the baseline impulse responses. In the second and fourth row the figure shows the point-wise mean of the differences between the baseline and the counterfactual effects together with 68% centered point-wise probability bands.

Figure 10: Channels of transmission for spillbacks from US monetary policy to consumption



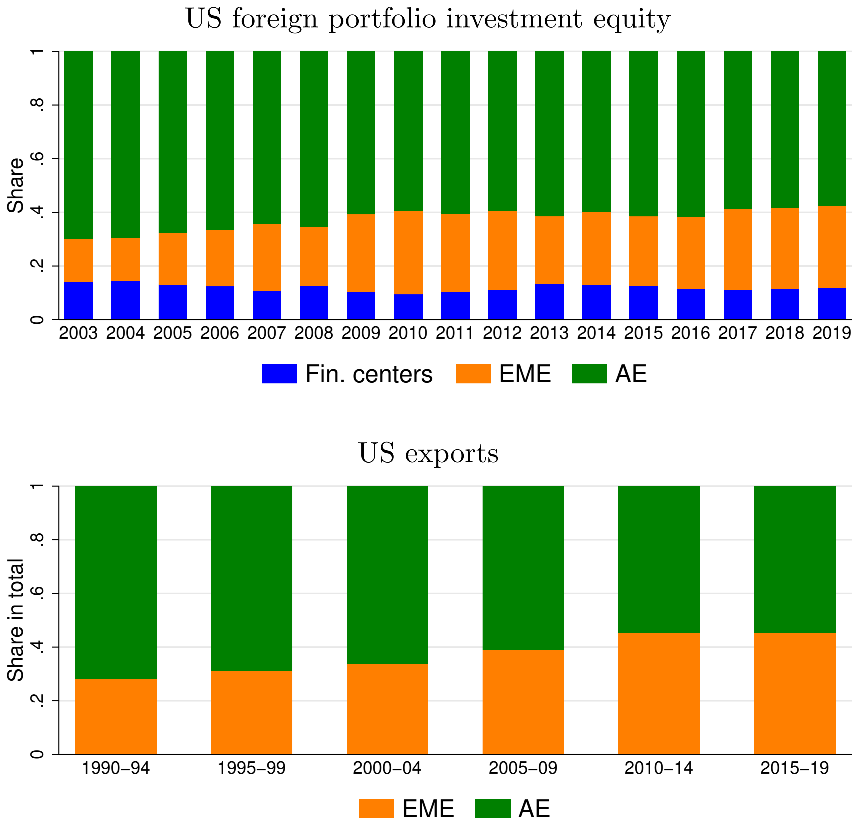
Notes: In the first row the figure shows the baseline and counterfactual impulse responses based on SSA with rest-of-the-world shocks (green lines with squares), SSA with all shocks (blue lines with triangles) and MRE (red lines with circles) for the Cleveland Fed/Haubrich et al. (2012) interest rate-term structure-based one-year real rate and the Dow Jones World excl. US index. The grey shaded areas represent 68% centered point-wise probability bands for the baseline impulse responses. In the second row the figure shows the point-wise mean of the differences between the baseline and the counterfactual effects together with 68% centered point-wise probability bands.

Figure 11: Spillbacks from US monetary policy through AEs and EMEs



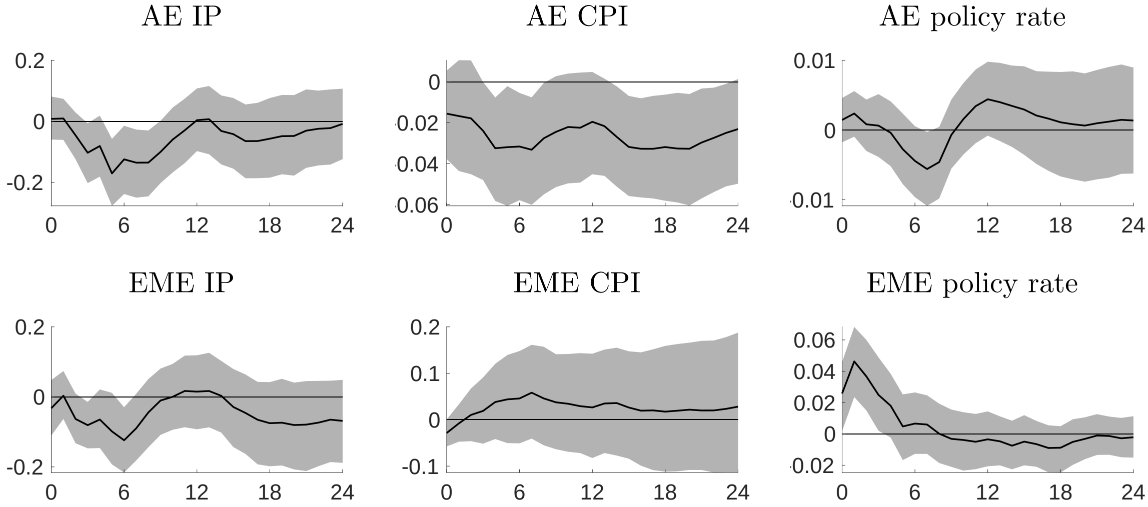
Notes: The black solid lines depict the response of US industrial production to a US monetary policy shock from VAR models in which rest-of-the-world industrial production is replaced with separate measures for AEs and EMEs industrial production and their impulse responses to a US monetary policy shock are not constrained; the grey shaded areas represent the associated 68% centered point-wise probability bands. The light blue lines with triangles depict counterfactual impulse responses in which spillovers to the rest-of-the-world are precluded, meaning that both AEs and EMEs industrial production are constrained to not respond to a US monetary policy shock. In the left-hand side panel the dark blue line with crosses depicts the counterfactual impulse response of US industrial production when AEs industrial production is constrained to not respond while EMEs industrial production is set to respond as in the unconstrained case. In the right-hand side panel the dark blue line with crosses depicts the counterfactual impulse response when AEs industrial production is constrained to respond as in the unconstrained case while EMEs industrial production is constrained to not respond to a US monetary policy shock. All counterfactual impulse responses shown are based on SSA with all shocks. Figure E.8 presents the counterfactual impulse responses based on SSA with rest-of-the-world shocks and MRE.

Figure 12: Country composition of US foreign portfolio investment equity holdings and US exports



Notes: The top panel shows the country composition of US foreign portfolio equity holdings through common stocks and mutual funds based on the analysis in Bertaut et al. (2019), which accounts for measurement problems related to multinationals, financial centres and mutual funds. The total underlying the shares does not include cross-border equity of firms that primarily operate in the US (for details see Bertaut et al., 2019). The list of financial centres is taken from Bertaut et al. (2019). The bottom panel shows the country composition of US exports of goods obtained from the IMF Direction of Trade Statistics as a proxy for the composition of US firms' sales to the rest of the world.

Figure 13: US monetary policy spillovers to AEs and EMEs



Notes: The figure shows point-wise posterior mean impulse responses (black solid lines) and 68% centered point-wise probability bands (grey areas). The impulse responses are estimated from a VAR model in which the variables are added at once to the vector of endogenous variables.

C The SSA framework of Antolin-Diaz et al. (2021)

Building on the work of Waggoner and Zha (1999), the SSA framework of Antolin-Diaz et al. (2021, henceforth ADPRR) provides a rigorous and general treatment on how to impose specific paths on observables in a VAR model as conditional forecasts with and without constraints on the set of offsetting—or 'driving'—shocks. Denoting by $\boldsymbol{y}'_{T+1,T+h} \equiv [\boldsymbol{y}'_{T+1}, \boldsymbol{y}'_{T+2}, \ldots, \boldsymbol{y}'_{T+h}]$ the $1 \times nh$ vector that stacks the future values of the observables over an horizon of h periods, the SSA framework of ADPRR consists of obtaining the distribution of the observables

$$\widetilde{\boldsymbol{y}}_{T+1,T+h} \sim N(\boldsymbol{\mu}_y, \boldsymbol{\Sigma}_y), \tag{C.1}$$

where the $nh \times 1$ vector vector $\widetilde{\boldsymbol{y}}_{T+1,T+h}$ contains the values of all observables—i.e. both those whose paths are constrained and those whose paths are unconstrained—under the conditional forecast. The $nh \times 1$ vector $\boldsymbol{\mu}_y$ contains the corresponding means of the distribution of the observables in $\widetilde{\boldsymbol{y}}_{T+1,T+h}$ under the conditional forecast, and the $nh \times nh$ matrix $\boldsymbol{\Sigma}_y$ the associated uncertainty.

In the framework of ADPRR, structural scenarios involve

(i) 'conditional-on-observables forecasting', i.e. specifying paths for a subset of observables in $\boldsymbol{y}_{T+1,T+h}$ that depart from their unconditional forecast, and/or

(ii) 'conditional-on-shocks forecasting', i.e. specifying the subset of (and potentially a path for) the structural shocks $\boldsymbol{\epsilon}_{T+1,T+h}$ that are allowed to depart from their unconditional distribution to produce the specified path of the observables in (i);

Both the case in which the path of observables under (i) and the case in which the path of structural shocks under (ii) is constrained can be laid out based on Equation (C.1). The goal is to determine $\boldsymbol{\mu}_y$ and $\boldsymbol{\Sigma}_y$ such that the constraints under (i) and (ii) are satisfied simultaneously.

Assume the structural parameters of the VAR model are known. The future values of the observables are given by

$$\boldsymbol{y}_{T+1,T+h} = \boldsymbol{b}_{T+1,T+h} + \boldsymbol{M}'\boldsymbol{\epsilon}_{T+1,T+h}, \tag{C.2}$$

where the $nh \times 1$ vector $\boldsymbol{b}_{T+1,T+h}$ represents the deterministic component due to initial conditions and the autoregressive dynamics of the VAR model, and the $nh \times nh$ matrix $\boldsymbol{M}'$ the impact of future structural shocks.

Under (i), 'conditional-on-observables forecasting' can be written as

$$\overline{\boldsymbol{C}}\widetilde{\boldsymbol{y}}_{T+1,T+h} = \overline{\boldsymbol{C}}\boldsymbol{b}_{T+1,T+h} + \overline{\boldsymbol{C}}\boldsymbol{M}'\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h} \sim N(\overline{\boldsymbol{f}}_{T+1,T+h}, \overline{\boldsymbol{\Omega}}_f). \tag{C.3}$$

where $\overline{\boldsymbol{C}}$ is a $k_o \times nh$ selection matrix, the $k_o \times 1$ vector $\overline{\boldsymbol{f}}_{T+1,T+h}$ is the mean of the distribution of the observables constrained under the conditional forecast and the $k_o \times k_o$ matrix $\overline{\boldsymbol{\Omega}}_f$ the associated uncertainty. In turn, under (ii), 'conditional-on-shocks forecasting' can be written as

$$\boldsymbol{\Xi}\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h} \sim N(\boldsymbol{g}_{T+1,T+h}, \boldsymbol{\Omega}_g), \tag{C.4}$$

where $\boldsymbol{\Xi}$ is a $k_s \times nh$ selection matrix, the $k_s \times 1$ vector $\boldsymbol{g}_{T+1,T+h}$ the mean of the distribution of the shocks constrained under the conditional forecast and the $k_s \times k_s$ matrix $\boldsymbol{\Omega}_g$ the associated uncertainty.[27] Under invertibility we have

$$\begin{aligned}
\boldsymbol{M}'^{-1}\widetilde{\boldsymbol{y}}_{T+1,T+h} &= \boldsymbol{M}'^{-1}\boldsymbol{b}_{T+1,T+h} + \widetilde{\boldsymbol{\epsilon}}_{T+1,T+h}, \\
\boldsymbol{\Xi}\boldsymbol{M}'^{-1}\widetilde{\boldsymbol{y}}_{T+1,T+h} &= \boldsymbol{\Xi}\boldsymbol{M}'^{-1}\boldsymbol{b}_{T+1,T+h} + \boldsymbol{\Xi}\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h}, & \text{(C.5)} \\
\underline{\boldsymbol{C}}\widetilde{\boldsymbol{y}}_{T+1,T+h} &= \underline{\boldsymbol{C}}\boldsymbol{b}_{T+1,T+h} + \boldsymbol{\Xi}\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h}, & \text{(C.6)}
\end{aligned}$$

and hence

$$\underline{\boldsymbol{C}}\widetilde{\boldsymbol{y}}_{T+1,T+h} = \underline{\boldsymbol{C}}\boldsymbol{b}_{T+1,T+h} + \boldsymbol{\Xi}\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h} \sim N(\underline{\boldsymbol{f}}_{T+1,T+h}, \underline{\boldsymbol{\Omega}}_f), \tag{C.7}$$

with $\underline{\boldsymbol{\Omega}}_f = \boldsymbol{\Omega}_g$.

Based on Equations (C.3) and (C.7), we can combine the k_o constraints on the observables under 'conditional-on-observables forecasting' and the k_s constraints on the structural shocks under 'conditional-on-shocks forecasting' by defining the $k \times nh$, $k = k_o + k_s$, matrices $\boldsymbol{C} \equiv [\overline{\boldsymbol{C}}', \underline{\boldsymbol{C}}']'$ and $\boldsymbol{D} \equiv [\boldsymbol{M}\overline{\boldsymbol{C}}', \boldsymbol{\Xi}']'$ to write

$$\boldsymbol{C}\widetilde{\boldsymbol{y}}_{T+1,T+h} \;=\; \boldsymbol{C}\boldsymbol{b}_{T+1,T+h} + \boldsymbol{D}\widetilde{\epsilon}_{T+1,T+h} \sim N(\boldsymbol{f}_{T+1,T+h}, \boldsymbol{\Omega}_f), \tag{C.8}$$

where the $k \times 1$ vector $\boldsymbol{f}_{T+1,T+h} \equiv [\overline{\boldsymbol{f}}'_{T+1,T+h}, \underline{\boldsymbol{f}}'_{T+1,T+h}]'$ stacks the means of the distributions under the 'conditional-on-observables forecasting' ($\overline{\boldsymbol{f}}_{T+1,T+h} = \overline{\boldsymbol{C}}\boldsymbol{b}_{T+1,T+h}$) and the 'conditional-on-shocks forecasting' ($\underline{\boldsymbol{f}}_{T+1,T+h} = \underline{\boldsymbol{C}}\boldsymbol{b}_{T+1,T+h} + \boldsymbol{g}_{T+1,T+h}$), and the $k \times k$ matrix $\boldsymbol{\Omega}_f \equiv diag(\overline{\boldsymbol{\Omega}}_f, \underline{\boldsymbol{\Omega}}_f)$.[28]

Based on the combination of 'conditional-on-observables forecasting' and 'conditional-on-shocks forecasting' in Equation (C.8), we can derive the solutions for $\boldsymbol{\mu}_y$ and $\boldsymbol{\Sigma}_y$. Define

$$\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h} \sim N(\boldsymbol{\mu}_\epsilon, \boldsymbol{\Sigma}_\epsilon), \quad \boldsymbol{\Sigma}_\epsilon = \boldsymbol{I} + \boldsymbol{\Psi}_\epsilon, \tag{C.9}$$

[27] For the conditional forecast that underlies an impulse response function to the i-th shock in period $T+1$ we have

$$\boldsymbol{\Xi} = \boldsymbol{I}_{nh}, \quad \boldsymbol{g}_{T+1,T+h} = [\boldsymbol{e}'_i, \boldsymbol{0}'_{n(h-1)\times 1}]'_{nh\times 1}, \quad \boldsymbol{\Omega}_g = \boldsymbol{0}_{nh\times nh},$$

where $\boldsymbol{e}_i$ is an $n \times 1$ vector of zeros with unity at the i-th position.

[28] Note that $\underline{\boldsymbol{f}}_{T+1,T+h}$ refers to the mean of $\underline{\boldsymbol{C}}\widetilde{\boldsymbol{y}}_{T+1,T+h} = \boldsymbol{\Xi}\boldsymbol{M}'^{-1}\widetilde{\boldsymbol{y}}_{T+1,T+h}$ and hence not just of a path of some observable(s). Instead, $\boldsymbol{\Xi}\boldsymbol{M}'^{-1}\widetilde{\boldsymbol{y}}_{T+1,T+h}$ are the values of the observables that are implied by a specific path of the structural shocks assumed under 'conditional-on-shocks forecasting'.

so that the $nh \times 1$ vector $\boldsymbol{\mu}_\epsilon$ and the $nh \times nh$ matrix $\boldsymbol{\Psi}_\epsilon$ represent the deviation of the mean and the variance of the structural shocks under the conditional forecast from their values in the unconditional forecast. Given Equations (C.8) and (C.9), we have

$$\begin{aligned} \boldsymbol{f}_{T+1,T+h} &= \boldsymbol{C}\boldsymbol{b}_{T+1,T+h} + \boldsymbol{D}\boldsymbol{\mu}_\epsilon, & \text{(C.10)} \\ \boldsymbol{\Omega}_f &= \boldsymbol{D}(\boldsymbol{I} + \boldsymbol{\Psi}_\epsilon)\boldsymbol{D}'. & \text{(C.11)} \end{aligned}$$

The solutions for $\boldsymbol{\mu}_\epsilon$ and $\boldsymbol{\Sigma}_\epsilon$ are given by

$$\begin{aligned} \boldsymbol{\mu}_\epsilon &= \boldsymbol{D}^*(\boldsymbol{f}_{T+1,T+h} - \boldsymbol{C}\boldsymbol{b}_{T+1,T+h}), & \text{(C.12)} \\ \boldsymbol{\Sigma}_\epsilon &= \boldsymbol{D}^*\boldsymbol{\Omega}_f\boldsymbol{D}^{*\prime} + (\boldsymbol{I} - \boldsymbol{D}^*\boldsymbol{D}\boldsymbol{D}'\boldsymbol{D}^{*\prime}), & \text{(C.13)} \end{aligned}$$

where the $nh \times k$ matrix $\boldsymbol{D}^*$ is the Moore-Penrose inverse of $\boldsymbol{D}$.[29] Equation (C.12) shows that the path of the implied future structural shocks under the conditional forecast depends on its deviation from the unconditional forecast. In turn, Equation (C.13) shows that the variance of the implied future structural shocks depends on the uncertainty the researcher attaches to the conditional forecast; if the uncertainty is zero, then $\boldsymbol{\Omega}_f = \boldsymbol{0}$ as $\overline{\boldsymbol{\Omega}}_f = \underline{\boldsymbol{\Omega}}_f = \boldsymbol{\Omega}_g = \boldsymbol{0}$, and hence $\boldsymbol{\Sigma}_\epsilon = 0$, meaning that a unique, certain path $\boldsymbol{\mu}_\epsilon$ for the structural shocks is implied by the conditional forecast.[30]

Finally, as

$$\widetilde{\boldsymbol{y}}_{T+1,T+h} = \boldsymbol{b}_{T+1,T+h} + \boldsymbol{M}'\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h}, \tag{C.14}$$

and given Equations (C.12) and (C.13) we have that

$$\begin{aligned} \boldsymbol{\mu}_y &= \boldsymbol{b}_{T+1,T+h} + \boldsymbol{M}'\boldsymbol{D}^*(\boldsymbol{f}_{T+1,T+h} - \boldsymbol{C}\boldsymbol{b}_{T+1,T+h}), & \text{(C.15)} \\ \boldsymbol{\Sigma}_y &= \boldsymbol{M}'\boldsymbol{M} - \boldsymbol{M}'\boldsymbol{D}^*(\boldsymbol{\Omega}_f - \boldsymbol{D}\boldsymbol{D}')\boldsymbol{D}^{*\prime}\boldsymbol{M}. & \text{(C.16)} \end{aligned}$$

Again, when $\boldsymbol{\Omega}_f = \boldsymbol{0}$ then $\boldsymbol{\Sigma}_y = \boldsymbol{0}$, and there is no uncertainty about the path of the observables under the conditional forecast.

It is useful to discuss how the framework of ADPRR is parsed in the context of our paper. Recall that we constrain the effect of a US monetary policy shock on rest-of-the world real activity to be zero, and we assume this occurs due to two offsetting rest-of-the world shocks. Ordering rest-of-the-world output last in $\boldsymbol{y}_t$, the US monetary policy shock first and the two rest-of-the-world shocks last in $\boldsymbol{\epsilon}_t$, and denoting by $\boldsymbol{e}_i$ a $n \times 1$ vector of zeros with unity at

[29] ADPRR discuss the properties of the solutions under different values for k relative to nh.

[30] As discussed in ADPRR, the researcher could impose that the uncertainty under the conditional forecast is identical to that of the unconditional forecast, i.e. set $\boldsymbol{\Omega}_f = \boldsymbol{D}\boldsymbol{D}'$.

the i-th position, for 'conditioning-on-observables forecasting' we have

$$\overline{\boldsymbol{C}} = \boldsymbol{I}_h \otimes \boldsymbol{e}'_n, \tag{C.17}$$

$$\overline{\boldsymbol{f}}_{T+1,T+h} = \boldsymbol{0}_{h\times 1}, \tag{C.18}$$

$$\overline{\boldsymbol{\Omega}}_f = \boldsymbol{0}_{h\times h}. \tag{C.19}$$

The intuition underlying Equations (C.17) and (C.18) is that in the conditional forecast that underlies the impulse response we constrain rest-of-the-world output (ordered at the n-th position in $\boldsymbol{y}_t$) to be zero over all horizons $T+1, T+2, \ldots, T+h$, and Equation (C.19) indicates that we do not allow for any uncertainty. In turn, for 'conditioning-on-shocks forecasting' we have

$$\boldsymbol{\Xi} = \begin{bmatrix} \boldsymbol{e}'_1 & \boldsymbol{0}_{1\times n(h-1)} \\ (\boldsymbol{0}_{n-3\times 1}, \boldsymbol{I}_{n-3}, \boldsymbol{0}_{n-3\times 2}) & \boldsymbol{0}_{n-3\times n(h-1)} \\ \boldsymbol{0}_{(h-1)(n-2)\times n} & \boldsymbol{I}_{h-1} \otimes (\boldsymbol{I}_{n-2}, \boldsymbol{0}_{n-2\times 2}) \end{bmatrix}_{h(n-2)\times nh} \tag{C.20}$$

$$\underline{\boldsymbol{f}}_{T+1,T+h} = \boldsymbol{g}_{T+1,T+h} = [1, \boldsymbol{0}_{1\times n-3}, \boldsymbol{0}_{1\times (n-2)(h-1)}]', \tag{C.21}$$

$$\underline{\boldsymbol{\Omega}}_f = \boldsymbol{\Omega}_g = \boldsymbol{0}_{h(n-2)\times h(n-2)}. \tag{C.22}$$

The first row in Equation (C.20) selects the US monetary policy shock ordered first in $\boldsymbol{\epsilon}_t$ and the first row in Equation (C.21) constrains it to be unity in the impact period $T+1$; the second row in Equation (C.20) selects the non-US monetary policy and the non-rest-of-the-world shocks ordered from position 2 to $n-3$ in $\boldsymbol{\epsilon}_t$ and the second entry in Equation (C.21) constrains them to be zero in the impact period $T+1$; the third row in Equation (C.20) selects the US monetary policy and the non-rest-of-the-world shocks and Equation (C.21) constrains them to be zero over horizons $T+2, T+3, \ldots, T+h$. It is furthermore interesting to consider—recalling that $\underline{\boldsymbol{C}} \equiv \boldsymbol{\Xi}\boldsymbol{M}'^{-1}$—the stacked matrices $\boldsymbol{C}$ and $\boldsymbol{D}$ in Equation (C.8)

$$\boldsymbol{C} = \begin{bmatrix} \overline{\boldsymbol{C}}_{h\times hn} \\ \underline{\boldsymbol{C}}_{h(n-2)\times hn} \end{bmatrix}_{h(n-1)\times hn}, \qquad \boldsymbol{D} = \begin{bmatrix} \overline{\boldsymbol{C}}\boldsymbol{M}' \\ \boldsymbol{\Xi} \end{bmatrix}_{h(n-1)\times nh}. \tag{C.23}$$

Note that the fact that $\boldsymbol{C}$ and $\boldsymbol{D}$ are not square and full rank reflects that at every horizon we have two rest-of-the-world shocks to impose one constraint (the absence of a rest-of-the-world real activity response to a US monetary policy shock), implying a multiplicity of solutions. ADPRR show that the solution chosen in this case—obtained using the Moore-Penrose inverse of $\boldsymbol{D}$—minimises the Frobenius norm of the deviation of the distribution of the structural shocks under the conditional forecast from the baseline, i.e. $\boldsymbol{\mu}_\epsilon$ from $\boldsymbol{0}$ and $\boldsymbol{\Sigma}_\epsilon$ from $\boldsymbol{I}$. Note that $\boldsymbol{C}$ and $\boldsymbol{D}$ become square and full rank if h additional constraint are imposed. For example, we could impose that the two rest-of-the-world shocks we use for the offsetting of the effects of the US monetary policy shock on rest-of-the-world output are of equal size. To do so, we would stack below $\boldsymbol{\Xi}$ in Equation (C.20) an $h \times nh$ matrix

$$\boldsymbol{\Xi}^{add} = \boldsymbol{I}_h \otimes [0, 0, \ldots, 0, 1, -1]_{1\times n}, \quad \text{(C.24)}$$

and below $\underline{\boldsymbol{f}}_{T+1,T+h}$ in Equation (C.21) an $h \times 1$ vector

$$\underline{\boldsymbol{f}}^{add}_{T+1,T+h} = \boldsymbol{0}_{h\times 1}. \quad \text{(C.25)}$$

C.1 How plausible is the counterfactual?

When constructing a counterfactual using SSA it might be that the implied shocks are so "unusual" that the analysis becomes subject to the Lucas critique. Against this background, ADPRR propose to use the Kullback-Leibler (KL) divergence $\mathcal{D}(F_{bl}||F_{cf})$ between the distributions of the implied shocks in the conditional forecasts in the baseline F_{bl} and in the counterfactual F_{cf}. While it is straightforward to compute $\mathcal{D}(F_{bl}||F_{cf})$, it is difficult to grasp intuitively whether a given numerical value for the KL divergence is large or small. In other words, the KL divergence can be easily used to rank scenarios, but it is hard to understand how far away they are from the unconditional forecast. To allow an intuitive interpretation of the KL divergence, ADPRR "calibrate" it based on two generic distributions Q to P, using the KL divergence between two easily interpretable distributions. In particular, ADPRR suggest comparing $\mathcal{D}(F_{bl}||F_{cf})$ with the KL divergence between two binomial distributions Q and P, one with probability q and the other with probability $p = 0.5$. ADPRR suggest calibrating the KL divergence from Q to P to a parameter q that would solve the following equation $\mathcal{D}(B(nh; 0.5)||B(nh; q)) = \mathcal{D}(F_{bl}||F_{cf})$. The solution to the equation is $q = 0.5(1 + \sqrt{1 - exp(-2z/nh)})$, where $z = \mathcal{D}(F_{bl}||F_{cf})$. Intuitively, the value for the KL divergence $\mathcal{D}(F_{bl}||F_{cf})$ is translated into a comparison between the flip of a fair and a biased coin. For example, a value of $q = 0.501$ suggests that the distribution of the shocks under the counterfactual is not at all far from the distribution under the baseline, so that the counterfactual can be considered as quite realistic relative to the baseline.

It is worthwhile noting that this measure of plausibility is similar in spirit to the concept of "modest" policy interventions proposed by Leeper and Zha (2003). In particular, the measure proposed by Leeper and Zha (2003) reports how unusual the path for a set of policy shocks needed to achieve some conditional forecast. For example, if the counterfactual implies a sequence of shocks close to their unconditional mean, the policy intervention is considered "modest", in the sense that the shocks are unlikely to induce agents to revise their beliefs about policy rules and the structure of the economy. Instead, if the counterfactual involves an unlikely sequence of shocks the analysis is likely to be subject to the Lucas critique. In contrast to the "modesty" statistic of Leeper and Zha (2003) the q-divergence of ADPRR compares the entire distribution rather than only the path of the shocks and generalises to counterfactuals that use more than a single driving shock.

ADPRR propose the KL divergence to assess the plausibility of a conditional forecast relative to an unconditional forecast. In the context of our paper, we need to slightly adjust their proposed KL divergence. In particular, while in the case of ADPRR the baseline is given by an unconditional forecast and the counterfactual by a conditional forecast both afflicted by uncertainty, in our case the baseline and the counterfactual are given by conditional forecasts both of which are *not* subject to any uncertainty. Obviously, the KL divergence is not defined in case the baseline and the counterfactual do not feature any uncertainty. For the purpose of assessing the plausibility of the shocks that materialise to produce our counterfactual, we therefore consider the following exercise. As baseline we consider a conditional forecast in which we assume that a US monetary policy shock of size 1 occurs in period $T+1$ with certainty, while all other non-US monetary policy shocks in period $T+1$ as well as all shocks in periods $T+2, T+3, \ldots, T+h$ follow their unconditional distributions. For the conditional forecast under the counterfactual, we impose the mean constraint from our main exercise (i.e. that rest-of-the-world output stays at zero and that there is a US monetary policy shock in period $T+1$) but we also allow for uncertainty.

Formally, this exercise involves setting for the baseline and the counterfactual $\ell \in \{bl, cf\}$ $\overline{\boldsymbol{C}}_\ell = \boldsymbol{I}$ and

$$\boldsymbol{f}_{bl} = \boldsymbol{\mu}_{y,bl} = \boldsymbol{M}'(\boldsymbol{e}_i', \boldsymbol{0}_{n(h-1)\times 1})', \tag{C.26}$$

$$\boldsymbol{f}_{cf} = \boldsymbol{\mu}_{y,cf}, \tag{C.27}$$

where i is the position of the US monetary policy shock, Equation (C.26) states that the observables on average shall follow the impulse response to a US monetary policy shock in period $T+1$ under the baseline, and Equation (C.26) that they shall follow the path we obtained in the SSA counterfactual. Moreover, we set $\boldsymbol{\Xi}_\ell = \boldsymbol{0}$ and $\underline{\boldsymbol{C}}_\ell = \boldsymbol{0}$ so that $\boldsymbol{D}_\ell = \boldsymbol{M}'$,

$\boldsymbol{\Psi}_{\epsilon,\ell} = \mathbf{0}$ as we allow the shocks to have their unconditional variance. Hence we have

$$\boldsymbol{\Omega}_{f,\ell} = \boldsymbol{D}_\ell \boldsymbol{D}_\ell' = \boldsymbol{M}'\boldsymbol{M}, \tag{C.28}$$

$$\boldsymbol{\Sigma}_{\epsilon,\ell} = \boldsymbol{D}_\ell^* \boldsymbol{\Omega}_{f,\ell} \boldsymbol{D}_\ell^{*\prime} = \boldsymbol{D}_\ell^{-1} \boldsymbol{\Omega}_{f,\ell} \boldsymbol{D}_\ell^{-1\prime} = \boldsymbol{M}'^{-1}\boldsymbol{M}'\boldsymbol{M}\boldsymbol{M}^{-1} = \boldsymbol{I}, \tag{C.29}$$

$$\boldsymbol{\mu}_{\epsilon,\ell} = \boldsymbol{D}_\ell^* \boldsymbol{f}_\ell = \boldsymbol{D}_\ell^{-1} \boldsymbol{f}_\ell = \boldsymbol{M}'^{-1} \boldsymbol{f}_\ell, \tag{C.30}$$

$$\begin{aligned} \boldsymbol{\Sigma}_{y,\ell} &= \boldsymbol{M}'\boldsymbol{M} - \boldsymbol{M}'\boldsymbol{D}_\ell^*(\boldsymbol{\Omega}_{f,\ell} - \boldsymbol{D}_\ell \boldsymbol{D}_\ell')\boldsymbol{D}_\ell^{*\prime}\boldsymbol{M} \\ &= \boldsymbol{M}'\boldsymbol{M} - \boldsymbol{M}'\boldsymbol{D}_\ell^{-1}(\boldsymbol{\Omega}_{f,\ell} - \boldsymbol{D}_\ell \boldsymbol{D}_\ell')\boldsymbol{D}_\ell^{-1\prime}\boldsymbol{M} \\ &= \boldsymbol{M}'\boldsymbol{M} - \boldsymbol{M}'\boldsymbol{M}'^{-1}(\boldsymbol{\Omega}_{f,\ell} - \boldsymbol{M}'\boldsymbol{M})\boldsymbol{M}^{-1}\boldsymbol{M} \\ &= \boldsymbol{M}'\boldsymbol{M} - (\boldsymbol{\Omega}_{f,\ell} - \boldsymbol{M}'\boldsymbol{M}) \\ &= \boldsymbol{M}'\boldsymbol{M}. \end{aligned} \tag{C.31}$$

Note that $\boldsymbol{\mu}_{\epsilon,bl}$ equals a vector of zeros with unity at the i^{th} position, where i is the position of the US monetary policy shock. The KL divergence between the distribution of the shocks under the baseline $\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h,bl}$ and the counterfactual $\widetilde{\boldsymbol{\epsilon}}_{T+1,T+h,cf}$ is then given by

$$\mathcal{D}(F_{bl}||F_{cf}) = \frac{1}{2}\left[tr\left(\boldsymbol{\Sigma}_{\epsilon,cf}^{-1}\boldsymbol{\Sigma}_{\epsilon,bl}\right) + \left(\boldsymbol{\mu}_{\epsilon,cf} - \boldsymbol{\mu}_{\epsilon,bl}\right)' \boldsymbol{\Sigma}_{\epsilon,cf}^{-1}\left(\boldsymbol{\mu}_{\epsilon,cf} - \boldsymbol{\mu}_{\epsilon,bl}\right) - nh + log\left(\frac{|\boldsymbol{\Sigma}_{\epsilon,cf}|}{|\boldsymbol{\Sigma}_{\epsilon,bl}|}\right)\right]. \tag{C.32}$$

D Implementation of the MRE approach

The posterior distribution of the impulse responses $f(\cdot)$ is approximated by N draws obtained from a Bayesian estimation algorithm. Following the importance sampling procedure of Arias et al. (2018, forthcoming), the re-sampled draws from the BPSVAR for $\boldsymbol{y}_{T+1,T+h}$ constitute an unweighted and independent sample from the posterior distribution $f(\cdot)$, and as such are assigned a weight of $w_i = 1/N,\ i = 1, 2, \ldots, N$. The counterfactual posterior distribution $f^{\star}(\cdot)$ can be approximated by assigning different weights w_i^* to the draws from the baseline posterior.

The relative entropy (or distance) between the approximated posterior distributions is measured by

$$\mathcal{D}(f^*, f) = \sum_{i=1}^{N} w_i^{\star} log\left(\frac{w_i^{\star}}{w_i}\right). \quad \text{(D.1)}$$

The goal of the MRE approach is to determine the counterfactual weights $\boldsymbol{w}^*$ that minimise $\mathcal{D}(\cdot)$ subject to

$$w_i^{\star} \geq 0, \qquad \forall\, i = 1, 2, ..., N, \quad \text{(D.2)}$$

$$\sum_{i=1}^{N} w_i^* = 1, \quad \text{(D.3)}$$

$$\sum_{i=1}^{N} w_i^* g(\boldsymbol{y}_{T+1,T+h}^{(i)}) = \bar{\boldsymbol{g}}, \quad \text{(D.4)}$$

where $\boldsymbol{y}_{T+1,T+h}^{(i)}$ are the impulse responses to a US monetary policy shock as defined in Section 5. Equations (D.2) and (D.3) reflect that the weights are probabilities, and Equation (D.4) that the counterfactual posterior distribution shall satisfy some constraint.

In particular, in our application for Equation (D.4) we have

$$\sum_{i=1}^{N} y_{ip^*,T+h}^{(i)} w_{i,h}^* = 0, \quad \text{(D.5)}$$

where $y_{ip^*,T+h}^{(i)}$ denotes the impulse response of rest-of-the-world real activity to a US monetary policy shock at horizon h associated with the i-th draw. Notice that—consistent with the baseline posterior for which we report point-wise means in Figure 2 and elsewhere in the paper as well as in line with Giacomini and Ragusa (2014)—we apply the MRE approach separately at each impulse response horizon $T+1, T+2, \ldots, T+h$.

As shown by Robertson et al. (2005) and Giacomini and Ragusa (2014), the weights of the counterfactual posterior distribution $\boldsymbol{w}_h^*$ can be obtained numerically by tilting the weights of the baseline posterior distribution $\boldsymbol{w}_h$ using the method of Lagrange. In particular, the weights of the counterfactual posterior distribution are given by

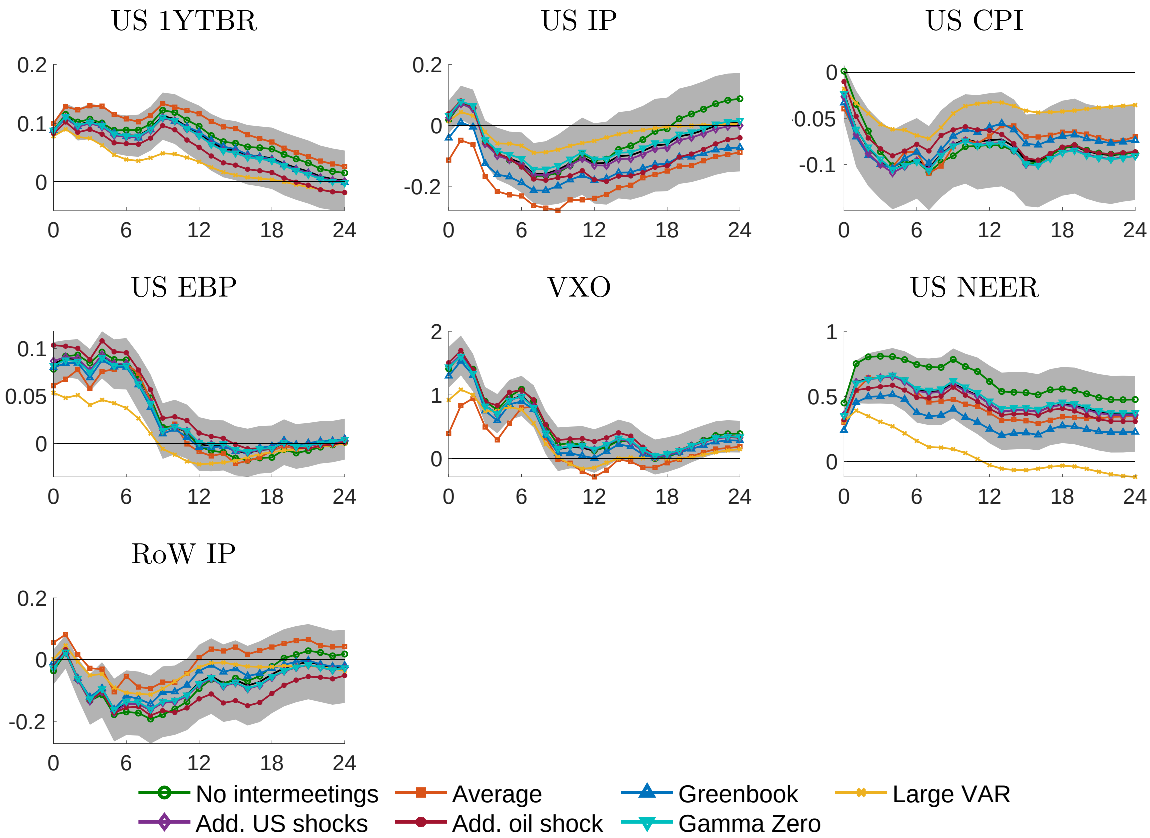
$$w^*_{i,h} = \frac{w_{i,h} \exp\left[\lambda_h g(y^{(i)}_{ip^*,T+h})\right]}{\sum_{i=1}^{N} w_{i,h} \exp\left[\lambda_h g(y^{(i)}_{ip^*,T+h})\right]}, \quad i = 1, 2, \ldots, N, \tag{D.6}$$

where λ_h is the Lagrange multiplier associated with the constraint $g(y^{(i)}_{ip^*,T+h}) = y^{(i)}_{ip^*,T+h} = 0$. It can be shown that the Lagrange multiplier can be obtained numerically as

$$\lambda_h = \arg\min_{\tilde{\lambda}_h} \sum_{i=1}^{N} w_{i,h} \exp\left\{\tilde{\lambda}_h \left[g(y^{(i)}_{ip^*,T+h})\right]\right\}. \tag{D.7}$$

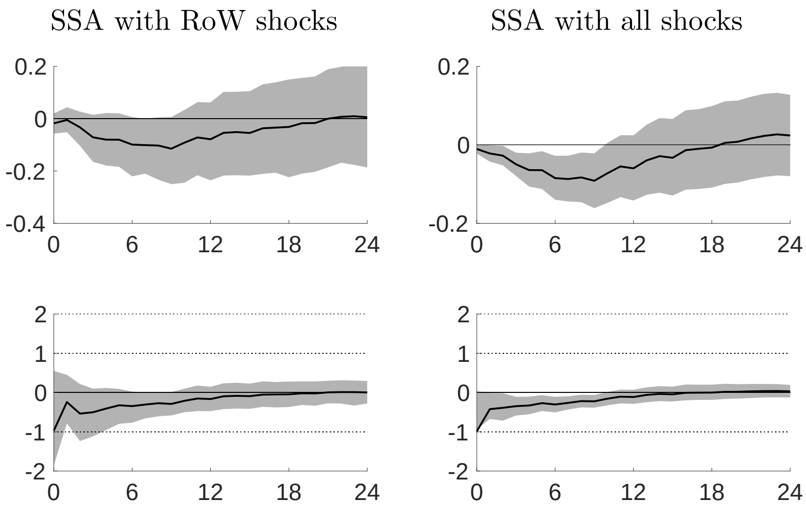
E Additional figures

Figure E.1: Impulse responses to US monetary policy shocks from alternative BPSVAR specifications



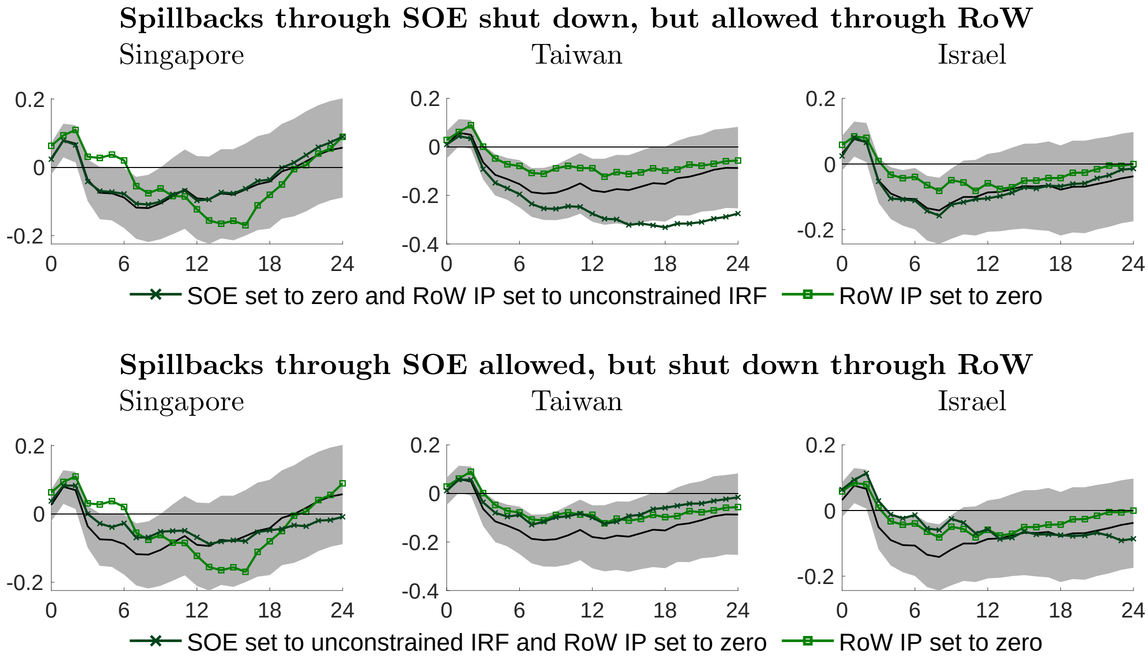
Notes: The figure shows point-wise posterior mean impulse responses from our baseline specification (black solid lines) and 68% centered point-wise probability bands (grey areas) and various robustness checks (coloured solid lines with markers). '1YTBR' stands for the one-year Treasury Bill rate, 'IP' for industrial production, 'CPI' for consumer-price index, 'EBP' for excess bond premium, 'VXO' is the S&P 500 stock market volatility index, and 'NEER' the nominal effective exchange rate. In the specification labelled 'No intermeetings' we exclude FOMC announcements on unscheduled, 'inter-meeting' dates; in 'Average' we temporally aggregate to monthly frequency the interest rate and gold price surprises originally available at daily frequency by taking monthly averages rather than as in Gertler and Karadi (2015); in 'Greenbook' we purge the interest rate surprises from Green Book forecast as suggested in Miranda-Agrippino and Ricco (2021) instead of applying the 'poor-man's' approach of Jarocinski and Karadi (2020); in 'Large VAR' we add rest-of-the-world consumer prices, AEs policy rate, US imports and exports, and the MSCI world stock price index to the vector of endogenous variables in the VAR model; in 'Add. US shocks' we additionally identify US demand and supply shocks with standard sign restrictions (we impose: negative demand shocks affect US IP, CPI, NEER, and 1YTBR negatively and US EBP positively; negative supply shocks affect US IP negatively and US CPI and EBP positively; the restrictions hold on impact); in 'Add. oil shock' we additionally identify global oil supply shocks using the high-frequency proxy variable of Känzig (2021); and in 'Gamma Zero' we set γ—the 'relevance threshold' of the proxy variables—to zero.

Figure E.2: Distribution of SSA spillback estimates to US CPI and 'modesty statistic' of Leeper and Zha (2003) for SSA counterfactuals



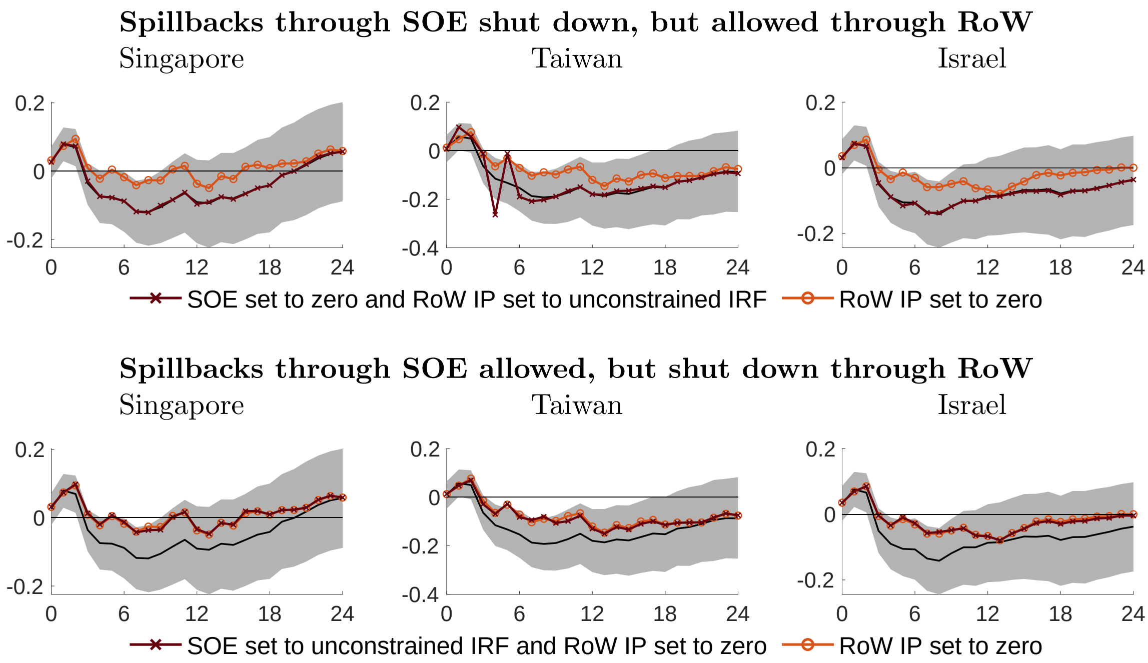
Notes: The top panels show the differences between the baseline and counterfactual effects of US monetary policy on domestic consumer prices. The bottom panels show the 'modesty statistic' of Leeper and Zha (2003) for the implied offsetting shocks needed to impose the counterfactual path of rest-of-the-world industrial production. The offsetting shocks are'modest'—meaning they would be unlikely to induce agents to adjust their expectation formation—if the statistic is smaller than two in absolute value. The black solid lines depict the point-wise mean and the grey shaded areas represent 68% centered point-wise probability bands.

Figure E.3: SSA with RoW shocks placebo-test responses of US industrial production



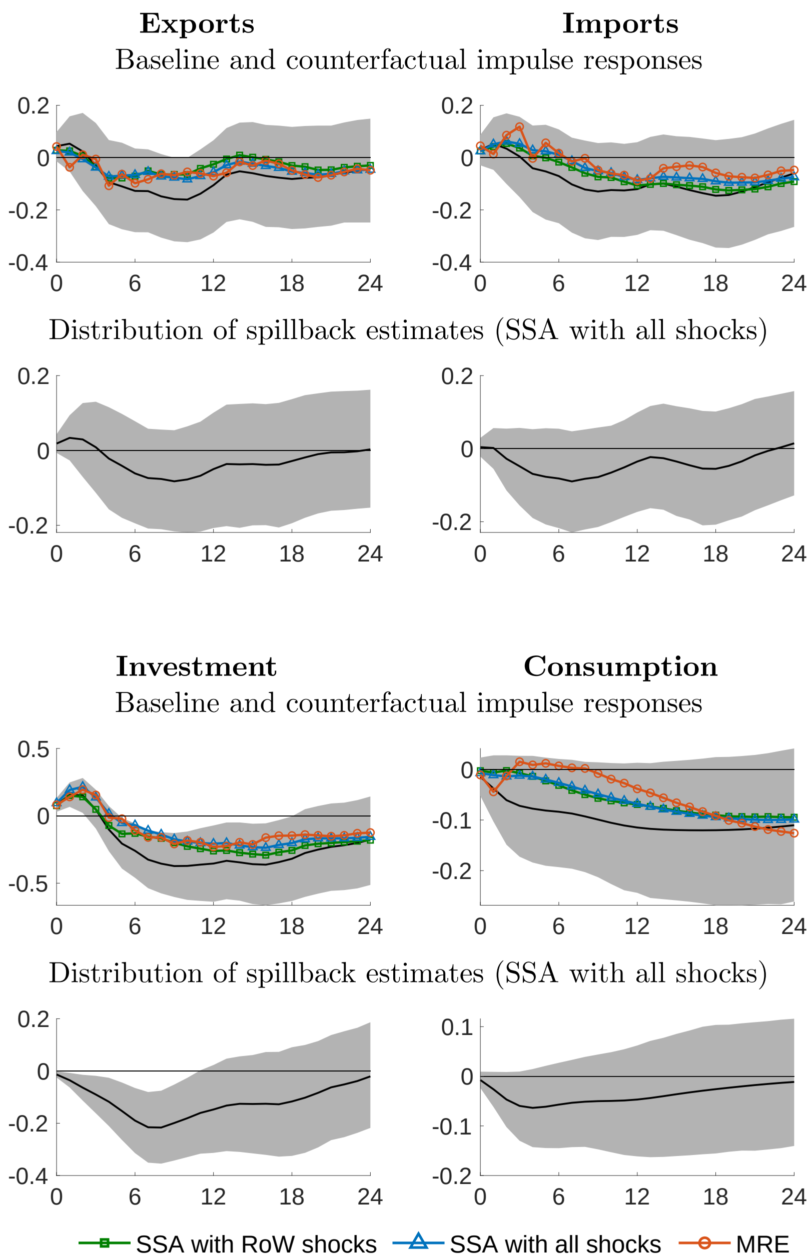
Notes: See the notes to Figure 7.

Figure E.4: MRE placebo-test responses of US industrial production



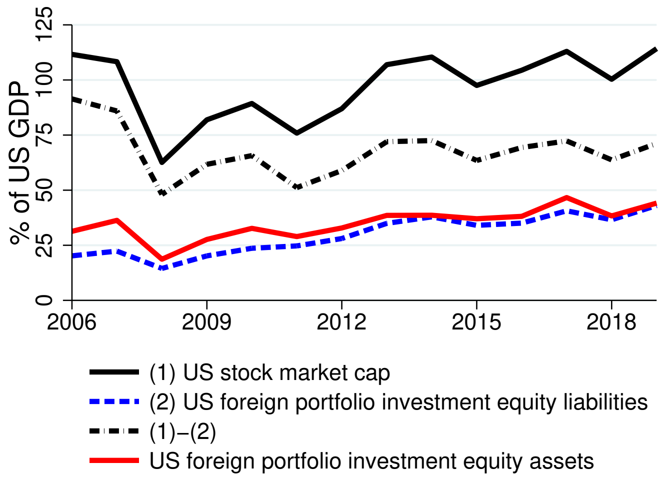
Notes: See the notes to Figure 7.

Figure E.5: Responses of GDP components to US monetary policy shock for the baseline and the counterfactual



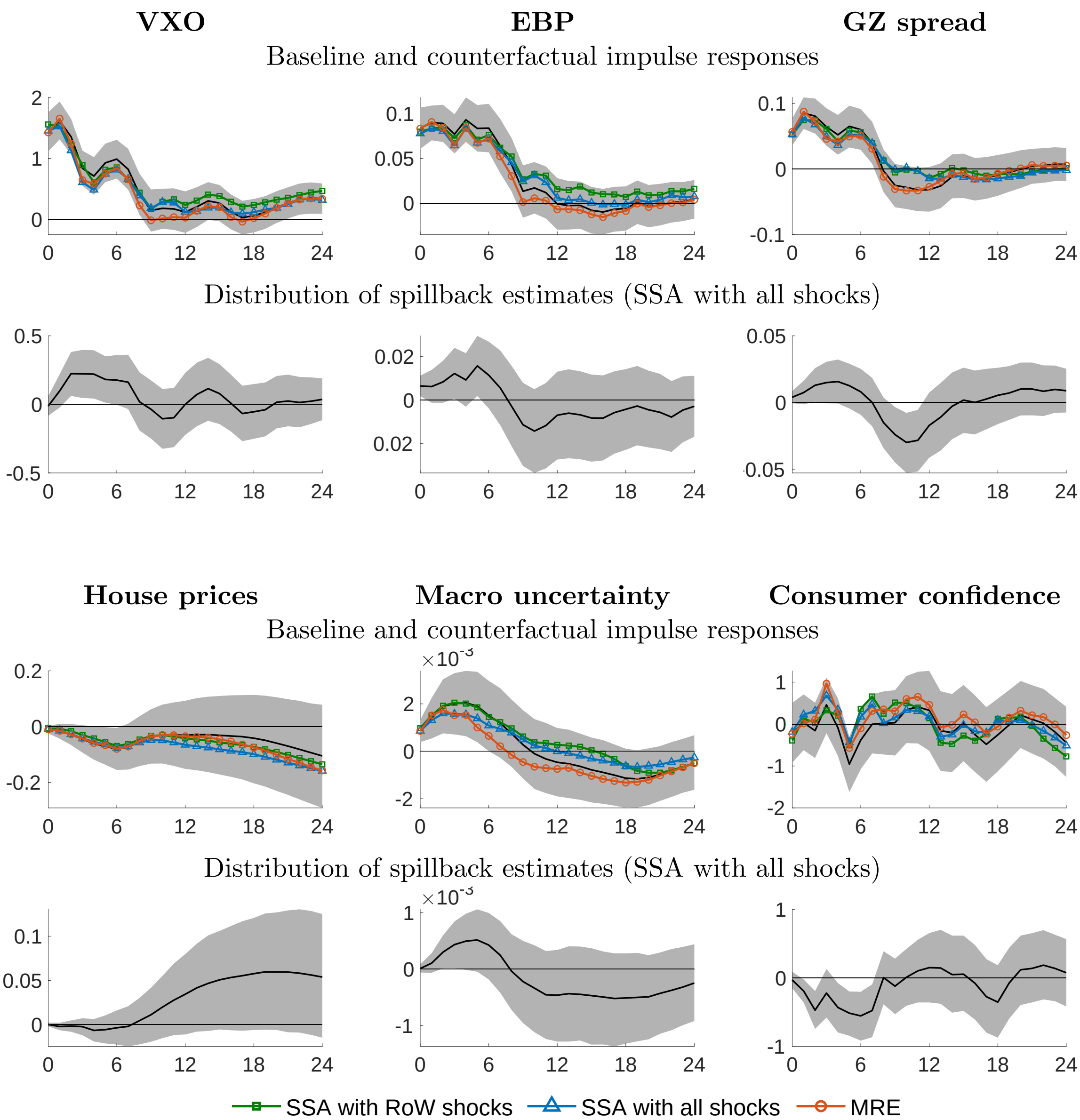
See the notes to Figure 8. The responses are based on quarterly data interpolated to monthly frequency, except for investment.

Figure E.6: US stock market capitalisation and US foreign portfolio investment equity assets and liabilities



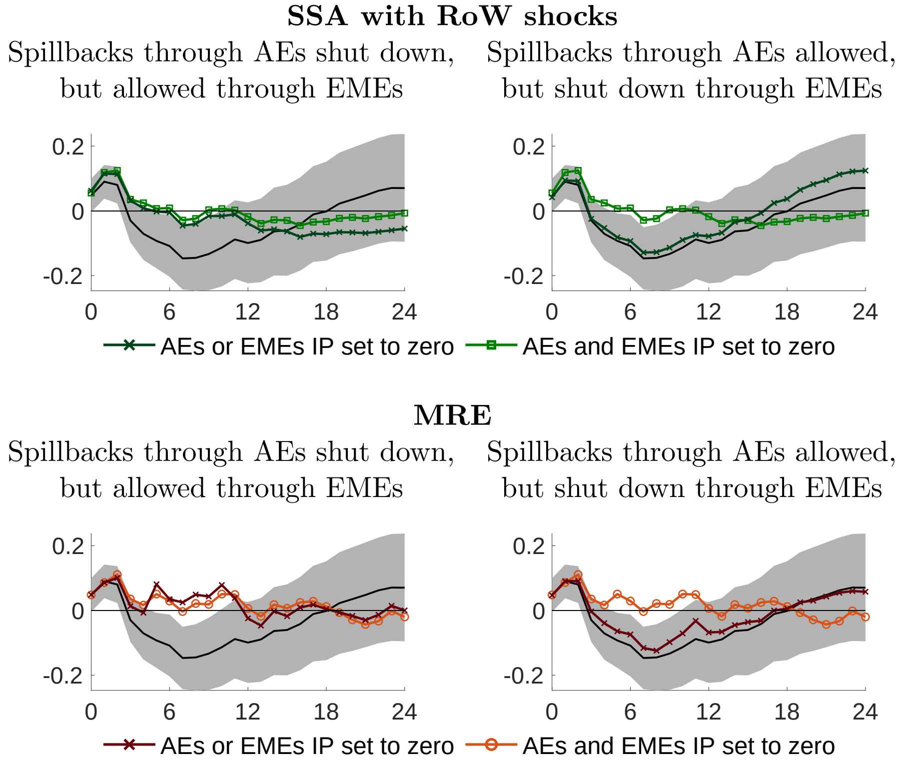
Notes: The figure shows the evolution of US (New York Stock Exchange) stock market capitalisation depicted by the black solid line as well as US foreign portfolio investment equity assets and liabilities depicted by the solid red and dashed blue lines, respectively; the black dashed line depicts US stock market capitalisation less US foreign portfolio investment equity liabilities. All variables are depicted as a percentage of US nominal annual GDP. The data on stock market capitalisation are obtained from the World Federation of Exchanges, those on US foreign equity assets and liabilities from the Bureau of Economic Analysis.

Figure E.7: Channels of transmission for spillbacks from US monetary policy: Additional variables



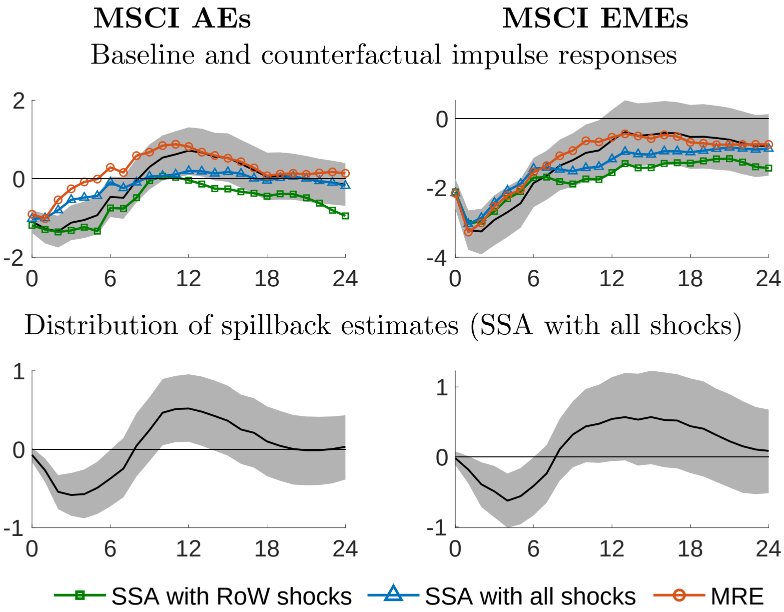
Notes: In the first and third row the figure shows the baseline and counterfactual impulse responses based on SSA with rest-of-the-world shocks (green lines with squares), SSA with all shocks (blue lines with triangles) and MRE (red lines with circles) for the VXO, the excess bond premium, the Gilchrist-Zakrajsek (GZ) spread, the S&P CoreLogic Case-Shiller home price index, the macroeconomic uncertainty index of Jurado et al. (2015), and the Conference Board consumer confidence index. The grey shaded areas represent 68% centered point-wise probability bands for the baseline impulse responses. In the second and fourth row the figure shows the point-wise mean of the differences between the baseline and the counterfactual effects together with 68% centered point-wise probability bands.

Figure E.8: Spillbacks from US monetary policy through AEs and EMEs (SSA RoW shocks and MRE counterfactuals)



Notes: See the notes to Figure 11.

Figure E.9: US monetary policy spillovers to AE and EME equity prices



Notes: In the first row the figure shows the baseline and counterfactual impulse responses based on SSA with rest-of-the-world shocks (green lines with squares), SSA with all shocks (blue lines with triangles) and MRE (red lines with circles) for the MSCI AEs index (excluding US stocks) and the MSCI EME index. The grey shaded areas represent 68% centered point-wise probability bands for the baseline impulse responses. In the second row the figure shows the point-wise mean of the differences between the baseline and the counterfactual effects together with 68% centered point-wise probability bands.

University of Innsbruck - Working Papers in Economics and Statistics
Recent Papers can be accessed on the following webpage:

https://www.uibk.ac.at/eeecon/wopec/

2021-05 **Max Breitenlechner, Georgios Georgiadis, Ben Schumann:** What goes around comes around: How large are spillbacks from US monetary policy?

2021-04 **Utz Weitzel, Michael Kirchler:** The Banker's Oath And Financial Advice

2021-03 **Martin Holmen, Felix Holzmeister, Michael Kirchler, Matthias Stefan, Erik Wengström:** Economic Preferences and Personality Traits Among Finance Professionals and the General Population

2021-02 **Christian König-Kersting:** On the Robustness of Social Norm Elicitation

2021-01 **Laura Hueber, Rene Schwaiger:** Debiasing Through Experience Sampling: The Case of Myopic Loss Aversion.

2020-34 **Kai A. Konrad, Florian Morath:** The Volunteer's Dilemma in Finite Populations

2020-33 **Katharina Momsen, Markus Ohndorf:** Expressive Voting vs. Self-Serving Ignorance

2020-32 **Silvia Angerer, Daniela Glätzle-Rützler, Christian Waibel:** Monitoring institutions in health care markets: Experimental evidence

2020-31 **Jana Friedrichsen, Katharina Momsen, Stefano Piasenti:** Ignorance, Intention and Stochastic Outcomes

2020-30 **Esther Blanco, Alexandra Baier, Felix Holzmeister, Tarek Jaber-Lopez, Natalie Struwe:** Substitution of social concerns under the Covid-19 pandemic

2020-29 **Andreas Hackethal, Michael Kirchler, Christine Laudenbach, Michael Razen, Annika Weber:** On the (ir)relevance of monetary incentives in risk preference elicitation experiments

2020-28 **Andrej Gill, Matthias Heinz, Heiner Schumacher, Matthias Sutter:** Trustworthiness in the Financial Industry

2020-27 **Matthias Sutter, Michael Weyland, Anna Untertrifaller, Manuel Froitzheim:** Financial literacy, risk and time preferences - Results from a randomized educational intervention

2020-26 **Rene Schwaiger, Jürgen Huber, Michael Kirchler, Daniel Kleinlercher, Utz Weitzel:** Unequal Opportunities, Social Groups, and Redistribution

2020-25 **Roman Inderst, Martin Obradovits:** Competitive Strategies when Consumers are Relative Thinkers: Implications for Pricing, Promotions, and Product Choice

2020-24 **Martin Obradovits, Philipp Plaickner:** Price-Directed Search and Collusion

2020-23 **Helena Fornwagner, Oliver P. Hauser:** Climate action for (my) children

2020-22 **Esther Blanco, Natalie Struwe, James M. Walker:** Incentivizing public good provision through outsider transfers: experimental evidence on sharing rules and additionality requirements

2020-21 **Loukas Balafoutas, Helena Fornwagner, Rudolf Kerschbamer, Matthias Sutter, Maryna Tverdostup:** Diagnostic Uncertainty and Insurance Coverage in Credence Goods Markets

2020-20 **Anna Ulrichshofer, Markus Walzl:** Customer Disputes, Misconduct, and Reputation Building in the Market for Financial Advice

2020-19 **Anna Ulrichshofer, Markus Walzl:** Social Comparison and Optimal Contracts in the Competition for Managerial Talent

2020-18 **Martin Obradovits, Philipp Plaickner:** Searching for Treatment

2020-17 **Jun Honda:** The Gender-Punishment Gap revisited

2020-16 **Jun Honda:** The Relation between Rankings and Risk-Taking in the Labor Market for Financial Advice

2020-15 **Christina Bannier, Eberhard Feess,Natalie Packham, Markus Walzl:** Differentiation and Risk-Aversion in Imperfectly Competitive Labor Markets

2020-14 **Felix Holzmeister, Rudolf Kerschbamer:** oTree: The Equality Equivalence Test

2020-13 **Parampreet Christopher Bindra, Graeme Pearce:** The effect of priming on fraud: Evidence from a natural field experiment

2020-12 **Alessandro De Chiara, Marco A. Schwarz:** A Dynamic Theory of Regulatory Capture

2020-11 **Christoph Huber, Jürgen Huber, Michael Kirchler:** Market shocks and professionals' investment behavior - Evidence from the COVID-19 crash

2020-10 **Elisabeth Gsottbauer, Daniel Müller, Samuel Müller, Stefan T. Trautmann, Galina Zudenkova:** Social class and (un)ethical behavior: Causal versus correlational evidence

2020-09 **Parampreet Christopher Bindra, Rudolf Kerschbamer, Daniel Neururer, Matthias Sutter:** Reveal it or conceal it: On the value of second opinions in a low-entry-barriers credence goods market

2020-08 **Robert Steiger, Eva Posch, Gottfried Tappeiner, Janette Walde:** Effects of climate change on tourism demand considering individual seasonal preferences

2020-07 **Fang Liu, Alexander Rasch, Marco A. Schwarz, Christian Waibel:** The role of diagnostic ability in markets for expert services

2020-06 **Matthias Stefan, Jürgen Huber, Michael Kirchler, Matthias Sutter, Markus Walzl:** Monetary and Social Incentives in Multi-Tasking: The Ranking Substitution Effect

2020-05 **Michael Razen, Jürgen Huber, Laura Hueber, Michael Kirchler, Matthias Stefan:** Financial Literacy, Economic Preferences, and Adolescents' Field Behavior

2020-04 **Christian König-Kersting, Johannes Lohse, Anna Louisa Merkel:** Active and Passive Risk-Taking

2020-03 **Christoph Huber, Jürgen Huber:** Bad bankers no more? Truth-telling and (dis)honesty in the finance industry

2020-02 **Dietmar Fehr, Daniel Müller, Marcel Preuss:** Social Mobility Perceptions and Inequality Acceptance

2020-01 **Loukas Balafoutas, Rudolf Kerschbamer:** Credence goods in the literature: What the past fifteen years have taught us about fraud, incentives, and the role of institutions

University of Innsbruck

Working Papers in Economics and Statistics

2021-05

Max Breitenlechner, Georgios Georgiadis, Ben Schumann

What goes around comes around: How large are spillbacks from US monetary policy?

Abstract
We quantify spillbacks from US monetary policy based on structural scenario analysis and minimum relative entropy methods applied in a Bayesian proxy structural vector-autoregressive model estimated on data for the time period from 1990 to 2019. We find that spillbacks account for a non-trivial share of the overall slowdown in domestic real activity in response to a contractionary US monetary policy shock. Our analysis suggests that spillbacks materialise as Tobin's q/cash ow and stock market wealth effects impinge on US investment and consumption. Contractionary US monetary policy depresses foreign sales of US firms, which reduces their valuations/cash ows and thereby induces cutbacks in investment. Similarly, as contractionary US monetary policy depresses US and foreign prices, the value of US households' portfolios is reduced, which triggers a in consumption. Net trade does not contribute to spillbacks because US monetary policy affects exports and imports similarly. Finally, spillbacks materialise through advanced rather than emerging market economies, relative importance in US firms' foreign demand and US foreign equity holdings.

ISSN 1993-4378 (Print)
ISSN 1993-6885 (Online)