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## Global risk and the dollar

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2057

# Discussion Papers

## Global Risk and the Dollar

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# Global risk and the dollar\*

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## Abstract

The dollar is a safe-haven currency and appreciates when global risk goes up. We investigate the dollar's role for the transmission of global risk to the world economy within a Bayesian proxy structural vectorautoregressive model. We identify global risk shocks using high-frequency asset-price surprises around narratively selected events. Global risk shocks appreciate the dollar, induce tighter global financial conditions and a synchronized contraction of global economic activity. We benchmark these effects against counterfactuals in which the dollar does not appreciate. In the absence of dollar appreciation, the contractionary impact of a global risk shock is much weaker, both in the rest of the world and the US. For the rest of the world, contractionary financial channels thus dominate expansionary expenditure switching when global risk rises and the dollar appreciates.

*Keywords:* Dollar exchange rate, global risk shocks, international transmission, Bayesian proxy structural VAR

*JEL-Classification:* F31, F42, F44

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# 1 Introduction

According to the received wisdom the dollar appreciates when global risk goes up. Figure 1 presents the Global Financial Crisis (GFC) and the COVID-19 pandemic as striking examples. This co-movement is a general pattern of the data and testifies to a fundamental asymmetry in a global financial system centered around the dollar.<sup>1</sup> While the dollar’s position can be rationalized on the ground that some assets are particularly safe or liquid (Farhi & Gabaix 2016; He et al. 2019; Gopinath & Stein 2021; Chahrour & Valchev 2022; Eren & Malamud 2022), the role of its appreciation in the transmission of global risk is unclear: Does it help the world economy in coping with global risk shocks or does it amplify their adverse impact?

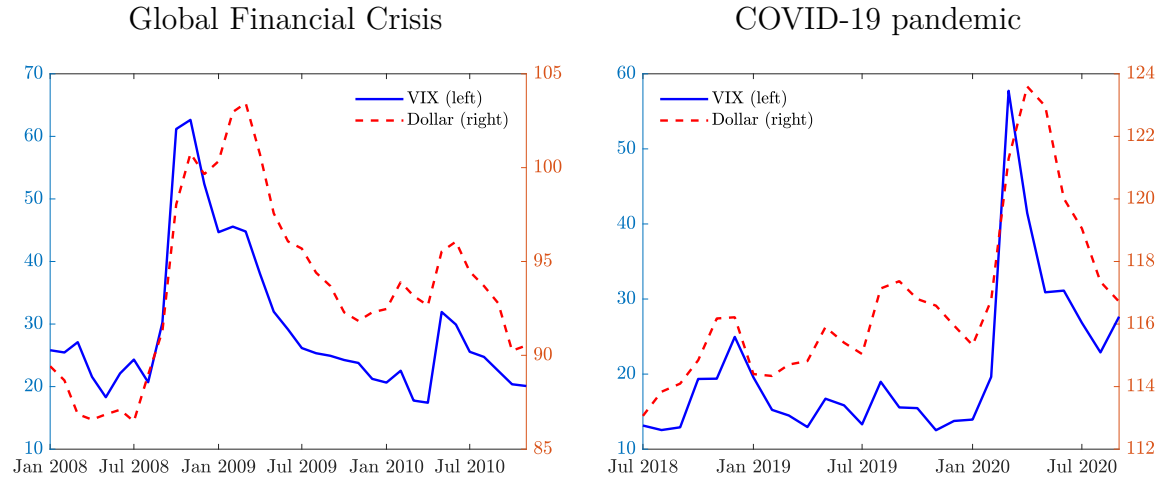
We shed light on this question by exploring the net effect of dollar appreciation in the transmission of global risk. We first upgrade the received wisdom to rigorous causal evidence using a state-of-the-art structural vector-autoregressive (VAR) model identified using narrative external instruments. We show that exogenous global risk shocks induce an appreciation of the dollar. They furthermore contract economic activity in the US and the rest of the world (RoW). Reflecting a trade channel, US net exports fall, suggesting that dollar appreciation induces expenditure switching in the RoW (Gopinath et al. 2020). Reflecting a financial channel, global equity prices drop, spreads increase and cross-border bank credit contracts (Bruno & Shin 2015; Jiang et al. 2021a; Kekre & Lenel 2021).

Second, we construct three conceptually different counterfactuals that simulate the effects of a global risk shock in the *absence* of dollar appreciation. The first counterfactual is based on the estimated VAR model and explores the most likely path of the endogenous variables conditional on a global risk shock in a scenario in which the dollar happens to not appreciate because additional, offsetting shocks materialize as well (Antolin-Diaz et al. 2021). The second counterfactual is a VAR-based policy-rule experiment assuming that conditional on a global risk shock the Federal Reserve (Fed) stabilized the dollar exchange rate (McKay & Wolf 2023). The third counterfactual is based on a structural model for the US and the RoW in which the deep parameters can be modified so that the dollar does not hold a dominant

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<sup>1</sup>In a regression of changes in the VIX on changes in the dollar exchange rate over the period 01/1990-12/2020 the  $t$ -value is 5.8, and 2.2 when excluding the period 7/2008-12/2009 and after 03/2020. Consistent with the findings in Lilley et al. (2022), the  $t$ -value is essentially zero for the time period prior to the GFC, it is 4.3 for the post-GFC period 1/2010-12/2020, and 3.6 for the inter-crisis period 1/2010-3/2020.

Figure 1: The US dollar and the VIX



Note: VIX is an index of expected stock market volatility compiled by Chicago Board of Options Exchange; dollar is the price of dollar expressed in foreign currency (in effective terms) such that an increase represents an appreciation.

status in cross-border credit and safe assets which are responsible for the appreciation upon a global risk shock in the first place.

We find that in all counterfactuals the contraction in activity caused by a global risk shock is substantially smaller both in the US and the RoW. Without dollar appreciation the response of US net exports hardly changes, while global financial conditions tighten much less. The contractionary effects of the dollar appreciation that materialize through tighter financial conditions thus dominate expansionary effects through expenditure switching.

In more detail, we estimate a Bayesian proxy structural VAR (BPSVAR) model using the approach of Arias et al. (2021). Specifically, we extend the closed-economy VAR model of Gertler & Karadi (2015) which features US industrial production, the 1-Treasury bill rate, the excess bond premium, and consumer prices and include the dollar nominal effective exchange rate, the 5-Treasury bill rate, the VXO, RoW industrial production and policy rates.

In order to identify a global risk shock we rely on an external instrument (Mertens & Ravn 2013). In particular, as in Piffer & Podstawski (2018) we use the change in the gold price around narrow intra-daily windows bracketing the time stamps of global risk events selected narratively originally by Bloom (2009). We estimate the model on monthly data for the period 1990–2019. In order to speak to the theoretical literature on the dominant role of

the dollar, we consider extended specifications with US exports and imports, cross-border bank credit to non-US borrowers, the Emerging Markets Bond Index (EMBI) spread, and RoW equity prices.

We find that a global risk shock appreciates the dollar and contracts US and RoW industrial production. US and RoW monetary policy loosen. Consistent with a trade channel, US net exports fall. Consistent with a financial channel, global financial conditions tighten as cross-border bank credit to non-US borrowers contracts, RoW equity prices fall and the EMBI spread rises.

We then construct no-appreciation counterfactuals in order to assess the dollar's contribution to the transmission of a global risk shock to the RoW. The first counterfactual is implemented in the BPSVAR model and is based on the idea that the dollar does not appreciate because additional, offsetting shocks materialize (Antolin-Diaz et al. 2021). To implement this counterfactual, we cast the impulse responses into a forecast that is conditioned on a global risk shock occurring in period  $t$  and subject to the constraint that the dollar does not appreciate along the forecast horizon. The additional, offsetting shocks that enforce the constraint are chosen so as to be as small as possible and least correlated, hence deviating minimally from the baseline of a standard, one-off global risk shock impulse response. Intuitively, this counterfactual can be thought of as the most likely scenario in which the dollar does not appreciate following a global risk shock and which could be observed in practice.

The second counterfactual assumes the Fed deviates from its actual policy rule and stabilizes the dollar exchange rate. McKay & Wolf (2023) show that even without knowing the true underlying structural model such a policy-rule counterfactual can be recovered in a VAR model using impulse responses to a set of distinct monetary policy shocks estimated from the data. To implement this counterfactual, we first additionally identify conventional Federal funds rate and forward guidance shocks. Along the lines of McKay & Wolf (2023) we then use these shocks and their impulse responses so that the dollar stays at its baseline value conditional on a global risk shock. Intuitively, this counterfactual mimics a counterfactual policy rule under which the Fed commits *ex ante* to stabilizing the exchange rate upon a global risk shock.

The third counterfactual is based on a structural two-country model for the US and the RoW in which the dollar appreciates upon a global risk shock because of the interplay between dollar dominance in safe assets and cross-border finance (Georgiadis et al. 2023). In the model, when global risk aversion goes up and the world economy contracts, holding US Treasuries increasingly loosens balance-sheet constraints of RoW banks indebted in foreign currency so that the Treasury convenience yield rises and the dollar appreciates. To implement the counterfactual in which the dollar does not appreciate upon a global risk shock, we shut down dollar dominance in cross-border finance and safe assets. Intuitively, this can be thought of as showing how a global risk shock would play out in a counterfactual world in which the dollar does not appreciate for structural reasons other than variation in the policy rule.

Across all counterfactuals the contractionary effect of a global risk shock on RoW activity is substantially reduced compared to the baseline by about 30-50%. This implies the contractionary effects that operate via the financial channel dominate the expansionary effects that operate via the trade channel.

*Related literature.* First, our empirical analysis speaks to theoretical work on the special role of the dollar and US assets in the international monetary system (Gopinath et al. 2020; Jiang et al. 2021a; Kekre & Lenel 2021; Bianchi et al. 2021; Devereux et al. 2022). Our analysis assesses the empirical relevance of the mechanisms spelled out in this work. More generally, our analysis also informs the theoretical literature on the role of exchange rates for the cross-border transmission of shocks through financial channels (Banerjee et al. 2016; Aoki et al. 2018; Akinici & Queralto 2019; Croce et al. 2022).

Second, our paper is related to empirical work that studies the role of the dollar as a global risk factor (Lustig et al. 2014; Verdelhan 2018), the predictive power of convenience yields (Engel & Wu 2018; Valchev 2020; Jiang et al. 2021b) and global risk (Lilley et al. 2022; Hassan et al. forthcoming) for the dollar, as well as the relationship between global risk, deviations from covered interest parity, the dollar and cross-border credit (Avdjiev et al. 2019; Erik et al. 2020). We complement this work by moving from forecasting and reduced-form regressions to isolating the effects of exogenous variation in global risk.

Third, our paper contributes to empirical work on the role of financial channels in the global transmission of risk shocks (Liu et al. 2017; Cesa-Bianchi et al. 2018; Epstein et al.



2019; Shousha 2019; Bhattarai et al. 2020). Relative to existing work, we zoom in on and quantify the role of the dollar within the broader class of financial channels. Finally, our findings on the role of the dollar for financial spillovers complement existing evidence based on micro data (Shim et al. 2021; Bruno & Shin 2023; Niepmann & Schmidt-Eisenlohr 2022). Relative to this work, our analysis allows us to contrast trade and financial channels and hence assess the net effects of dollar appreciation.

Fourth, our paper is related to the literature on shock identification using external instruments in VAR models (Mertens & Ravn 2013; Gertler & Karadi 2015; Caldara & Herbst 2019). In contrast to much of the existing work we employ the Bayesian estimation approach of Arias et al. (2021) to jointly identify several structural shocks by means of multiple external instruments and use exact finite sample inference in order to bypass questions about the appropriate asymptotic inference in the presence of multiple and potentially weak instruments (Jentsch & Lunsford 2019; Montiel Olea et al. 2021). Moreover, we postulate only relatively weak additional exogeneity assumptions in order to avoid set-identification and difficulties in posterior inference (Baumeister & Hamilton 2015; Giacomini & Kitagawa 2021).

The rest of the paper is structured as follows. Section 2 lays out the BPSVAR framework and describes our empirical specification. Section 3 presents results for the effects of global risk shocks in the data. Section 4 explores no-appreciation counterfactuals. Section 5 concludes.

## 2 Empirical strategy

We first outline the BPSVAR framework of Arias et al. (2021) and discuss our specification and identification assumptions. We keep the discussion short and refer to the working paper version of this paper for details (Georgiadis et al. 2021).

### 2.1 The BPSVAR framework

Consider the structural VAR model

$$\mathbf{y}'_t \mathbf{A}_0 = \mathbf{y}'_{t-1} \mathbf{A}_1 + \boldsymbol{\epsilon}'_t, \tag{1}$$

where  $\mathbf{y}_t$  is an  $n \times 1$  vector of endogenous variables and  $\boldsymbol{\epsilon}_t$  an  $n \times 1$  vector of structural shocks. Assume there is a  $k \times 1$  vector of observed proxy variables—or, in alternative jargon, external instruments— $\mathbf{p}_t$  that are correlated with the  $k$  unobserved structural shocks of interest  $\boldsymbol{\epsilon}_t^*$  (relevance condition) and orthogonal to the remaining unobserved structural shocks  $\boldsymbol{\epsilon}_t^o$  (exogeneity condition):

$$E[\mathbf{p}_t \boldsymbol{\epsilon}_t^{*'}] = \mathbf{V}, \quad E[\mathbf{p}_t \boldsymbol{\epsilon}_t^{o'}] = \mathbf{0}. \quad (2)$$

Arias et al. (2021) develop a Bayesian algorithm that imposes these assumptions in the estimation of the VAR model in Equation (1) augmented with equations for the proxy variables. The estimation thereby identifies the structural shocks.

## 2.2 BPSVAR model specification

Our point of departure is the closed-economy US VAR model of Gertler & Karadi (2015), which includes in  $\mathbf{y}_t$  the logarithms of US industrial production and consumer prices, the excess bond premium of Gilchrist & Zakrajsek (2012), and the 1-year Treasury bill rate as monetary policy indicator. We augment  $\mathbf{y}_t$  with the VXO, the logarithm of an index of non-US, RoW industrial production, a weighted average of advanced economies' (AEs) policy rates, the 5-year Treasury bill rate, and the logarithm of the US dollar nominal effective exchange rate (NEER).<sup>2</sup> We use monthly data for the time period from February 1990 to December 2019 and flat priors for the VAR parameters. Below we consider a robustness check for a larger VAR model that includes several additional variables and that is estimated with informative Minnesota-type priors and optimal hyperpriors/prior tightness (Giannone et al. 2015). Data descriptions are provided in Table C.1 in the Online Appendix.

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<sup>2</sup>We use AE instead of RoW policy rates as the latter exhibit spikes reflecting periods of hyperinflation in some EMEs. In the Online Appendix we consider an extension in which we include AE and EME industrial production, prices and policy rates separately (Figure B.1). Furthermore, we document in the Online Appendix that the results are robust to including a measure of RoW prices (Figure B.11).

## 2.3 Identification

For ease of exposition, we first only discuss the identification of the global risk shock given it is our key shock of interest. We explain in Section 4.2 below how we additionally identify the US monetary policy shocks we use in one of the counterfactuals. We think of a global risk shock as an incident that is associated with an exogenous drop in investors’ risk appetite, which can be understood as the price—as opposed to the quantity—of risk (Miranda-Agrippino & Rey 2020b; Bauer et al. 2023).

The proxy variable  $p_t^{\epsilon,r}$  for the global risk shock is based on intra-daily data in the spirit of work on the high-frequency identification of monetary policy shocks (see e.g. Gertler & Karadi 2015). In particular, we use intra-daily changes in the price of gold around the time stamps of narratively selected events originally selected by Bloom (2009) and later updated by Piffer & Podstawski (2018) and Bobasu et al. (2021). We consider the events labeled as ‘global’ and ‘US’ by Piffer & Podstawski (2018). We assume global risk shocks drive gold-price surprises on the narratively selected events, that is in the relevance condition in Equation (2) we have  $E[p_t^{\epsilon,r} \epsilon_t^r] \neq 0$ . The intuition is that an increase in global risk raises the price of the archetypical safe asset of gold (Baur & McDermott 2010; Ludvigson et al. 2021).

Regarding the exogeneity condition  $E[p_t^{\epsilon,r} \epsilon_t^o] = 0$  in Equation (2), Piffer & Podstawski (2018) document that the intra-daily gold-price surprises on the narratively selected events are not systematically correlated with a range of measures of non-risk shocks. In other words, we assume the only shock that occurred systematically in the intra-daily windows across the narratively selected events is the global risk shock. Note that what is critical for the exogeneity condition to be satisfied is that across the full list of narratively selected events the gold-price surprises around the intra-daily windows were driven *systematically* only by global risk shocks. For this, the selection of events and the width of the intra-daily windows around the corresponding time stamps rather than the specific asset price are crucial. We explore robustness checks for both aspects below.

Finally, for consistency we follow Caldara & Herbst (2019) as well as Arias et al. (2021) and impose a ‘relevance threshold’ to express a prior belief that the proxy variables are relevant instruments. In particular, we require that at least a share  $\gamma = 0.1$  of the variance

of the proxy variables is accounted for by the identified shocks, respectively; this is weaker than the relevance threshold of  $\gamma = 0.2$  used by Arias et al. (2021), and—although not straightforward to compare conceptually—lies below the ‘high-relevance’ prior of Caldara & Herbst (2019). Put differently, specifying the relevance threshold at  $\gamma = 0.1$  implies there is a lot of room for the measurement error in the BPSVAR model to account for events on which global risk shocks occurred but for which the recorded gold-price surprise is zero as they are not selected by Bloom (2009), Piffer & Podstawski (2018) and Bobasu et al. (2021). We explore robustness checks without relevance threshold below.

### 3 The effect of global risk shocks on the world economy

Figure 2 shows the first result: A one-standard deviation global risk shock increases the VXO and appreciates the dollar. This implies the positive co-movement between global risk and the dollar shown in Figure 1 is at least to some extent accounted for by global risk shocks. US and RoW industrial production both contract, but the effect in the US is more immediate and somewhat larger. US consumer prices fall after a short delay and the excess bond premium rises. US and RoW monetary policy are loosened.

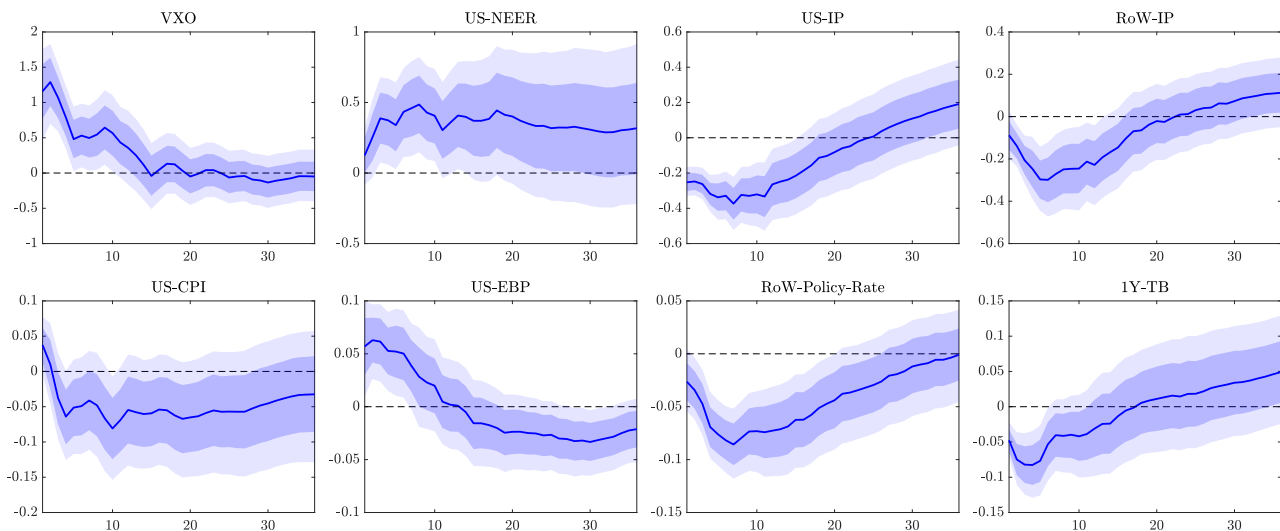
Figure 3 presents the responses of global financial conditions and US trade. Consistent with a financial channel, cross-border bank credit to non-US borrowers declines, RoW equity prices contract and spreads increase. Consistent with a trade channel through expenditure switching US net exports contract.<sup>3</sup>

In the Online Appendix we present results for several extensions of our baseline specification. We document that in response to a global risk shock: also other safe-haven currencies such as the Japanese yen and the Swiss franc appreciate, while non safe-haven currencies such as the euro and the British pound depreciate; the price of safety in terms of the Treasury premium of Du et al. (2018) increases; consistent with the model of Bianchi et al. (2021) banks raise the ratio of safe and liquid dollar assets to liabilities (Figure B.1); that there is

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<sup>3</sup>That the contraction is more immediate in US exports than imports is consistent with dominant-currency paradigm (DCP) in trade invoicing (Gopinath et al. 2020). As under DCP US export prices are sticky in dollar, a dollar appreciation induces immediate expenditure switching in the RoW. In contrast, as also RoW export prices are sticky in dollar, there is no expenditure switching in the US; the response of US imports to a global risk shock is then driven only by the hump-shaped contraction in US demand.

Figure 2: Impulse responses to a global risk shock



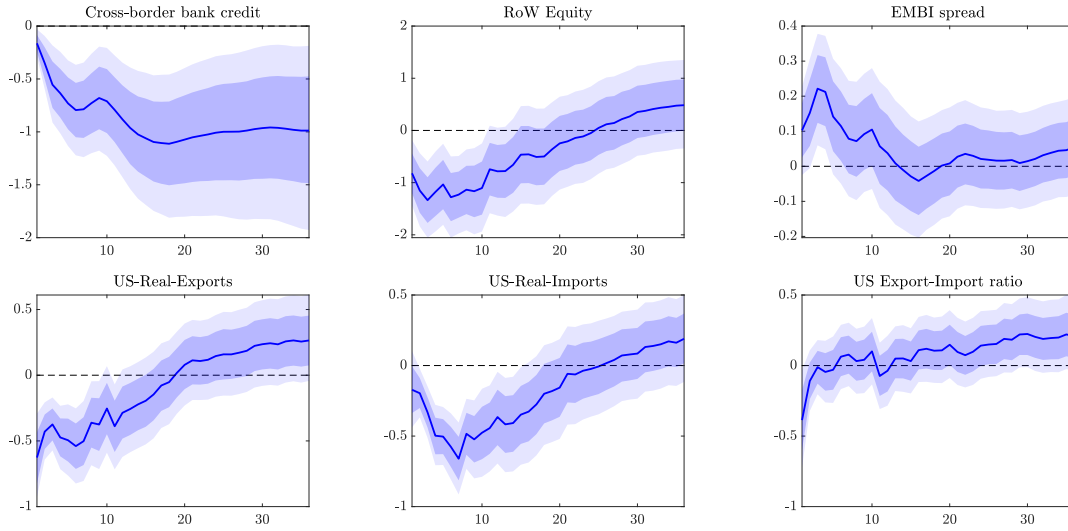

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Note: Horizontal axis measures time in months, vertical axis deviation from pre-shock level; size of shock is one standard deviation; blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets. VXO measured in levels, the dollar NEER, US and RoW industrial production, US consumer prices in logs, and the excess bond premium, the RoW policy as well as the US 1-year Treasury Bill rates in percent.

evidence for ‘fear-of-floating’ as EME monetary policy tightens at the same time as output contracts (Figure B.2); when we additionally impose forecast error variance decomposition in the spirit of Francis et al. (2014) to disentangle shocks to the price—risk appetite—and the quantity—uncertainty—of risk, both shocks appreciate the dollar and exhibit qualitatively similar patterns, but the impulse responses to the global risk appetite shock correspond more closely to those from our baseline, consistent with our goal to capture a shock to the price of risk (Figure B.3).

In the Online Appendix we also document that the estimated effects of global risk shocks hardly change if: as in Ludvigson et al. (2021) we relax the exogeneity condition and only impose  $|E[p_t^{\epsilon, r} \epsilon_t^r]| > |E[p_t^{\epsilon, r} \epsilon_t^\ell]|$  for  $\ell \neq r$  (Figure B.5); we address concerns that the gold-price surprises calculated over windows of several hours across two auctions are contaminated by other shocks occurring close to the narratively selected event time stamps by considering long-term Treasury yield and US dollar/euro exchange rate surprises over narrower windows (Figure B.6 & B.7); we abandon the narratively selected events and instead consider monthly

Figure 3: Impulse responses of trade and financial variables to a global risk shock



Note: See notes to Figure 2.

changes in the Geopolitical Risk Index of Caldara & Iacoviello (2022) as proxy variable (Figure B.8); we estimate a larger BPSVAR model with many more US and RoW variables (Figure B.9); we do not impose a relevance threshold (Figure B.10).

## 4 The role of the dollar

Our results suggest the dollar appreciation caused by a global risk shock impacts the RoW through both a trade and a financial channel. And given that the appreciation impacts RoW real activity with different signs depending on the channel, its net effect is ambiguous. In this section we determine the net effect by benchmarking the baseline impulse responses against a counterfactual in which the dollar does not appreciate. To robustify our analysis, we consider three conceptually distinct no-appreciation counterfactuals.

### 4.1 A possible empirical scenario

The first approach is based on structural scenario analysis (SSA; Antolin-Diaz et al. 2021, ADPRR). ADPRR develop SSA as a flexible framework for conditional forecasts, which typically take the end of the sample period as the initial condition. We apply SSA to construct

a no-appreciation counterfactual. In particular, we first represent the impulse responses as conditional forecasts for a system that is in its steady state and then hit by a single shock. Then, we determine the smallest and least correlated shocks that would have to materialize over the forecast horizon  $t, t + 1, \dots, t + h$  in order to offset the effect of the period- $t$  global risk shock on the dollar. Intuitively, this counterfactual can be thought of as the most likely scenario that could be observed in practice in which the dollar does not appreciate upon a global risk shock.

Formally, assume for simplicity but without loss of generality that the VAR model in Equation (1) is stationary and that it does not include deterministic terms. After iterating forward from period  $t$  to  $t + h$  we have

$$\mathbf{y}_{t,t+h} = \mathbf{b}_{t,t+h} + \mathbf{M}'\boldsymbol{\epsilon}_{t,t+h}, \quad (3)$$

where the  $n(h + 1) \times 1$ -vectors  $\mathbf{y}_{t,t+h} \equiv (\mathbf{y}'_t, \mathbf{y}'_{t+1}, \dots, \mathbf{y}'_{t+h})'$  and  $\boldsymbol{\epsilon}_{t,t+h} \equiv (\boldsymbol{\epsilon}'_t, \boldsymbol{\epsilon}'_{t+1}, \dots, \boldsymbol{\epsilon}'_{t+h})'$  stack the endogenous variables and structural shocks for periods  $t, t + 1, \dots, t + h$ , respectively, the  $n(h + 1) \times n(h + 1)$  matrix  $\mathbf{M} = \mathbf{M}(\mathbf{A}_0, \mathbf{A}_1)$  represents the effects of these structural shocks in terms of impulse responses, and  $\mathbf{b}_{t,t+h}$  period- $(t-1)$  initial conditions. Assume further the VAR model is in steady state in period  $t - 1$  so that  $\mathbf{b}_{t,t+h} = \mathbf{0}$ . The impulse responses to a period- $t$  global risk shock are then given by the forecast  $\mathbf{y}_{t,t+h}$  conditional on  $\boldsymbol{\epsilon}_{t,t+h}$ , with  $\epsilon_t^r = 1$ ,  $\epsilon_{t+s}^r = 0$  for  $s > 0$  and  $\epsilon_{t+s}^\ell = 0$  for  $s \geq 0$ ,  $\ell \neq r$ .

In order to obtain the counterfactual conditional forecast  $\tilde{\mathbf{y}}_{t,t+h}$  SSA determines a series of additional shocks  $\tilde{\boldsymbol{\epsilon}}_{t,t+h}$  that materialize over periods  $t, t + 1, \dots, t + h$  and whose effects offset the dollar appreciation caused by the period- $t$  global risk shock. This no-dollar appreciation constraint can be written as  $\tilde{\mathbf{C}}\tilde{\mathbf{y}}_{t,t+h} = \mathbf{0}$ , where  $\tilde{\mathbf{C}}$  is a  $(h + 1) \times n(h + 1)$  matrix that selects the conditional forecast of the dollar over periods  $t, t + 1, \dots, t + h$ .<sup>4</sup> Constraints on the structural shocks are written as  $\tilde{\boldsymbol{\Xi}}\tilde{\boldsymbol{\epsilon}}_{t,t+h} = \mathbf{g}_{t,t+h}$ , and  $\tilde{\boldsymbol{\Xi}}$  is a  $k_s \times n(h + 1)$  matrix that first selects the period- $t$  global risk shock and then any  $k_s - 1$  structural shocks over periods  $t, t + 1, \dots, t + h$  that shall not be used to enforce the counterfactual constraint.

ADPRR show how to obtain the SSA solution  $\tilde{\boldsymbol{\epsilon}}_{t,t+h}$  which satisfies the counterfactual no-

<sup>4</sup>Ordering the dollar last in  $\mathbf{y}_t$ , we have  $\tilde{\mathbf{C}} = \mathbf{I}_{h+1} \otimes \mathbf{e}'_n$ , where  $\mathbf{e}_i$  is  $n \times 1$ -vector of zeros with unity at the  $i$ -th position.

dollar appreciation constraint  $\widetilde{\mathbf{C}}\widetilde{\mathbf{y}}_{t,t+h} = \mathbf{0}$  and the constraint on the set of structural shocks  $\Xi\widetilde{\boldsymbol{\epsilon}}_{t,t+h} = \mathbf{g}_{t,t+h}$ . The solution implies the counterfactual impulse response  $\widetilde{\mathbf{y}}_{t,t+h} = \mathbf{M}'\widetilde{\boldsymbol{\epsilon}}_{t,t+h}$ .

In order to stay agnostic and let the data select the most likely offsetting shocks—see below for the intuition—we perform SSA without constraint on the set of structural shocks used to offset the effect of a global risk shock on the dollar in the counterfactual.<sup>5</sup> Incidentally, this also means we do not have to identify additional structural shocks. Technically, this is because any orthogonal decomposition of the reduced-form shocks (i.e. any set of additionally identified structural shocks) that satisfies the exogeneity restriction would produce the same result (see Section 2.1 of ADPRR).

Because in every period  $t, t + 1, \dots, t + h$  we have up to  $n$  shocks to impose the no-appreciation counterfactual constraint, there is a multiplicity of SSA solutions. ADPRR show that in this case the SSA solution minimizes the Frobenius norm of the deviation of  $\widetilde{\boldsymbol{\epsilon}}_{t,t+h}$  from their baseline value of zero and their baseline variance matrix. This means the solution selects the smallest and least correlated shocks that enforce the no-appreciation constraint. We therefore interpret the SSA counterfactual as reflecting the most likely scenario that could be observed in practice in which the dollar does not appreciate following a global risk shock.

The first column in Figure 4 shows the SSA counterfactual together with the baseline impulse responses. In response to a global risk shock the dollar does not appreciate by assumption, and both US and RoW real activity drop less than in the baseline; the reduction in the recessionary impact of the global risk shock amounts to up to 30%.<sup>6</sup>

The first column in Figure 5 shows the SSA counterfactual together with the baseline impulse responses for variables reflecting the trade and financial channels. Two results stand out. First, consistent with the absence of expenditure switching when the dollar does not appreciate, US net exports drop by a little less. This suggests the dollar appreciation is expansionary for the RoW in the baseline through the trade channel, although the latter is not very powerful. Second, RoW equity prices and cross-border bank credit drop and credit spreads increase by much less than in the baseline. This suggests dollar appreciation is

<sup>5</sup>Ordering the global risk shock last in  $\boldsymbol{\epsilon}_t$ , we have  $\mathbf{g}_{t,t+h} = \mathbf{1}$  and  $\Xi = [\mathbf{e}'_n, \mathbf{0}_{1 \times hn}]$ , where  $\mathbf{e}_i$  is an  $n \times 1$  vector of zeros with unity at the  $i$ -th position.

<sup>6</sup>In Figure B.23 in the Online Appendix we plot the resulting distribution of differences across the baseline and the counterfactual. We show that for this difference  $\approx 90\%$  of the posterior probability mass is larger than zero.



contractionary through the financial channel in the baseline, and that the latter is rather powerful. Together with our findings for RoW activity, these results suggest the net effect of dollar appreciation upon a global risk shock is contractionary for the RoW and that the financial channel dominates the trade channel.<sup>7</sup>

The SSA counterfactual is appealing at a conceptual level because it uses those offsetting shocks which are most likely to realize in practice and is otherwise agnostic about the nature of these shocks. Yet for this very reason it is not possible to tell why the dollar does not appreciate in the counterfactual. In what follows, we therefore complement the SSA counterfactual with two alternatives which allow for a structural interpretation. The first alternative counterfactual we consider has a concrete economic interpretation as a monetary-policy-rule counterfactual. In particular, we next explore how a global risk shock would affect the RoW if the Fed were to stabilize the dollar.

## 4.2 What if the Fed stabilized the dollar?

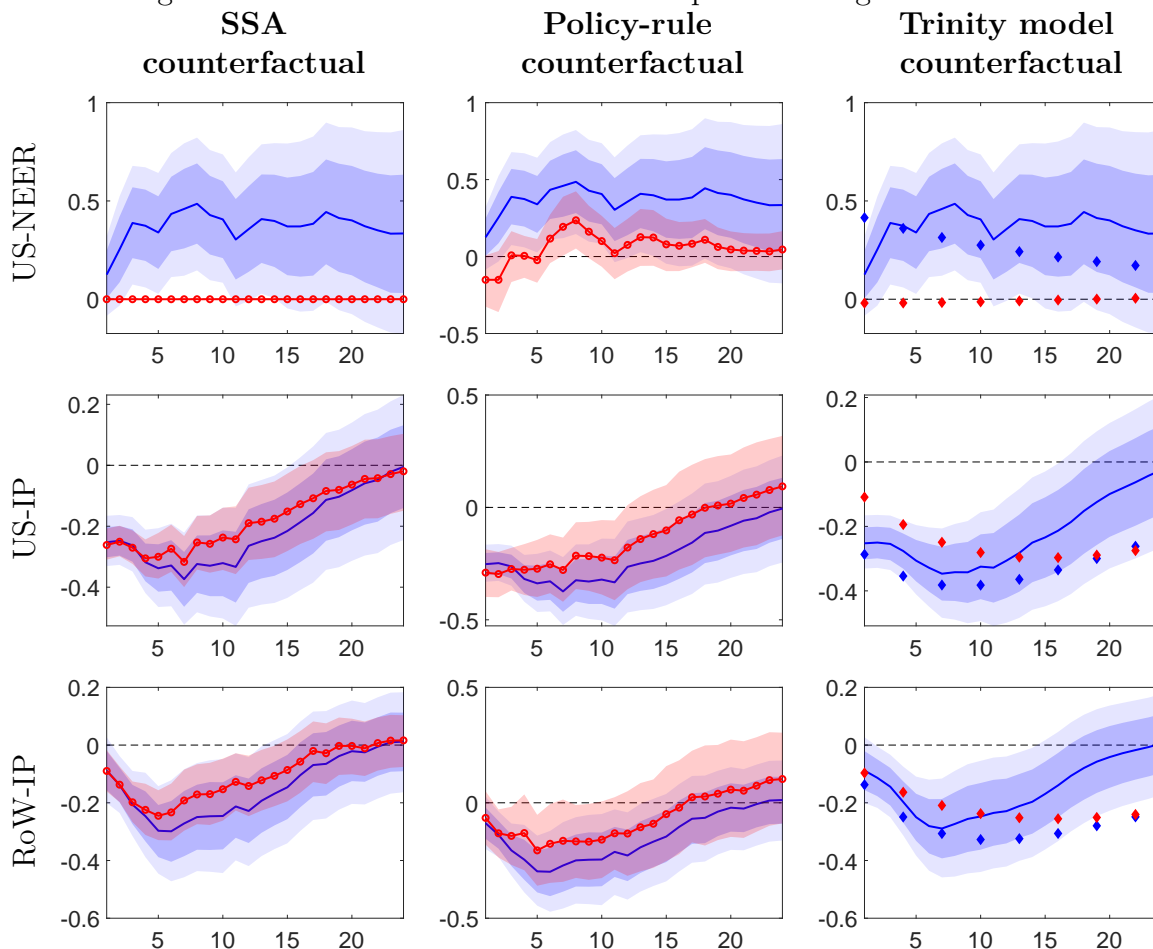
VAR-based policy counterfactuals based on structural shocks have a long history in the literature (see e.g. Sims & Zha 2006). Typically, these counterfactuals are constructed in an SSA-like fashion with unexpected policy shocks materializing every period along the impulse-response horizon. These counterfactuals are often conceived as a change in the policy rule (see for example Kilian & Lewis 2011). However, this approach may be subject to the Lucas critique and in general does not recover the true policy-rule counterfactual McKay & Wolf (2023, henceforth MW). Intuitively, this is because it is assumed that although agents are being repeatedly surprised they do not adjust their expectations about future policy behaviour. Put differently, this approach ignores a possible expectations channel through which policy-rule changes may impact the economy.

MW develop an approach for constructing policy-rule counterfactuals in VAR models that is robust to the Lucas critique and recovers the true policy-rule counterfactual for a broad range of underlying structural frameworks, including standard representative and heterogeneous-agent New Keynesian models. In particular, they show that using appropriate

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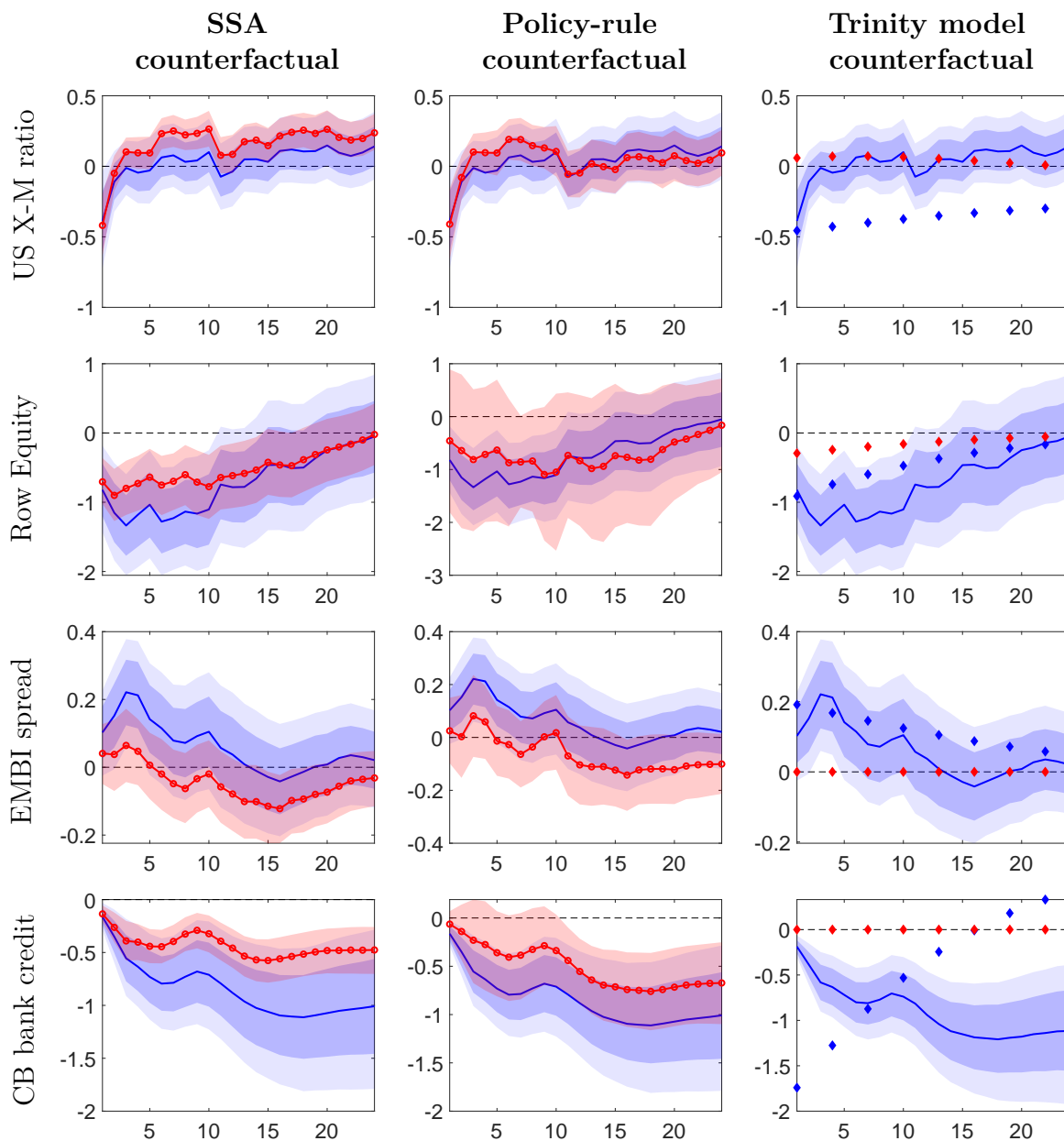
<sup>7</sup>We report the counterfactual results for the remaining variables in the BPSVAR model in the Online Appendix (see Figure B.22).

Figure 4: Baseline and counterfactual responses to a global risk shock



Note: The figure shows the baseline BPSVAR model (blue solid) and counterfactual (red circled) impulse responses to a global risk shock. SSA counterfactuals are shown in the first column, policy-rule counterfactuals in the second column, and the trinity-model counterfactuals in the third column. In the first two columns the red shaded areas represent 68% credible sets obtained from computing the counterfactual for each draw from the posterior distribution. In the third column, the blue (red) diamonds depict the baseline (counterfactual) impulse responses to a global risk aversion shock in the trinity model. We do not connect the dots depicting the counterfactual because the trinity model is calibrated to quarterly frequency while the BPSVAR model is estimated at the monthly frequency. The global risk aversion shock in the trinity model is scaled such that the average of the response of the dollar over the first year is the same as the response from the BPSVAR model. The real GDP (output) response in the trinity model is multiplied by 2.5 to make it comparable to the industrial production response from the BPSVAR model given that in the data the latter is 2.5 times more volatile than the former. In the Online Appendix we document that the BPSVAR model impulse response of S&P Global's US monthly GDP is indeed about 2.5 times smaller than for US industrial production (see Figure B.12), while their time profiles are rather similar.

Figure 5: Baseline and counterfactual responses of trade and financial variables to a global risk shock



Note: See notes to Figure 4. As the trinity model does not include an exact match for equity prices (the EMBI spread) we plot the response of the price of capital (RoW cross-border credit spread) instead. In the counterfactual structural model dollar dominance is absent so that standard UIP holds. Therefore any exchange-rate-adjusted cross-border border return differential is zero.

impact-period—that is, period- $t$ —*news* shocks about current and future policy recovers the impulse responses that would be obtained under a counterfactual policy rule.

Formally, motivated by the representation of structural models in sequence space introduced by Auclert et al. (2021), MW consider a linear, perfect-foresight, infinite-horizon economy in terms of deviations from the deterministic steady state for periods  $t = 0, 1, 2, \dots$  summarized by

$$\mathcal{H}_x \mathbf{x} + \mathcal{H}_z \mathbf{z} + \mathcal{H}_\epsilon \boldsymbol{\epsilon} = \mathbf{0}, \quad (4)$$

$$\mathcal{A}_x \mathbf{x} + \mathcal{A}_z \mathbf{z} + \boldsymbol{\nu} = \mathbf{0}, \quad (5)$$

where  $\mathbf{x} \equiv (\mathbf{x}'_1, \mathbf{x}'_2, \dots, \mathbf{x}'_{n_x})'$  stacks the time paths of the  $n_x$  endogenous variables, analogously  $\mathbf{z}$  the  $n_z$  policy instruments,  $\boldsymbol{\epsilon}$  the  $n_\epsilon$  non-policy structural shocks and  $\boldsymbol{\nu}$  the  $n_\nu$  policy news shocks; the latter are deviations from the policy rule announced at date  $t$  but implemented only in some future period  $t + s$ ,  $s > 0$ . The key assumption reflected in Equations (4) and (5) is that  $\{\mathcal{H}_x, \mathcal{H}_z, \mathcal{H}_\epsilon\}$  do not depend on the coefficients of the policy rule  $\{\mathcal{A}_x, \mathcal{A}_z\}$ , so that policy affects the private sector's decisions only through the path of the instrument  $\mathbf{z}$ , rather than through the policy rule *per se*. Under some mild assumptions the solution to Equations (4) and (5) can be written using impulse response coefficients  $\Theta_{\mathcal{A}}$  as

$$\begin{pmatrix} \mathbf{x} \\ \mathbf{z} \end{pmatrix} = \Theta_{\mathcal{A}} \times \begin{pmatrix} \boldsymbol{\epsilon} \\ \boldsymbol{\nu} \end{pmatrix}, \quad \Theta_{\mathcal{A}} \equiv (\Theta_{\epsilon, \mathcal{A}}, \Theta_{\nu, \mathcal{A}}) \equiv \begin{pmatrix} \Theta_{x, \epsilon, \mathcal{A}} & \Theta_{x, \nu, \mathcal{A}} \\ \Theta_{z, \epsilon, \mathcal{A}} & \Theta_{z, \nu, \mathcal{A}} \end{pmatrix}. \quad (6)$$

MW show that knowledge of the impulse responses  $\Theta_{\mathcal{A}}$  under the baseline policy rule is sufficient to determine the impulse responses to the structural shock  $\boldsymbol{\epsilon}$  under any counterfactual policy rule  $\tilde{\mathcal{A}}_x \mathbf{x} + \tilde{\mathcal{A}}_z \mathbf{z} = \mathbf{0}$  as

$$\mathbf{x}_{\tilde{\mathcal{A}}}(\boldsymbol{\epsilon}) = \mathbf{x}_{\mathcal{A}}(\boldsymbol{\epsilon}) + \Theta_{x, \nu, \mathcal{A}} \times \tilde{\boldsymbol{\nu}}, \quad \mathbf{z}_{\tilde{\mathcal{A}}}(\boldsymbol{\epsilon}) = \mathbf{z}_{\mathcal{A}}(\boldsymbol{\epsilon}) + \Theta_{z, \nu, \mathcal{A}} \times \tilde{\boldsymbol{\nu}}. \quad (7)$$

In particular, the impulse response to the structural shock  $\boldsymbol{\epsilon}$  under the counterfactual policy rule is given by the sum of the corresponding impulse responses to the same structural shock under the baseline policy rule  $\mathbf{x}_{\mathcal{A}}(\boldsymbol{\epsilon})$  and the impulse responses to some policy news shocks  $\tilde{\boldsymbol{\nu}}$ .

The latter are chosen so that the counterfactual policy rule holds

$$\tilde{\mathcal{A}}_x [\mathbf{x}_{\mathcal{A}}(\epsilon) + \Theta_{x,\nu,\mathcal{A}} \times \tilde{\nu}] + \tilde{\mathcal{A}}_z [\mathbf{z}_{\mathcal{A}}(\epsilon) + \Theta_{z,\nu,\mathcal{A}} \times \tilde{\nu}] = \mathbf{0}. \quad (8)$$

The intuition is that as long as the private sector’s decisions depend on the path of the policy instrument rather than the rule *per se* it does not matter whether the path comes about due to the systematic conduct of policy or due to policy news shocks.

A practical challenge of this approach is that one needs to identify news shocks  $\tilde{\nu}$  which communicate changes in future policy over all possible horizons  $t, t + 1, t + 2, \dots$ . However, MW show that in practice for the news shocks one can use a set of distinct monetary policy shocks  $\mathbf{s}$  that are routinely estimated in the empirical literature as long as each entails a different future path of the policy instrument. Moreover, MW show that one can use estimates of the latter’s impulse responses  $\Omega_{s,\mathcal{A}}$ . And MW show that rather than requiring impulse responses to as many shocks as horizons over which the counterfactual policy-rule is assumed, using even only a small number of shocks  $\mathbf{s}$  that solve

$$\min_{\mathbf{s}} \|\tilde{\mathcal{A}}_x [\mathbf{x}_{\mathcal{A}}(\epsilon) + \Omega_{x,s,\mathcal{A}} \times \mathbf{s}] + \tilde{\mathcal{A}}_z [\mathbf{z}_{\mathcal{A}}(\epsilon) + \Omega_{z,s,\mathcal{A}} \times \mathbf{s}]\|, \quad (9)$$

produces a reliable “best Lucas-critique-robust approximation”.

Against this background, we explore how a global risk shock would affect the RoW if the Fed were to stabilize the dollar. As in Wolf (2023), we specify the counterfactual policy rule implicitly as  $\mathbf{e}_{usd}\mathbf{x} = \mathbf{0}$ , where  $\mathbf{e}_{usd}$  is a  $1 \times n_x$ -vector of zeros with unity at the position of the dollar in  $\mathbf{x}_t$ . Confining the counterfactual to periods  $t = 0, 1, 2, \dots, h$ , Equation (9) becomes

$$\min_{\mathbf{s}} \|\mathbf{e}_{usd}\mathbf{x}_{\mathcal{A},t,t+h}(\epsilon) + \Omega_{x,s,\mathcal{A}} \times \mathbf{s}\|, \quad (10)$$

which boils down to solving a least-squares minimization problem for  $n_s$  unknown period- $t$  Fed policy shocks  $\mathbf{s}$  in  $h + 1$  equations.

We implement this policy-rule counterfactual using  $n_s = 2$  distinct US monetary policy shocks in  $\mathbf{s}$ , just like MW do in their illustration. In particular, in addition to the global risk shock we jointly identify conventional monetary policy and forward guidance shocks

using similar proxy variables as Miranda-Agrippino & Rey (2020a) and Miranda-Agrippino & Nenova (2022), namely intra-daily surprises in the 3-month Federal funds futures and the 5-year Treasury bill rate in a narrow window around FOMC announcements as proxy variables.<sup>8,9</sup> We follow Miranda-Agrippino & Nenova (2022) and apply the poor-man’s approach of Jarociński & Karadi (2020) and purge these surprises from central bank information effects on the basis of the sign of the corresponding equity-price surprise.<sup>10</sup>

The panels in the second column in Figures 4 and 5 present the results for this policy-rule counterfactual. Note that the dollar is not perfectly stabilized because we are using only  $n_s = 2$  rather than  $h + 1$  policy shocks in Equation (10). In the Online Appendix we document that results are similar if we identify a third US monetary policy shock (i.e.  $n_s = 3$ ) using ten-year Treasury bill rate surprises as proxy variable so that the dollar is more stable upon a global risk shock (see Figure B.21). Despite the conceptually different approach, the results of this policy-rule counterfactual are quite similar to those of the SSA counterfactual.

### 4.3 A world economy without structural dollar dominance

The VAR-based counterfactuals take the non-policy structure of the world economy as given and explore what would happen if offsetting shocks materialized or if the Fed were to stabilize

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<sup>8</sup>This means that in Equation (1) the structural shocks of interest are given by  $\epsilon_t^* \equiv (\epsilon_t^r, \epsilon_t^{cmp}, \epsilon_t^{fg})'$ , where  $\epsilon_t^{cmp}$  and  $\epsilon_t^{fg}$  denote the conventional monetary policy and forward guidance shocks, respectively, and the corresponding proxy variables are given by  $\mathbf{p}_t \equiv (p_t^{\epsilon, r}, p_t^{\epsilon, 3m}, p_t^{\epsilon, 5y})'$ . In Equation (2) we impose the additional identifying assumptions that the 3-month and 5-year-rate surprises are not driven by the global risk shock,  $E[p_t^{\epsilon, 3m} \epsilon_t^r] = E[p_t^{\epsilon, 5y} \epsilon_t^r] = 0$  (Gertler & Karadi 2015; Jarociński & Karadi 2020; Miranda-Agrippino & Rey 2020b). Note that these assumptions imply two zeros in the first column of  $V$  in Equation (2), which are sufficient to point-identify of the global risk shock. It would be intuitive to go further and impose that  $V$  is diagonal to disentangle the conventional monetary policy and forward guidance shocks, but this would imply over-identifying restrictions and cannot be implemented in the estimation algorithm of Arias et al. (2021). In order to nonetheless disentangle the two monetary policy shocks we impose magnitude restrictions. In particular, we assume that the 3-month-rate (5-year-rate) surprise is affected more strongly by the conventional monetary policy (forward guidance) shock than by the forward guidance (conventional monetary policy) shock, that is  $E[p_t^{\epsilon, 3m} \epsilon_t^{cmp}] > E[p_t^{\epsilon, 3m} \epsilon_t^{fg}]$  and  $E[p_t^{\epsilon, 5y} \epsilon_t^{fg}] > E[p_t^{\epsilon, 5y} \epsilon_t^{cmp}]$ .

<sup>9</sup>Because the 5-year-rate surprises are only available from 1996 to us, as in Känzig (2021) we replace the missing values by zero (see Noh 2017, for a formal justification of this approach). Figures B.15 and B.16 in the Online Appendix documents that our results are robust to starting the estimation in 1996.

<sup>10</sup>In the Online Appendix we document that we estimate conventional monetary policy and forward guidance shocks to be contractionary for real activity in the US and the RoW, to appreciate the dollar, and to tighten global financing conditions (see Figures B.13 & B.14). Moreover, we document that results are similar if instead of the 3-month and 5-year-rate surprises we use as proxy variables the conventional monetary policy and forward guidance surprises of Jarociński (2021) or Lewis (forthcoming), which also account for central bank information effects (see Figure B.17-B.21).

the dollar. Although the latter provides a clean structural explanation for the missing appreciation, it explicitly leverages changes in policy, and thereby intertwines the effect of the dollar appreciation with the change in the policy rates. Therefore, as an alternative, one may consider changing the non-policy features of the world economy that underpin the dollar’s response to a global risk shock in the first place. Hence, in what follows we construct a third counterfactual based on a structural business-cycle model. The model matches the empirical impulses responses and allows us to modify the non-policy structural features so that the dollar does not appreciate upon a global risk shock.

We draw on the two-country model for the US and the RoW with dollar dominance in cross-border credit, safe assets and trade invoicing developed in Georgiadis et al. (2023). Laying out the structure of this ‘trinity model’ is beyond the scope of this paper, and so we only provide an intuitive description.<sup>11</sup> In the model, US banks intermediate domestic dollar funds to banks in the RoW. Cross-border dollar borrowing is cheap but also risky relative to domestic funding in the RoW, and therefore tightens banks’ balance-sheet constraints. Because they are viewed as the global safe asset, US Treasuries are held as liquidity-buffers by RoW banks to loosen balance-sheet constraints and thereby earn an additional, indirect pecuniary return that can be interpreted as a convenience yield.

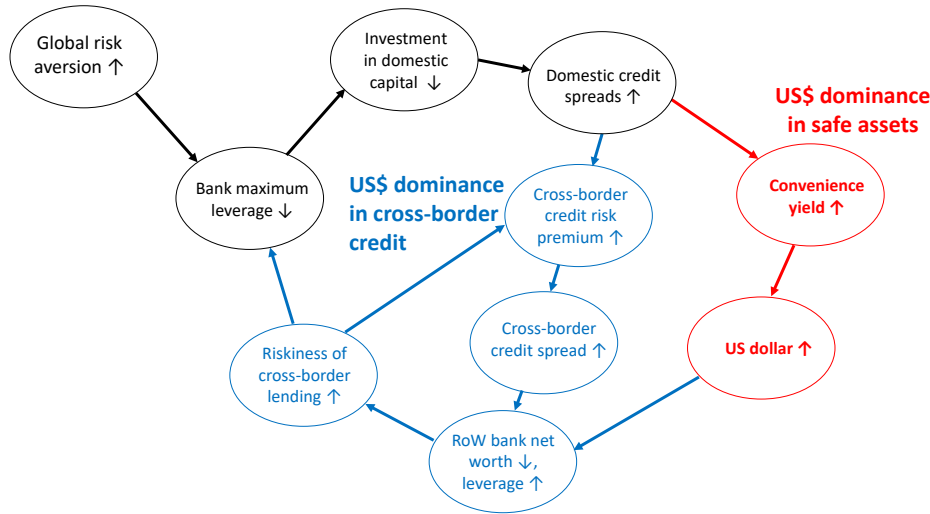
In the trinity model dollar dominance in cross-border credit and safe assets interact so that the dollar appreciates in response to a global risk shock. In particular, an increase in global risk aversion—modeled as an exogenous reduction in the willingness of creditors to provide funding to banks for a given level of net worth—raises domestic credit spreads so that leveraging up by loosening the balance sheet constraint becomes more profitable, which causes the Treasury convenience yield to rise, and eventually the dollar to appreciate. This dollar appreciation triggers a global financial accelerator. In particular, as RoW banks exhibit a currency mismatch on their balance sheets due to their borrowing from US banks not being perfectly hedged by holdings of Treasuries, dollar appreciation reduces RoW banks’ net worth. As a result, the balance-sheet constraint of the lenders of RoW banks—US banks—tightens and forces them to deleverage, which raises US and RoW domestic credit spreads.

Figure 6 summarizes the mechanics of this global financial accelerator and highlights

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<sup>11</sup>We provide a detailed discussion of the model, all equations and the calibration in Online Appendix D.

Figure 6: The global financial accelerator in the trinity model of Georgiadis et al. (2023)



Note: The figure presents a schematic overview of the global financial accelerator in the dollar trinity model of Georgiadis et al. (2023).

how dollar dominance in safe assets and cross-border credit interact to give rise to dollar appreciation when risk aversion rises: Dollar dominance in safe assets underpins a dollar appreciation when global risk aversion rises, and dollar dominance in cross-border credit underpins a global financial accelerator when the dollar appreciates.<sup>12</sup>

The panels in the right column of Figures 4 and 5 show that the impulse responses to a global risk aversion shock for the baseline calibration of the trinity model depicted by the blue dots match the BPSVAR model impulse responses depicted by the blue solid lines fairly well.<sup>13</sup>

For the counterfactual we assume the dollar does not hold any dominant position in the world economy: There is no cross-border dollar credit and RoW banks do not demand Treasury securities as safe asset.<sup>14</sup> The counterfactual impulse responses depicted by the

<sup>12</sup>There is an additional amplification channel shown in the middle of Figure 6 that arises because US banks also raise cross-border credit spreads as their balance-sheet constraints tighten, which reduces RoW banks' net worth independently from the dollar appreciation.

<sup>13</sup>In order to make percentage deviations of flow variables, such as output, from the quarterly business-cycle model comparable to those from the monthly BPSVAR model we report the three-month trailing moving average of the latter's impulse responses as suggested by Born & Pfeifer (2014).

<sup>14</sup>In particular, we simulate a version of the model where we assume there is no cross-border dollar credit between banks and RoW banks do not demand Treasuries as they are no longer special.



red dots show that without dollar dominance the dollar does not appreciate when global investors' risk aversion increases (Figure 4), that global financial conditions in terms of equity valuations, spreads and cross-border credit tighten by less (Figure 5), and that output drops by less both in the US and the RoW (Figure 4). The reason is that without dollar dominance in safe assets, holding Treasuries no longer loosens balance-sheet constraints of RoW banks and hence does not earn a convenience yield. As a result, the dollar does not appreciate when global investors' risk aversion increases. And without dollar appreciation and dollar dominance in cross-border credit there is no global financial accelerator mechanism that amplifies the effect of a global risk aversion shock on the RoW. Finally, US net exports fall by less—in fact rise—in the absence of dollar dominance.

Taken together, the results from the trinity-model counterfactuals are consistent with those for the SSA and the policy-rule counterfactuals. Across approaches, we find that the contractionary financial channel dominates the expansionary trade channel. The net effect of dollar appreciation upon a global risk shock is contractionary for the RoW.

## 5 Conclusion

In this paper we provide evidence that global risk shocks cause an appreciation of the dollar and a slowdown in world real activity. In order to shed light on the role of the dollar in the international transmission of global risk, we construct three conceptually distinct no-appreciation counterfactuals. The results uniformly suggest that without dollar appreciation the slowdown in global economic activity would be much weaker. This raises important normative questions about the design of the international financial architecture that underpin the key role of the dollar in the global economy. These are, however, beyond the scope of the present paper.

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# Global risk and the dollar

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## Online Appendix

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# A Online Appendix - Advantages of the BPSVAR framework over the traditional frequentist external instruments SVAR framework

The BPSVAR framework has several appealing features relative to traditional frequentist external instrument SVAR models that render it particularly well-suited for the purpose of estimating the effects of global risk and US monetary policy shocks on the world economy. First, it requires relatively weak additional identifying assumptions when more than one structural shock is to be identified by proxy variables. In this case, the shocks are only set identified as rotations of the structural shocks  $\mathbf{Q}\boldsymbol{\epsilon}_t^*$  with orthonormal matrices  $\mathbf{Q}$  also satisfy the relevance and exogeneity conditions in Equation (2) in the manuscript. Therefore, additional restrictions are needed in order to point-identify the structural shocks in  $\boldsymbol{\epsilon}_t^*$ . In the frequentist external instruments VAR model these additional restrictions are imposed on the contemporaneous relationships between the *endogenous variables*  $\mathbf{y}_t$  reflected in  $\mathbf{A}_0^{-1}$  (Mertens & Ravn 2013; Lakdawala 2019). However, Arias et al. (2021) show that relaxing this type of additional identifying assumptions can change the results profoundly. Instead, the BPSVAR framework allows us to impose the additional identifying assumptions on the contemporaneous relationships between the *structural shocks*  $\boldsymbol{\epsilon}_t^*$  and *proxy variables*  $\mathbf{m}_t$  reflected in  $\mathbf{V}$  in the relevance condition in Equation (2) in the manuscript. For example, we can impose the restriction that a particular structural shock does not affect a particular proxy variable. Restrictions on the contemporaneous relationships are arguably weaker for structural shocks and proxy variables in  $\mathbf{V}$  than for the endogenous variables in  $\mathbf{A}_0^{-1}$ .

27 Second, the BPSVAR framework allows coherent and exact finite sample inference, even  
28 in settings in which the proxy variables are weak instruments and only set rather than  
29 point identification is achieved with a combination of sign, magnitude and zero restrictions  
30 (see Moon & Schorfheide 2012; Caldara & Herbst 2019; Arias et al. 2021). In particular,  
31 frequentist external instruments VAR models are estimated in a two-step procedure (Mertens  
32 & Ravn 2013; Gertler & Karadi 2015): (i) estimate the reduced-form VAR model; (ii) regress  
33 the reduced-form residuals on the proxy variable to obtain the structural parameters. This  
34 two-step procedure is inefficient, as the estimation of the reduced-form VAR model in (i) is not  
35 informed by the proxy variable. In contrast, the BPSVAR model considers the joint likelihood  
36 of the endogenous variables and the proxy variables, so that the proxy variables inform the  
37 estimation of both reduced-form and structural parameters. The BPSVAR framework also  
38 facilitates inference, as the joint estimation captures all sources of uncertainty. Furthermore, as  
39 long as the prior distribution is proper, in a Bayesian setting inference is straightforward even  
40 when the instruments are weak (Poirier 1998). By contrast, frequentist external instruments  
41 VAR models require an explicit theory to accommodate weak instruments (Montiel Olea et al.  
42 2021), either to derive the asymptotic distributions of the estimators or to ensure satisfactory  
43 coverage in bootstrap algorithms.<sup>1</sup>

44 Third, from from the BPSVAR model augmented with equations for the proxy variables  
45 it can be seen that framework is relatively flexible in that it allows for the proxy variables  
46 to be serially correlated and to be affected by lags of the endogenous variables as well as  
47 by measurement error. This is a useful feature as it has been shown that some widely-used

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<sup>1</sup>To the best of our knowledge, there is no consensus yet on how to conduct inference in frequentist external instruments VAR models, even in a setting with only a single proxy variable (Jentsch & Lunsford 2019).



48 proxy variables are serially correlated and/or contaminated by measurement error (Miranda-  
 49 Agrippino & Ricco 2021). In these cases, it is typically proposed to cleanse the proxy variables  
 50 in an additional step preceding the analysis in the VAR model, exacerbating issues regarding  
 51 efficiency and coherent inference.

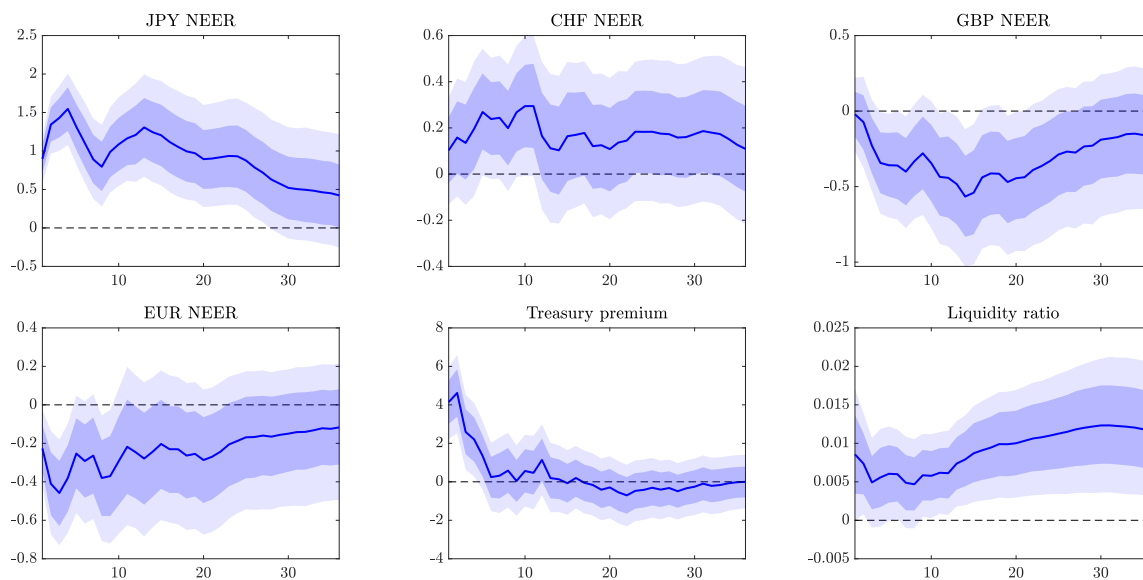
52 And fourth, the BPSVAR model allows us to incorporate a prior belief about the strength  
 53 of the proxy variables as instruments based on the notion that “researchers construct proxies  
 54 to be relevant” (Caldara & Herbst 2019, p. 165). In particular, consider the ‘reliability  
 55 matrix’  $\mathbf{R}$  derived in Mertens & Ravn (2013) given by

$$\mathbf{R} = \left( \Gamma_{0,2}^{-1'} \Gamma_{0,2} + \mathbf{V}\mathbf{V}' \right)^{-1} \mathbf{V}\mathbf{V}'. \quad (\text{A.1})$$

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

## 60 B Online appendix - Additional figures

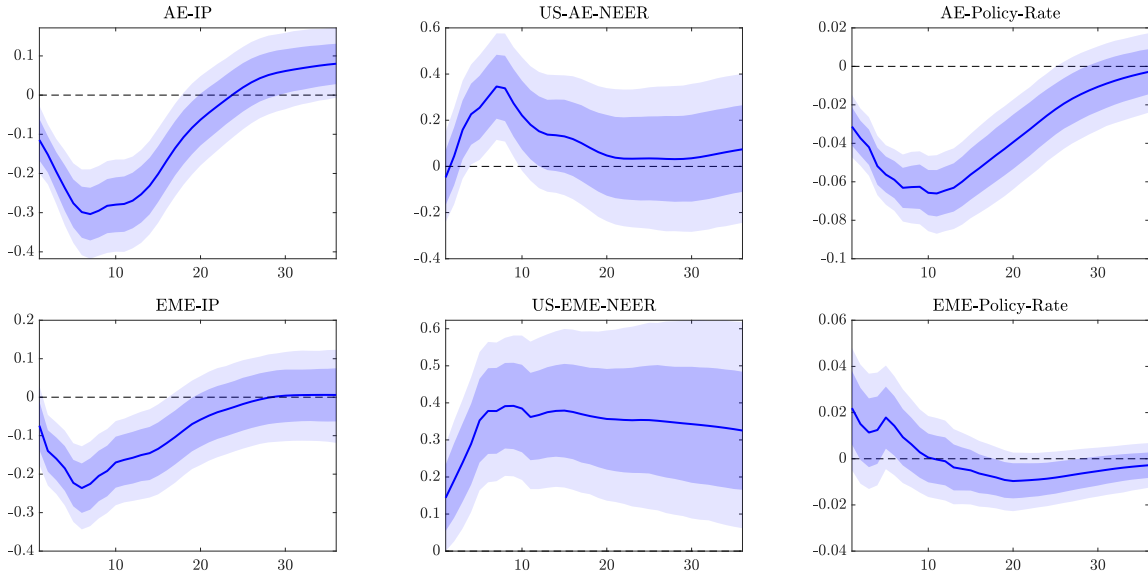
Figure B.1: Impulse responses of additional variables



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Note: Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets. Responses are obtained from estimating the baseline BPSVAR model with the vector  $\mathbf{y}_t$  augmented with one additional variable at a time. Because data on the liquidity ratio is only available from 2001 we use informative priors and optimal hyperpriors/prior tightness as suggested by Giannone et al. (2015).

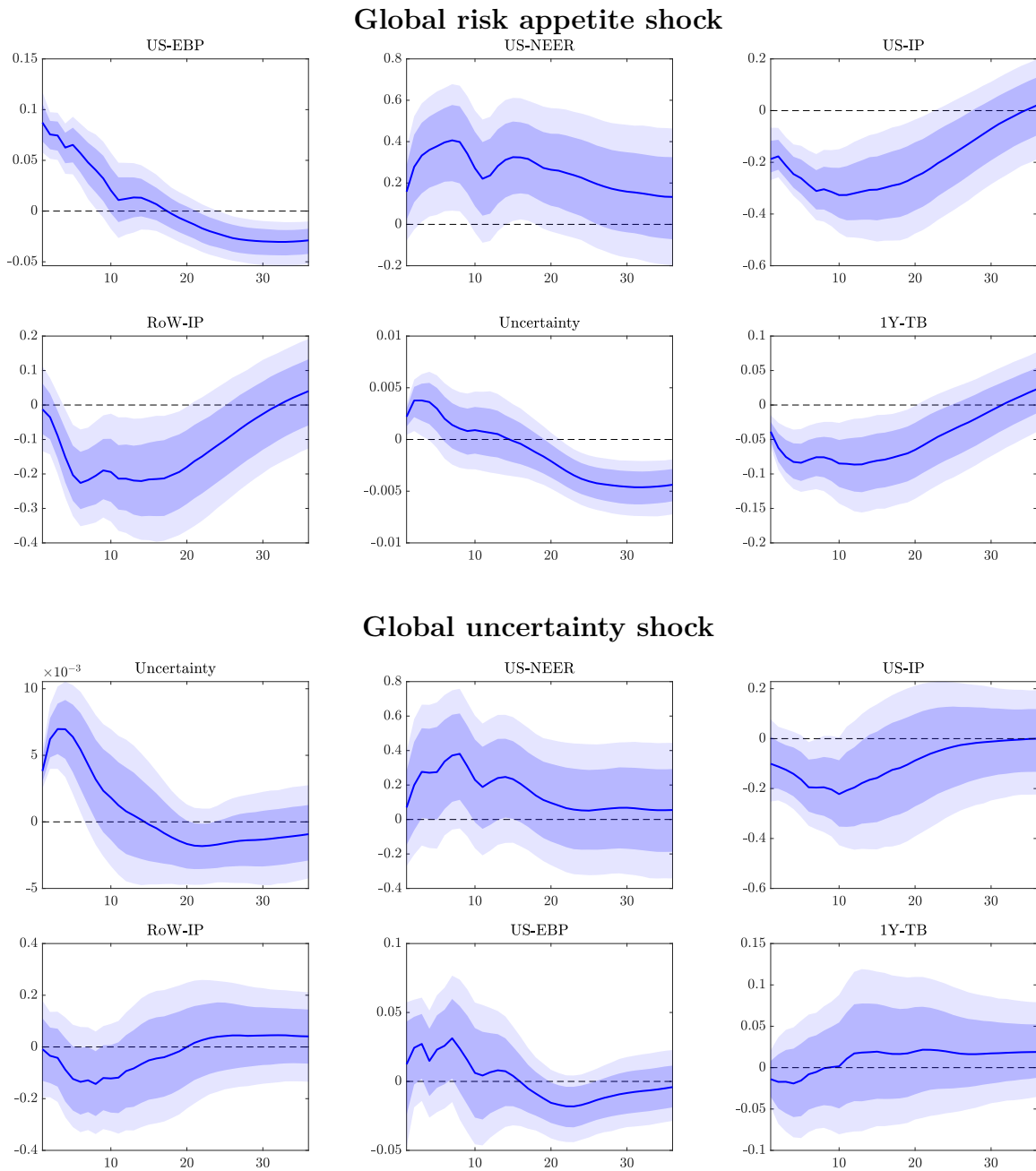
Figure B.2: Impulse responses for AEs and EMEs to a global risk shock



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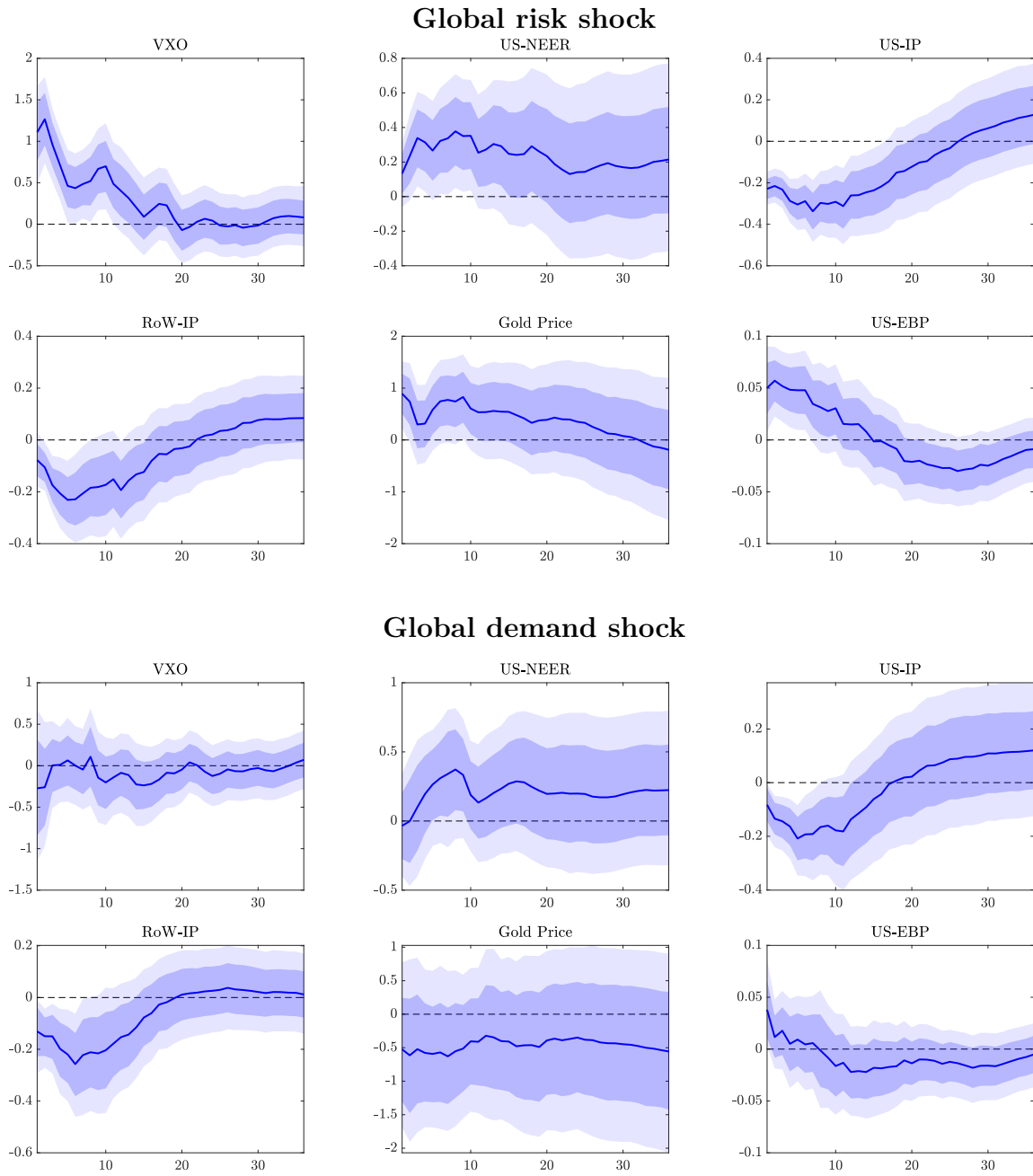
Note: The figure presents the impulse responses to a one-standard deviation global risk shock. Due to the larger dimensionality of the VAR model we use informative Minnesota-type priors and optimal hyperpriors/prior tightness as suggested by Giannone et al. (2015) in the estimation. Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets.

Figure B.3: Impulse responses to global risk appetite and global uncertainty shocks identified with FEVD restrictions



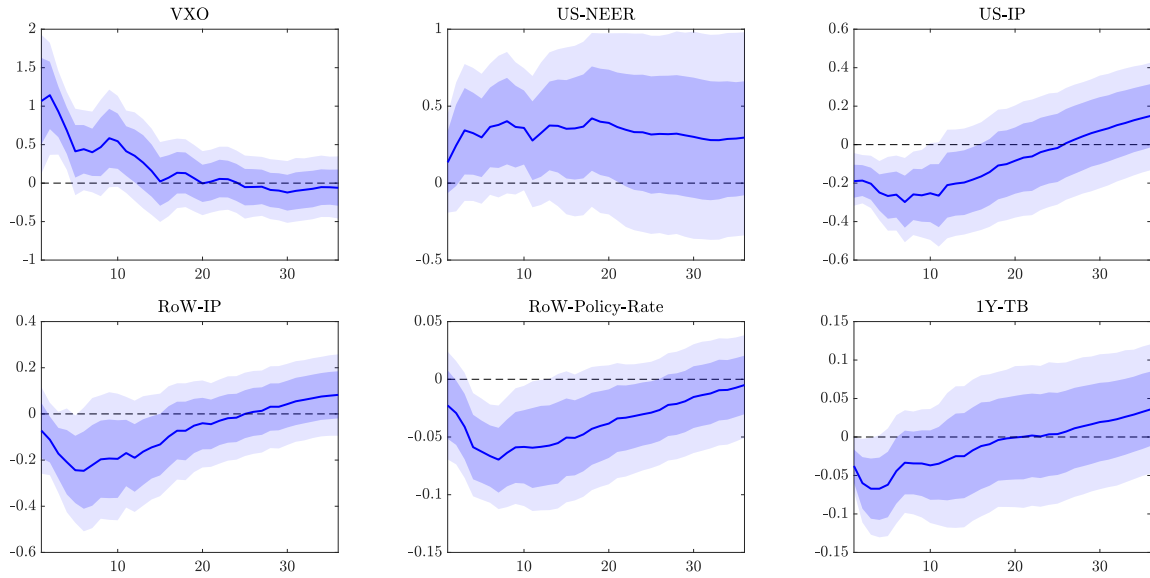
Note: The figure presents the impulse responses to a one-standard deviation global appetite risk and global uncertainty shocks based on an alternative identification scheme in which we (i) allow both shocks to drive the gold price surprises (ii) impose that the global risk appetite (uncertainty) shock explains the largest share of the FEVD of the excess bond premium (macroeconomic uncertainty measure of Jurado et al. 2015). We drop the VXO from the BPSVAR model as it reflects both risk aversion and uncertainty and replace it by the macroeconomic uncertainty measure of Jurado et al. (2015). Impulse responses of RoW Policy Rate and the US CPI are omitted to save space. Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets.

Figure B.4: Impulse responses to global risk and global demand shock shocks identified with sign restrictions



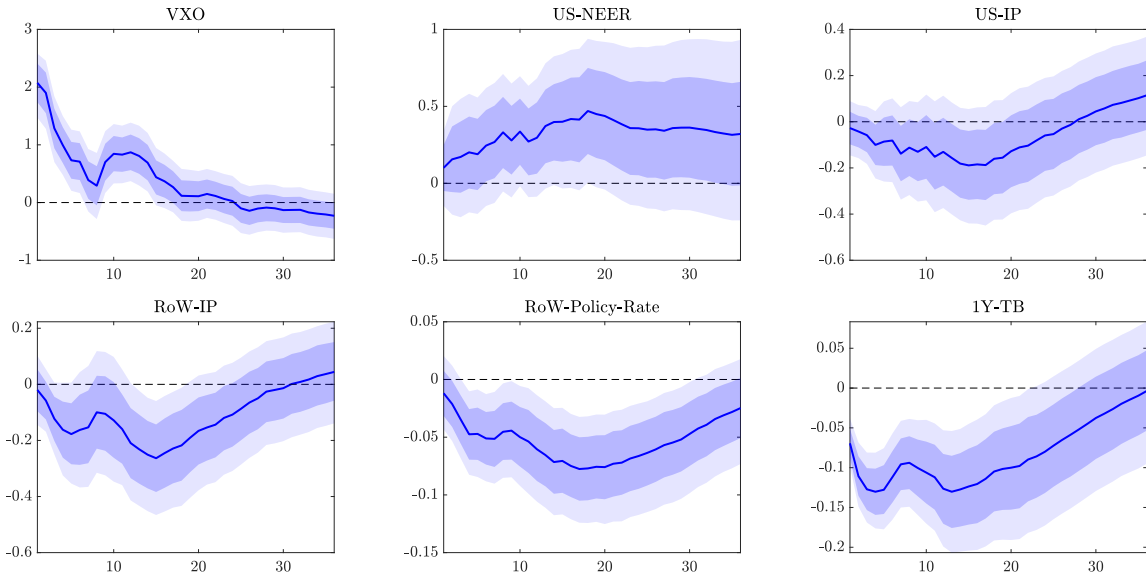
Note: The figure presents the impulse responses to a one-standard deviation global risk and global demand shocks based on an alternative identification scheme in which we identify the global demand shock by means of standard contemporaneous sign restrictions. We include the gold price as an additional endogenous variable. Impulse responses of RoW Policy Rate and the US CPI are omitted to save space. Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets.

Figure B.5: Impulse responses to a global risk shock when allowing the gold price surprises to be correlated with all structural shocks



Note: The figure presents the impulse responses to a one-standard deviation global risk shock based on an alternative identification scheme in which the gold price surprises are allowed to be correlated with all structural shocks, imposing only that the correlation is strongest with the global risk shock. Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets. Impulse responses of US CPI and the EBP are omitted to save space.

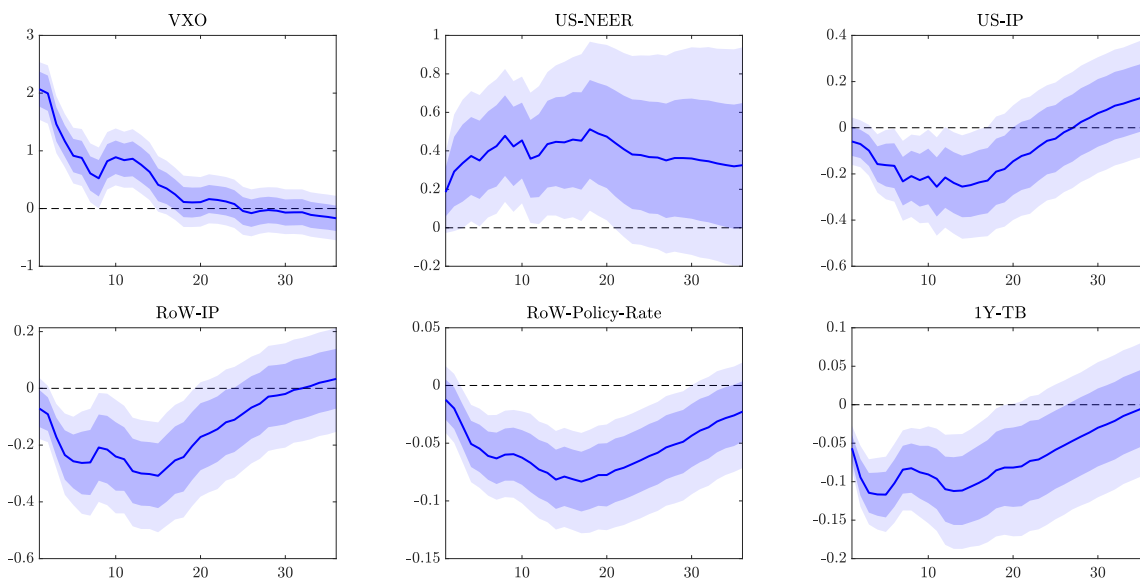
Figure B.6: Impulse responses to a global risk shock when considering intra-daily surprises in 30-year Treasury yields instead of the gold price as proxy variable




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Note: Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets. The results are obtained from a BPSVAR model with intra-daily 30-year Treasury yield surprises as proxy variable. We drop the identification of the monetary policy shocks for this specification because we don't compute any counterfactuals using this specification. Impulse responses of US CPI and the EBP are omitted to save space.

Figure B.7: Impulse responses to a global risk shock when considering intra-daily surprises in the US dollar-euro exchange rate instead of the gold price as proxy variable

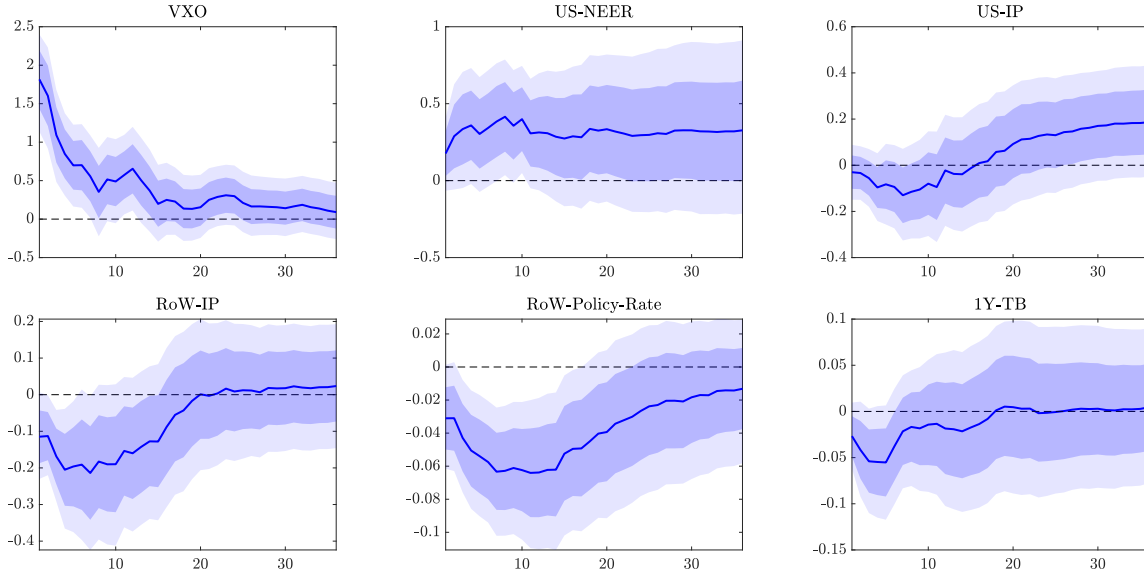



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Note: Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets. The results are obtained from a BPSVAR model with intra-daily US dollar-euro exchange rate surprises as proxy variable. We drop the identification of the monetary policy shocks for this specification because we don't compute any counterfactuals using this specification. Impulse responses of US CPI and the EBP are omitted to save space.



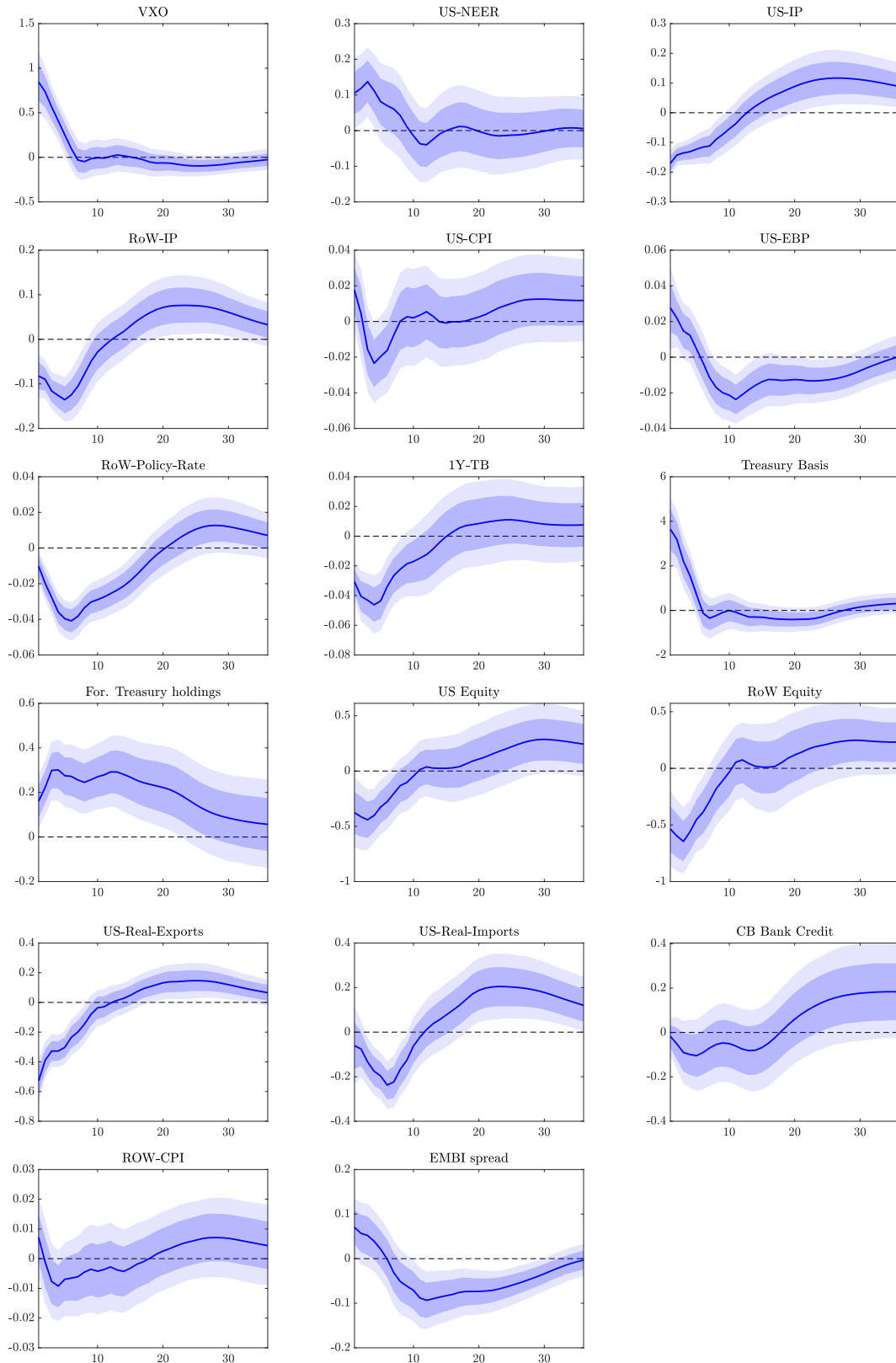
Figure B.8: Impulse responses to a global risk shock when considering changes in the Geopolitical Risk Index of Caldara & Iacoviello (2022) instead of gold price surprises as proxy variable




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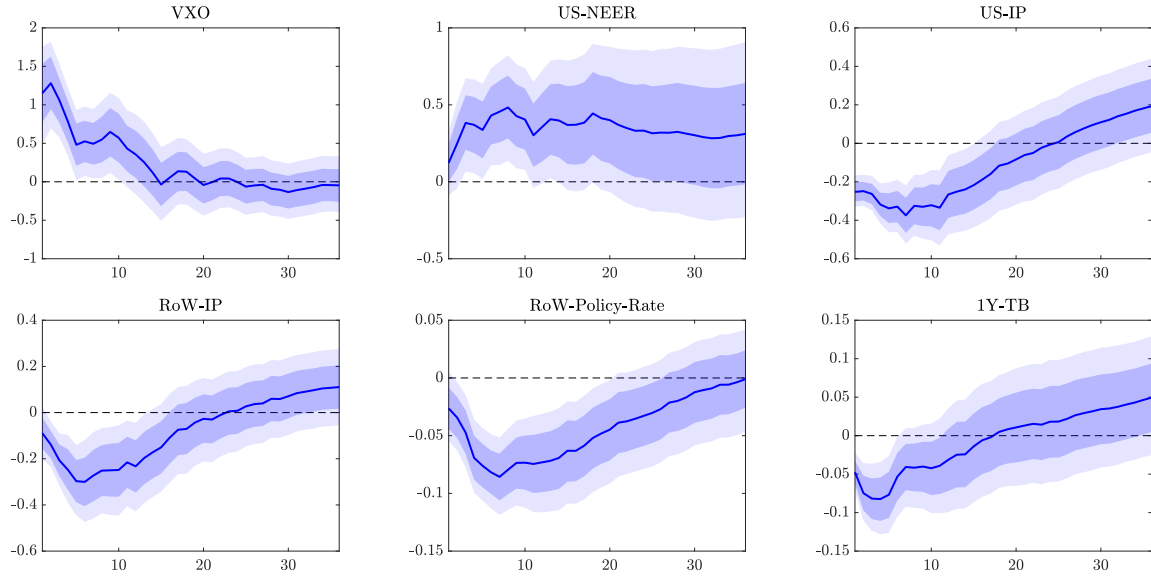
Note: Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets. The results are obtained from a BPSVAR model with monthly changes in the Geopolitical Risk index of Caldara & Iacoviello (2022) as proxy variable. We drop the identification of the monetary policy shocks for this specification because we don't compute any counterfactuals using this specification. Impulse responses of US CPI and the EBP are omitted to save space.

Figure B.9: Impulse responses to a global risk shock from a large BPSVAR model



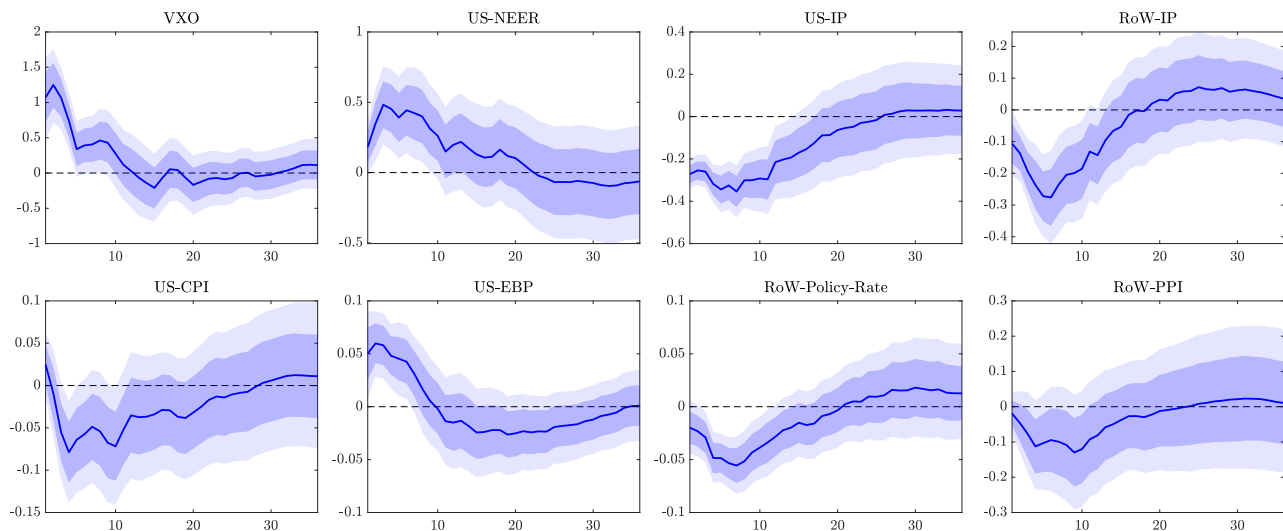
Note: Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets. The model is estimated with informative Minnesota-type priors and optimal hyperpriors/prior tightness as in Giannone et al. (2015). We do not include the liquidity ratio in the VAR model because it is only available for a substantially shorter sample period (see Table C.1).

Figure B.10: Impulse responses to global risk shock when no relevance threshold is imposed



Note: The figure presents the impulse responses to a one-standard deviation global risk shock based on an alternative identification scheme in which we do not impose any relevance threshold. Impulse responses of US CPI and the EBP are omitted to save space. Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets.

Figure B.11: Impulse responses to a global risk shock when including RoW PPI



Note: Horizontal axis measures time in months, vertical axis deviation from pre-shock level; size of shock is one standard deviation; blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets. VXO measured in levels, the dollar NEER, US and RoW industrial production, US consumer prices in logs, and the excess bond premium, the RoW policy as well as the US 1-year Treasury Bill rates in percent.

Figure B.12: Impulse responses and counterfactuals when including RoW PPI

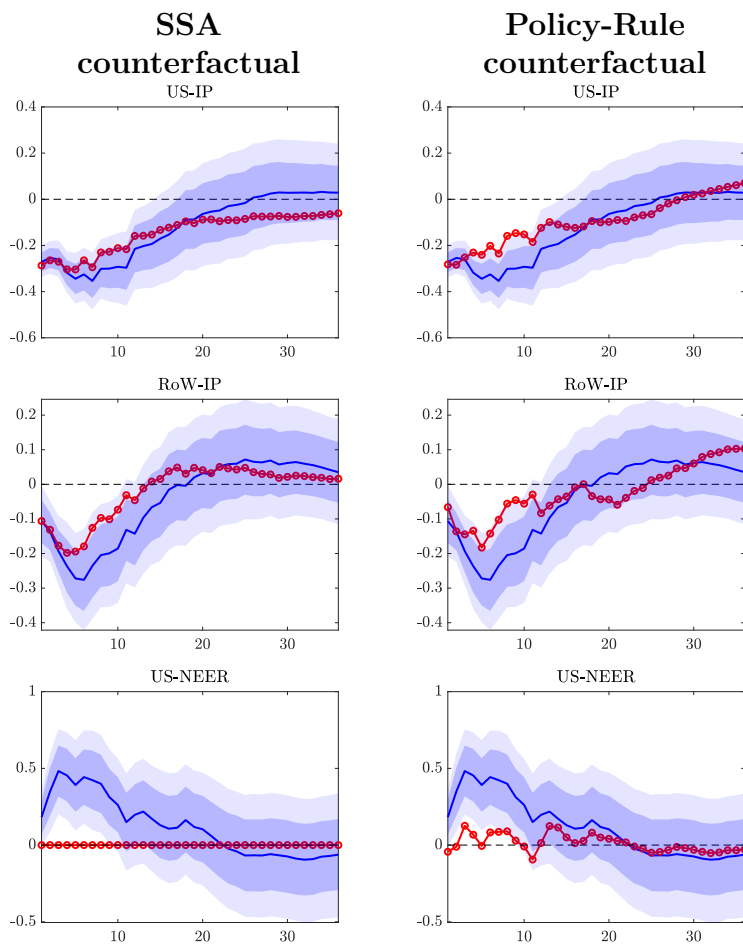
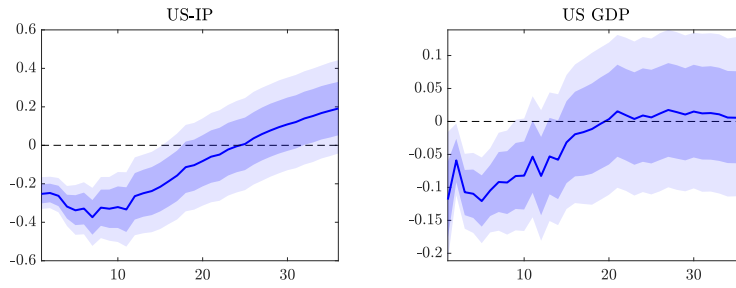


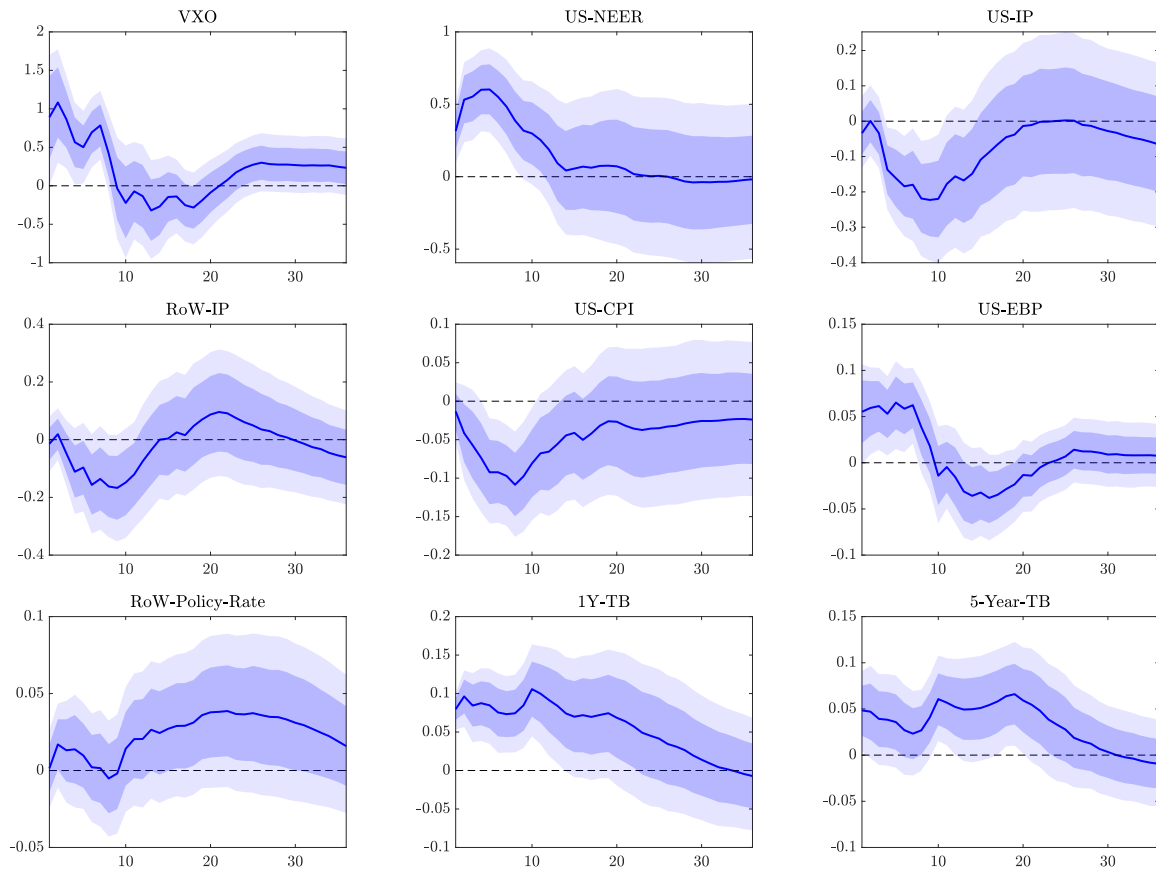
Figure B.13: IRF of US IP and monthly US GDP



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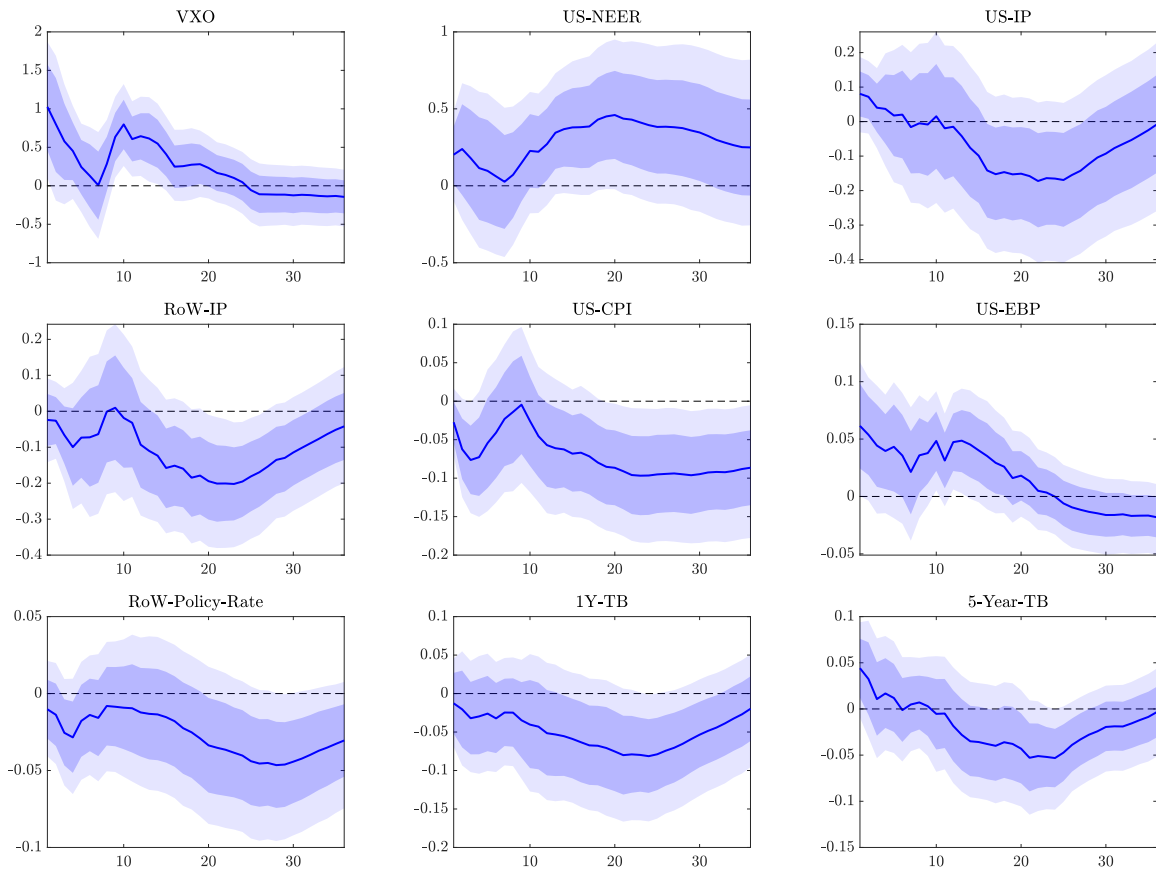
Note: The left-hand side panel depicts the of US IP from the baseline BPSVAR, whereas the right-hand side panel depicts the response of a monthly estimate of US GDP from Standard & Poors. The IRFs confirm that the response of US IP is roughly 2.5 times larger than those of US GDP, which we assume when comparing the DSGE model to the BPSVAR. Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets.

Figure B.14: Responses to a contractionary conventional US monetary policy shock



Note: The figure presents the impulse responses to a one-standard deviation US monetary policy shock. Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets.

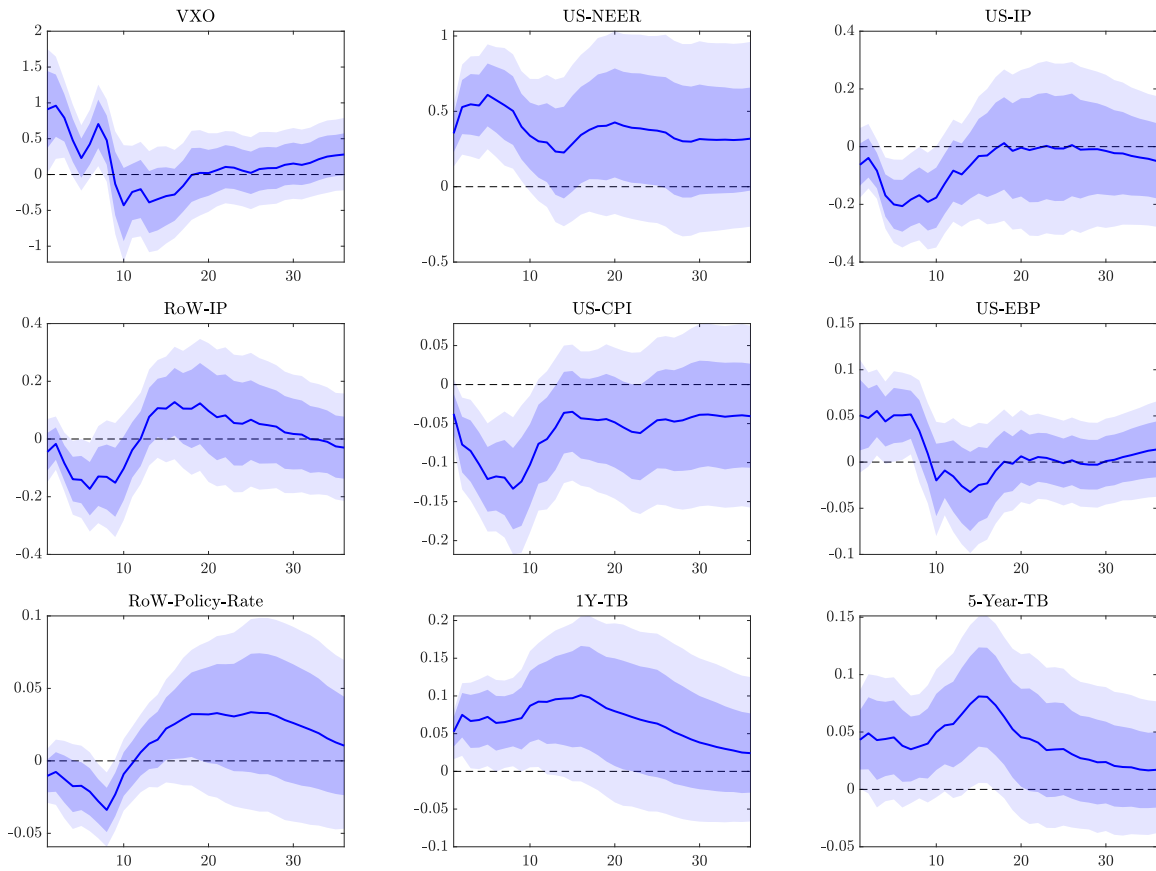
Figure B.15: Responses to a contractionary US forward guidance shock



Note: The figure presents the impulse responses to a one-standard deviation US forward guidance shock. Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets.

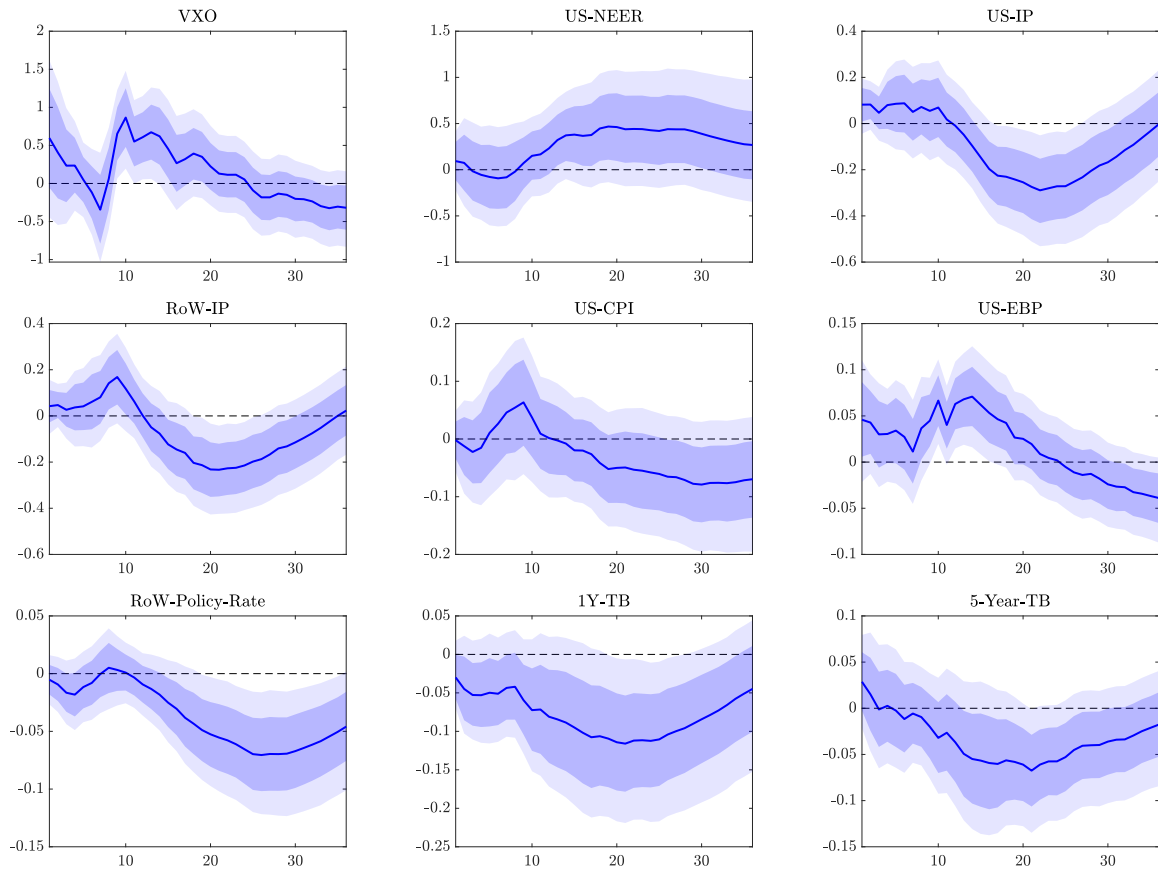


Figure B.16: Responses to a contractionary conventional US monetary policy shock when estimation starts in 1996



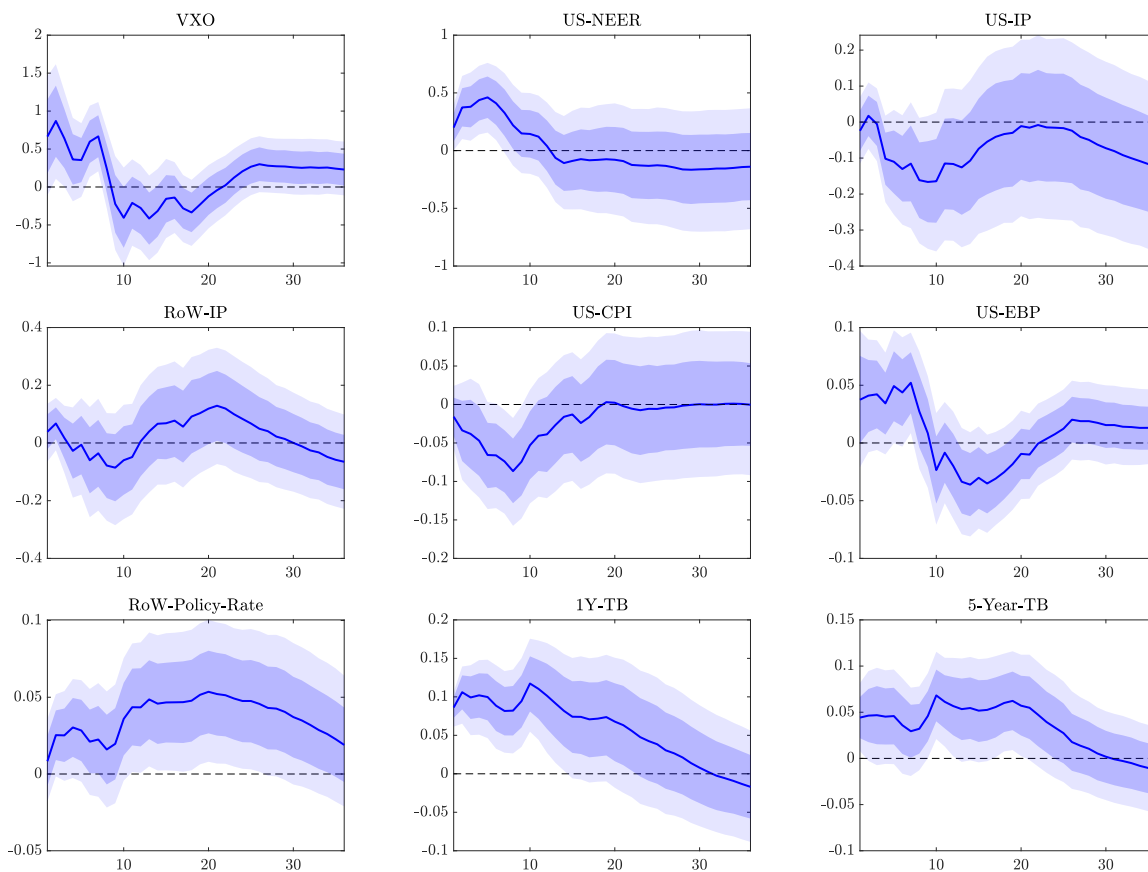
Note: The figure presents the impulse responses to a one-standard deviation US monetary policy shock when we start the estimation from 1996 and don't replace the pre 1996 missing values of the 5 year Treasury Bill futures with zeros. Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets.

Figure B.17: Responses to a contractionary US forward guidance shock when estimation starts in 1996



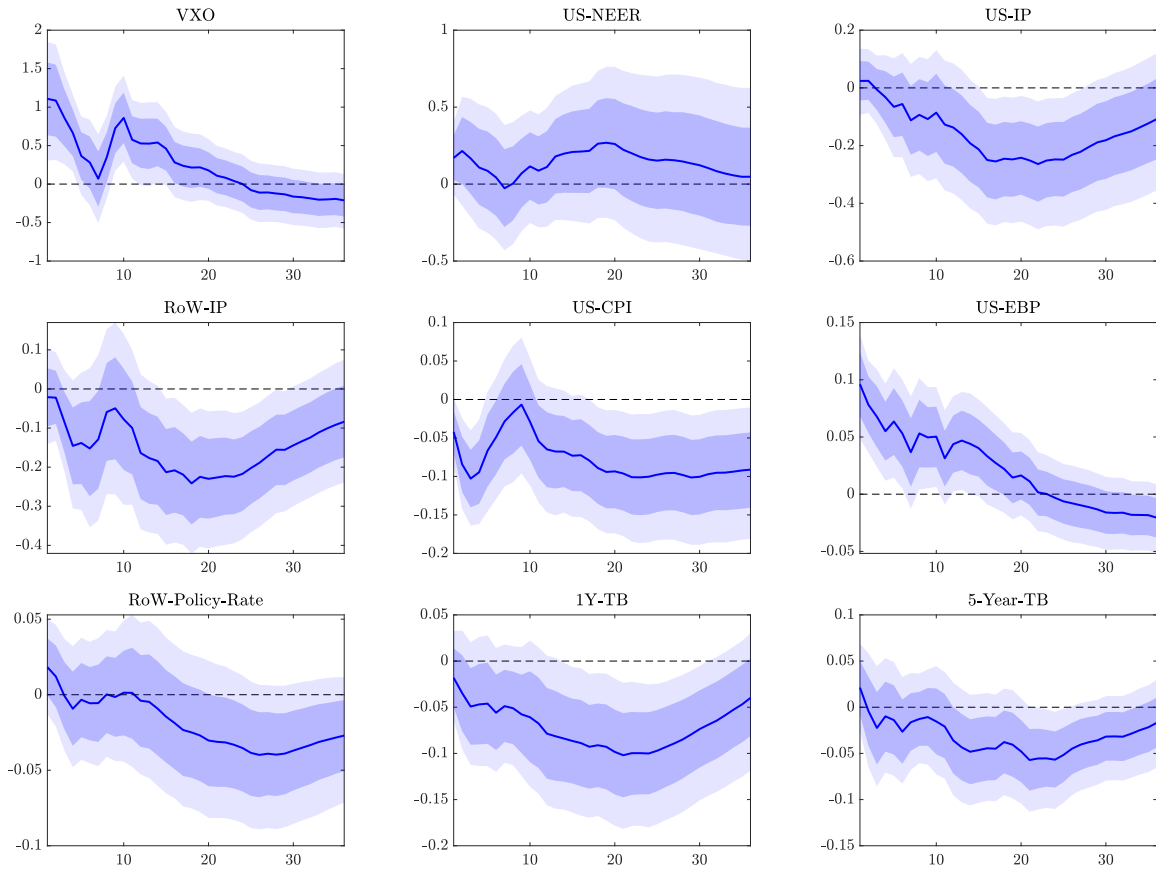
Note: The figure presents the impulse responses to a one-standard deviation US forward guidance shock when we start the estimation from 1996 and don't replace the pre 1996 missing values of the 5 year Treasury Bill futures with zeros. Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets.

Figure B.18: Responses to a contractionary conventional US monetary policy shock when using the proxies of Jarociński (2021)



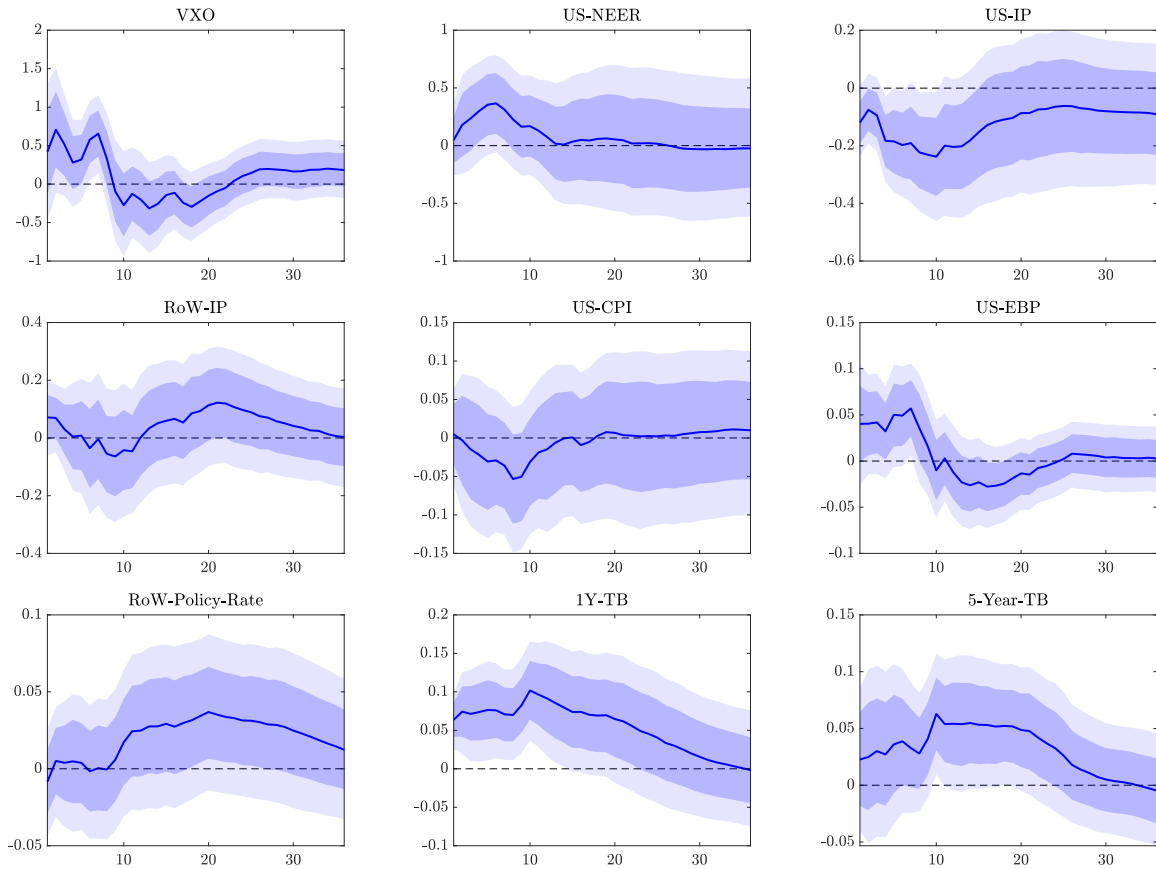
Note: The figure presents the impulse responses to a one-standard deviation US monetary policy shock when using the monetary policy proxies provided in Jarociński (2021) instead of the raw surprises. Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets.

Figure B.19: Responses to a contractionary US forward guidance shock when using the proxies of Jarociński (2021)



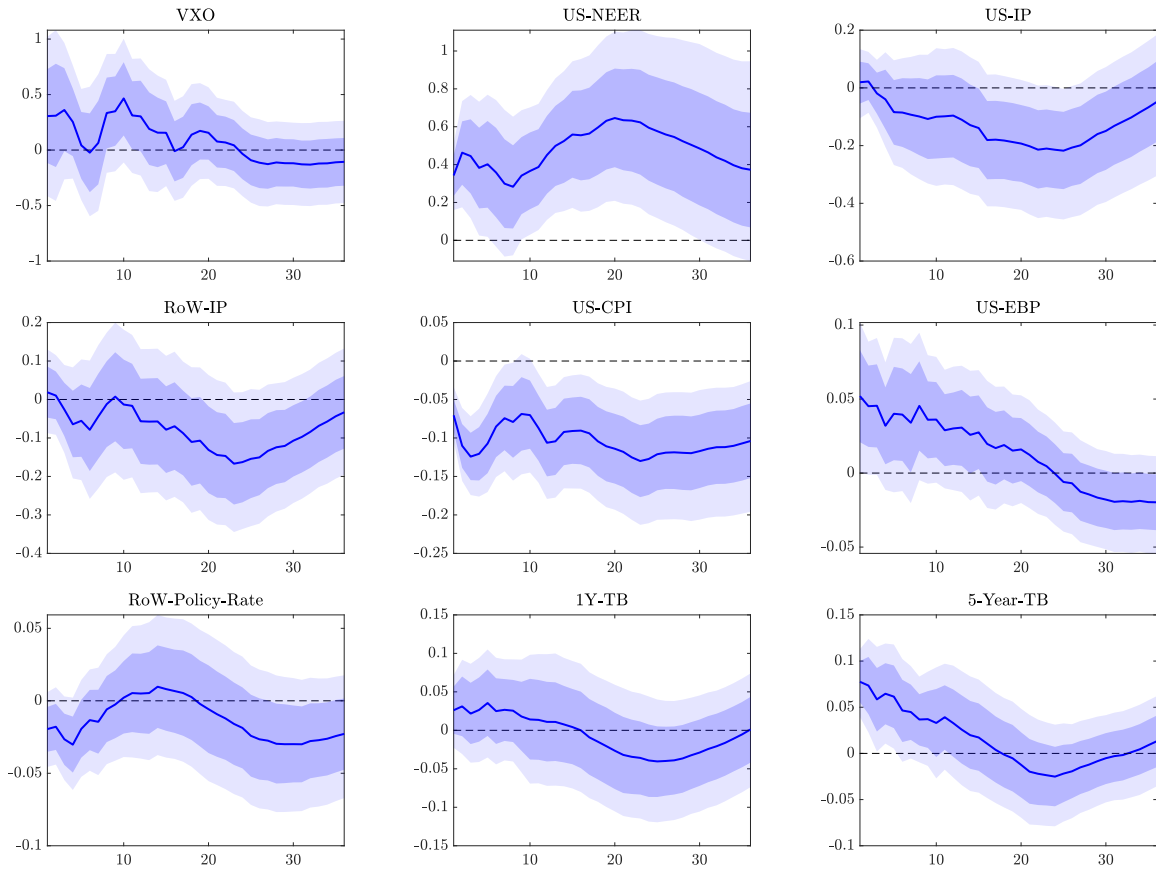
Note: The figure presents the impulse responses to a one-standard deviation US FG shock when using the monetary policy proxies provided in Jarociński (2021) instead of the raw surprises. Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets.

Figure B.20: Responses to a contractionary conventional US monetary policy shock when using the proxies of Lewis (forthcoming)



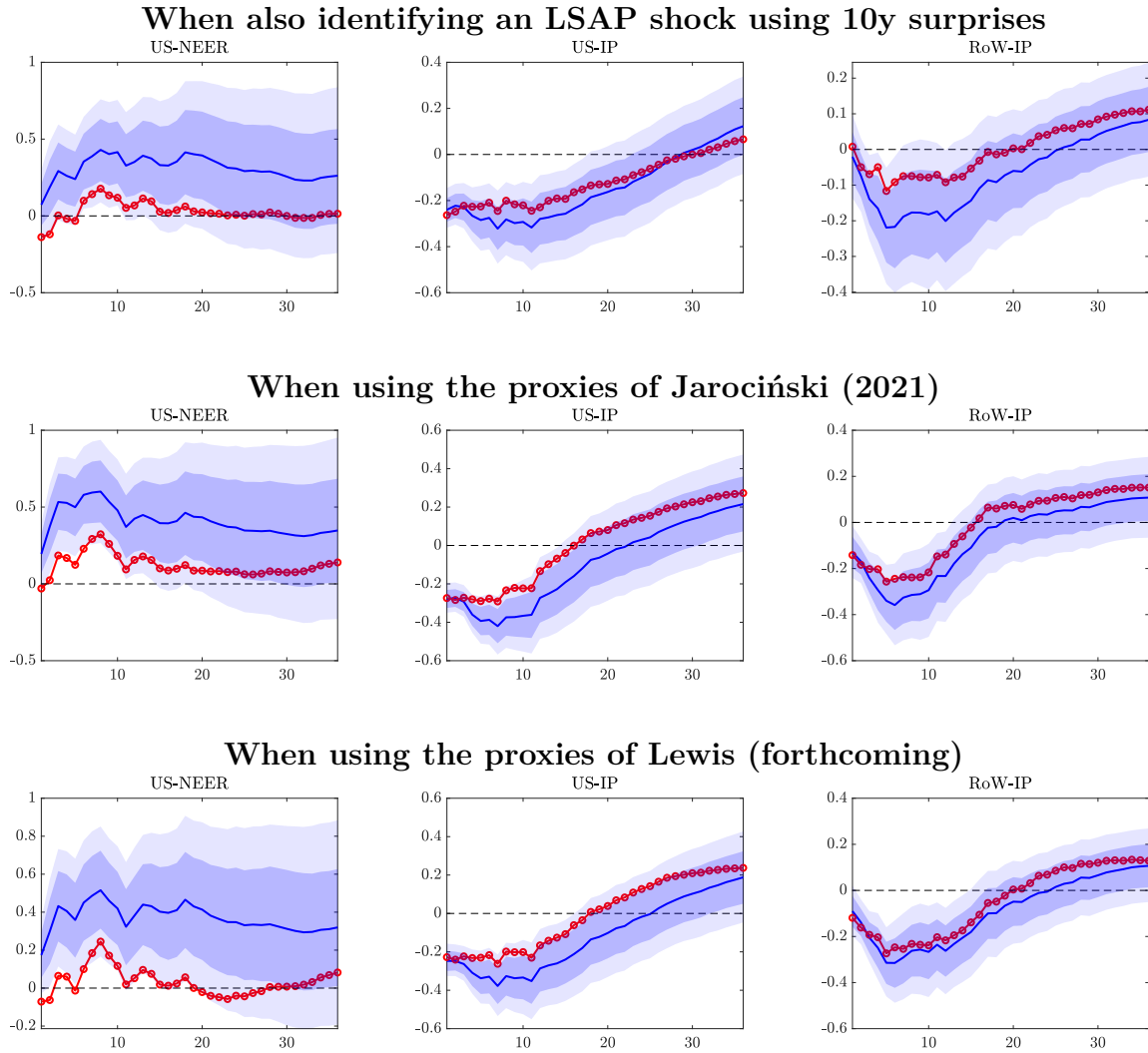
Note: The figure presents the impulse responses to a one-standard deviation US monetary policy shock when using the monetary policy proxies provided in Lewis (forthcoming) instead of the raw surprises. Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets.

Figure B.21: Responses to a contractionary US forward guidance shock when using the proxies of Lewis (forthcoming)



Note: The figure presents the impulse responses to a one-standard deviation US FG shock when using the monetary policy proxies provided in Lewis (forthcoming) instead of the raw surprises. Horizontal axis measures time in months, vertical axis deviation from pre-shock level. Blue solid line represents point-wise posterior mean and shaded areas 68%/90% equal-tailed, point-wise credible sets.

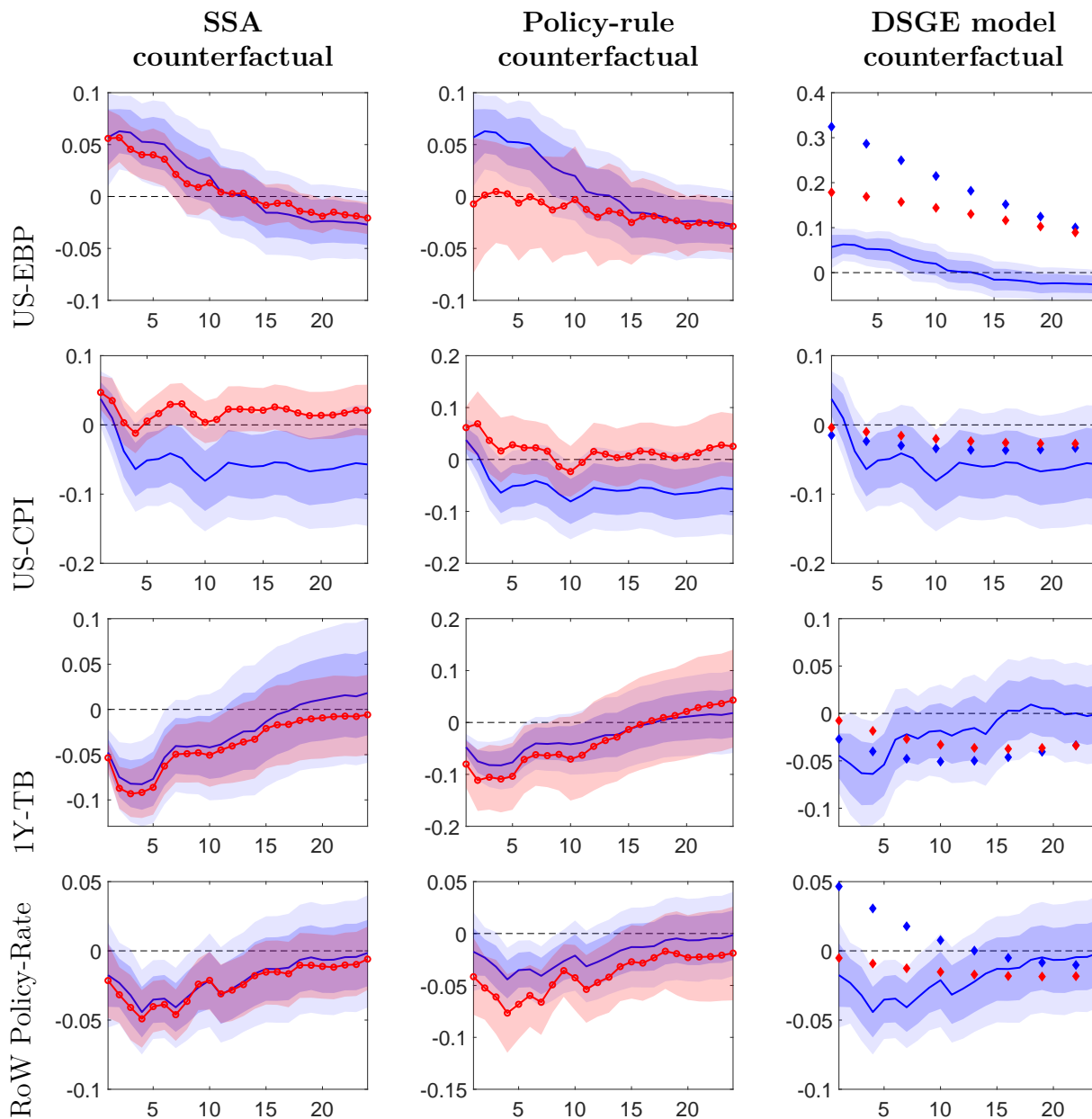
Figure B.22: Robustness for the Policy Rule counterfactual




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Note: The figures plots the estimated IRFs to the global risk (blue) against the pointwise mean of the IRFs under the counterfactual policy rule, where the FED commits to stabilizing the US-\$. Note that, in order to stabilize the dollar perfectly over the entire impulse response horizon using the approach of McKay & Wolf (2023), one would need to identify 36 different policy shocks. As we only identify 2 shocks, we compute the least squares solution to the problem as suggested in McKay & Wolf (2023)

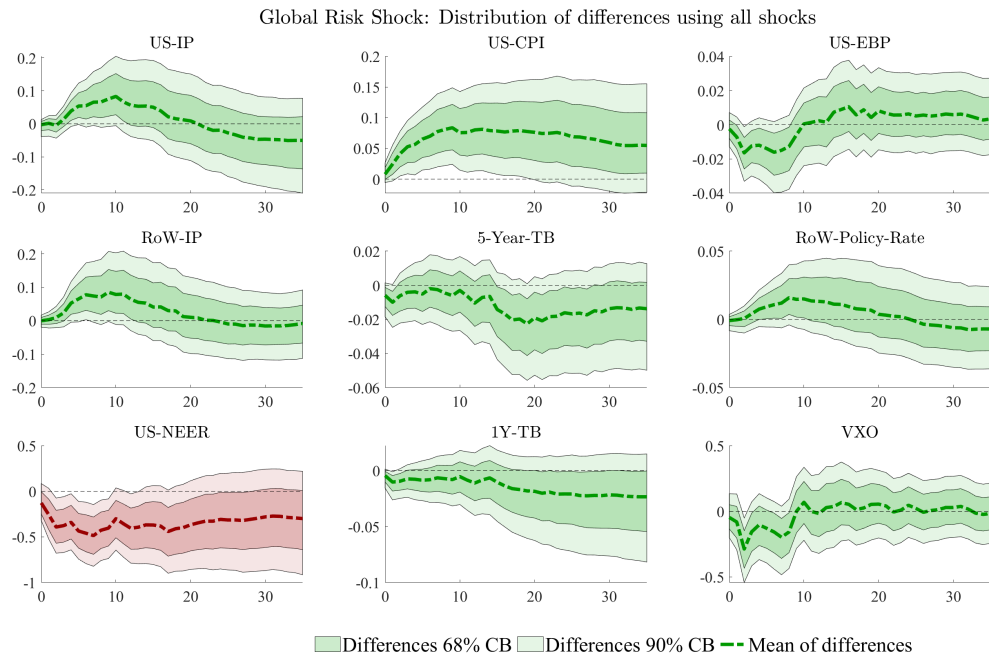
Figure B.23: Baseline and counterfactual responses of remaining BPSVAR model variables to a global risk shock



Note: See notes to 4. As the model of Georgiadis et al. (2023) does not include an exact counterpart US EBP we plot the responses of the US credit spread instead. While in the baseline specification of the BPSVAR we included the AE policy rate as our indicator for the RoW policy stance as weighted average of the policy rates of the “entire” RoW as computed in the Dallas Fed Global Economic Indicators data (Grossman et al. 2014) are extremely volatile volatility in the 1990s due to several crises involving major emerging market economies (EMEs), including Mexico, Brazil, Russia, Thailand, Indonesia, Malaysia, South Korea, Philippines, Argentina and Turkey. As in the DSGE model we want to capture the policy stance in the “entire” RoW the blue lines in the last row corresponds to results from a specification with a ‘hybrid’ RoW policy rate. : Due to the extreme values in the beginning of the sample we impute backwards from 2000 the levels of RoW policy rates in the AE policy rate. Given that the size of EMEs—especially of China—took off only after the late 1990s, this should introduce only mild distortions in the RoW aggregate series. Due to the extreme values in the beginning of the sample we impute backwards from 2000 the levels of RoW policy rates changes in the AE policy rates.



Figure B.24: Distribution of differences for the SSA



Note: The figures shows the posterior distribution of the differences between the baseline impulse response from the BPSVAR and the counterfactual impulse responses from the SSA. Dark (light) green bands represent 68% (90%) point-wise credible sets. The figure shows that for most of the variables roughly 90% of the posterior probability mass lies below or above the zero line indicating that the differences between the baseline and the counterfactual outcome are “significant”.

## 61 C Online appendix - Additional tables

Table C.1: Data description

Variable	Description	Source	Coverage
US 1-year TB rate	1-year Treasury Bill yield at constant maturity	US Treasury/Haver	1990m1 - 2019m12
US IP	Industrial production excl. construction	FRB/Haver	1990m1 - 2019m12
US CPI	US consumer price index	BLS/Haver	1990m1 - 2019m12
US EBP		Favara et al. (2016)	
US dollar NEER	Nominal broad trade-weighted Dollar index	FRB/Haver	1990m1-2019m12
VXO	CBOE market volatility index VXO	Wall Street Journal/Haver	1990m1 - 2019m12
RoW IP	Industrial production, see Martínez-García et al. (2015)	Dallas Fed Global Economic Indicators/Haver	1990m1 - 2019m12
RoW CPI	Consumer price index	Dallas Fed Global Economic Indicators/Haver (Martínez-García et al. 2015)	1990m1 - 2019m12
RoW policy rate	Short-term official/policy rate, see Martínez-García et al. (2015)	Dallas Fed Global Economic Indicators/Haver	1990m1 - 2019m12
Yen, euro, Swiss franc, British pound NEER	Nominal broad effective exchange rate	J.P. Morgan/Haver	1990m1-2019m12
US real exports	Exports of goods and services (chnd. 2012\$)	BEA/Haver	1990q1-2019q2, interpolated to monthly frequency
US real imports	Imports of goods and services (chnd. 2012\$)	BEA/Haver	1990q1-2019q2, interpolated to monthly frequency
Non-US USD cross-border bank credit	Banks' external liabilities in USD of banks owned by the world less external liabilities in USD of banks owned by US nationals	BIS Locational Banking Statistics, Table A7/Haver	1990q1-2019q2, interpolated to monthly frequency
Non-US non-USD cross-border bank credit	Banks' external liabilities in non-USD of banks owned by the world less external liabilities in non-USD of banks owned by US nationals	BIS Locational Banking Statistics, Table A7/Haver	1990q1-2019q2, interpolated to monthly frequency
EMBI spread	EMBI Brady bonds sovereign spread	JP Morgan Emerging Markets Bond Indexes /Haver	1990m1-2019m12
International debt securities	Debt securities issued outside of the resident's home market	BIS International Debt Issuance Statistics/Haver	1990q1-2019q4, interpolated to monthly frequency
AE and EME IP	Industrial production, see Martínez-García et al. (2015)	Dallas Fed Global Economic Indicators/Haver	1990m1 - 2019m12
AE and EME CPI	Consumer price index, see Martínez-García et al. (2015)	Dallas Fed Global Economic Indicators/Haver	1990m1 - 2019m12
AE and EME policy rate	Short-term official/policy rate, see Martínez-García et al. (2015)	Dallas Fed Global Economic Indicators/Haver	1990m1 - 2019m12
US dollar AE NEER	Nominal broad trade-weighted Dollar index against AEs	FRB/Haver	1990m1-2019m12
US dollar EME NEER	Nominal broad trade-weighted Dollar index against EMEs	FRB/Haver	1990m1-2019m12
US Treasury premium	Defined as the deviation from covered interest parity between US and G10 government bond yields	Du et al. (2018)	1991m4-2019m12
Commercial banks' Treasury and agency securities	Used for calculation of liquidity ratio	FRB/Haver	1990m1-2019m12
Total reserve balances with Federal Reserve banks	Used for calculation of liquidity ratio	FRB/Haver	1990m1-2019m12
Total demand deposits	Used for calculation of liquidity ratio	FRB/Haver	1990m1-2019m12
Financial commercial paper outstanding	Used for calculation of liquidity ratio	FRB/Haver	2001m1-2019m12
S&P 500	S&P 500 Composite	S&P/Haver	1990m1 - 2019m12
MSCI World excl. US	MSCI world excluding US	MSCI/Bloomberg	1990m1 - 2019m12
Macroeconomic uncertainty		Jurado et al. (2015)	1990m1 - 2019m12

Notes: BLS stands for Bureau of Labour Statistics, FRB for Federal Reserve Board, BEA for Bureau of Economic Analysis, and BIS for Bank for International Settlements.

## 62 **D Additional model details**

### 63 **D.1 Model structure**

64 The model of Georgiadis et al. (2023) consists of two economies, the US denoted by  $U$ , and a  
65 RoW block denoted by  $R$ , which are linked through trade, cross-border bank lending and  
66 investment in US Treasuries. The model features standard real and nominal frictions such as  
67 sticky prices and wages, habit formation in consumption, investment adjustment costs and  
68 variable capital utilization. At the heart of the model are US and RoW banks that engage  
69 in leveraged domestic and cross-border lending and borrowing. We assume the structure of  
70 frictions is (up to parametrization) symmetric for the US and the RoW; the key exceptions  
71 are financial frictions and global trade. In particular on the financial side, we assume US  
72 banks intermediate domestic dollar funds to the RoW and that US Treasuries are the global  
73 safe asset. Regarding international trade we assume that (i) for trade between the US and  
74 the RoW is largely prices are largely sticky in US\$ and (ii) a fraction of intra RoW trade  
75 is also sticky in US\$. The latter comes about because the RoW block is supposed to be an  
76 aggregate of countries and as document by Gopinath et al. (2020), even if the US is not  
77 directly involved in the trade, countries tend to invoice a lot of their trade in US\$. Figure  
78 D.1 gives a schematic overview of the model structure. As frictions are largely symmetric  
79 for the two blocks, we lay out the equations for the RoW block unless indicated otherwise.  
80 Generally the exposition closely follows the model description in Georgiadis et al. (2023).

Figure D.1: Schematic overview of the model

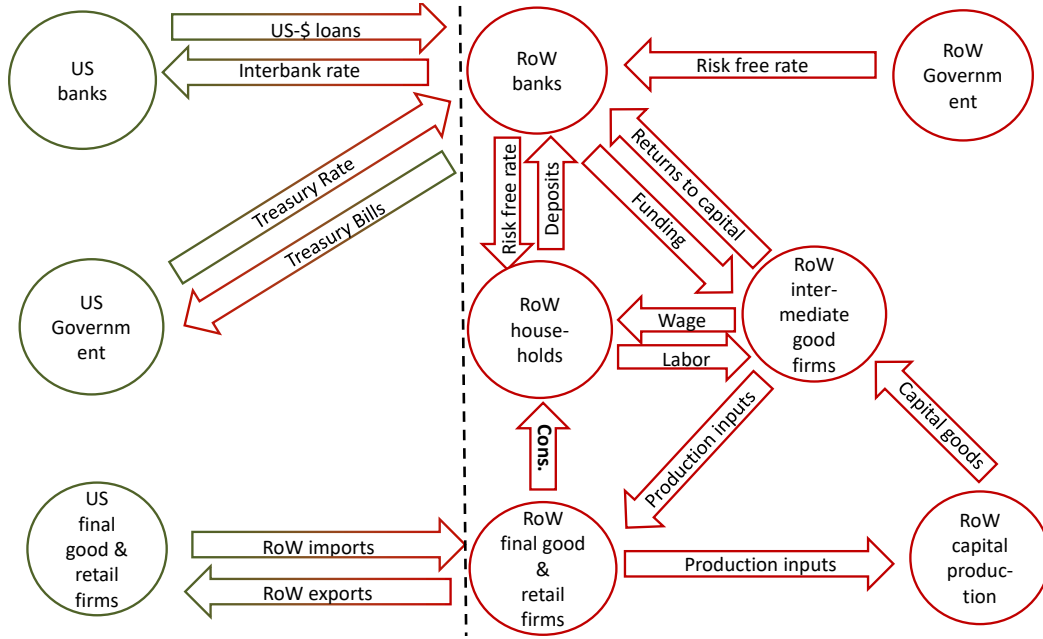
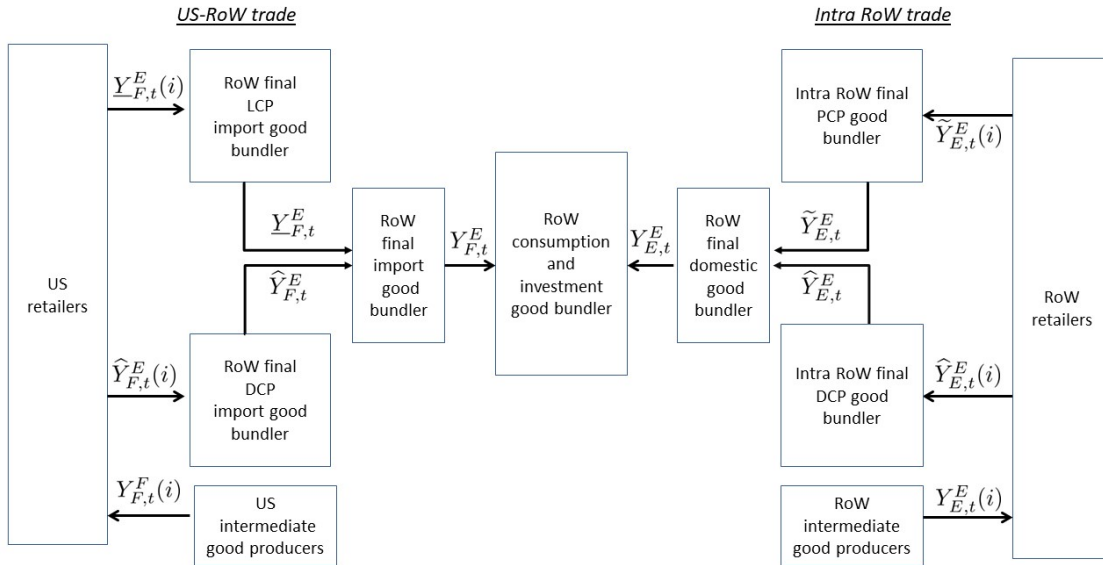


Figure D.2: Multi-layered production structure for the RoW consumption and investment good



Note: The figure lays out the multi-layered production structure in the structural model, focusing on the RoW consumption and investment good.

## 81 D.2 Households and unions

82 In each period a household consumes a non-traded final good subject to habit formation  
 83 in consumption. Furthermore each households is a monopolistic supplier of a differentiated  
 84 labor service  $L_{R,t}(h)$  and sells this to a perfectly competitive union that transforms it into  
 85 an aggregate labor supply using a constant elasticity of substitution (CES) technology.  
 86 Households satisfy demand for labor given the wage rate  $W_{R,t}$ , with wage setting being  
 87 subject to frictions à la Calvo. The period-by-period utility function is given by

$$U(C_{R,t}, L_{R,t}) = \frac{1}{1 - \sigma^c} (C_{R,t} - h_R C_{R,t-1})^{1 - \sigma^c} - \frac{\kappa_{R,w}}{1 + \varphi} L_{R,t}^{1 + \varphi}. \quad (\text{D.1})$$

88 with  $\sigma^c, \varphi, h_R, \kappa_{R,w}$  as the intertemporal elasticity of substitution, the inverse Frisch elasticity  
 89 of labor supply, the habit formation parameter and an exogenous labor scale parameter  
 90 respectively. Households maximize utility subject to the following budget constraint

$$\frac{B_{R,t}^n}{P_{R,t}^C} + C_{R,t} = \frac{B_{R,t-1}^n R_{R,t-1}}{P_{R,t}^C} + \frac{W_{R,t}(h) L_{R,t}(h) + IS_{R,t}(h)}{P_{R,t}^C} + \frac{\Pi_{R,t}^C}{P_{R,t}^C} + \frac{\Pi_{R,t}^R}{P_{R,t}^C},$$

91 where we chose the final consumption and investment good price  $P_{R,t}^C$  as the numeraire.  $R_{R,t-1}$   
 92 is the predetermined domestic risk-free rate paid on nominal deposits with domestic banks  
 93  $B_{R,t}^n$ .  $IS_{R,t}$  furthermore denotes an income stream from domestic state-contingent securities  
 94 ensuring that all households will choose the same consumption and savings plans, despite  
 95 temporarily receiving different wages due to the assumption of Calvo-type wage setting.  
 96 Lastly  $\Pi_{R,t}^C$  and  $\Pi_{R,t}^R$  represent nominal profits from domestic (RoW) capital producing and  
 97 retail firms respectively. The first-order condition of the household with respect to the choice

98 of consumption is given by

$$\Lambda_{R,t} = (C_{R,t} - h_R C_{R,t-1})^{-\sigma_c} - \beta_R h_R \mathbb{E}_t[(C_{R,t+1} - h_R C_{R,t})^{-\sigma_c}] \quad (\text{D.2})$$

99 with  $\Lambda_{R,t}$  as the marginal utility of consumption. The intertemporal optimality conditions  
 100 for the individual holdings of deposits with the local bank reads as

$$\Lambda_{R,t} = \mathbb{R}_t \left[ \beta_R \Lambda_{R,t+1} \frac{R_{R,t}}{1 + \pi_{R,t+1}^C} \right]. \quad (\text{D.3})$$

101 where  $\pi_{R,t+1}^C$  corresponds to the net inflation rate of the final consumption good. The working  
 102 part of the household also sells its differentiated labor services  $L_{R,t}(h)$  to a competitive union,  
 103 which combines the differentiated labor services into a composite labor good using CES  
 104 technology. Lastly the union leases the combined labor service to the intermediate good  
 105 firms at the aggregate nominal wage rate  $W_{R,t}$ . The worker optimally chooses its wage given  
 106 labor demand by the union taking into account that wage setting is subject to frictions à la  
 107 Calvo, meaning that in each period they face a constant probability  $(1 - \theta_{w,R})$  of being able  
 108 to adjust their nominal wage. As such the aggregate real wage index evolves as

$$w_{R,t}^{1-\psi_w} = (1 - \theta_{w,R}) \tilde{w}_{R,t}^{1-\psi_w} + \theta_{w,R} (1 + \pi_{R,t}^C)^{\psi_w - 1} w_{R,t-1}^{1-\psi_w} \quad (\text{D.4})$$

109 with  $\tilde{w}_{R,t}$  as the optimal reset wage and  $w_{R,t}$  as the economy wide real wage.

## 110 D.3 RoW financial intermediaries new

### 111 D.3.1 RoW banks

112 We assume RoW banks raise funds through domestic deposits and cross-border dollar loans  
113 from US banks and use them to finance claims on domestic capital and holdings of US  
114 Treasuries. Specifically, consider RoW bank  $j$  and let  $K_{R,j,t}$  be its claims on domestic capital  
115 in period  $t$ ,  $Q_{R,t}$  the price of such a claim relative to the price of the RoW final consumption  
116 good  $P_{R,t}^C$ ,  $GB_{R,j,t}$  holdings of US Treasuries,  $B_{R,j,t}$  deposits from households,  $CDDL_{R,j,t}$   
117 funding through cross-border dollar loans, and  $N_{R,j,t}$  net worth. The bank's balance sheet  
118 identity in real terms is

$$Q_{R,t}K_{R,j,t} + RER_tGB_{R,j,t} = B_{R,j,t} + RER_tCDDL_{R,j,t} + N_{R,j,t}, \quad (\text{D.5})$$

119 where  $RER_t = \mathcal{E}_t P_{U,t}^C / P_{R,t}^C$  represents the real exchange rate in terms of relative consumer-  
120 price levels and  $\mathcal{E}_t$  the nominal exchange rate defined as the price of a dollar in units of RoW  
121 currency; an increase in  $\mathcal{E}_t$  thus represents an appreciation of the dollar.

122 On the asset side of the RoW bank's balance sheet in Equation (D.5), claims on domestic  
123 capital  $K_{R,j,t}$  earn the rate  $R_{R,t}^K$ , and—when converted to RoW currency—holdings of US  
124 Treasuries  $GB_{R,j,t}$  earn the rate  $D\mathcal{E}_t R_{U,t-1}^{GB}$ ,  $D\mathcal{E}_t \equiv \mathcal{E}_t / \mathcal{E}_{t-1}$ . On the liability side, deposits  
125 of domestic households  $B_{R,j,t}$  cost the rate  $R_{R,t-1}$ —which we assume equals the RoW risk-  
126 free, central bank rate—and cross-border dollar loans from US banks  $CDDL_{R,j,t}$  the rate

127  $D\mathcal{E}_t R_{U,t-1}^{CBDDL}$ . The law of motion for the RoW bank's net worth is

$$N_{R,j,t} = \frac{1}{1 + \pi_{R,t}^C} \left\{ R_{R,t-1} N_{R,j,t-1} + \left[ (1 - \alpha_{R,j,t-1}^{GB}) R_{R,t}^K + \alpha_{R,j,t-1}^{GB} D\mathcal{E}_t R_{U,t-1}^{GB} \right. \right. \quad (D.6)$$

$$\left. \left. - (1 - \ell_{R,j,t-1}^{CBDDL}) R_{R,t-1} - \ell_{R,j,t-1}^{CBDDL} D\mathcal{E}_t R_{U,t-1}^{CBDDL} \right] AS_{R,j,t-1} \right\},$$

128 where  $AS_{R,j,t} \equiv Q_{R,t} K_{R,j,t} + RER_t GB_{R,j,t}$  denotes the bank's total assets,  $\alpha_{R,j,t}^{GB} \equiv RER_t GB_{R,j,t} / AS_{R,j,t}$

129 the share of total assets accounted for by US Treasuries, and  $\ell_{R,j,t}^{CBDDL} \equiv RER_t CBDDL_{R,j,t} / AS_{R,j,t}$

130 the share of total assets funded by cross-border dollar loans.

131 Equation (D.6) shows that a RoW bank's net worth generally fluctuates with the dollar

132 exchange rate. In particular, even when returns on US Treasuries equal the costs of cross-

133 border dollar loans ( $R_{U,t-1}^{GB} = R_{U,t-1}^{CBDDL}$ ), if the share of assets funded by cross-border dollar

134 loans exceeds the asset share of Treasuries ( $\ell_{R,j,t}^{CBDDL} - \alpha_{R,j,t}^{GB} > 0$ ) the bank's net worth drops

135 when the dollar appreciates ( $D\mathcal{E}_t > 0$ ).

136 The objective of a RoW bank is to maximize the discounted value of current and expected

137 future equity streams. The bank's value function is

$$V_{R,j,t} = \max \mathbb{E}_t \sum_{s=0}^{\infty} (1 - \theta_B) \Theta_{R,t,t+s} N_{E,j,t+1+s}, \quad (D.7)$$

138 where  $\Theta_{R,t,t+s}$  is the household's real stochastic discount factor.

139 In order to put a ceiling on the amount of leverage a RoW bank can take on we assume it

140 faces a balance-sheet constraint in the spirit of Gertler & Karadi (2011). We motivate this

141 balance-sheet constraint as an eligibility requirement the bank needs to satisfy in order for

142 creditors to provide funding. In particular, for the bank to attract creditors and be able to



143 leverage, the sum of its discounted current and expected future equity streams has to be  
 144 larger than a risk-weighted sum of its current assets

$$V_{R,j,t} \geq \delta_{R,j,t}(Q_{R,j,t}K_{R,j,t} + \Gamma_R^{GB} RER_t GB_{R,j,t}). \quad (\text{D.8})$$

145 We assume creditors apply two types of risk weights in the balance-sheet constraint in  
 146 Equation (D.8). First, the *asset-specific* risk weight  $\Gamma_R^{GB}$  represents the perceived riskiness of  
 147 Treasuries relative to claims on domestic capital (for a similar interpretation see Karadi &  
 148 Nakov 2021; Coenen et al. 2018). In particular, we assume that US Treasuries are perceived  
 149 to be less risky than claims on domestic capital ( $\Gamma_R^{GB} < 1$ ).

150 Second, the *balance-sheet-specific* risk weight  $\delta_{R,j,t}$  represents the perceived riskiness of  
 151 the bank's relative *asset and liability* composition. The balance-sheet constraint in Equation  
 152 (D.8) thus shows how creditors weigh the perceived riskiness of the size and structure of  
 153 the bank's asset and liability portfolio on the right-hand side against its discounted current  
 154 and expected future level of equity on the left-hand side.<sup>2</sup> In particular, we assume the  
 155 balance-sheet-specific risk weight varies with the asset and liability shares according to

$$\delta_{R,j,t}(\ell_{R,j,t}^{CBDL}, \alpha_{R,j,t}^{GB}) = \bar{\delta}_R \left[ 1 + \frac{\kappa_{R,\alpha,\ell}}{2} (\alpha_{R,j,t}^{GB} - \ell_{R,j,t}^{CBDL})^2 - \epsilon_{R,\alpha} \alpha_{R,j,t}^{GB} \right] + \epsilon_t^{\delta_R}, \quad (\text{D.9})$$

156 where  $\epsilon_t^{\delta_R}$  is an exogenous shock which we interpret as a shock to the willingness of creditors  
 157 to provide funding for a given level of net worth. In other words we assume that this shock  
 158 raises the risk aversion of creditors. Because we are interested in a *global* risk aversion shock,

<sup>2</sup>The balance-sheet constraint in Equation (D.8) is algebraically very similar to that postulated in Gertler & Karadi (2011), who motivate it referring to the idea that the banker can 'abscond' with a fraction of assets.

159 we assume that for each country  $i$ , the shock  $\epsilon^{\delta_{i,B}}$  has a factor structure with a domestic  
 160 component  $\eta_t^{\delta_i}$  and a global component  $\eta_t^{\delta_G}$  and evolves as

$$\epsilon_t^{\delta_{i,B}} = \rho_\delta \epsilon_{t-1}^{\delta_{i,B}} + \eta_t^{\delta_i} + \eta_t^{\delta_G}. \quad (\text{D.10})$$

161 The specification of the balance-sheet-specific risk weight in Equation (D.9) is key for the  
 162 transmission mechanisms in the model. First, cross-border dollar loan funding increases the  
 163 balance-sheet-specific risk weight as long as it is not met by corresponding dollar assets in  
 164 terms of holdings of US Treasuries ( $\kappa_{R,\alpha,\ell} > 0$ ). We make this assumption because unhedged  
 165 cross-border dollar borrowing exposes the RoW bank's net worth to fluctuations in the  
 166 exchange rate and dollar funding shortages.<sup>3</sup> Second, apart from hedging funding through  
 167 cross-border dollar loans, holding US Treasuries reduces the balance-sheet-specific risk weight  
 168 ( $\epsilon_{R,\alpha} > 0$ ). We make this assumption because Treasuries are viewed as the safe asset whose  
 169 market price is relatively stable so that it can be sold with limited losses or even gains on  
 170 its face value in times of stress in order to provide liquidity buffer in any type of funding  
 171 shortage (Bianchi et al. 2021). In other words, Equation (D.9) incorporates a general and a  
 172 dollar-specific incentive for holding Treasuries as liquidity-buffer.<sup>4</sup>

173 It can be shown that the value function of a bank, just like the law of motion its equity,

<sup>3</sup>Under the ‘absconding’ interpretation of the balance-sheet constraint of Gertler & Karadi (2011) this assumption entails that the amount of assets the bank can run away with increases with the unhedged share of funding through cross-border dollar loans. This assumption may be motivated by the observation that bankruptcy laws are biased towards domestic lenders (Akinci & Queralto 2019).

<sup>4</sup>Note that strictly speaking Equation (D.9) states that also a positive net dollar exposure ( $\alpha_{R,j,t}^{GB} - \ell_{R,j,t}^{CBDL} > 0$ ) increases the balance-sheet-specific risk weight. Thus, Equation (D.9) can also be read as stating that the bank has an incentive to take on cross-border dollar loans to hedge holdings of Treasuries. However, as we discuss in the calibration below, in the steady state the bank has a *negative* net dollar exposure.

174 is linear in its components. In particular after guessing the value function can be written as

$$V_{R,j,t} = \left[ (1 - \alpha_{R,j,t}^{GB})v_{R,t} + \alpha_{R,j,t}^{GB}v_{R,t}^{GB} - \ell_{R,j,t}u_{R,t} \right] AS_{R,j,t} + n_{R,t}N_{R,j,t} \quad (\text{D.11})$$

175 its possible to verify procedure the solution to the bankers problem can be characterized by  
 176 the following set of equations.

$$v_{R,t} = \mathbf{E}_t \left( \Omega_{R,t,t+1} (R_{R,k,t+1} - R_{R,t}) \right) \quad (\text{D.12})$$

$$v_{R,t}^{GB} = \mathbf{E}_t \left( \Omega_{R,t,t+1} (\mathcal{E}_{t+1}/\mathcal{E}_t R_{R,t}^{GB} - R_{R,t}) \right) \quad (\text{D.13})$$

$$n_{R,t} = \mathbf{E}_t \left( \Omega_{E,t,t+1} (R_{R,t}) \right) \geq 1 \quad (\text{D.14})$$

$$u_{R,t} = \mathbf{E}_t \left( \Omega_{R,t,t+1} \mathcal{E}_{t+1}/\mathcal{E}_t R_{U,t}^{CDDL} - R_{E,t} \right) \quad (\text{D.15})$$

$$\Omega_{R,t,t+1} = \mathbf{E}_t \left( \frac{\beta_R \Lambda_{R,t+1}}{\Lambda_{R,t} (1 + \pi_{R,t+1}^c)} \left[ (1 - \theta_B) \right. \right. \\ \left. \left. + \theta_B ([v_{R,t+1} (1 - \alpha_{R,j,t+1}^{GB}) + v_{R,t+1}^{GB} \alpha_{R,j,t+1}^{GB} - u_{R,t+1} \ell_{R,j,t+1}^{CDDL}] \phi_{R,j,t+1} + n_{R,t+1}) \right] \right) \quad (\text{D.16})$$

177 Equations D.12, D.13, D.14, D.15, represent the discounted excess returns from borrowing  
 178 domestically and lending domestically, the discounted excess returns from borrowing domes-  
 179 tically and investing into US government bonds, the discounted excess costs of borrowing in  
 180 US-\$ instead of acquiring domestic deposits and the discounted marginal value of an additional  
 181 unit of equity. Equation D.16 is the bankers “augmented” real stochastic discount factor,  
 182 which accounts for marginal value of funds internal to the financial intermediary and the fact  
 183 that the bank may have to close with a probability of  $1 - \theta_B$ . Lastly  $\phi_{R,j,t} = AS_{R,j,t}/N_{R,j,t}$   
 184 corresponds to the optimal leverage ratio of the RoW bank described below.

185 With a closed form solution for  $V_{R,j,t}$  at hand its straightforward to derive the first order  
186 conditions taking into account the balance sheet constraint in Equation (D.8). Regarding the  
187 choice of the optimal composition of asset side its possible to show that this the following  
188 first order condition.

$$\mathbf{E}_t \left[ \Omega_{R,j,t,t+1} \left( D\mathcal{E}_{t+1} R_{U,t}^{GB} - R_{R,t} \right) \right] + CY_{R,j,t} = RP_{R,j,t}^{GB}. \quad (\text{D.17})$$

189 The first term on the left-hand side coincides with the UIP condition in a standard  
190 model without financial frictions and safe asset demand. In particular, in a standard setup,  
191 in order to rule out arbitrage profits for RoW banks the exchange-rate-adjusted return of  
192 Treasuries—whose dollar-return equals the US risk-free rate  $R_{U,t}^{GB} = R_{U,t}$  by assumption—has  
193 to equal the cost of funding through domestic deposits in terms of the risk-free rate  $R_{R,t}$ .  
194 Equation (D.17) shows that our model gives rise to two UIP deviations  $CY_{R,j,t}$  and  $RP_{R,j,t}^{GB}$ .

195 The first UIP deviation is given by

$$RP_{R,j,t}^{GB} = \Gamma_R^{GB} \mathbf{E}_t \left[ \Omega_{R,j,t,t+1} \left( R_{R,t+1}^K - R_{R,t} \right) \right], \quad (\text{D.18})$$

196 and arises because optimal portfolio choice requires that in equilibrium the overall, exchange-  
197 rate-adjusted excess return of US Treasuries on the left-hand side in Equation (D.17) has to  
198 equal the risk-weight-adjusted excess return of the alternative investment in domestic capital  
199 on the right-hand side in Equation (D.17).

200 The second UIP deviation is given by

$$CY_{R,j,t} = -\frac{\partial\delta_{R,j,t}/\partial\alpha_{R,j,t}^{GB}}{\delta_{R,j,t}} \left[ (1 - \alpha_{R,j,t}^{GB}) + \Gamma_R^{GB} \alpha_{R,j,t}^{GB} \right] \mathbf{E}_t \left[ \Omega_{R,j,t,t+1} \left( R_{R,t+1}^K - R_{R,t} \right) \right], \quad (\text{D.19})$$

201 and arises because in our setup the *overall* return of US Treasuries for a RoW bank on the  
 202 left-hand side is made up of the direct component  $R_{U,t}^{GB}$  and an additional, *indirect* component:  
 203 Holding Treasuries loosens a RoW bank's balance-sheet constraint in Equations (D.8) and  
 204 (D.9), thereby allows it to leverage more, exploit more investment opportunities and generate  
 205 additional profits. In other words, because of their dominant safe asset property, holding  
 206 Treasuries may be optimal for a RoW bank even if their direct, expected, exchange-rate-  
 207 adjusted return is lower than the risk-weight-adjusted return of domestic capital  $RP_{R,j,t}^{GB}$ . We  
 208 interpret this indirect return  $CY_{R,j,t}$  as a convenience yield.

209 Equation (D.19) shows that the magnitude of the convenience yield is pinned down  
 210 by the degree to which holding Treasuries reduces a RoW bank's balance-sheet-specific  
 211 risk weight, how the freed leverage translates into additional claims on domestic capital,  
 212 and the corresponding excess return. For example, when domestic credit spreads are high,  
 213 holding additional Treasuries and thereby relaxing a RoW bank's balance-sheet constraint  
 214 is particularly profitable, and hence the convenience yield is high. Note that Equation  
 215 (D.17) instills a structural interpretation to the convenience yield in the UIP condition in  
 216 the no-arbitrage finance framework in Krishnamurthy & Lustig (2019). Apart from the risk  
 217 premium  $RP_{R,j,t}^{GB}$ , Equation (D.17) also coincides with the UIP condition in the structural  
 218 model of Jiang et al. (2021a). However, in their setup the convenience yield is introduced  
 219 *ad hoc* as a UIP deviation that is assumed to decline in the global stock of safe assets. In

220 contrast, in our model the convenience yield and its relation to global financing conditions  
 221 emerge endogenously from the optimal portfolio choice of RoW banks.

222 As a UIP condition Equation (D.17) pins down the evolution of the dollar exchange  
 223 rate. First, for a given RoW domestic deposit rate ( $R_{R,t}$ ), in standard UIP logic an increase  
 224 in the US risk-free rate and hence by assumption the return on Treasuries ( $R_{U,t}^{GB}$ ) requires  
 225 an expected depreciation of the dollar ( $D\mathcal{E}_{t+1}$  declines), which is in part achieved by a  
 226 contemporaneous appreciation. Second, for a given RoW domestic deposit rate ( $R_{R,t}$ ) and  
 227 US risk-free rate ( $R_{U,t}^{GB}$ ), an increase in the convenience yield ( $CY_{R,j,t}$ ) has to be accompanied  
 228 by an expected depreciation of the dollar ( $D\mathcal{E}_{t+1}$  declines), which is again in part achieved  
 229 by a contemporaneous appreciation.

230 Regarding the optimal choice of the liability composition, it can be shown that the total  
 231 returns on cross border dollar loans  $R_{U,t}^{CDDL}$  have to equal the costs of domestic funding up to  
 232 an endogenous wedge.

$$\mathbf{E}_t(\Omega_{R,j,t,t+1}R_{R,t}) = \mathbf{E}_t\left(\Omega_{R,j,t,t+1}D\mathcal{E}_{t+1}R_{U,t}^{CDDL}\right) + RP_{R,j,t}^{CDDL}, \quad (\text{D.20})$$

233 with

$$RP_{R,j,t}^{CDDL} = \frac{\partial\delta_{R,j,t}/\partial\ell_{R,j,t}^{CDDL}}{\delta_{R,j,t}}\mathbf{E}_t\Omega_{R,j,t,t+1}\left[(1 - \alpha_{R,j,t}^{GB})(R_{R,t+1}^K - R_{R,t}) + \alpha_{R,j,t}^{GB}\left(D\mathcal{E}_{t+1}R_{U,t}^{GB} + CY_{R,j,t} - R_{R,t}\right)\right]. \quad (\text{D.21})$$

234 Cross-border dollar borrowing has an additional, *indirect* cost, as it tightens the RoW bank's  
 235 balance-sheet constraint in Equations (D.8) and (D.9), thereby limits its leverage and thus

236 reduces profits. This risk premium implies that in order for the RoW bank to borrow  
 237 cross-border dollar funds the *direct* cost has to be lower than for domestic deposits. Thus,  
 238 consistent with the data, in our model cross-border dollar borrowing is—or at least appears  
 239 to be—cheap compared to domestic funding (Caramichael et al. 2021; Gutierrez et al. 2023).  
 240 Analogous to the UIP condition in Equation (D.17), also Equation (D.20) provides intuition  
 241 for the evolution of the dollar exchange rate. For example, when global financing conditions  
 242 tighten so that domestic credit spreads rise, the risk premium on cross-border dollar loans  
 243 increases. Equation (D.20) shows that for a given deposit rate and cross-border dollar credit  
 244 rate this rise in the risk premium has to be accompanied by an expected depreciation of the  
 245 dollar. This is partly accomplished by a contemporaneous appreciation. This mechanism is  
 246 similar to the “two-way feedback between balance sheets and exchange rates” in Akinici &  
 247 Queralto (2019, p.3).

248 The remaining equations of the RoW banking block are fairly standard. In particular, we  
 249 impose market clearing for domestic capital, US treasuries and specify the start-up funds  
 250 for a newly entering bank  $n$  as a fraction of last period’s portfolio,  $N_{R,n,t} = \omega_R AS_{R,t-1}$ . In  
 251 equilibrium all banks choose the same portfolio structure as they face the same returns and  
 252 costs. The law of motion for aggregate net worth of the RoW banking sector is given by

$$\begin{aligned}
 N_{R,t} = \frac{\theta_B}{1 + \pi_{R,t}^C} & \left\{ R_{R,t-1} N_{R,t-1} + \left[ (1 - \alpha_{R,t-1}^{GB}) R_{R,t}^K + \alpha_{R,t-1}^{GB} D \mathcal{E}_t R_{U,t-1}^{GB} \right. \right. & (D.22) \\
 & \left. \left. - (1 - \ell_{R,t-1}^{CDDL}) R_{R,t-1} - \ell_{R,t-1}^{CDDL} D \mathcal{E}_t R_{U,t-1}^{CDDL} \right] AS_{R,t-1} \right\} + \omega_R AS_{R,t-1}
 \end{aligned}$$

253 When the model is parameterized so that the balance-sheet constraint in Equation (D.8)

254 binds in a neighbourhood of the steady-state, the maximum equilibrium leverage ratio is  
 255 given by

$$\phi_{R,j,t} \equiv \frac{AS_{R,j,t}}{N_{R,j,t}} = \frac{n_{R,j,t}}{\mathcal{R}_{R,j,t} - \mathcal{P}_{R,j,t}}, \quad (\text{D.23})$$

256 where

$$\mathcal{R}_{R,j,t} \equiv \delta_{R,j,t} \left[ (1 - \alpha_{R,j,t}^{GB}) + \Gamma_R^{GB} \alpha_{R,j,t}^{GB} \right], \quad (\text{D.24})$$

$$\begin{aligned} \mathcal{P}_{R,j,t} \equiv \mathbf{E}_t \Omega_{R,j,t,t+1} & \left[ (1 - \alpha_{R,j,t}^{GB}) R_{R,t+1}^K + \alpha_{R,j,t}^{GB} D\mathcal{E}_{t+1} R_{U,t}^{GB} \right. \\ & \left. - (1 - \ell_{R,j,t}^{CBDL}) R_{R,t} - \ell_{R,j,t}^{CBDL} D\mathcal{E}_{t+1} R_{U,t}^{CBDL} \right], \quad (\text{D.25}) \end{aligned}$$

257 are the RoW bank's asset-share-weighted bank and asset-specific risk weight and its expected  
 258 profitability, respectively; the terms  $\Omega_{R,j,t,t+1}$  and  $n_{R,j,t}$  denote the bank's stochastic discount  
 259 factor and the expected discounted returns to equity respectively. Equation (D.23) shows that  
 260 the RoW bank's maximum leverage is pinned down by its portfolio's expected profitability  
 261 and perceived riskiness in terms of risk weights. In particular, the RoW bank can attain  
 262 a higher leverage ratio, thereby exploit more investment opportunities and generate more  
 263 profits if (i) the perceived riskiness in terms of  $\mathcal{R}_{R,j,t}$  is low, (ii) its expected profitability in  
 264 terms of  $\mathcal{P}_{R,j,t}$  is high, and/or (iii) expected discounted returns to equity in terms of  $n_{R,j,t}$   
 265 are large.



## 266 D.4 US financial intermediaries

267 US banks differ from RoW banks in four ways. First, a US bank acts as cross-border lender  
 268 rather than borrower, and so dollar loans appear on the asset side of its balance sheet

$$Q_{U,t}K_{U,j,t} + CBDDL_{U,j,t} = B_{U,j,t} + N_{U,j,t}, \quad (\text{D.26})$$

269 where  $K_{U,j,t}$ ,  $CBDDL_{U,j,t}$ ,  $B_{U,j,t}$  and  $N_{U,j,t}$  are the total amount of claims on domestic capital,  
 270 cross-border dollar loans, domestic deposits and net worth, respectively, deflated by the price  
 271 of the US consumption good.

272 Second, for simplicity and in order to focus on the RoW, we assume US banks do not  
 273 hold Treasuries. In contrast to RoW banks a US bank's net worth

$$N_{U,j,t} = \frac{1}{1 + \pi_{U,t}^C} \left[ (R_{U,t}^K - R_{U,t-1})Q_{U,t-1}K_{U,j,t-1} \right. \\ \left. + (R_{U,t-1}^{CBDL} - R_{U,t-1})CBDDL_{U,j,t-1} + R_{U,t-1}N_{U,j,t-1} \right], \quad (\text{D.27})$$

274 is not affected by exchange rate valuation effects as its liabilities and assets are all denominated  
 275 in dollar.

276 Third, for a US bank we assume the balance-sheet constraint

$$V_{U,j,t} \geq \delta_{U,j,t}(Q_{U,t}K_{U,j,t} + \Gamma_{U,t}^{CBDL}CBDDL_{U,j,t}), \quad (\text{D.28})$$

277 with the asset-specific risk weight creditors attach to cross-border dollar loans

$$\Gamma_{U,t}^{CDDL} = \bar{\Gamma}_U^{CDDL} + \Phi_{U,\phi} \phi_{R,j,t}, \quad (\text{D.29})$$

278 and where  $\phi_{R,j,t}$  is the leverage ratio of RoW banks from Equation (D.23). Specifically, in  
 279 Equation (D.29) we assume cross-border dollar lending is perceived to be more risky by a US  
 280 bank's creditors when RoW banks are more leveraged. The motivation for this specification  
 281 is that while RoW banks lend to the US government (the least risky borrower by assumption)  
 282 and US firms (which pledge the entire return to capital), US banks also lend to leveraged  
 283 and thus risky RoW banks, whose leverage (and thereby riskiness) endogenously fluctuates  
 284 with the state of the economy.

285 Fourth, in contrast to RoW banks, a US bank does not engage in foreign-currency  
 286 borrowing so that there is no asset-liability currency mismatch creditors may be concerned  
 287 about. Therefore, we assume the balance-sheet-specific risk weight  $\delta_{U,j,t}$  for a US bank does  
 288 not vary endogenously and is given by

$$\delta_{U,j,t} = \bar{\delta}_U + \epsilon_t^{\delta_U}, \quad (\text{D.30})$$

289 where  $\epsilon_t^{\delta_U}$  is an exogenous risk aversion shock discussed previously.

290 We assume for simplicity that the return on US Treasuries equals the risk-free, monetary  
 291 policy rate:  $R_{U,t}^{GB} = R_{U,t}$ .<sup>5</sup>

292 As in the RoW case, the objective of the US banker is to maximize the discounted value

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<sup>5</sup>This would result endogenously if we assumed US banks can hold Treasuries, if the corresponding asset-specific risk weight in the balance-sheet constraint in Equation (D.28) was zero, and if the balance-sheet-specific risk weight in Equation (D.30) was independent of these holdings

293 of current and future equity streams subject to the balance sheet constraint. The bank's  
 294 value function is

$$V_{U,j,t} = \max \mathbb{E}_t \sum_{s=0}^{\infty} (1 - \theta_B) \Theta_{U,t,t+s} N_{U,j,t+1+s}, \quad (\text{D.31})$$

295 where  $\Theta_{U,t,t+s}$  is the household's real stochastic discount factor.

296 Defining  $\alpha_{U,j,t}^{CBDL} = \frac{CBDL_{U,j,t}}{AS_{U,j,t}}$  as the asset ratio of cross border dollar loans to total assets  
 297 of the banks assuming that the value function  $V_{U,j,t}$  is linear in the components of the LOM  
 298 for net worth its possible to show that

$$V_{U,j,t} = \left[ (1 - \alpha_{U,j,t}^{CBDL}) v_{U,t} + \alpha_{U,j,t}^{CBDL} v_{U,t}^{CBDL} \right] AS_{U,j,t} + n_{U,t} N_{U,j,t} \quad (\text{D.32})$$

$$v_{U,t} = \mathbb{E}_t \left( \Omega_{U,t,t+1} (R_{U,t+1}^K - R_{U,t}) \right) \quad (\text{D.33})$$

$$v_{U,t}^{CBDL} = \mathbb{E}_t \left( \Omega_{U,t,t+1} (R_{U,t}^{CBDL} - R_{U,t}) \right) \quad (\text{D.34})$$

$$n_{U,t} = \mathbb{E}_t \left( \Omega_{U,t,t+1} (R_{U,t}) \right) \quad (\text{D.35})$$

$$\Omega_{U,t,t+1} = \mathbb{E}_t \left( \frac{\Theta_{U,t,t+1}}{(1 + \pi_{U,t+1}^e)} \left[ (1 - \theta_B) + \theta_B \left( [(1 - \alpha_{U,j,t+1}^{CBDL}) v_{U,t+1} + \alpha_{U,j,t+1}^{CBDL} v_{U,t+1}^{CBDL}] \phi_{U,j,t+1} + n_{U,t+1} \right) \right] \right). \quad (\text{D.36})$$

299 With  $V_{U,j,t}$ ,  $v_{U,t}$ ,  $v_{U,t}^{CBDL}$ ,  $n_{U,t}$  and  $\Omega_{U,t,t+1}$  as the slightly different versions of their RoW coun-  
 300 terparts touched up on the previous section.

301 As in the RoW case the optimal portfolio choice of US banks choice requires

$$\Gamma_{U,t}^{CBDL} \mathbb{E}_t \left[ \Omega_{U,j,t,t+1} (R_{U,t+1}^K - R_{U,t}) \right] = \mathbb{E}_t \left[ \Omega_{U,j,t,t+1} (R_{U,t}^{CBDL} - R_{U,t}) \right] - RP_{U,j,t}^{CBDL}, \quad (\text{D.37})$$

302 stating that the expected risk-weight-adjusted excess returns on domestic capital on the  
 303 left-hand side and cross-border dollar loans on the right-hand side have to equalize.

304 Apart from the term  $RP_{U,j,t}^{CDDL}$ , Equation (D.37) coincides with the equilibrium condition  
 305 in a standard model without financial frictions on cross-border dollar lending and borrowing.  
 306 In particular, in a standard setup expected, risk-weight-adjusted returns of different assets  
 307 have to equalize. In Equation (D.37) this means that the expected, risk-weight-adjusted  
 308 excess returns on claims on domestic capital have to equal the expected excess returns on  
 309 cross-border lending. Equation (D.37) shows that in our model the *direct* expected excess  
 310 return of cross-border dollar lending has to be higher than the risk-weight-adjusted excess  
 311 return of claims on domestic capital due to a risk premium  $RP_{U,j,t}^{CDDL}$ .

312 In particular, this risk premium on cross-border lending is given by

$$\begin{aligned}
 RP_{U,j,t}^{CDDL} = \frac{\partial \Gamma_{U,t}^{CDDL}}{\partial \alpha_{U,j,t}^{CDDL}} \alpha_{U,j,t}^{CDDL} \mathbf{E}_t \Omega_{U,j,t,t+1} & \left[ (1 - \alpha_{U,j,t}^{CDDL})(R_{U,t+1}^K - R_{U,t}) \right. \\
 & \left. + \alpha_{U,j,t}^{CDDL}(R_{U,t}^{CDDL} - R_{U,t}) \right], \tag{D.38}
 \end{aligned}$$

313 and arises because the US bank's cross-border dollar lending raises the RoW bank's leverage,  
 314 which feeds back and raises the US bank's asset-specific risk weight (see Equation (D.29)) and  
 315 thereby has an additional, *negative indirect* return: It tightens the US bank's balance-sheet  
 316 constraint in Equations (D.28) and (D.29), which limits its leverage and thus reduces profits.<sup>6</sup>

317 Equation (D.38) shows that the magnitude of this risk premium is pinned down by the  
 318 degree to which cross-border dollar lending raises the US bank's asset-specific risk weight

<sup>6</sup>Using the market clearing conditions alongside the balance sheets of the two banks it can be shown that  
 $\frac{\partial \Gamma_{U,t}^{CDDL}}{\partial \alpha_{U,j,t}^{CDDL}} = \Phi_{U,\phi}^F \frac{\frac{1-s}{s} RER_t AS_{U,t}}{N_{R,t}}$

319 on cross-border dollar lending, how the ensuing reduction in the bank's leverage cuts into  
320 claims on domestic capital and cross-border dollar lending, and their corresponding excess  
321 returns. For example, when domestic credit spreads are high, the foregone profits implied by  
322 the tightening in the bank's balance-sheet constraint due to cross-border dollar lending are  
323 particularly high, and hence the risk premium on cross-border dollar lending is high.

324 The remaining equations of the US banking block are fairly standard. In particular, we  
325 impose market clearing for domestic capital, cross border dollar loans and specify the start-up  
326 funds for a newly entering bank  $n$  as a fraction of last period's portfolio,  $N_{U,n,t} = \omega_U AS_{U,t-1}$ .  
327 The law of motion for aggregate net worth of the US banking sector is given by

$$N_{U,t} = \frac{\theta_B}{1 + \pi_{U,t}^C} \left\{ R_{U,t-1} N_{U,t-1} + \left[ (1 - \alpha_{U,t-1}^{CDDL})(R_{U,t}^K - R_{U,t-1}) + \alpha_{U,t-1}^{CDDL}(R_{U,t-1}^{GB} - R_{U,t-1}) \right] AS_{U,t-1} \right\} + \omega_U AS_{U,t-1} \quad (\text{D.39})$$

328 When the model is parameterized so that the balance-sheet constraint in Equation (D.8)  
329 binds in a neighbourhood of the steady-state, the maximum equilibrium leverage ratio again  
330 reflects a risk-profitability trade-off

$$\phi_{U,j,t} \equiv \frac{AS_{U,j,t}}{N_{U,j,t}} = \frac{Q_{U,t} K_{U,j,t} + CDDL_{U,j,t}}{N_{U,j,t}} = \frac{n_{U,j,t}}{\mathcal{R}_{U,j,t} - \mathcal{P}_{U,j,t}}, \quad (\text{D.40})$$

331 where

$$\mathcal{R}_{U,j,t} = \delta_{U,j,t} \left[ (1 - \alpha_{U,j,t}^{CDDL}) + \Gamma_{U,t}^{CDDL} \alpha_{U,j,t}^{CDDL} \right], \quad (\text{D.41})$$

$$\mathcal{P}_{U,j,t} = \mathbf{E}_t \Omega_{U,j,t,t+1} \left[ (1 - \alpha_{U,j,t}^{CDDL}) R_{U,t+1}^K + \alpha_{U,j,t}^{CDDL} R_{U,t}^{CDDL} - R_{U,t} \right], \quad (\text{D.42})$$

### 332 D.4.1 Intermediate good firms

333 In each economy there exists a continuum of perfectly competitive intermediate goods firms  
 334 that sell their output to domestic retailers. We assume that at the end of period  $t$  but before  
 335 the realization of shocks the intermediate good firm acquires capital for use in next period's  
 336 production. To do so, the intermediate good firm  $i$  claims equal to the number of units  
 337 of capital acquired, and prices each claim at the real price of a unit of capital  $Q_{R,t}$ . The  
 338 production function is

$$Z_{R,i,t} = \left( U_{R,i,t} K_{R,i,t-1} \right)^\alpha L_{R,i,t}^{(1-\alpha)}, \quad (\text{D.43})$$

339 with  $Z_{R,i,t}$  the amount of output produced by the individual RoW intermediate good firm  
 340 in period  $t$ ,  $L_{R,i,t}$  the labor used in production, and  $U_{R,i,t}$  the employed utilization rate of  
 341 capital.

342 Cost minimization yields the standard equations for the optimal amount of production  
 343 inputs

$$MC_{R,t}^r = \frac{w_{R,t}^{1-\alpha} \tau_{R,t}(U_{R,t})'^\alpha}{(1-\alpha)^{(1-\alpha)} \alpha^\alpha}. \quad (\text{D.44})$$

$$\frac{w_{R,t}}{\tau_{R,t}(U_{R,t})'} = \frac{1-\alpha}{\alpha} \frac{(U_{R,t} K_{R,t-1})}{L_{R,t}}, \quad (\text{D.45})$$

344 where  $MC_{R,t}^r$  denote the real marginal costs of the intermediate good firms deflated by the  
 345 RoW final good price  $P_{R,t}^C$  and  $\tau_{R,t}(U_{R,t})'$  as the derivative of the adjustment cost function,  
 346 which maps a change in utilization rate into a change in the depreciation rate<sup>7</sup>. The optimal  
 347 choice of capital gives the resulting gross nominal returns on capital, which are transferred to

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<sup>7</sup>The adjustment cost function is given by  $\tau_{R,t}(U_{R,t}) = \tau_{R,ss,scal} + \zeta_{R,1} \frac{U_t^{1+\zeta_2}}{1+\zeta_2}$  with  $\tau_{R,ss,scal}$  as an exogenous scale parameter in order to normalize utilization in the steady state.

348 the bank in exchange for funding

$$R_{K,E,t} = (1 + \pi_{R,t}^c) \frac{\left( MC_{R,t}^r \alpha \frac{Z_{R,t}}{K_{t-1}} \right) + (Q_{R,t} - \tau_{R,t} U_{R,t})}{Q_{R,t-1}}. \quad (\text{D.46})$$

## 349 D.5 Capital producers

350 Capital producing firms buy and refurbish depreciated capital from the intermediate goods  
 351 firm at price  $P_{R,t}^C$  and also produce new capital using the RoW final good, which consists  
 352 of domestically produced and imported retail goods, as an input. Furthermore we assume  
 353 that they face quadratic adjustment costs on net investment<sup>8</sup> and that profits, which arise  
 354 outside of the steady state, are distributed lump sum to the households. The optimal choice  
 355 of investment yields the familiar *Tobins Q* relation for the evolution of the relative price of  
 356 capital

$$Q_{R,t} = 1 + \frac{\Psi}{2} \left( \frac{In_{R,t} + Iss_R}{In_{R,t-1} + Iss_R} - 1 \right)^2 + \Psi \left( \frac{In_{R,t} + Iss_R}{In_{R,t-1} + Iss_R} - 1 \right) \frac{In_{R,t} + Iss_R}{In_{R,t-1} + Iss_R} - \beta \frac{\Lambda_{E,t+1}}{\Lambda_{E,t}} \Psi \left( \frac{In_{R,t+1} + Iss_R}{In_{R,t} + Iss_R} - 1 \right) \left( \frac{In_{R,t+1} + Iss_R}{In_{R,t} + Iss_R} \right)^2 \quad (\text{D.47})$$

357 alongside the law of motion for capital

$$K_{R,t} = K_{R,t-1} + In_{R,t} \quad (\text{D.48})$$

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<sup>8</sup>Following Gertler & Karadi (2011) we assume that adjustment costs are only present when changing net investment in order for the optimal choice of the utilization rate to be independent from fluctuations in the relative price of capital  $Q_{R,t}$

## 358 **D.6 Goods bundling and pricing**

359 The third key element in our model is dollar dominance in terms of DCP in bilateral trade  
360 between the US and the RoW, following the seminal work of Gopinath et al. (2020). This  
361 means that the prices of both US and RoW exports are sticky in dollar.

362 In our model we go beyond DCP in bilateral trade between the US and the RoW and  
363 assume that prices of a share of domestic sales in the RoW are also sticky in dollar. In  
364 particular, Boz et al. (2022) document that a large share of trade among countries in the  
365 RoW is also priced in dollar; this is the actual meaning of a dominant—in the context of trade  
366 also often termed ‘vehicle’—currency. It implies that when the dollar appreciates expenditure  
367 switching does not only affect imports from the US, but imports in general. Therefore, dollar  
368 pricing in third-country trade—in our model captured by domestic sales in the RoW—may  
369 be consequential for the effects of dollar appreciation in the context of a global risk aversion  
370 shock. To incorporate dollar pricing of a share of domestic sales in the RoW, we consider  
371 a multi-layered production structure in the spirit of Georgiadis & Schumann (2021) and  
372 depicted in Figure D.3

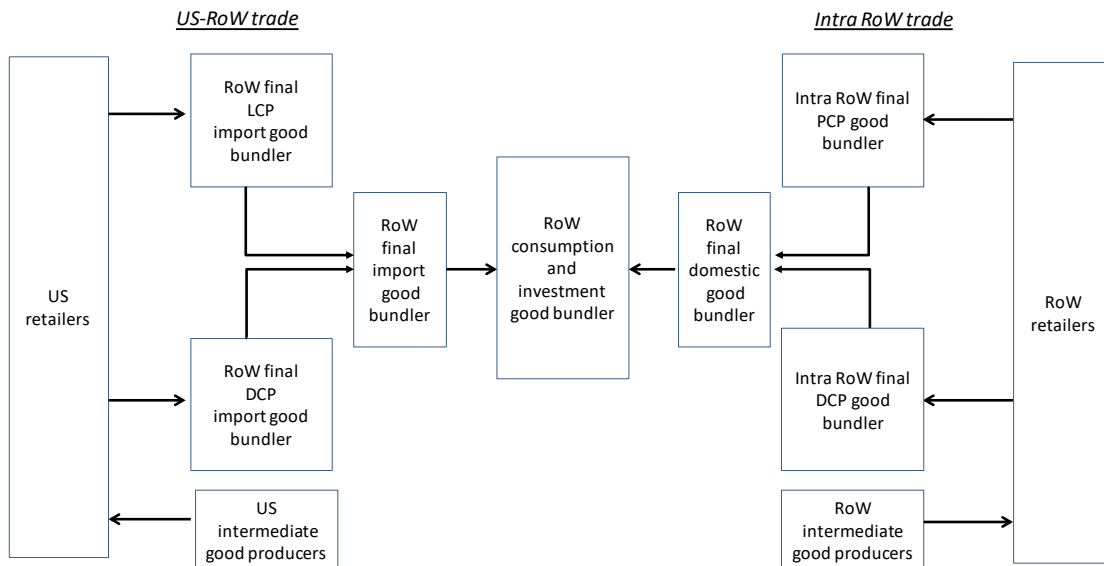
### 373 **D.6.1 Final consumption and investment good**

374 This sector operates at the top layer of this production structure and is populated by a  
375 continuum of firms that operate under perfect competition and combine a final domestically  
376 produced good  $Y_{R,t}^R$  and a final import good  $Y_{U,t}^R$  into a combined final good, employing the  
377 following CES technology

$$Y_{E,t}^C = \left[ n_R^{\frac{1}{\psi_f}} Y_{R,t}^R^{\frac{\psi_f-1}{\psi_f}} + (1 - n_R)^{\frac{1}{\psi_f}} Y_{U,t}^R^{\frac{\psi_f-1}{\psi_f}} \right]^{\frac{\psi_f}{\psi_f-1}}. \quad (\text{D.49})$$



Figure D.3: Multi-layered production structure for the RoW consumption and investment good



Note: The figure lays out the multi-layered production structure in the structural model, focusing on the RoW consumption and investment good.

378 The parameter  $n_R$  governs the share of domestically produced goods and thereby the degree  
 379 of home bias in the assembling process<sup>9</sup>. The parameter  $\psi_f$  on the other hand corresponds  
 380 to the elasticity of substitution between the final domestic and import good.

381 Taking the prices of the domestic final good  $P_{R,t}^R$  and the price of the final import good  
 382 expressed in domestic currency  $(\mathcal{E}_t P_{U,t}^R)^{10}$  as well as total demand from consumers and capital  
 383 producers as given, the optimal demand for goods produced domestically and abroad is

<sup>9</sup>The home bias parameter is adjusted in order to take into account the differences in country size as in Sutherland (2005). In particular, given a degree of general trade openness  $op_R$  and the relative country size of the RoW  $s$ , the parameter  $n_R$  takes the value  $n_R = 1 - op_R(1 - s)$  with a similar adjustment for the US counterpart

<sup>10</sup>Note that because of the pricing-to-market assumption the price for US exports expressed in US-\$  $P_{U,t}^R$  will in general be different from the price charged for US goods sold in the US  $P_{U,t}^U$ .

384 governed by

$$Y_{R,t}^R = n_R \left( \frac{P_{R,t}^R}{P_{R,t}^C} \right)^{-\psi_f} Y_{R,t}^C \quad (\text{D.50})$$

$$Y_{U,t}^R = (1 - n_R) \left( \frac{\mathcal{E}_t P_{U,t}^R}{P_{R,t}^C} \right)^{-\psi_f} Y_{R,t}^C. \quad (\text{D.51})$$

385 Lastly note that the three equations above imply that the price of the final consumption and  
 386 investment good in the RoW  $P_{E,t}^C$  is (up to first order) a weighted average of the prices of the  
 387 final domestic and import good

$$P_{E,t}^c = \left[ n_E P_{E,t}^{E^{1-\psi_f}} + (1 - n_E) (\mathcal{E}_t^F P_{F,t}^E)^{1-\psi_f} \right]^{\frac{1}{1-\psi_f}}. \quad (\text{D.52})$$

### 388 D.6.2 RoW domestically produced and sold final good

389 We assume markets are partly segmented and firms set different prices in different markets  
 390 depending on demand conditions. We assume a fraction of RoW firms  $1 - \gamma_R^R$  sets their  
 391 prices for domestic sales in dollar, while the remaining prices are sticky in RoW currency.  
 392 As in Gopinath et al. (2020), we assume firms cannot choose their pricing currency, but are  
 393 assigned to it exogenously and do not change it over time.

394 The firms that put together the RoW final domestic good  $Y_{R,t}^R$  shown on the right side  
 395 in Figure D.3 operate under perfect competition and combine inputs  $\tilde{Y}_{R,t}^R$  and  $\hat{Y}_{R,t}^R$  using a  
 396 CES technology. The inputs are produced by two branches of firms that also operate under  
 397 perfect competition and combine RoW retail goods. The firms in the first branch combine  
 398 RoW retail goods  $\hat{Y}_{R,t}^R(i)$  priced in dollar (DCP goods) into the RoW final DCP good  $\hat{Y}_{R,t}^R$ ;  
 399 analogously, the firms in the second branch combine RoW retail goods  $\tilde{Y}_{R,t}^R(i)$  priced in the

Table D.1: RoW domestic sales bundling

Production function/Price index	Demand functions
RoW domestically produced final good	
$Y_{R,t}^R = \left[ \gamma_R^R \frac{1}{\tilde{Y}_{R,t}^R} \frac{\psi_i-1}{\psi_i} + (1 - \gamma_R) R^{\frac{1}{\psi_i}} \hat{Y}_{R,t}^R \frac{\psi_i-1}{\psi_i} \right]^{\frac{\psi_i}{\psi_i-1}}$ $P_{R,t}^R = \left[ \gamma_R^R \tilde{P}_{R,t}^{R^{1-\psi_i}} + (1 - \gamma_R^R) \left( \mathcal{E}_t \hat{P}_{R,t}^R \right)^{1-\psi_i} \right]^{\frac{1}{1-\psi_i}}$	$\tilde{Y}_{R,t}^R = \gamma_R^R \left( \frac{\tilde{P}_{R,t}^R}{P_{R,t}^R} \right)^{-\psi_i} Y_{R,t}^R$ $\hat{Y}_{R,t}^R = (1 - \gamma_R^R) \left( \frac{\mathcal{E}_t \hat{P}_{R,t}^R}{P_{R,t}^R} \right)^{-\psi_i} Y_{R,t}^R$
RoW domestically sold PCP good	
$\tilde{Y}_{R,t}^R = \left[ \left( \frac{1}{\gamma_R^R} \right)^{\frac{1}{\psi_i}} \int_0^{\gamma_R^R} \tilde{Y}_{R,t}^R(i)^{\frac{\psi_i-1}{\psi_i}} di \right]^{\frac{\psi_i}{\psi_i-1}}$ $\tilde{P}_{R,t}^R = \left[ \frac{1}{\gamma_R^R} \int_0^{\gamma_R^R} \tilde{P}_{R,t}^R(i)^{1-\psi_i} di \right]^{\frac{1}{1-\psi_i}}$	$\tilde{Y}_{R,t}^R(i) = \frac{1}{\gamma_R^R} \left( \frac{\tilde{P}_{R,t}^R(i)}{\tilde{P}_{R,t}^R} \right)^{-\psi_i} \tilde{Y}_{R,t}^R$ $= \left( \frac{\tilde{P}_{R,t}^R(i)}{\tilde{P}_{R,t}^R} \right)^{-\psi_i} Y_{R,t}^R$
RoW domestically sold DCP good	
$\hat{Y}_{R,t}^R = \left[ \left( \frac{1}{1-\gamma_R^R} \right)^{\frac{1}{\psi_i}} \left( \int_{\gamma_R^R}^1 \hat{Y}_{R,t}^R(i)^{\frac{\psi_i-1}{\psi_i}} di \right) \right]^{\frac{\psi_i}{\psi_i-1}}$ $\mathcal{E}_t \hat{P}_{R,t}^R = \left[ \frac{1}{(1-\gamma_R^R)} \int_{\gamma_R^R}^1 \left( \mathcal{E}_t \hat{P}_{R,t}^R(i) \right)^{1-\psi_i} di \right]^{\frac{1}{1-\psi_i}}$	$\hat{Y}_{R,t}^R(i) = \frac{1}{1-\gamma_R^R} \left( \frac{\mathcal{E}_t \hat{P}_{R,t}^R(i)}{\mathcal{E}_t \hat{P}_{R,t}^R} \right)^{-\psi_i} \hat{Y}_{R,t}^R$ $= \left( \frac{\mathcal{E}_t \hat{P}_{R,t}^R(i)}{\mathcal{E}_t \hat{P}_{R,t}^R} \right)^{-\psi_i} Y_{R,t}^R$

400 producer's currency (PCP goods) into the RoW final PCP good  $\tilde{Y}_{R,t}^R$ .

401 The next layer consists of RoW retail-goods-producing firms which buy and repackage  
402 RoW intermediate goods. These firms operate under monopolistic competition and serve the  
403 RoW as well as the US market; for simplicity Figure D.3 only shows their domestic sales. The  
404 share of RoW retail-goods-producing firms whose domestic sales prices are sticky in dollar is  
405 given by  $(1 - \gamma_R^R)$ . Therefore,  $(1 - \gamma_R^R)$  also reflects the degree to which movements in the  
406 dollar exchange rate cause fluctuations in the RoW aggregate producer-price index  $P_{R,t}^R$ .

407 Table D.1 provides an overview of the core equations and first order conditions for the  
408 multistage bundling process.

### 409 D.6.3 Import good bundling

410 As shown on the left side in Figure D.3, the RoW import good  $Y_{U,t}^R$  is produced analogously  
411 to the RoW final domestic good  $Y_{R,t}^R$ .<sup>11</sup> In particular, RoW final import good producers use

<sup>11</sup>Notice that the subscript indicates the country where the good is produced and the superscript the country where it is consumed.

Table D.2: US import good bundling

Production function/Price index	Demand functions
US final import goods	
$Y_{R,t}^U = \left[ \gamma_U^R \frac{1}{\gamma_U^{\psi_i}} \tilde{Y}_{R,t}^U \frac{\psi_i - 1}{\psi_i} + (1 - \gamma_U)^R \hat{Y}_{R,t}^U \frac{\psi_i - 1}{\psi_i} \right]^{\frac{\psi_i}{\psi_i - 1}}$ $P_{U,t}^{R^I} = \left[ \gamma_F^E \left( \frac{\hat{P}_{E,t}^F}{\mathcal{E}_{E,t}^F} \right)^{1 - \psi_i} + (1 - \gamma_F^E) \hat{P}_{E,t}^{F^{1 - \psi_i}} \right]^{\frac{1}{1 - \psi_i}}$	$\tilde{Y}_{R,t}^U = \gamma_U^R \left( \frac{\hat{P}_{U,t}^R}{\mathcal{E}_t P_{U,t}^{R^I}} \right)^{-\psi_i} Y_{R,t}^U$ $\hat{Y}_{R,t}^U = (1 - \gamma_U^R) \left( \frac{\hat{P}_{R,t}^U}{P_{U,t}^{R^I}} \right)^{-\psi_i} Y_{R,t}^U.$
US imported PCP good	
$\tilde{Y}_{R,t}^U = \left[ \left( \frac{1}{\gamma_F^E} \right)^{\frac{1}{\psi_i}} \left( \int_0^{\gamma_U^R} \tilde{Y}_{R,t}^U(i) \frac{\psi_i - 1}{\psi_i} di \right) \right]^{\frac{\psi_i}{\psi_i - 1}}$ $\frac{\hat{P}_{R,t}^U}{\mathcal{E}_t} = \left[ \frac{1}{\gamma_U^R} \int_0^{\gamma_U^R} \left( \frac{\hat{P}_{R,t}^U(i)}{\mathcal{E}_t} \right)^{1 - \psi_i} di \right]^{\frac{1}{1 - \psi_i}}$	$\tilde{Y}_{R,t}^U(i) = \frac{1}{\gamma_U^R} \left( \frac{\hat{P}_{R,t}^U(i)}{\hat{P}_{U,t}^U} \right)^{-\psi_i} \tilde{Y}_{R,t}^U$ $= \left( \frac{\hat{P}_{R,t}^U(i)}{\mathcal{E}_t P_{U,t}^{R^I}} \right)^{-\psi_i} Y_{R,t}^U$
US imported DCP good	
$\hat{Y}_{R,t}^U = \left[ \left( \frac{1}{1 - \gamma_U^R} \right)^{\frac{1}{\psi_i}} \left( \int_{\gamma_U^R}^1 \hat{Y}_{R,t}^U(i) \frac{\psi_i - 1}{\psi_i} di \right) \right]^{\frac{\psi_i}{\psi_i - 1}}$ $\hat{P}_{R,t}^U = \left[ \frac{1}{(1 - \gamma_U^R)} \int_{\gamma_U^R}^1 \hat{P}_{R,t}^U(i)^{1 - \psi_i} di \right]^{\frac{1}{1 - \psi_i}}$	$\hat{Y}_{R,t}^U(i) = \frac{1}{1 - \gamma_U^R} \left( \frac{\hat{P}_{R,t}^U(i)}{\hat{P}_{R,t}^U} \right)^{-\psi_i} \hat{Y}_{R,t}^U$ $= \left( \frac{\hat{P}_{R,t}^U(i)}{P_{U,t}^{R^I}} \right)^{-\psi_i} Y_{R,t}^U$

412 inputs from two branches of firms that operate under perfect competition and aggregate goods  
413 from US retail goods producers. The latter operate under monopolistic competition and set  
414 prices that are either sticky in the producer's currency (PCP goods) or in the importer's  
415 currency (LCP goods). Likewise, we assume that when exporting a fraction  $(1 - \gamma_U^R)$  of RoW  
416 and  $(1 - \gamma_U^R)$  of US retailers faces prices that are sticky in the currency of the importer, while  
417 the prices of the remaining firms are sticky in the producer's currency.

418 Table D.2 provides an overview of the core equations and first order conditions for the  
419 multistage bundling process of the final import good in the US. Equations are analogues for  
420 the RoW import good bundling process.

## 421 D.7 Retail good pricing

422 There exists a continuum of firms that operate under monopolistic competition and use  
423 intermediate goods to produce a retail good that is eventually sold to the specialized branches

424 farther up. Each retail firm sells its product in the domestic and foreign markets; as mentioned  
425 above, for simplicity we only show sales to RoW in Figure D.3. When selling in the RoW  
426 (i.e. domestic) market, a fraction  $\gamma_R^R$  of RoW retail-goods-producing firms sets prices in RoW  
427 currency, while the remaining  $(1 - \gamma_R^R)$  share of firms sets their prices in dollar. A similar  
428 setting exists in the market for US imports, with  $\gamma_U^R$  indicating the fraction of RoW firms that  
429 price their exports in the producer's currency. Regardless of the pricing currency, all firms use  
430 the same production technology and face the same factor costs. Because firms are subject to  
431 Calvo-style price-setting frictions and can only change their price with a probability  $(1 - \theta_p^R)$   
432 each period, the mark-up of a firm whose price is sticky in dollar fluctuates with the exchange  
433 rate. As RoW firms serving domestic and US markets, respectively, set their prices optimally  
434 and as in each market they use different pricing currencies, their profit functions differ as  
435 shown in table D.3. As standard in Calvo-style price setting, firms choose their optimal reset  
436 price given demand and their pricing currency while taking into account that they might not  
437 be able to reset their price in the future. For instance the optimal price choice of a DCP firm  
438  $i$  for its sales in the RoW market, taking into account the fact that it may not be able to  
439 reset its US-\$ denominated price  $\hat{P}_{E,t}^E(i)$ , can be written as

$$\max_{\hat{P}_{E,t}^E(i)} \mathbb{E}_t \sum_{s=0}^{\infty} \theta_p^{E_s} \Theta_{E,t,t+s} \left[ \mathcal{E}_{E,t}^E \hat{P}_{E,t}^E(i) Y_{E,t}^E(i) - MC_{E,t} Y_{E,t}^E(i) \right]. \quad (\text{D.53})$$

440 It is possible to show that the optimal reset price of a firm that sets its price for the RoW  
441 market in US-\$, relative to the aggregate RoW DCP sales price index  $\hat{P}_{E,t}^E$ , is given by

$$\frac{\hat{P}_{E,t}^E(i)}{\hat{P}_{E,t}^E} = \hat{p}_{E,t}^E = \frac{\psi_i}{(\psi_i - 1)} \frac{\hat{x}_{E,1,t}^E}{\hat{x}_{E,2,t}^E}. \quad (\text{D.54})$$

442 The auxiliary recursive variables  $\hat{x}_{E,1,t}^E$  and  $\hat{x}_{E,2,t}^E$  read as

$$\hat{x}_{E,1,t}^E = \Lambda_{E,t} \left( \frac{\mathcal{E}_{E,t}^F \hat{P}_{E,t}^E}{P_{E,t}^E} \right)^{-\psi_i} Y_{E,t}^E \frac{P_{E,t}^E}{P_{E,t}^C} MC_{E,t}^{rp} + \beta \theta_p \mathbb{E}_t \hat{x}_{E,1,t+1}^E (1 + \hat{\pi}_{E,t+1}^E)^{\psi_i} \quad (\text{D.55})$$

$$\hat{x}_{E,2,t}^E = \Lambda_{E,t} \left( \frac{\mathcal{E}_{E,t}^F \hat{P}_{E,t}^E}{P_{E,t}^E} \right)^{-\psi_i} Y_{E,t}^E \left( \frac{\mathcal{E}_{E,t}^F \hat{P}_{E,t}^E}{P_{E,t}^C} \right) + \beta \theta_p^E \mathbb{E}_t \hat{x}_{E,1,t+1}^E (1 + \hat{\pi}_{E,t+1}^E)^{\psi_i - 1}, \quad (\text{D.56})$$

443 with  $MC_{E,t}^{rp}$  as marginal costs deflated in by the aggregate producer price  $P_{E,t}^E$ . It becomes  
444 apparent that not only does the exchange rate  $\mathcal{E}_{E,t}^F$  impact the optimal DCP price setting  
445 decision as it determines the demand for DCP goods via the relative price  $\frac{\mathcal{E}_{E,t}^F \hat{P}_{E,t}^E}{P_{E,t}^E}$ , it also  
446 impacts the optimal reset price via the term  $\frac{\mathcal{E}_{E,t}^F \hat{P}_{E,t}^E}{P_{E,t}^C}$ , which translates the local currency  
447 revenues that a DCP firm makes from selling one unit of its good  $\mathcal{E}_{E,t}^F \hat{P}_{E,t}^E$  into the unit  
448 of account that the firm's owners (households) care about  $P_{E,t}^C$ . Everything else equal, an  
449 appreciation of the US-\$ exchange rate, will cause the local currency revenues per unit of  
450 DCP good sold to rise, while the input costs, which are denominated in the RoW currency,  
451 remain roughly stable. Thus the mark-up rises above the optimal mark-up and a DCP good  
452 firm would like to lower its US-\$ price in response to an appreciation of the US-\$ over and  
453 above what the induced fall in RoW demand for the DCP good would dictate. It is easy to  
454 verify that when aggregating across intra RoW sales of RoW DCP firms the inflation rate of  
455 the aggregate RoW sales DCP price (expressed in US-\$) is given by

$$1 = (1 - \theta_p) \hat{p}_{E,t}^{E^{1-\psi_i}} + \theta_p (1 + \hat{\pi}_{E,t}^E)^{(\psi_i - 1)}, \quad (\text{D.57})$$

456 where  $\hat{p}_{E,t}^E$  denotes the ratio of the optimal reset price relative to the aggregate price index.

457 Using the profit functions in table D.3 its easy its easy to show similar equations hold for the

Table D.3: Market and pricing paradigm specific profit functions of RoW firms

Type of firm and market	Profit function
RoW market PCP firm	$\tilde{\Pi}_{E,t}^E(i) = \tilde{P}_{E,t}^E(i)\tilde{Y}_{E,t}^E(i) - MC_{E,t}\tilde{Y}_{E,t}^E(i)$
RoW market DCP firm	$\hat{\Pi}_{E,t}^E(i) = \mathcal{E}_{E,t}^F\hat{P}_{E,t}^E(i)\hat{Y}_{E,t}^E(i) - MC_{E,t}\hat{Y}_{E,t}^E(i)$
US import market PCP firm	$\tilde{\Pi}_{E,t}^F(i) = \tilde{P}_{E,t}^F(i)\tilde{Y}_{E,t}^F(i) - MC_{E,t}\tilde{Y}_{E,t}^F(i)$
US import market DCP firm	$\hat{\Pi}_{E,t}^F(i) = \mathcal{E}_{E,t}^F\hat{P}_{E,t}^F(i)\hat{Y}_{E,t}^F(i) - MC_{E,t}\hat{Y}_{E,t}^F(i)$

458 optimal price of RoW retail firms that set their prices in the US import market in US-\$ as  
 459 well as, with slight adaptations, for PCP firms.

### 460 D.7.1 Fiscal and monetary policy

461 We assume the US government issues new bonds and transfers the accrued funds to households  
 462 in a lump-sum fashion. The US government's balance sheet reads as

$$GB_{U,t} = TRA_{U,t} + R_{U,t-1}^{GB}GB_{U,t-1}. \quad (D.58)$$

463 Central banks set the nominal risk-free rate according to a standard Taylor-rule

$$\hat{r}_{i,t} = \rho_{i,r}\hat{r}_{i,t-1} + (1 - \rho_{i,r})(\phi_{i,\pi}\hat{\pi}_{i,t}^c + \phi_{i,z}\hat{z}_{i,t}) + \sigma_{i,\varepsilon}^r\varepsilon_{i,t}^r, \quad i \in U, R, \quad (D.59)$$

464 where  $\pi_{i,t}^C$  is final (consumption) good inflation,  $Z_{i,t}$  real GDP,  $\varepsilon_{i,t}^r$  is a monetary policy shock,  
 465 and hats denote deviations from steady state.

## 466 D.8 Market clearing and the aggregate budget constraint

467 Turning to the market clearing conditions, aggregate demand for the domestic consumption  
 468 good  $Y_{E,t}^C$  is given by the sum of individual demand from all sources that either consume the

469 good or use it as an input in production

$$Y_{R,t}^C = C_{R,t} + I_{R,t} + \frac{\Psi}{2} \left( \frac{In_{R,t} + Iss_R}{In_{R,t-1} + Iss_R} - 1 \right)^2 (In_{R,t} + Iss_R). \quad (\text{D.60})$$

470 Aggregating across all intermediate and retail goods firms and imposing market clearing

471 yields the aggregate production function of the economy

$$Z_{R,t} = (U_{R,t} K_{R,t-1})^\alpha L_{R,t}^{(1-\alpha)} = \delta_{R,t}^R Y_{R,t}^R + \delta_{R,t}^F Y_{R,t}^F, \quad (\text{D.61})$$

472 with  $\delta_{R,t}^R$  and  $\delta_{R,t}^F$  as price dispersion terms which are zero up to a first order approximation.

473  $Y_{R,t}^R$  corresponds to the aggregate domestic demand for the final *domestically produced* RoW

474 good given by

$$Y_{R,t}^R = n_R \left( \frac{P_{R,t}^R}{P_{R,t}^C} \right)^{-\psi_f} Y_{R,t}^C, \quad (\text{D.62})$$

475 with  $Y_{R,t}^C$  as the households and firms demand for the final good. Furthermore the aggregate

476 demand for RoW goods produced for exports reads as

$$Y_{R,t}^F = \frac{1-s}{s} (1-n_F) \left( \frac{\mathcal{E}_t P_{R,t}^F}{P_{F,t}^C} \right)^{-\psi_f} Y_{F,t}^C, \quad (\text{D.63})$$

477 where it is important to note that variables are expressed in per capita terms and therefore,

478 following Sutherland (2005), the relative population size has to be taken when aggregating

479 across countries as indicated by the ratio  $\frac{1-s}{s}$ .

480 We assume financial markets clear, which implies  $GB_{U,t} = \frac{s}{1-s} GB_{R,t}$  and  $CBDL_{U,t} =$

481  $\frac{s}{1-s} CBDL_{R,t}$ , where  $s$  is the relative country size parameter. When aggregating across budget



482 constraints in the RoW, we recover the national accounting identity

$$\begin{aligned}
 RER_t \left[ \left( GB_{R,t} - \frac{R_{U,t-1}^{GB}}{1 + \pi_{U,t}^C} GB_{R,t-1} \right) - \left( CBDDL_{R,t} - \frac{R_{U,t-1}^{CBDL}}{1 + \pi_{U,t}^C} CBDDL_{R,t-1} \right) \right] = & \quad (D.64) \\
 \frac{P_{R,t}^R}{P_{R,t}^C} Y_{R,t}^R + \frac{\mathcal{E}_t P_{R,t}^F}{P_{R,t}^C} Y_{R,t}^U - Y_{R,t}^C. &
 \end{aligned}$$

483 The left-hand side represents the sum of the changes in the RoW net foreign asset position and  
 484 the net financial account, while the right-hand side is the trade balance (taking into account  
 485 that prices charged differ across domestically produced and exported goods). Importantly,  
 486 and in contrast to Akinici & Queralto (2019), Devereux et al. (2020) and many others, we  
 487 explicitly model *gross* rather than only net financial flows. As a consequence, the national  
 488 accounting identity does not dictate the evolution of all financial flows as in a net-flows model.  
 489 In a net-flow model, where, for instance, RoW banks can only borrow in dollars but not hold  
 490 dollar assets (i.e. gross liabilities equal net liabilities), the trade balance and costs of funds  
 491 borrowed in the previous period determine uniquely the foreign banking sector's liability  
 492 position in the next period. In contrast, in our model the national accounting identity only  
 493 uniquely determines the *sum of the changes* in gross assets and liabilities has to equal the  
 494 sum of the trade balance and the financial account.

## 495 **D.9 Calibration**

496 We generally allow parameter values to differ across the US and the RoW (see Table D.4).  
 497 For parameters that govern standard model elements, to the extent possible we draw on  
 498 estimates from existing literature. In particular, for US parameters we rely on Justiniano  
 499 et al. (2010). For the RoW it is more difficult to find suitable estimates, as it reflects an

500 aggregate of countries. Since the euro area accounts for roughly one quarter of the RoW in  
501 the data in terms of output, we use the estimates in Coenen et al. (2018) for many of the  
502 RoW parameters. We next discuss the calibration of the parameters that govern DCP in  
503 trade and cross-border credit.

504       Regarding DCP in trade we first calibrate the relative country size  $s$  such that the  
505 steady-state share of US real GDP in global output is 25%. Given the country sizes, we set  
506 the general RoW openness vis-à-vis the US ( $op_R$ ) such that the steady-state share of imports  
507 from the US in the aggregate RoW bundle ( $1 - \eta_R$ ) is roughly 5.1%, in line with the data  
508 over 1990-2019. In the same vein, we set US trade openness ( $op_U$ ) such that the share of  
509 imports in the US bundle ( $1 - \eta_U$ ) is roughly 14%. We set the share of RoW firms that face  
510 sticky dollar prices when exporting to the US ( $1 - \gamma_U^R$ ) to 93%, in line with invoicing shares  
511 documented in Gopinath (2015). Based on the calculations in Georgiadis & Schumann (2021)  
512 we assume that US exporters almost exclusively face sticky prices in dollar and set  $\gamma_R^U$  to 3%.  
513 We set the share of intra-RoW *sales* that is priced in dollar ( $1 - \gamma_R^R$ ) to 9%, which implies  
514 that 37.5% of intra-RoW *exports* are priced in dollar as indicated by the invoicing data in  
515 Boz et al. (2022).<sup>12</sup> We almost exclusively choose the parameters that govern the endogenous  
516 portfolio choices of RoW and US banks in order to meet some steady-state targets. For  
517 both the US and the RoW banking sectors we follow Akinci & Queralto (2019) and assume  
518 a (risk weight adjusted) steady-state leverage ratio of five. Furthermore, we impose that  
519 the steady-state domestic credit spread ( $R_i^K - R_i$ ) equals 200 basis points, which roughly  
520 corresponds to the average of the GZ-spread of Gilchrist & Zakrajsek (2012). These two

<sup>12</sup>We first calculate the fraction of intra-RoW trade (global exports without US imports and exports) over global non-US GDP and then take the yearly average from 1990-2019 ( $\approx 24\%$ ). Next, we use the average share of global exports invoiced in dollar as calculated in Boz et al. (2022) and subtract the fraction of US trade in global trade to arrive at 37.5%. Multiplying the two numbers we arrive at about 9%.

521 assumptions imply the country specific values for the start-up fund parameter ( $\omega_B$ ) and  
 522 the constants in balance-sheet-specific risk weights ( $\bar{\delta}$ ) shown in Table D.4. We assume an  
 523 average bank planning horizon of 7.5 years, which lies in between the 10 year of Gertler &  
 524 Karadi (2011) and the one in Akinci & Queralto (2019). This implies that we set  $\theta_{U,B} = \theta_{R,B}$   
 525 of 0.9667. For the parameters governing the portfolio choice of US banks we target a risk  
 526 premium that is a fifth of the US domestic credit spread (a conservative choice) as well as an  
 527 annualized steady-state ‘exorbitant privilege’ (Gourinchas & Rey 2007) of 1%, which pins  
 528 down  $\bar{\Gamma}_U^{CDDL}$  and  $\Phi_{U,\phi}$ . For RoW banks we jointly determine the parameters  $\epsilon_{R,\alpha}$ ,  $\bar{\delta}_R$  and  
 529  $\kappa_{R,\alpha,\ell}$  in order to hit three steady state targets: A leverage ratio of five and a portfolio such  
 530 that RoW banks invest 15% of their total liabilities in US Treasuries and finance 25% of their  
 531 total assets using cross-border dollar loans. The latter roughly corresponds to the average  
 532 liability structure of non-US, internationally active banks in the BIS Locational Banking  
 533 Statistics.<sup>13</sup>

534 Finally, we impose that the US and RoW steady-state risk-free rates are 2% and 3.5%,  
 535 respectively. These values roughly correspond to the averages in the data and pin down the  
 536 discount factors  $\beta_U$  and  $\beta_R$ . These assumptions imply that the steady-state trade deficit to  
 537 GDP ratio of the US is 1.8%, which is close to the average in the data. The US finances this  
 538 trade deficit by a positive net financial income, which results from the US earning higher

<sup>13</sup>Combined with the assumption that banks are the only entities engaging in global financial markets our model calibration implies that the RoW has a negative net dollar exposure and is a net debtor to the US ( $\alpha_R^{TREAS} - \ell_R^{CDDL} < 0$ ). While this is in line with the negative net dollar exposures of the RoW banking sector documented in Shin (2012), the entire RoW economy has a positive net dollar exposure vis-à-vis and is a net creditor to the US. This lies at the heart of the ‘exorbitant duty’ (Gourinchas et al. 2012; Gourinchas & Rey 2022). In Georgiadis et al. (2023) we consider a simple extension in which we introduce an additional RoW entity whose asset holdings render the aggregate RoW economy a net creditor with a negative net dollar exposure. We show that when this entity is unconstrained—thus to be thought of as a central bank holding foreign exchange reserves, pension or sovereign wealth funds—the exorbitant duty is an exchange rate valuation effect without real implications.

539 returns from cross-border dollar lending to the RoW than it pays for Treasuries held by the  
540 RoW. Therefore, the US maintains a higher steady-state per capita consumption than the  
541 RoW as a direct consequence of the exorbitant privilege.

Table D.4: Parameter values used in the simulations

Param.	Val.	Description	Source
Households			
$h_R$	0.620	Habit persistence in consumption RoW	CKSW(2018) <sup>a</sup>
$h_U$	0.790	Habit persistence in consumption US	JPT(2010)
$\sigma_c$	1.002	Intertemporal elasticity of substitution	$\approx$ log utility
$\varphi$	2.000	Inverse Frisch elasticity of labor	CKSW(2018)
$\beta_U$	0.995	Discount factor US	2% ann. US rate
$\beta_R$	0.9913	Discount factor ROW	3.5% ann. RoW rate
RoW financial intermediaries			
$\omega_B^U$	0.00036	Start up funds RoW	endogenous in SS
$\theta_B^U$	0.9667	Survival probability of Banks RoW	1/2(AQ(2019)+GK(2011))
$\epsilon_{R,\alpha}$	0.5479	IC parameter for US GB	endogenous in SS
$\Gamma_R^{GB}$	0	Risk weight for US GB	endogenous in SS
$\kappa_{R,\alpha,\ell}$	2.7397	IC parameter unhedged US\$ debt	endogenous in SS
$\bar{\delta}_{B,U}$	0.6790	Constant in incentive constraint (IC)	endogenous in SS
US financial intermediaries			
$\omega_B^U$	0.00026	Start-up funds parameter US	endogenous in SS

Table D.4 –

Param.	Val.	Description	Source
$\theta_B^U$	0.966	Survival probability of Banks US	1/2(AQ(2019)+GK(2011))
$\bar{\delta}_{B,U}$	1.0468	Constant in incentive constraint (IC)	endogenous in SS
$\bar{\Gamma}_U^{CBDL}$	0.3	SS Risk weight of global interbank loans	endogenous in SS
$\Phi_{\Gamma,U}$	0.1012	semielasticity of $\Gamma_U^{CBDL}$ wrt $\phi_{R,t}$	endogenous in SS
$\rho_\delta$	0.95	Common persistence of global risk shock	VAR dynamics
Wage decision			
$\psi_w$	6.000	Elasticity of substitution labor services	20% wage mark up
$\theta_w^R$	0.780	Calvo parameter wages RoW	CKSW(2018)
$\theta_w^U$	0.840	Calvo parameter wages US	JPT(2010)
International trade			
$\psi_f$	1.120	Trade price elasticity	CKSW(2018)
$op_R$	0.200	General trade openness RoW	$\eta_R \approx 0.95$
$op_U$	0.185	General trade openness US	$\eta_U \approx 0.86$
$n$	0.750	Share of RoW in global economy	$1 - \frac{GDP_{US}}{GDP_{RoW}}$
Intermediate goods production			
$\alpha$	0.333	Share of capital in production	AQ(2019)
$\zeta_2$	5.800	Elasticity of depreciation wrt. to utilization	JPT(2010)
$\tau_{R,ss}$	0.020	Normalization parameter depreciation RoW	endogenous in SS
$\zeta_1^R$	0.035	Normalization of utilization parameter RoW	endogenous in SS
$\zeta_1^U$	0.035	Normalization of utilization parameter US	endogenous in SS

Table D.4 –			
Param.	Val.	Description	Source
$\tau_{U,ss}$	0.020	Normalization parameter depreciation US	endogenous in SS
Retail good pricing			
$\psi_i$	6.000	Elasticity of substitution retail goods	20% mark up
$\theta_P^R$	0.820	Calvo parameter retail firms RoW	CKSW(2018)
$\theta_P^U$	0.840	Calvo parameter retail firms US	JPT(2010)
$\widehat{\gamma}_R^R = 1 - \gamma_R^R$	0.09	Share of RoW domestic sales DCP firms	37.5% intra RoW exp.
$\widehat{\gamma}_{UR} = 1 - \gamma_U^R$	0.97	Share of RoW export to US DCP firms	$\approx$ G(2015) invoicing
$\widetilde{\gamma}_R^U = 1 - \gamma_R^U$	0.05	Share of US export LCP firms	$\approx$ G(2015) invoicing
Capital goods production			
$\Psi_R$	5.770	Investment adjustment costs RoW	CKSW(2018)
$\Psi_U$	2.950	Investment adjustment costs US	JPT(2010)
Monetary Policy			
$\rho_{U,r}$	0.930	RoW interest rate smoothing	CKSW(2018)
$\phi_{U,\pi}$	2.740	RoW Taylor Rule coefficient inflation	CKSW(2018)
$\phi_{U,z}$	0.030	RoW Taylor Rule coefficient output	CKSW(2018)
$\rho_{R,r}$	0.810	US interest rate smoothing	JPT (2010)
$\phi_{R,\pi}$	1.970	US Taylor Rule coefficient inflation	JPT(2010)
$\phi_{R,z}$	0.050	US Taylor Rule coefficient output	JPT(2010)
Steady State targets			
$L_{R,ss}$	0.333	SS labor target RoW	GK(2011)

Table D.4 –

Param.	Val.	Description	Source
$U_{ss}$	1.000	SS utilization rate target RoW and US	JPT(2010)
$\tau_{ss}$	0.025	SS depreciation rate target RoW and US	JPT(2010)
$S_{R,ss}$	0.005	SS credit spread target RoW (quarterly)	$\approx$ CKSW(2018)
$S_{U,ss}$	0.005	SS credit spread target US (quarterly)	$\approx$ avg. GZ spread
$\phi_{R,ss}$	5.00	SS (risk weighted) leverage target, RoW	CKSW(2018)
$\phi_{U,ss}^F$	5.00	SS (risk weighted) local leverage target, US	GK(2011)
$\ell_{R,j,t}^{CDDL}$	0.25	SS dollar debt portfolio share RoW	$\approx$ LBS avg.
$\alpha_{R,j,t}^{GB}$	0.15	SS US treasuries portfolio share RoW	$\approx$ LBS avg.
$R_{U,ss}^{CDDL} - R_{U,ss}^{GB}$	0.0025	SS Exorbitant privilege	1% annualized
$CY_{R,ss}$	0.0115	SS convenience yield	$\approx$ JKL(2012)
$RP_{U,ss}^{CDDL}$	0.001	SS interbank risk premium	1/5 of credit spread

<sup>a</sup> GK(2011), JPT(2010), CKSW(2018), GZ(2012), JKL(2021), AQ(2019), G(2015), represent abbreviations for Gertler & Karadi (2011), Justiniano et al. (2010), Coenen et al. (2018), Gilchrist & Zakrajsek (2012), Jiang et al. (2021b) Akinci & Queralto (2019) and Gopinath (2015) respectively.

## 542 E List of all model equations

543 This section contains all the relevant model equations of the Trinity model of Georgiadis et  
544 al. (2023) as they appear in the corresponding code.<sup>14</sup>

<sup>14</sup>The corresponding *DYNARE* file is available upon request

545 **E.1 Households**

546 Marginal Utility RoW

$$\Lambda_{Rt} = \exp\left(\varepsilon_{Rt}^\beta\right) (C_{Rt} - h_R C_{Rt-1})^{(-\sigma_c)} - \beta_R h_R \left(\exp\left(\varepsilon_{Rt+1}^\beta\right) C_{Rt+1} - C_{Rt} h_R\right)^{(-\sigma_c)} \quad (\text{E.1})$$

547 Euler equation RoW

$$\Lambda_{Rt} = \beta_R (1 + R_{Rt}) \frac{\Lambda_{Rt+1}}{1 + \pi_{Rt+1}^C} \quad (\text{E.2})$$

548 Demand shock RoW

$$\varepsilon_{Rt}^\beta = \rho^\beta \varepsilon_{Rt-1}^\beta + \frac{\eta_{Rt}^\beta}{100} \quad (\text{E.3})$$

549 Marginal Utility US

$$\Lambda_{Ut} = \exp\left(\varepsilon_{Ut}^\beta\right) (C_{Ut} - h_U C_{Ut-1})^{(-\sigma_c)} - \beta_U h_U \left(\exp\left(\varepsilon_{Ut+1}^\beta\right) (C_{Ut+1} - C_{Ut} h_U)\right)^{(-\sigma_c)} \quad (\text{E.4})$$

550 Euler equation US

$$\Lambda_{Ut} = \beta_U (1 + R_{Ut}) \frac{\Lambda_{Ut+1}}{1 + \pi_{Ut+1}^C} \quad (\text{E.5})$$

551 Demand Shock US

$$\varepsilon_{Ut}^\beta = \rho^\beta \varepsilon_{Ut-1}^\beta + \frac{\eta_{Ut}^\beta}{100} \quad (\text{E.6})$$

552 UIP deviation

$$\widehat{UIP}_t = (1 + R_{Ut}) (1 + D\mathcal{E}_{t+1}) - (1 + R_{Rt}) \quad (\text{E.7})$$



553 **E.2 RoW financial intermediaries**

554 Discounted excess return to investing in domestic capital RoW

$$v_{Rt} = \Omega_{Rt+1} \left( R_{K,Rt+1} - (1 + R_{Rt}) \right) \quad (\text{E.8})$$

555 Discounted return to equity RoW

$$n_{Rt} = (1 + R_{Rt}) \Omega_{Rt+1} \quad (\text{E.9})$$

556 Aggregate Net worth RoW financial sector

$$N_{Rt} = N_{R,et} + N_{R,nt} \quad (\text{E.10})$$

557 RoW credit spread

$$S_{Rt} = R_{K,Rt+1} - (1 + R_{Rt}) \quad (\text{E.11})$$

558 RoW capital price expressed in dollars

$$Q_{R,US\$t} = \frac{Q_{Rt}}{RE_{Rt}} \quad (\text{E.12})$$

559 Aggregate Assets RoW (taking into account that  $\phi_{R,t}$  is the *risk adjusted* leverage ratio in the code)

$$AS_{Rt} = \frac{N_{Rt} \phi_{Rt}}{(1 - \alpha_R^{GB})_t + \Gamma_R^{GB} \alpha_R^{GB}_t} \quad (\text{E.13})$$

560 Net Worth of new banks RoW

$$N_{R,nt} = \omega^R (AS_{R,t-1}) \quad (\text{E.14})$$

561 Discounted excess costs of borrowing in Dollars

$$u_{Rt} = \Omega_{Rt+1} \left( (1 + D\mathcal{E}_{t+1}) R_{U,t}^{CDDL} - (1 + R_{Rt}) \right) \quad (\text{E.15})$$

562 RoW banks stochastic discount factor

$$\Omega_{Rt} = \beta_R \frac{\Lambda_{Rt}}{\Lambda_{Rt-1}} \frac{1}{1 + \pi_{Rt}^C} \left( 1 - \theta_B^R + \theta_B^R \left( n_{Rt} + (v_{Rt} (1 - \alpha_R^{GB})_t + \alpha_R^{GB} v_{Rt}^{GB} - u_{Rt} \ell_{R,t}^{CDDL}) \frac{\phi_{Rt}}{(1 - \alpha_R^{GB})_t + \Gamma_R^{GB} \alpha_R^{GB} \phi_{Rt}} \right) \right) \quad (\text{E.16})$$

563 FOC optimal liability choice RoW

$$-u_{Rt} = \frac{\delta'_{R,\ell t}}{\delta_{R,Bt}} \left( v_{Rt} (1 - \alpha_R^{GB})_t + \alpha_R^{GB} (v_{Rt}^{GB} + CV_{Rt}) \right) \quad (\text{E.17})$$

564 Risk weight adjusted optimal leverage ratio RoW

$$\phi_{Rt} = \frac{n_{Rt} \left( (1 - \alpha_R^{GB})_t + \Gamma_R^{GB} \alpha_R^{GB} \phi_{Rt} \right)}{u_{Rt} \ell_{R,t}^{CDDL} + (1 - \alpha_R^{GB})_t \delta_{R,Bt} + \alpha_R^{GB} \Gamma_R^{GB} \delta_{R,Bt} - v_{Rt} (1 - \alpha_R^{GB})_t - \alpha_R^{GB} v_{Rt}^{GB}} \quad (\text{E.18})$$

565 Time varying balance sheet specific risk weight RoW

$$\delta_{R,Bt} = \bar{\delta}_R \left( 1 - \alpha_R^{GB} \epsilon_{R,\alpha} + \frac{\kappa_{R,\alpha,\ell t}}{2} (\alpha_R^{GB} - \ell_{R,t}^{CDDL})^2 \exp(\epsilon^{\delta^R}_t) \right) \quad (\text{E.19})$$

566 Risk aversion shock RoW

$$\epsilon^{\delta^R}_t = \rho^\delta \epsilon^{\delta^R}_{t-1} + \sigma_\eta^{\delta^R} \eta_{Ut}^\delta + \sigma_\eta^{\delta^G} \eta_{Gt}^\delta \quad (\text{E.20})$$

567 LOM aggregate equity of existing banks RoW banking sector

$$N_{R,e_t} = \frac{1}{1 + \pi_{Rt}^C} \theta_B^R \left( (R_{K,Rt} - (1 + R_{Rt-1})) (1 - \alpha_R^{GB})_{t-1} + ((1 + D\mathcal{E}_t) R_{R,t-1}^{GB} - (1 + R_{Rt-1})) \alpha_{R,t-1}^{GB} \right. \\ \left. - ((1 + D\mathcal{E}_t) R_{U,t-1}^{CDDL} - (1 + R_{Rt-1})) \ell_{R,t-1}^{CDDL} AS_{Rt-1} + (1 + R_{Rt-1}) N_{Rt-1} \right) \quad (\text{E.21})$$

568 Definition of CBDL portfolio share

$$\ell_{R,t}^{CBDL} = \frac{RER_t CBDL_{R,t}}{AS_{Rt}} \quad (\text{E.22})$$

569 Aggregate assets RoW banking sector

$$AS_{Rt} = Q_{Rt} K_{Rt} + RER_t GB_{Rt} \quad (\text{E.23})$$

570 Definition of US treasury portfolio share RoW

$$\alpha_{R,t}^{GB} = \frac{GB_{R,val_t}}{AS_{Rt}} \quad (\text{E.24})$$

571 Definition of domestic investment portfolio share RoW (redundant)

$$(1 - \alpha_{R,t}^{GB}) = \frac{Q_{Rt} K_{Rt}}{AS_{Rt}} \quad (\text{E.25})$$

572 Total value of US treasuries held by RoW banks

$$GB_{R,val_t} = RER_t GB_{Rt} \quad (\text{E.26})$$

573 Return on treasuries (in US- $\$$ )

$$R_{R,t}^{GB} = 1 + R_{Ut} \quad (\text{E.27})$$

574 Discounted excess returns (in RoW currency) from investing in US treasuries

$$v_{R,t}^{GB} = \Omega_{Rt+1} \left( (1 + D\mathcal{E}_{t+1}) R_{R,t}^{GB} - (1 + R_{Rt}) \right) \quad (\text{E.28})$$

575 Derivative of time varying balance sheet specific risk weight wrt. CBDL share

$$\delta'_{R,\ell_t} = \bar{\delta}_R (\epsilon_{R,\ell} (\ell_{R,t}^{CBDL} - \bar{\ell}_R) + \kappa_{R,\alpha,\ell_t} (\ell_{R,t}^{CBDL} - \alpha_{R,t}^{GB})) \quad (\text{E.29})$$

576 Derivative of time varying balance sheet specific risk weight wrt. treasury share

$$\delta'_{R,\alpha_t} = \bar{\delta}_R (\kappa_{R,\alpha,\ell_t} (\alpha_{R,t}^{GB} - \ell_{R,t}^{CBDL}) - \epsilon_{R,\alpha}) \quad (\text{E.30})$$

577 Convenience yield from investing in treasuries RoW banks

$$CV_{Rt} = v_{Rt} \left( - \left( (1 - \alpha_{R,t}^{GB}) + \Gamma_{R,t}^{GB} \alpha_{R,t}^{GB} \right) \frac{\delta'_{R,\alpha_t}}{\delta_{R,Bt}} \right) \quad (\text{E.31})$$

578 FOC asset choice

$$v_{R,t}^{GB} = v_{Rt} \Gamma_{R,t}^{GB} - CV_{Rt} \quad (\text{E.32})$$

### 579 **E.3 US financial intermediaries**

580 Discounted returns to investing domestically US

$$v_{Ut} = \Omega_{Ut+1} \left( R_{K,U_{t+1}} - (1 + R_{Ut}) \right) \quad (\text{E.33})$$

581 Discounted returns to equity US

$$n_{Ut} = (1 + R_{Ut}) \Omega_{Ut+1} \quad (\text{E.34})$$

582 US balance sheet specific risk weight (constant up to shock)

$$\delta^U_t = \bar{\delta}_U \exp(\epsilon^{\delta}_{Ut}) \quad (\text{E.35})$$

583 US risk aversion shock

$$\epsilon_{U_t}^\delta = \sigma_\eta^{\delta_G} \eta_{G_t}^\delta + \rho^\delta \epsilon_{U_{t-1}}^\delta + \sigma_\eta^{\delta_U} \eta_{R_t}^\delta \quad (\text{E.36})$$

584 Aggregate equity US financial sector

$$N_{U_t} = N_{U,e_t} + N_{U,n_t} \quad (\text{E.37})$$

585 Credit spread US

$$S_{U_t} = R_{K,U_{t+1}} - (1 + R_{U_t}) \quad (\text{E.38})$$

586 Aggregate equity US financial sector

$$N_{U,n_t} = \omega^U AS_{U,t-1} \quad (\text{E.39})$$

587 Time varying asset specific risk weight of cross border lending

$$\Gamma_{U_t}^{CDDL} = \Gamma_{R,ss}^{CDDL} \exp(\epsilon_{\Gamma_t}) + \Phi_U^\Gamma (\phi_{R_t} - (\bar{\phi}_R)) \quad (\text{E.40})$$

588 Shock to asset specific risk weight of cross border dollar lending

$$\epsilon_{\Gamma_t} = \rho_\Gamma \epsilon_{\Gamma_{t-1}} + \sigma_\eta^\Gamma \eta_{U_t}^\Gamma \quad (\text{E.41})$$

589 Ratio of total CDDL to domestic lending (This is equivalent to  $\alpha_{U,t}^{CDDL}/(1 - \alpha_{U,t}^{CDDL})$ )

$$\xi_{U_t}^{CDDL} = \frac{AS_{R_t} \ell_{R,t}^{CDDL} \frac{s}{1-s}}{RER_t Q_{U_t} K_{U_t}} \quad (\text{E.42})$$

590 Ratio of total CBDL to domestic lending excluding valuation effects

$$\xi_{U,real,t}^{CBDL} = \frac{AS_{Rt} \ell_{R,t}^{CBDL} \frac{s}{1-s}}{RER_t K_{Ut}} \quad (E.43)$$

591 Stochastic discount factor US Banks

$$\Omega_{Ut} = \beta_U \frac{\Lambda_{Ut}}{\Lambda_{Ut-1}} \frac{1}{1 + \pi_{Ut}^C} \left( 1 - \theta_B^U + \theta_B^U \left( n_{Ut} + \frac{v_{Ut} + \xi_{U,t}^{CBDL} v_{U,t}^{CBDL}}{1 + \Gamma_{U,t}^{CBDL} \xi_{U,t}^{CBDL}} \phi_{Ut} \right) \right) \quad (E.44)$$

592 Discounted excess returns from cross border lending

$$v_{U,t}^{CBDL} = \Omega_{Ut+1} (R_{U,t}^{CBDL} - (1 + R_{Ut})) \quad (E.45)$$

593 CBDL risk premium in Dollar

$$RP_{U,t}^{CBDL} = \Phi_U^\Gamma (v_{Ut} + \xi_{U,t}^{CBDL} v_{U,t}^{CBDL}) \frac{K_{Ut} Q_{Ut} RER_t \frac{(1-s)}{s} \xi_{U,t}^{CBDL}}{N_{Rt}} \quad (E.46)$$

594 FOC optimal asset choice US

$$v_{U,t}^{CBDL} = RP_{E,b,t}^F + v_{Ut} \Gamma_{U,t}^{CBDL} \quad (E.47)$$

595 Existing banks equity US

$$N_{U,e_t} = \frac{1}{1 + \pi_{Ut}^C} \theta_B^U \left( K_{Ut-1} (R_{K,Ut} - (1 + R_{Ut-1})) + (R_{U,t-1}^{CBDL} - (1 + R_{Ut-1})) \xi_{U,t-1}^{CBDL} Q_{Ut-1} \right. \\ \left. + (1 + R_{Ut-1}) N_{Ut-1} \right) \quad (E.48)$$

596 Definition of aggregate assets US banks

$$AS_{Ut} = K_{Ut} Q_{Ut} (1 + \xi_{U,t}^{CBDL}) \quad (E.49)$$

597 Definition of of portfolio share of domestic investment (redundant)

$$(1 - \alpha_{U,t}^{CDDL}) = \frac{Q_{U,t} K_{U,t}}{AS_{U,t}} \quad (\text{E.50})$$

598 Definition of of portfolio share of CDDL investment US

$$\alpha_{U,t}^{CDDL} = \frac{CDDL_{Rt} \frac{s}{1-s}}{AS_{U,t}} \quad (\text{E.51})$$

599 Risk weight adjusted optimal leverage ratio US

$$\phi_{U,t} = \frac{n_{U,t} \left( (1 - \alpha_{U,t}^{CDDL}) + \Gamma_{U,t}^{CDDL} \alpha_{U,t}^{CDDL} \right)}{\delta_{U,t} \left( (1 - \alpha_{U,t}^{CDDL}) + \Gamma_{U,t}^{CDDL} \alpha_{U,t}^{CDDL} \right) - v_{U,t} (1 - \alpha_{U,t}^{CDDL}) - v_{U,t}^{CDDL} \alpha_{U,t}^{CDDL}} \quad (\text{E.52})$$

600 Aggregate Assets US (taking into account that  $\phi_{U,t}$  is the *risk adjusted* leverage ratio in the code)

$$AS_{U,t} = \frac{N_{U,t} \phi_{U,t}}{(1 - \alpha_{U,t}^{CDDL}) + \Gamma_{U,t}^{CDDL} \alpha_{U,t}^{CDDL}} \quad (\text{E.53})$$

601 Cross border lending spread (in US- $\$$ )

$$S_{U,t}^{CDDL} = R_{U,t}^{CDDL} - (1 + R_{U,t}) \quad (\text{E.54})$$

## 602 **E.4 Wage setting**

603 Numerator Calvo style wages RoW

$$X_{1,R_t}^w = \kappa_w^R \exp(\epsilon_{R,t}^W) w_{R,t}^{\psi_w (1+\varphi)} L_{R,t}^{1+\varphi} + \beta_R \theta_w^R (1 + \pi_{R,t+1}^C)^{\psi_w (1+\varphi)} X_{1,R_{t+1}}^w \quad (\text{E.55})$$

604 Denominator Calvo style wages RoW

$$X_{2,R_t}^w = L_{R,t} \Lambda_{R,t} w_{R,t}^{\psi_w} + \beta_R \theta_w^R (1 + \pi_{R,t+1}^C)^{\psi_w - 1} X_{2,R_{t+1}}^w \quad (\text{E.56})$$

605 Optimal real reset wage RoW

$$\tilde{w}_{Rt}^{1+\psi_w \varphi} = \frac{X_{1,Rt}^w \frac{\psi_w}{\psi_w-1}}{X_{2,Rt}^w} \quad (\text{E.57})$$

606 Evolution real wage RoW

$$w_{Rt}^{1-\psi_w} = (1 - \theta_w^R) \tilde{w}_{Rt}^{1-\psi_w} + \theta_w^R (1 + \pi_{Rt}^C)^{\psi_w-1} w_{Rt-1}^{1-\psi_w} \quad (\text{E.58})$$

607 Labor supply shock RoW (redundant)

$$\epsilon_{Rt}^W = \rho_w \epsilon_{Rt-1}^W + \frac{\eta_{Rt}^W}{100} \quad (\text{E.59})$$

608 Numerator Calvo style wages US

$$X_{1,Ut}^w = \kappa_w^U \exp(\epsilon_{Ut}^W) w_{Ut}^{\psi_w(1+\varphi)} L_{Ut}^{1+\varphi} + \beta_U \theta_w^U (1 + \pi_{Ut+1}^C)^{\psi_w(1+\varphi)} X_{1,Ut+1}^w \quad (\text{E.60})$$

609 Denominator Calvo style wages US

$$X_{2,Ut}^w = L_{Ut} \Lambda_{Ut} w_{Ut}^{\psi_w} + \beta_U \theta_w^U (1 + \pi_{Ut+1}^C)^{\psi_w-1} X_{2,Ut+1}^w \quad (\text{E.61})$$

610 Optimal real reset wage US

$$\tilde{w}_{Ut}^{1+\psi_w \varphi} = \frac{\frac{\psi_w}{\psi_w-1} X_{1,Ut}^w}{X_{2,Ut}^w} \quad (\text{E.62})$$

611 Evolution of real wage US

$$w_{Ut}^{1-\psi_w} = (1 - \theta_w^U) \tilde{w}_{Ut}^{1-\psi_w} + \theta_w^U (1 + \pi_{Ut}^C)^{\psi_w-1} w_{Ut-1}^{1-\psi_w} \quad (\text{E.63})$$



612 Labour Supply Shock US (redundant)

$$\epsilon_{U,t}^W = \rho_w \epsilon_{U,t-1}^W + \frac{\eta_{U,t}^W}{100} \quad (\text{E.64})$$

## 613 **E.5 Final Good Bundler**

614 RoW demand for domestically produced goods

$$Y_{R,t}^R = \eta_{R,t} \exp(\epsilon_{R,t}^\eta) IP_{R,t}^{(-\psi_f)} Y_{R,t}^C \quad (\text{E.65})$$

615 RoW demand for import good from the US

$$Y_{U,t}^R = Y_{R,t}^C \frac{n}{1-n} (1 - \eta_{R,t} \exp(\epsilon_{R,t}^\eta)) (IP_{R,t} IT_{R,t}^U)^{(-\psi_f)} \quad (\text{E.66})$$

616 RoW home bias shock (redundant)

$$\epsilon_{R,t}^\eta = \rho_\eta \epsilon_{R,t-1}^\eta + \frac{\eta_{R,t}^\eta}{100} \quad (\text{E.67})$$

617 US demand for domestically produced goods

$$Y_{U,t}^U = \eta_{F,t} \exp(\epsilon_{U,t}^\eta) IP_{U,t}^{(-\psi_f)} Y_{U,t}^C \quad (\text{E.68})$$

618 US demand for for import good from RoW

$$Y_{R,t}^U = Y_{U,t}^C \frac{1-n}{n} (1 - \eta_{F,t} \exp(\epsilon_{U,t}^\eta)) (IP_{U,t} IT_{U,t}^R)^{(-\psi_f)} \quad (\text{E.69})$$

619 Definition of US imports (in US per capita units)

$$Imp_{U,t} = Y_{U,t}^C (1 - \eta_{F,t} \exp(\epsilon_{U,t}^\eta)) (IP_{U,t} IT_{U,t}^R)^{(-\psi_f)} \quad (\text{E.70})$$

620 US home bias shock (redundant)

$$\epsilon_{Ut}^\eta = \rho_\eta \epsilon_{Ut-1}^\eta + \frac{\eta_{Ut}^\eta}{100} \quad (\text{E.71})$$

621 Definition of US export import ratio

$$\frac{Exp}{imp_{Ut}} = \frac{Y_{U,t}^R}{Imp_{Ut}} \quad (\text{E.72})$$

## 622 **E.6 Intermediate Goods producers**

623 Depreciation Function RoW

$$\tau_{Rt} = \tau_{R,ss,scale} + \frac{\zeta_1^R U_{Rt}^{1+\zeta_2}}{1 + \zeta_2} \quad (\text{E.73})$$

624 Derivative Depreciation Function RoW

$$\tau'_{Rt} = \zeta_1^R U_{Rt}^{\zeta_2} \quad (\text{E.74})$$

625 Optimal RoW capital services to labor ratio (implicitly defining optimal utilization)

$$\frac{w_{Rt}}{\tau'_{Rt}} = \frac{\frac{1-\alpha}{\alpha} K_{Rt-1} U_{Rt}}{L_{Rt}} \quad (\text{E.75})$$

626 Real marginal costs in CPI terms RoW

$$MC_{Rt}^r = \frac{w_{Rt}^{1-\alpha} \tau'_{Rt}^\alpha}{(1-\alpha)^{1-\alpha} \alpha^\alpha} \quad (\text{E.76})$$

627 Real marginal costs in PPI terms RoW

$$MC_{Rt}^{rp} = \frac{MC_{Rt}^r}{IP_{Rt}} \quad (\text{E.77})$$

628 RoW gross returns to capital

$$R_{K,R_t} = (1 + \pi_{R_t}^C) \frac{Q_{R_t} + \frac{\alpha MC_{R_t}^r Z_{R_t}}{K_{R_{t-1}}} - \tau_{R_t}}{Q_{R_{t-1}}} \quad (\text{E.78})$$

629 Depreciation Function US

$$\tau_{U_t} = \tau_{U,ss, scale} + \frac{\zeta_1^U U_{U_t}^{1+\zeta_2}}{1 + \zeta_2} \quad (\text{E.79})$$

630 Derivative Depreciation Function US

$$\tau'_{U_t} = \zeta_1^U U_{U_t}^{\zeta_2} \quad (\text{E.80})$$

631 Optimal US capital services to labor ratio (implicitly defining optimal utilization)

$$\frac{w_{U_t}}{\tau'_{U_t}} = \frac{1-\alpha}{\alpha} \frac{K_{U_{t-1}} U_{U_t}}{L_{U_t}} \quad (\text{E.81})$$

632 Real marginal costs in US CPI

$$MC_{U_t}^r = \frac{w_{U_t}^{1-\alpha} \tau'_{U_t} \alpha}{(1-\alpha)^{1-\alpha} \alpha^\alpha} \quad (\text{E.82})$$

633 Real marginal costs in US PPI terms

$$MC_{U_t}^{rp} = \frac{MC_{U_t}^r}{IP_{U_t}} \quad (\text{E.83})$$

634 US gross returns to capital

$$R_{K,U_t} = (1 + \pi_{U_t}^C) \frac{Q_{U_t} + \frac{\alpha MC_{U_t}^r Z_{U_t}}{K_{U_{t-1}}} - \tau_{U_t}}{Q_{U_{t-1}}} \quad (\text{E.84})$$

635 **E.7 RoW Capital Goods Producers**

636 RoW Tobins Q/RoW Price of Capital

$$\begin{aligned}
 Q_{Rt} = & 1 + \frac{\Psi_R}{2} \left( \frac{In_{Rt} + (\bar{I}_R)}{(\bar{I}_R) + In_{Rt-1}} - 1 \right)^2 + \frac{In_{Rt} + (\bar{I}_R)}{(\bar{I}_R) + In_{Rt-1}} \Psi_R \left( \frac{In_{Rt} + (\bar{I}_R)}{(\bar{I}_R) + In_{Rt-1}} - 1 \right) \\
 & - \Psi_R \frac{\beta_R \Lambda_{Rt+1}}{\Lambda_{Rt}} \left( \frac{(\bar{I}_R) + In_{Rt+1}}{In_{Rt} + (\bar{I}_R)} - 1 \right) \left( \frac{(\bar{I}_R) + In_{Rt+1}}{In_{Rt} + (\bar{I}_R)} \right)^2
 \end{aligned} \tag{E.85}$$

637 RoW LOM for capital

$$K_{Rt} = K_{Rt-1} + In_{Rt} \tag{E.86}$$

638 Definition of net investment

$$In_{Rt} = I_{Rt} - K_{Rt-1} \tau_{Rt} \tag{E.87}$$

639 US Tobins Q/US Price of Capital

$$\begin{aligned}
 Q_{Ut} = & 1 + \frac{\Psi_U}{2} \left( \frac{In_{Ut} + (\bar{I}_U)}{(\bar{I}_U) + In_{Ut-1}} - 1 \right)^2 + \frac{In_{Ut} + (\bar{I}_U)}{(\bar{I}_U) + In_{Ut-1}} \Psi_U \left( \frac{In_{Ut} + (\bar{I}_U)}{(\bar{I}_U) + In_{Ut-1}} - 1 \right) \\
 & - \Psi_U \frac{\beta_U \Lambda_{Ut+1}}{\Lambda_{Ut}} \left( \frac{(\bar{I}_U) + In_{Ut+1}}{In_{Ut} + (\bar{I}_U)} - 1 \right) \left( \frac{(\bar{I}_U) + In_{Ut+1}}{In_{Ut} + (\bar{I}_U)} \right)^2
 \end{aligned} \tag{E.88}$$

640 US LOM for capital

$$K_{Ut} = K_{Ut-1} + In_{Ut} \tag{E.89}$$

641 US definition of net investment

$$In_{Ut} = I_{Ut} - K_{Ut-1} \tau_{Ut} \tag{E.90}$$

## 642 E.8 Intra RoW retail good pricing

643 Numerator Calvo pricing PCP intra RoW sales

$$\tilde{X}_{R,1t}^R = Y_{Rt}^R MC_{Rt}^{rp} IP_{Rt} \Lambda_{Rt} \widetilde{CP}_{Rt}^{R(-\psi_i)} + \beta_R \theta_P^R (1 + \tilde{\pi}_{Rt+1}^R)^{\psi_i} \tilde{X}_{R,1t+1}^R \quad (\text{E.91})$$

644 Denominator Calvo pricing PCP intra RoW sales

$$\tilde{X}_{R,2t}^R = Y_{Rt}^R IP_{Rt} \Lambda_{Rt} \widetilde{CP}_{Rt}^{R1-\psi_i} + \beta_R \theta_P^R (1 + \tilde{\pi}_{Rt+1}^R)^{\psi_i-1} \tilde{X}_{R,2t+1}^R \quad (\text{E.92})$$

645 Optimal reset price Calvo pricing PCP intra RoW sales

$$\tilde{p}_{Rt}^R = \frac{\tilde{X}_{R,1t}^R \frac{\psi_i}{\psi_i-1}}{\tilde{X}_{R,2t}^R} \quad (\text{E.93})$$

646 RoW domestic sales PCP retailers inflation

$$1 = (1 - \theta_P^R) \tilde{p}_{Rt}^{R1-\psi_i} + \theta_P^R (1 + \tilde{\pi}_{Rt}^R)^{\psi_i-1} \quad (\text{E.94})$$

647 Numerator Calvo pricing DCP intra RoW sales

$$\hat{X}_{R,1t}^R = Y_{Rt}^R MC_{Rt}^{rp} IP_{Rt} \Lambda_{Rt} \widehat{CP}_{Rt}^{R(-\psi_i)} + \beta_R \theta_P^R (1 + \hat{\pi}_{Rt+1}^R)^{\psi_i} \hat{X}_{R,1t+1}^R \quad (\text{E.95})$$

648 Denominator Calvo pricing DCP intra RoW sales

$$\hat{X}_{R,2t}^R = Y_{Rt}^R IP_{Rt} \Lambda_{Rt} \widehat{CP}_{Rt}^{R1-\psi_i} + \beta_R \theta_P^R (1 + \hat{\pi}_{Rt+1}^R)^{\psi_i-1} \hat{X}_{R,2t+1}^R \quad (\text{E.96})$$

649 Optimal reset price Calvo pricing DCP intra RoW sales

$$\hat{p}_{Rt}^R = \frac{\frac{\psi_i}{\psi_i-1} \hat{X}_{R,1t}^R}{\hat{X}_{R,2t}^R} \quad (\text{E.97})$$

650 RoW domestic sales DCP retailers inflation

$$1 = (1 - \theta_P^R) \hat{p}_{Rt}^{R^{1-\psi_i}} + \theta_P^R (1 + \hat{\pi}_{Rt}^R)^{\psi_i-1} \quad (\text{E.98})$$

## 651 **E.9 Intra US retail good pricing**

652 Numerator Calvo pricing intra US sales

$$X_{U,1t}^U = Y_{U,t}^U MC_{U,t}^{r_p} \Lambda_{U,t} IP_{U,t} + \beta_U \theta_P^U (1 + \pi_{U,t+1}^U)^{\psi_i} X_{U,1,t+1}^U \quad (\text{E.99})$$

653 Denominator Calvo pricing intra US sales

$$X_{U,2t}^U = Y_{U,t}^U \Lambda_{U,t} IP_{U,t} + \beta_U \theta_P^U (1 + \pi_{U,t+1}^U)^{\psi_i-1} X_{U,2,t+1}^U \quad (\text{E.100})$$

654 Optimal reset price Calvo pricing intra US sales

$$\bar{p}_{U,t}^U = \frac{\frac{\psi_i}{\psi_i-1} X_{U,1t}^U}{X_{U,2t}^U} \quad (\text{E.101})$$

655 US domestic retail good price inflation

$$1 = (1 - \theta_P^U) \bar{p}_{U,t}^{U^{1-\psi_i}} + \theta_P^U (1 + \pi_{U,t}^U)^{\psi_i-1} \quad (\text{E.102})$$

## 656 **E.10 Export Pricing**

657 Numerator Calvo Pricing RoW PCP exports to US

$$\tilde{X}_{R,1t}^U = Y_{R,t}^U IP_{Rt} MC_{R,t}^{r_p} \Lambda_{Rt} \widetilde{CP}_{Rt}^{U(-\psi_i)} + \beta_R \theta_P^R (1 + \tilde{\pi}_{R,t+1}^U)^{\psi_i} \tilde{X}_{R,1,t+1}^U \quad (\text{E.103})$$

658 Denominator Calvo Pricing RoW PCP exports to US

$$\tilde{X}_{R,2t}^U = Y_{Rt}^U IP_{Rt} \Lambda_{Rt} \widetilde{CP}_{Rt}^{U(-\psi_i)} \widetilde{EM}_{Rt}^U + \beta_R \theta_P^R (1 + \tilde{\pi}_{Rt+1}^U)^{\psi_i-1} \tilde{X}_{R,2t+1}^U \quad (\text{E.104})$$

659 Optimal reset price Calvo Pricing RoW PCP exports to US

$$\tilde{p}_{Rt}^U = \frac{\frac{\psi_i}{\psi_i-1} \tilde{X}_{R,1t}^U}{\tilde{X}_{R,2t}^U} \quad (\text{E.105})$$

660 PCP price inflation RoW exports to US

$$1 = (1 - \theta_P^R) \tilde{p}_{Rt}^{U^{1-\psi_i}} + \theta_P^R (1 + \tilde{\pi}_{Rt}^U)^{\psi_i-1} \quad (\text{E.106})$$

661 Numerator Calvo Pricing RoW DCP exports to US

$$\hat{X}_{R,1t}^U = Y_{Rt}^U IP_{Rt} MC_{Rt}^{r_p} \Lambda_{Rt} \widehat{CP}_{Rt}^{U(-\psi_i)} + \beta_R \theta_P^R (1 + \hat{\pi}_{Rt+1}^U)^{\psi_i} \hat{X}_{R,1t+1}^U \quad (\text{E.107})$$

662 Denominator Calvo Pricing RoW DCP exports to US

$$\hat{X}_{R,2t}^U = Y_{Rt}^U IP_{Rt} \Lambda_{Rt} \widehat{CP}_{Rt}^{U(-\psi_i)} \widehat{EM}_{Rt}^U + \beta_R \theta_P^R (1 + \hat{\pi}_{Rt+1}^U)^{\psi_i-1} \hat{X}_{R,2t+1}^U \quad (\text{E.108})$$

663 Optimal reset price Calvo Pricing RoW DCP exports to US

$$\hat{p}_{Rt}^U = \frac{\frac{\psi_i}{\psi_i-1} \hat{X}_{R,1t}^U}{\hat{X}_{R,2t}^U} \quad (\text{E.109})$$

664 DCP price inflation RoW exports to US

$$1 = (1 - \theta_P^R) \hat{p}_{Rt}^{U^{1-\psi_i}} + \theta_P^R (1 + \hat{\pi}_{Rt}^U)^{\psi_i-1} \quad (\text{E.110})$$

665 Numerator Calvo Pricing US DCP exports to RoW

$$\tilde{X}_{U,1t}^R = Y_{U,t}^R IP_{U,t} MC_{U,t}^{rp} \Lambda_{U,t} \widetilde{CP}_{U,t}^{R(-\psi_i)} + \beta_U \theta_P^U (1 + \tilde{\pi}_{U,t+1}^R)^{\psi_i} \tilde{X}_{U,1t+1}^R \quad (\text{E.111})$$

666 Denominator Calvo Pricing US DCP exports to RoW

$$\tilde{X}_{U,2t}^R = Y_{U,t}^R IP_{U,t} \Lambda_{U,t} \widetilde{CP}_{U,t}^{R(-\psi_i)} \widetilde{EM}_{U,t}^R + \beta_U \theta_P^U (1 + \tilde{\pi}_{U,t+1}^R)^{\psi_i-1} \tilde{X}_{U,2t+1}^R \quad (\text{E.112})$$

667 Optimal reset price Calvo Pricing US DCP exports to RoW

$$\tilde{p}_{U,t}^R = \frac{\frac{\psi_i}{\psi_i-1} \tilde{X}_{U,1t}^R}{\tilde{X}_{U,2t}^R} \quad (\text{E.113})$$

668 DCP price inflation US exports to RoW

$$1 = (1 - \theta_P^U) \tilde{p}_{U,t}^{R^{1-\psi_i}} + \theta_P^U (1 + \tilde{\pi}_{U,t}^R)^{\psi_i-1} \quad (\text{E.114})$$

669 Numerator Calvo Pricing US LCP exports to RoW

$$\underline{X}_{U,1t}^R = Y_{U,t}^R IP_{U,t} MC_{U,t}^{rp} \Lambda_{U,t} \underline{CP}_{U,t}^{R(-\psi_i)} + \beta_U \theta_P^U (1 + \underline{\pi}_{U,t+1}^R)^{\psi_i} \underline{X}_{U,1t+1}^R \quad (\text{E.115})$$

670 Denominator Calvo Pricing US LCP exports to RoW

$$\underline{X}_{U,2t}^R = Y_{U,t}^R IP_{U,t} \Lambda_{U,t} \underline{CP}_{U,t}^{R(-\psi_i)} \underline{EM}_{U,t}^R + \beta_U \theta_P^U (1 + \underline{\pi}_{U,t+1}^R)^{\psi_i-1} \underline{X}_{U,2t+1}^R \quad (\text{E.116})$$

671 Optimal reset price Calvo Pricing US LCP exports to RoW

$$\underline{p}_{U,t}^R = \frac{\frac{\psi_i}{\psi_i-1} \underline{X}_{U,1t}^R}{\underline{X}_{U,2t}^R} \quad (\text{E.117})$$



$$1 = (1 - \theta_P^U) p_{U_t}^{R^{1-\psi_i}} + \theta_P^U (1 + \pi_{U_t}^R)^{\psi_i-1} \quad (\text{E.118})$$

673 **E.11 Monetary Policy**674 RoW Taylor rule

$$\frac{1 + R_{Rt}}{1 + R_{E,SS}} = \left( \frac{1 + R_{Rt-1}}{1 + R_{E,SS}} \right)^{\rho_{R,r}} \left( \left( \frac{1 + \pi_{Rt}^C}{1 + (\pi_{Rt}^C)} \right)^{\phi_{R,\pi}} \left( \frac{Z_{Rt}}{\bar{Z}_R} \right)^{\phi_{R,z}} \right)^{1-\rho_{R,r}} \exp(\varepsilon_{Rt}^R) \quad (\text{E.119})$$

675 US Taylor rule

$$\frac{1 + R_{Ut}}{1 + R_{SS_{F,ss}}} = \left( \frac{1 + R_{Ut-1}}{1 + R_{F,ss}} \right)^{\rho_{U,r}} \left( \left( \frac{1 + \pi_{Ut}^C}{1 + (\pi_{Ut}^C)} \right)^{\phi_{U,\pi}} \left( \frac{Z_{Ut}}{\bar{Z}_U} \right)^{\phi_{U,z}} \right)^{1-\rho_{U,r}} \exp(\varepsilon_{Ut}^R) \quad (\text{E.120})$$

676 RoW MP shock

$$\varepsilon_{Rt}^R = \rho_\epsilon^r \varepsilon_{Rt-1}^R + \sigma_{R,\epsilon}^r \eta_{Rt}^r \quad (\text{E.121})$$

677 US MP shock

$$\varepsilon_{Ut}^R = \rho_\epsilon^r \varepsilon_{Ut-1}^R + \frac{\sigma_{U,\epsilon}^r}{100} \eta_{Ut}^r \quad (\text{E.122})$$

678 **E.12 Relative Prices**679 Relative price of RoW domestic DCP sales and RoW domestic PCP sales

$$\hat{IT}_{Rt}^R = \hat{IT}_{Rt-1}^R \frac{(1 + D\mathcal{E}_t) (1 + \hat{\pi}_{Rt}^R)}{1 + \tilde{\pi}_{Rt}^R} \quad (\text{E.123})$$

680 Relative price of RoW domestic PCP sales to Aggregate RoW PPI

$$\widetilde{CP}_{Rt}^R = \left( \gamma_R^{R,PCP} + (1 - \gamma_R^{R,PCP}) \widehat{IT}_{Rt}^{R^{1-\psi_i}} \right)^{\frac{1}{\psi_i-1}} \quad (\text{E.124})$$

681 Relative price of RoW domestic DCP sales to Aggregate RoW PPI

$$\widehat{CP}_{Rt}^R = \widetilde{CP}_{Rt}^R \widehat{IT}_{Rt}^R \quad (\text{E.125})$$

682 Aggregate RoW PPI inflation as a function of domestic PCP and DCP prices

$$1 + \pi_{Rt}^R = (1 + \widetilde{\pi}_{Rt}^R) \frac{\widetilde{CP}_{Rt-1}^R}{\widetilde{CP}_{Rt}^R} \quad (\text{E.126})$$

683 Export margins for DCP exports from RoW to US in RoW currency (price of DCP exports over domestic sales price)

$$\widehat{EM}_{Rt}^U = \widehat{EM}_{Rt-1}^U \frac{(1 + D\mathcal{E}_t) (1 + \widehat{\pi}_{Rt}^U)}{1 + \pi_{Rt}^R} \quad (\text{E.127})$$

684 Export margins for PCP exports from RoW to US in RoW currency (price of DCP exports over domestic sales price)

$$\widetilde{EM}_{Rt}^U = \widetilde{EM}_{Rt-1}^U \frac{1 + \widetilde{\pi}_{Rt}^U}{1 + \pi_{Rt}^R} \quad (\text{E.128})$$

685 Aggregate margins for exports from RoW to US in RoW currency (agg. export price over domestic sales PPI)

$$EM_{Rt}^U = \left( \gamma_{U,t}^{R,PCP} \widetilde{EM}_{Rt}^{U^{1-\psi_i}} + (1 - \gamma_{U,t}^{R,PCP}) \widehat{EM}_{Rt}^{U^{1-\psi_i}} \right)^{\frac{1}{1-\psi_i}} \quad (\text{E.129})$$

686 Import price inflation of US imports from the RoW in US-D

$$1 + \pi_{U,t}^I = \frac{(1 + \pi_{Rt}^R) \frac{EM_{Rt}^U}{EM_{Rt-1}^U}}{1 + D\mathcal{E}_t} \quad (\text{E.130})$$

687 Export margins for PCP exports from the US to RoW in US-D (price of PCP exports over domestic sales price)

$$\widetilde{EM}_{U_t}^R = \widetilde{EM}_{U_{t-1}}^R \frac{1 + \widetilde{\pi}_{U_t}^R}{1 + \pi_{U_t}^U} \quad (\text{E.131})$$

688 Export margins for LCP exports from the US to RoW in US-D (price of LCP exports over domestic sales price)

$$\underline{EM}_{U_t}^R = \frac{(1 + \pi_{U_t}^R) \frac{EM_{U_{t-1}}^R}{1 + D\mathcal{E}_t}}{1 + \pi_{U_t}^U} \quad (\text{E.132})$$

689 Aggregate margins for exports from US to RoW in US-D currency (agg. export price over domestic sales PPI)

$$EM_{U_t}^R = \left( \gamma_{E,t}^{F,PCP} \widetilde{EM}_{U_t}^{R^{1-\psi_i}} + (1 - \gamma_{E,t}^{F,PCP}) \underline{EM}_{U_t}^{R^{1-\psi_i}} \right)^{\frac{1}{1-\psi_i}} \quad (\text{E.133})$$

690 Import price inflation of RoW imports from the US in RoW currency

$$1 + \pi_{R_t}^{U^I} = (1 + D\mathcal{E}_t) (1 + \pi_{U_t}^U) \frac{EM_{U_t}^R}{EM_{U_{t-1}}^R} \quad (\text{E.134})$$

691 Interior terms of trade RoW (US exports prices (in RoW currency) relative to RoW PPI)

$$IT_{R_t}^U = IT_{R_{t-1}}^U \frac{1 + \pi_{R_t}^{U^I}}{1 + \pi_{R_t}^R} \quad (\text{E.135})$$

692 Interior Producer Price RoW (PPI over CPI)

$$IP_{R_t} = \left( \eta_{R,t} + (1 - \eta_{R,t}) IT_{R_t}^{U^{1-\psi_f}} \right)^{\frac{1}{\psi_f-1}} \quad (\text{E.136})$$

693 RoW CPI inflation

$$1 + \pi_{R_t}^C = (1 + \pi_{R_t}^R) \frac{IP_{R_{t-1}}}{IP_{R_t}} \quad (\text{E.137})$$

694 Interior terms of trade US (RoW exports prices (in US-D currency) relative to US PPI)

$$IT_{U_t}^R = \frac{EM_{R_t}^U EM_{U_t}^R}{IT_{R_t}^U} \quad (\text{E.138})$$

695 Interior Producer Price US (PPI over CPI)

$$IP_{U_t} = \left( \eta_{U,t} + (1 - \eta_{U,t}) IT_{U_t}^{R^{1-\psi_f}} \right)^{\frac{1}{\psi_f-1}} \quad (\text{E.139})$$

696 US consumer price inflation

$$1 + \pi_{U_t}^C = (1 + \pi_{U_t}^U) \frac{IP_{U_{t-1}}}{IP_{U_t}} \quad (\text{E.140})$$

697 Definition of the Real exchange rate (in terms of CPI baskets)

$$RER_t = \frac{IP_{R_t} EM_{R_t}^U}{IP_{U_t} IT_{U_t}^R} \quad (\text{E.141})$$

698 PCP export price over agg. US import price

$$\widehat{CP}_{R_t}^U = \frac{IP_{R_t} \widetilde{EM}_{R_t}^U}{IP_{U_t}} \frac{1}{RER_t} \quad (\text{E.142})$$

699 DCP export price over agg. US import price

$$\widehat{CP}_{R_t}^U = \frac{1}{RER_t} \frac{IP_{R_t} \widetilde{EM}_{R_t}^U}{IP_{U_t}} \quad (\text{E.143})$$

700 DCP export price over agg. RoW import price

$$\widetilde{CP}_{U_t}^R = RER_t \frac{IP_{U_t} \widetilde{EM}_{U_t}^R}{IP_{R_t}} \quad (\text{E.144})$$

701 LCP export price over agg. RoW import price

$$\underline{CP}_{U_t}^R = RER_t \frac{IP_{U_t} \frac{EM_{U_t}^R}{IT_{R_t}^U}}{IP_{R_t}} \quad (\text{E.145})$$

## 702 **E.13 Market Clearing**

703 Agg. demand for RoW final composite good

$$Y_{R_t}^C = C_{R_t} + I_{R_t} + (In_{R_t} + (\bar{I}_R)) \frac{\Psi_R}{2} \left( \frac{In_{R_t} + (\bar{I}_R)}{(\bar{I}_R) + In_{R_{t-1}}} - 1 \right)^2 \quad (\text{E.146})$$

704 Agg. demand for US final composite good

$$Y_{U_t}^C = C_{U_t} + I_{U_t} + (In_{U_t} + (\bar{I}_U)) \frac{\Psi_U}{2} \left( \frac{In_{U_t} + (\bar{I}_U)}{(\bar{I}_U) + In_{U_{t-1}}} - 1 \right)^2 \quad (\text{E.147})$$

705 RoW aggregate production function

$$Z_{R_t} = (K_{R_{t-1}} U_{R_t})^\alpha L_{R_t}^{1-\alpha} \quad (\text{E.148})$$

706 US aggregate production

$$Z_{U_t} = (K_{U_{t-1}} U_{U_t})^\alpha L_{U_t}^{1-\alpha} \quad (\text{E.149})$$

707 RoW market clearing

$$Z_{R_t} = Y_{R_t}^R \delta_{R_t}^R + Y_{R_t}^U \delta_{R_t}^U \quad (\text{E.150})$$

708 US market clearing

$$Z_{U_t} = Y_{U_t}^U \delta_{U_t}^U + Y_{U_t}^R \delta_{U_t}^R \quad (\text{E.151})$$

709 **E.14 Price dispersion terms (constant up to first order)**

$$\tilde{\delta}_{Rt}^R = (1 - \theta_P^R) \tilde{p}_{Rt}^{R(-\psi_i)} + \theta_P^R (1 + \tilde{\pi}_{Rt}^R)^{\psi_i} \tilde{\delta}_{Rt-1}^R \quad (\text{E.152})$$

710

$$\hat{\delta}_{Rt}^R = (1 - \theta_P^R) \hat{p}_{Rt}^{R(-\psi_i)} + \theta_P^R (1 + \hat{\pi}_{Rt}^R)^{\psi_i} \hat{\delta}_{Rt-1}^R \quad (\text{E.153})$$

711

$$\delta_{Rt}^R = \tilde{\delta}_{Rt}^R \widetilde{CP}_{Rt}^{R(-\psi_i)} \gamma_{R,t}^{R,PCP} + \hat{\delta}_{Rt}^R \widehat{CP}_{Rt}^{R(-\psi_i)} (1 - \gamma_{R,t}^{R,PCP}) \quad (\text{E.154})$$

712

$$\tilde{\delta}_{Rt}^U = (1 - \theta_P^R) \tilde{p}_{Rt}^{U(-\psi_i)} + \theta_P^R (1 + \tilde{\pi}_{Rt}^U)^{\psi_i} \tilde{\delta}_{Rt-1}^U \quad (\text{E.155})$$

713

$$\hat{\delta}_{Rt}^U = (1 - \theta_P^R) \hat{p}_{Rt}^{U(-\psi_i)} + \theta_P^R (1 + \hat{\pi}_{Rt}^U)^{\psi_i} \hat{\delta}_{Rt-1}^U \quad (\text{E.156})$$

714

$$\delta_{Rt}^U = \tilde{\delta}_{Rt}^U \widetilde{CP}_{Rt}^{U(-\psi_i)} \gamma_{U,t}^{R,PCP} + \hat{\delta}_{Rt}^U \widehat{CP}_{Rt}^{U(-\psi_i)} (1 - \gamma_{U,t}^{R,PCP}) \quad (\text{E.157})$$

715

$$\delta_{Ut}^U = (1 - \theta_P^U) \underline{p}_{Ut}^{U(-\psi_i)} + \theta_P^U (1 + \pi_{Ut}^U)^{\psi_i} \delta_{Ut-1}^U \quad (\text{E.158})$$

716

$$\tilde{\delta}_{Ut}^R = (1 - \theta_P^U) \tilde{p}_{Ut}^{R(-\psi_i)} + \theta_P^U (1 + \tilde{\pi}_{Ut}^R)^{\psi_i} \tilde{\delta}_{Ut-1}^R \quad (\text{E.159})$$

717

$$\underline{\delta}_{Ut}^R = (1 - \theta_P^U) \underline{p}_{Ut}^{R(-\psi_i)} + \theta_P^U (1 + \underline{\pi}_{Ut}^R)^{\psi_i} \underline{\delta}_{Ut-1}^R \quad (\text{E.160})$$

$$\delta_{U_t}^R = \tilde{\delta}_{U_t}^R \widetilde{CP}_{U_t}^{R(-\psi_i)} \gamma_{R,t}^{U,PCP} + \delta_{U_t}^R \underline{CP}_{U_t}^{R(-\psi_i)} \left(1 - \gamma_{R,t}^{U,PCP}\right) \quad (\text{E.161})$$

## 719 E.15 Balance of Payments

720 RoW Current account in RoW currency

$$CA_{R,nom_t}^F = Y_{R_t}^R IP_{R_t} + Y_{R_t}^U IT_{U_t}^R RER_t IP_{U_t} - Y_{R_t}^C \quad (\text{E.162})$$

721 Balance of Payments

$$RER_t \left( GB_{R_t} - \frac{R_{R_t}^{GB}}{1 + \pi_{U_t}^C} (GB_{R_{t-1}}) \right) - RER_t \left( CBDL_{R_t} - CBDL_{R_{t-1}} \frac{R_{U,t-1}^{CBDL}}{1 + \pi_{U_t}^C} \right) = CA_{R,nom_t}^F \quad (\text{E.163})$$

722 Trade Balance RoW

$$TB_{R_t} = Y_{R_t}^U - \frac{(1-n) Y_{U_t}^R}{n} \quad (\text{E.164})$$

723 Change in the NFA (including valuation effects) relative to RoW GDP

$$\Delta NFA_{R_t} = \frac{RER_t (GB_{R_{t-1}}) - (GB_{R_{t-1}}) RER_{t-1} - RER_t CBDL_{R_{t-1}} + CBDL_{R_{t-1}} RER_{t-1}}{(\bar{Z}_R)} \quad (\text{E.165})$$

## 724 E.16 Model local variables

725 Share of PCP goods in US Import Basket

$$\gamma_U^{R,PCP} = 1 - \hat{\gamma}_U^R$$

726 Share of PCP goods in RoW Import basket

$$\gamma_R^{U,PCP} = 1 - \tilde{\gamma}_R^U$$

727 Share of PCP goods in RoW Local Basket

$$\gamma_R^{R,PCP} = 1 - \hat{\gamma}_R^R$$

728 RoW steady state net interest rate

$$R_{R,SS} = \frac{1}{\beta_R} - 1$$

729 US steady state net interest rate

$$R_{R,SS} = \frac{1}{\beta_U} - 1$$

730 Size adjusted import share RoW

$$\eta_R = (1 - op_R)(1 - s)$$

731 Size adjusted import share US

$$\eta_{US} = (1 - op_U)s$$



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