DIW BERLIN

2058

Discussion Papers

Deutsches Institut für Wirtschaftsforschung 2023

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IMPRESSUM

DIW Berlin, 2023

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ISSN electronic edition 1619-4535

Dollar Trinity and the Global Financial Cycle*

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August 2023

Abstract

We develop a two-country business-cycle model of the US and the rest of the world with dollar dominance in trade invoicing, in cross-border credit, and in safe assets. The interplay between these elements—*dollar trinity*—rationalizes salient features of the Global Financial Cycle in the data: When its tide subsides, the dollar appreciates, financial conditions tighten, the world business cycle slows down, and emerging-market central banks face a trade-off between mitigating the recession and dampening price pressures. We find the dollar is no sideshow in this, but central for the transmission of the Global Financial Cycle to the world economy.

Keywords: Dollar dominance, dominant currency paradigm, Bayesian proxy structural VAR model, convenience yield.

JEL-Classification: F31, F42, F44

*We thank our discussants Nuno Coimbra and Simon Lloyd, conference participants at the 2^{nd} BoE-CfM-EUI-LSE Workshop on International Macro and Finance, the HKIMR-AMRO-ECB-ESM-BOFIT Conference Recent Developments and Future Prospects for the International Monetary System, 1^{st} Innsbruck Workshop on Empirical Macroeconomics, 4^{th} Emerging Market MacroEconomics Workshop, 2022 Banque de France Conference on Financial Frictions in International Economics, and seminar participants at the ECB, Bank of Greece, Swiss National Bank, BIS, and KOF Swiss Economic Institute for useful comments. The views expressed in the paper are those of the authors and do not necessarily reflect those of the ECB or the Eurosystem and should not be reported as such.

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1 Introduction

A key feature of the international monetary system is that risky asset prices, leverage and capital flows co-move across global financial markets. This pattern has been dubbed the Global Financial Cycle (GFCyc) and attributed to changes in global investors' risk aversion (Miranda-Agrippino & Rey 2020). It has also been established that the GFCyc has powerful effects on the world business cycle and that it entails policy trade-offs in macroeconomic stabilization in open—especially emerging market—economies (Figure 1; Rey 2016).

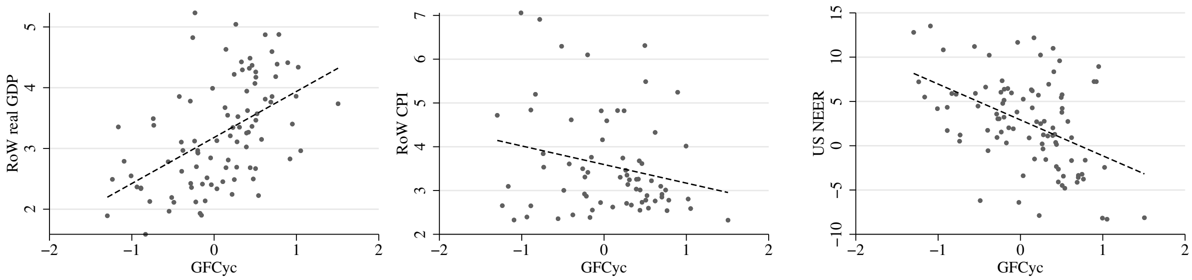
At the same time, the international monetary system is dominated by the dollar (Bertaut et al. 2021). Prominent theoretical work lays out how the dollar has emerged as the dominant currency in the denomination of safe assets (Farhi & Gabaix 2016; He et al. 2019; Coppola et al. 2023), cross-border financial contracts (Bocola & Lorenzoni 2020; Gopinath & Stein 2021; Chahrour & Valchev 2022; Eren & Malamud 2022), and global trade invoicing (Devereux & Shi 2013; Gopinath & Stein 2021; Chahrour & Valchev 2022; Mukhin 2022). Against this background it is remarkable that the dollar also co-moves with the GFCyc (Figure 1; Obstfeld & Zhou 2023).

While this pattern is striking, it leaves open the question whether the dollar is just a 'correlate' or whether it plays a central role in the transmission of the GFCyc to the world economy, and, if so, whether and how this is grounded in dollar dominance. We address these questions in this paper. We pull together threads on dominance in trade invoicing, cross-border credit and safe asset supply—*dollar trinity*—and show how they interact to shape the dollar's role in the transmission of the GFCyc to the world economy.

Based on causal evidence from a Bayesian proxy structural vector-autoregressive model and a structural two-country model we establish that dollar trinity can rationalize the patterns in the GFCyc, exchange rates, the world business cycle and policy trade-offs in the data. In short: Dominance in safe asset supply accounts for the dollar's appreciation when global investors' risk aversion rises; dominance in cross-border credit accounts for the tightening in global financing conditions when the dollar appreciates; and dominance in trade invoicing accounts for the trade-off between stabilizing output and consumer prices when the dollar appreciates. The dollar emerges as the linchpin in the transmission of the GFCyc to the world economy.

In more detail: We first explore the transmission of the GFCyc to global financial markets, trade and the business cycle in the data extending the analysis in Georgiadis et al. (2021). We estimate the direct effect of the GFCyc and how it endogenously transmits US monetary policy to the world economy (Kalemli-Özcan 2019; Degasperi et al. 2020; Miranda-Agrippino & Rey 2020). To do so, we exploit exogenous variation in global risk aversion and US monetary policy in terms of intra-daily asset-price surprises on narratively selected events. We use these surprises as external instruments in the Bayesian proxy structural vector-autoregressive (BPSVAR) model of Arias et al. (2021). We find that movements in the GFCyc—reflecting exogenous variation in risk aversion or the endogenous transmission of US monetary policy—appreciate the dollar, raise the price of safe assets given by US Treasuries, reduce cross-border credit, tighten global financing conditions, slow down the global business cycle, and give rise to monetary policy trade-offs at least in parts of the RoW.

Figure 1: The co-movement between the GFCyc, the global business cycle, and the dollar



Note: Year-on-year changes in percent for the time period from 1990 to 2019, excluding the Global Financial Crisis and 9/11. Global factor in risky asset prices taken from Miranda-Agrippino & Rey (2020) and real GDP and consumer price inflation from the Dallas Fed Global Economic Indicators (Martínez-García et al. 2015).

We then present a structural two-country model for the US and the RoW with dollar trinity that rationalizes the unconditional patterns in the GFCyc, exchange rates, the world business cycle and policy trade-offs in the data as well as the causal evidence from the BPSVAR analysis. 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, and therefore tightens balance-sheet constraints of RoW banks. Because they are viewed as the global safe asset, US Treasuries are held as dollar liquidity-buffers by RoW banks to loosen balance-sheet constraints and thereby earn an additional, indirect return that we label as 'convenience yield'. An increase in global investors' risk aversion—again either occurring exogenously or resulting endogenously from a US monetary policy tightening—triggers a global financial accelerator mechanism under which domestic credit spreads widen so that leverage becomes more profitable, the convenience yield of Treasuries rises, causing the dollar to appreciate, cross-border dollar credit to fall and associated spreads to increase. Due to dollar invoicing in US and non-US trade dollar appreciation puts upward pressure on consumer prices at the same time as output contracts, and thereby gives rise to a trade-off for monetary policy in the RoW.

We show that with a standard calibration the structural model matches our estimates for the transmission of the GFCyc obtained from the BPSVAR model. Against this background, we explore counterfactual versions of the structural model to assess how the different dimensions of dollar trinity interact to shape the role of the dollar in the transmission of the GFCyc in the data. In particular, without dollar dominance in safe asset supply, 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. Without dollar appreciation and dollar dominance in cross-border credit there is no global financial accelerator mechanism that amplifies the effects of shocks on the RoW. And without dollar appreciation and dominance in trade invoicing, import prices in the RoW do not increase so as to raise consumer prices as output contracts. In sum, without dollar trinity an increase in global investors' risk aversion entails no dollar appreciation, a much milder financial amplification, and no monetary policy trade-offs in the RoW. The dollar exchange rate emerges as the linchpin of the transmission of the GFCyc to the world economy because of dollar trinity.

Related literature. Our paper is related to empirical work on the role of the dollar as a global risk factor (Lustig et al. 2014; Verdelhan 2018), the predictive power of convenience yields (Valchev 2020; Jiang et al. 2021b; Engel & Wu forthcoming) and global risk measures (Lilley et al. 2022; Hassan et al. forthcoming) for the dollar, and the relationship between global risk, deviations from covered interest parity, the dollar and cross-border credit (Avdjiev et al. 2019; Erik et al. 2020; Hofmann et al. 2020). We complement this work by moving from forecasting and reduced-form regressions to estimating the effect of exogenous variation in global risk aversion on the dollar exchange rate, the Treasury premium, and cross-border credit. Moreover, we provide a theoretical framework that rationalizes the empirical patterns in risk, the dollar exchange rate and global financing conditions documented in this literature. More generally, our empirical analysis 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; Akinci & Queralto 2019; Jiang et al. 2021a; Kekre & Lenel 2021).

Our paper is also related to theoretical work on the special role of the dollar in the international monetary system. We bring together dominant-currency paradigms (DCPs) in trade (Gopinath et al. 2020; Akinci, Benigno, et al. 2022), cross-border credit (Akinci & Queralto 2019; Banerjee et al. 2016; Akinci, Kalemli-Ozcan, & Queralto 2022; Hofmann et al. 2022) and safe asset supply (Bianchi et al. 2021; Jiang et al. 2021a; Kekre & Lenel 2021; Devereux et al. 2022). The combination of dollar dominance in these dimensions allows our model to rationalize how an increase in global investors' risk aversion causes an appreciation of the dollar, a tightening of global financial conditions, a contraction of the world economy, and trade-offs for monetary policy in the RoW. Our model therefore also resolves the 'reserve currency paradox' of Maggiori (2017), and gives rise to an endogenous 'exorbitant privilege' of the US in normal times as well as—in a straightforward extension—to an 'exorbitant duty' in crisis times (Gourinchas & Rey 2022).

A technical innovation in our model is to introduce optimal portfolio choice for dollar assets *and* liabilities in the RoW. On the liability side we depart from the assumptions in Banerjee et al. (2016), Jiang et al. (2021a) and Hofmann et al. (2022) that the share of cross-border dollar funding in total liabilities is given exogenously. Instead, we assume—similarly to Akinci & Queralto (2019)—that RoW banks trade off lower funding costs against the increased exchange rate exposure and the ensuing tightening of their balance-sheet constraints when choosing the amount of dollar liabilities. We connect this optimal dollar liability choice with the optimal dollar asset choice. The structure of incentives for choosing dollar assets and liabilities we assume gives rise to an endogenous Treasury convenience yield which reflects their ability to loosen balance-sheet constraints. This is in contrast to the model of Jiang et al. (2021a), in which a convenience yield is introduced *ad hoc* as uncovered interest parity deviation that is assumed to decline in the global stock of dollar assets. While in some other models the convenience yield does emerge endogenously as in our setup, it is usually a direct implication of the assumption that agents derive utility from holding Treasuries (see Engel 2016; Kekre & Lenel 2021).

While our model shares many similarities with that of Devereux et al. (2022), there are two key differences. First, the mechanisms giving rise to a convenience yield and its economic interpretation differ. In Devereux et al. (2022) the convenience yield reflects a non-pecuniary return Treasuries earn because they are assumed to be more pledgeable as collateral than otherwise identical foreign government bonds. In contrast, in our model the convenience yield reflects an additional, indirect pecuniary return Treasuries earn because they are assumed to loosen balance-sheet constraints due to their unique liquidity properties. The mechanisms giving rise to the convenience yield in our model and in Devereux et al. (2022) are thus different but complementary. Second, in our model banks face a liability in addition to an asset portfolio choice problem. This additional margin is key because it gives rise to a global financial accelerator that is triggered by a dollar appreciation and plays out in variation in cross-border dollar credit supply and spreads. This amplification mechanism is critical for the role of the dollar as the linchpin in the transmission of the GFCyc to the world economy in our model, but is absent in the framework of Devereux et al. (2022).

The rest of the paper is organized as follows. Section 2 lays out our empirical analysis. In Section 3 we introduce the structural model with dollar trinity. In Section 4 we discuss the transmission of the GFCyc in the model and we explore the role of dollar trinity. In Section 5 we conclude.

2 The transmission of the Global Financial Cycle in the data

We first provide some empirical evidence for the transmission of the GFCyc to the world economy that we later use to benchmark our trinity model against the data. We use external instruments to identify global risk aversion and US monetary policy shocks in the BPSVAR model of Arias et al. (2021). We start with a brief outline of the framework and then discuss our specification and identification assumptions. We refer to Georgiadis et al. (2021) for a more detailed exposition.

2.1 BPSVAR framework

Consider the structural VAR model

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

where $\boldsymbol{y}_t$ is an $n \times 1$ vector of endogenous variables and $\boldsymbol{\epsilon}_t$ an $n \times 1$ vector of structural shocks. To achieve identification the BPSVAR framework exploits a $k \times 1$ vector of observed proxy variables—or, in alternative jargon, external instruments—$\boldsymbol{p}_t$. The proxy variables are assumed to be 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):

$$E[\boldsymbol{p}_t\boldsymbol{\epsilon}_t^{*\prime}] = \boldsymbol{V}, \qquad E[\boldsymbol{p}_t\boldsymbol{\epsilon}_t^{o\prime}] = \boldsymbol{0}. \tag{2}$$

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

2.2 VAR model specification

As in Georgiadis et al. (2021) our point of departure is the US VAR model of Gertler & Karadi (2015), which includes as endogenous variables in $\boldsymbol{y}_t$ the logarithms of US industrial production and consumer prices, the 1-year Treasury bill rate as monetary policy indicator, and the excess bond premium (EBP) of Gilchrist & Zakrajsek (2012) as a measure of risk aversion.[1] As in Georgiadis et al. (2021) we then augment $\boldsymbol{y}_t$ with the logarithm of non-US, RoW industrial production, RoW policy rates, the logarithm of the dollar nominal effective exchange rate (NEER), but furthermore add RoW consumer prices, the global factor in risky asset prices of Miranda-Agrippino & Rey (2020) updated in Miranda-Agrippino et al. (2020) as a measure of the GFCyc, and the macroeconomic uncertainty measure of Jurado et al. (2015).[2]

Given that the model includes ten endogenous variables and we have monthly data for the time period from February 1990 to December 2019 we impose informative Minnesota-type priors and optimal hyperpriors/prior tightness on the VAR parameters (Giannone et al. 2015). Data descriptions are provided in Table B.1. Further below we show results for extended specifications with additional endogenous variables as well as for a modified specification in which we split RoW variables into their AE and EME components.

2.3 Identification

There are two shocks of interest we identify: A global risk aversion and a US monetary policy shock. In addition, extending our analysis in Georgiadis et al. (2021), we sharpen the identification and distinguish between shocks to risk aversion—the price of risk—and uncertainty—the quantity of risk; see Bauer et al. (2023) for a detailed discussion of this distinction. We do so imposing restrictions on the forecast error variance decomposition (FEVD) described in more detail below.

2.3.1 Proxy variables

For the global risk aversion and uncertainty shocks we use the intra-daily changes in the price of gold around the time stamps of narratively selected events. The latter were originally selected by Bloom (2009), later updated by Piffer & Podstawski (2018) and Bobasu et al. (2021). The biggest of these (positive) gold-price surprises are recorded for the launch of Operation Desert Storm in the early 1990s, the 9/11 attacks in 2001, when American International Group requested emergency

[1] The EBP is given by firm-level corporate-bond credit spreads cleansed from expected default risk, thereby "capturing investor attitudes toward corporate credit risk and credit market sentiment" (Favara et al. 2016).

[2] The uncertainty measure of Jurado et al. (2015) is given by the estimated time-varying variance of the forecast error of a range of US macroeconomic data and therefore reflects second-moment shocks. Alternatives such as the Global Economic Policy Uncertainty Index of Baker et al. (2016) or the World Uncertainty Index of Ahir et al. (2022) exist, but reflect different conceptions of uncertainty that are less relevant for our context and/or are not available at the monthly frequency for the sample period we study. Because of extreme values due to hyper-inflation episodes in some EMEs in the early to mid-1990s we use changes in AE policy rates and consumer prices to extend backward the RoW time series from 2000.

lending and Lehman Brothers filed for bankruptcy at the height of the GFC in September 2008, and the release of the results of the Brexit referendum in June 2016. In robustness checks below we alternatively consider intra-daily surprises in long-term Treasury yields and the euro-dollar exchange rate.

For the US monetary policy shock we follow the industry standard and use the intra-daily change in three-month Federal (Fed) funds futures around FOMC announcements (Gertler & Karadi 2015; Miranda-Agrippino & Rey 2020). We account for the possible presence of central bank information effects by keeping only the interest-rate surprises for FOMC meetings for which the associated equity-price surprises have the opposite sign (Jarociński & Karadi 2020; Miranda-Agrippino & Ricco 2021). In robustness checks below we alternatively consider the Fed-funds-futures surprises of Miranda-Agrippino & Ricco (2021) cleansed by central bank information effects using non-publicly available Fed Greenbook forecasts and the conventional interest rate policy, forward guidance and large-scale asset purchases (LSAP) surprises of Jarociński (2021) to account for the Fed's use of unconventional policy measures during a non-trivial part of our sample period.

2.3.2 Identifying assumptions

Denote by ϵ_t^r the global risk aversion shock, ϵ_t^u the global uncertainty shock, and ϵ_t^{mp} the US monetary policy shock, and define $\boldsymbol{\epsilon}_t^* \equiv (\epsilon_t^r, \epsilon_t^u, \epsilon_t^{mp})'$. Further denote by p_t^g the monthly time series of the intra-daily gold-price surprises on the narratively selected events, by p_t^i monthly time series of the intra-daily Fed-funds-futures surprises around FOMC meetings, and define $\boldsymbol{p}_t \equiv (p_t^g, p_t^i)'$. The relevance and exogenity conditions are

$$E[\boldsymbol{\epsilon}_t^* \boldsymbol{p}_t'] = \begin{pmatrix} E[p_t^g \epsilon_t^r] & E[p_t^i \epsilon_t^r] \\ E[p_t^g \epsilon_t^u] & E[p_t^i \epsilon_t^u] \\ E[p_t^g \epsilon_t^{mp}] & E[p_t^i \epsilon_t^{mp}] \end{pmatrix} = \boldsymbol{V}, \tag{3a}$$

$$E[\boldsymbol{\epsilon}_t^o \boldsymbol{p}_t'] = \begin{pmatrix} E[p_t^g \boldsymbol{\epsilon}_t^o] & E[p_t^i \boldsymbol{\epsilon}_t^o] \end{pmatrix} = \boldsymbol{0}. \tag{3b}$$

First, in the relevance condition in Equation (3a) we assume that global risk aversion and uncertainty shocks drive gold-price surprises in intra-daily windows around the narratively selected events, that is $E[p_t^g \epsilon_t^r] \neq 0$ and $E[p_t^g \epsilon_t^u] \neq 0$. Intuitively, an increase in global risk aversion and an increase in global uncertainty push up the price of gold as the archetypical safe asset (Baur & McDermott 2010). Piffer & Podstawski (2018) provide evidence that gold-price surprises are relevant instruments for risk/uncertainty shocks based on F-tests and Granger-causality tests. Ludvigson et al. (2021) use gold price changes as a proxy variable in a similar context; and Engel & Wu (2018) use the gold price as a proxy for risk. Regarding the exogeneity condition $E[p_t^g \boldsymbol{\epsilon}_t^o] = 0$ in Equation (3b), 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 aversion/uncertainty shocks. This is consistent with the notion that the only shocks that occurred systematically in the intra-daily windows across the narratively selected events are global risk aversion and uncertainty shocks.[3]

Second, we assume that US monetary policy shocks drive the Fed-funds-futures surprises in intra-daily windows around FOMC announcements in the relevance condition in Equation (3a), $E[p_t^i \epsilon_t^{mp}] \neq 0$ (Gertler & Karadi 2015; Jarociński & Karadi 2020; Miranda-Agrippino & Rey 2020). Regarding the exogeneity condition $E[p_t^i \boldsymbol{\epsilon}_t^o] = 0$ in Equation (3b), it is plausible that around FOMC meetings—especially after cleansing from central bank information effects—Fed-funds-futures surprises are driven only by monetary policy shocks.

Third, we impose two sets of additional restrictions to (i) achieve point rather than only set-identification of the US monetary policy shock (Mertens & Ravn 2013) and (ii) to disentangle global risk aversion and uncertainty shocks.

For (i), we impose the additional restriction that Fed-funds-futures surprises on FOMC meeting days are not driven by global risk aversion and uncertainty shocks, that is $E[p_t^i \epsilon_t^r] = E[p_t^i \epsilon_t^u] = 0$. This additional restriction is implicitly maintained in the literature on the effects of monetary policy (Gertler & Karadi 2015; Jarociński & Karadi 2020; Miranda-Agrippino & Rey 2020; Miranda-Agrippino & Ricco 2021). It would be natural to impose the analogous additional restriction that gold-price surprises on the narratively selected events are not driven by US monetary policy shocks, that is $E[p_t^g \epsilon_t^{mp}] = 0$. However, in the estimation algorithm of Arias et al. (2021) such over-identifying restrictions cannot be implemented. Therefore, we do not impose this additional restriction.

For (ii), we impose FEVD restrictions in the spirit of Francis et al. (2014). In particular, while both shocks drive the gold-price surprise, we assume global risk aversion shocks account for a larger share of the one-month ahead FEVD of the EBP than global uncertainty shocks. Analogously, we assume global uncertainty shocks account for a larger share of the one-month ahead FEVD of the macroeconomic uncertainty measure of Jurado et al. (2015) than global risk aversion shocks. As a result, global risk aversion and uncertainty shocks are set identified.

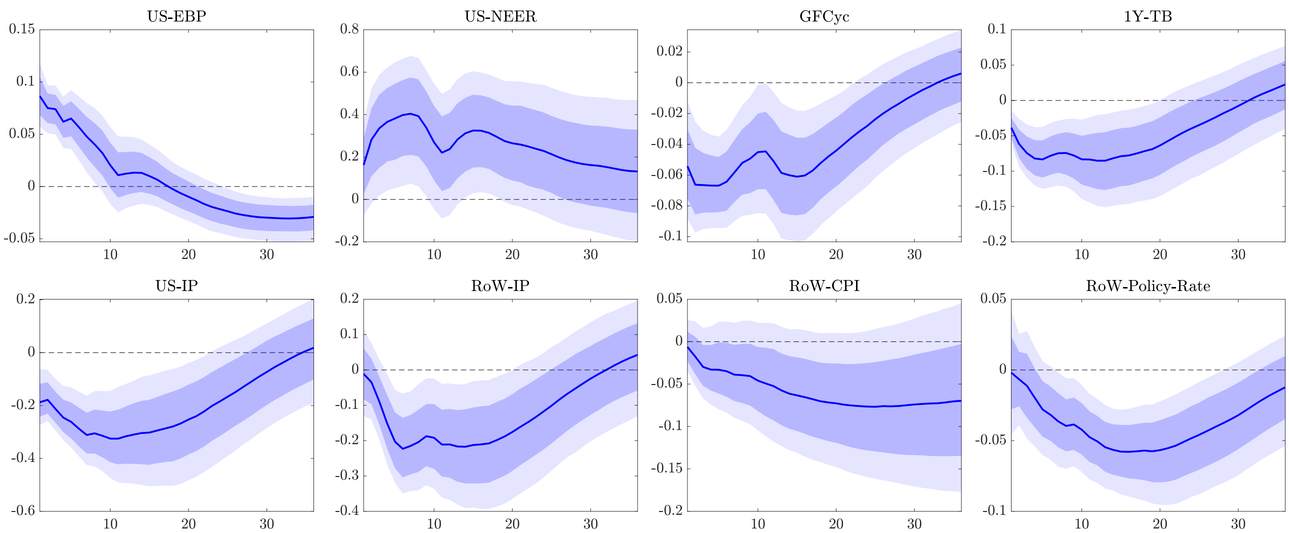
2.4 Effects of global risk aversion and US monetary policy shocks

Figure 2 presents the effects of a one-standard deviation contractionary global risk aversion shock. The shock causes an increase in the EBP, a dampening of the GFCyc, and an appreciation of the dollar. US and RoW industrial production contract in tandem, RoW consumer prices fall. US and RoW monetary policy are loosened. The effects of global uncertainty shocks are similar, with the difference that the EBP rises less clearly on impact and much less overall, the GFCyc is dampened less, the dollar appreciates less sharply, and US and RoW monetary policy loosen less, if at all (Figure A.1).

Figure 3 presents the impulse responses to a one-standard deviation contractionary US monetary policy shock. The shock causes an increase in the EBP, a dampening of the GFCyc, and a persistent

[3] Note that the exogeneity condition $E[p_t^g \boldsymbol{\epsilon}_t^o] = 0$ does not state that on every narratively selected event only risk aversion and uncertainty shocks occurred. Instead, the exogeneity condition states that only risk aversion and uncertainty shocks occurred *systematically* across *all* narratively selected events. For example, while the release of the outcome of the Brexit referendum may have involved a negative productivity news shock, this is unlikely to have been the case for the 9/11 terrorist attacks. At the same time, both events were arguably associated with risk and uncertainty shocks.

Figure 2: Responses to a contractionary global risk aversion shock

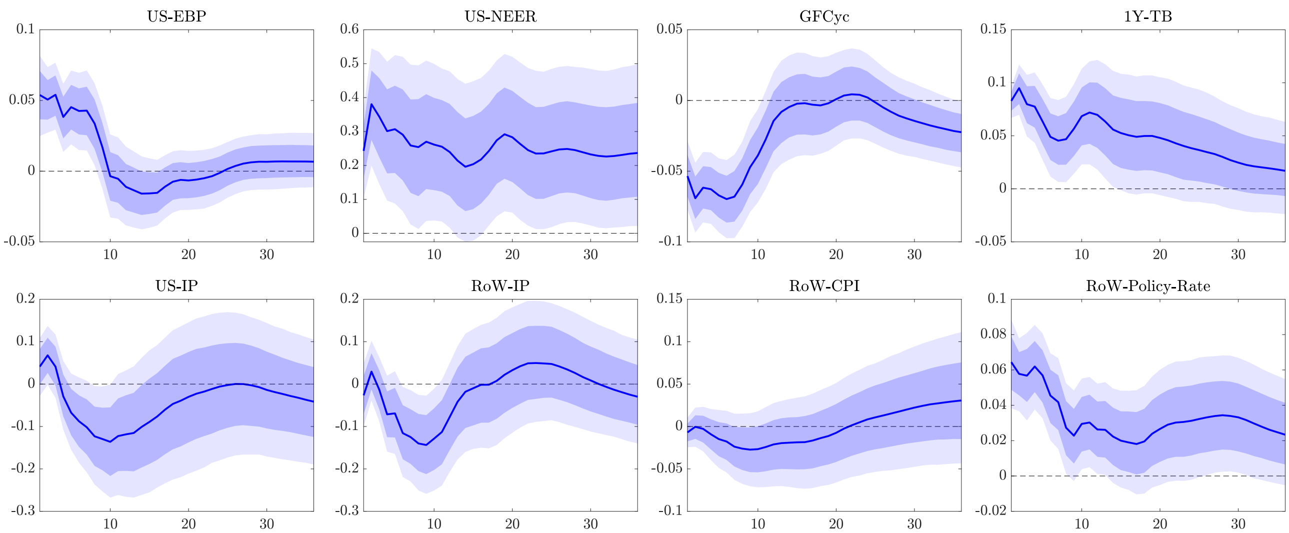


Note: The horizontal axis denotes time in months. The vertical axis deviation from pre-shock level in percent/percentage points. The size of shock is one standard deviation. Blue solid lines represent point-wise posterior means and shaded areas 68%/90% equal-tailed, point-wise credible sets. The dollar NEER, US and RoW industrial production, RoW consumer prices are in logarithms multiplied by 100, and the EBP, the RoW policy as well as the US 1-year Treasury Bill rates are in percent. The GFCyc is measured by the global factor in risky asset prices of Miranda-Agrippino & Rey (2020) and Miranda-Agrippino et al. (2020) and has a standard normal distribution. The responses of US consumer prices and US macroeconomic uncertainty are omitted to save space.

appreciation of the dollar. US and RoW industrial production contract in tandem. RoW consumer prices drop, although not markedly. Despite the contraction and the drop in consumer prices, RoW monetary policy tightens. This is consistent with a trade-off between stabilizing output and inflation giving rise to ‘fear-of-floating under which a monetary policy loosening would depreciate the exchange rate even more strongly, entail a greater increase in import prices, and eventually cause an increase in consumer prices (see e.g. Corsetti et al. 2021); in fact, at least unconditionally the GFCyc is positively correlated with RoW output growth but negatively with consumer-price inflation (Figure 1). Overall, our estimates for the effects of US mnetary policy are consistent with existing work for domestic effects (Gertler & Karadi 2015; Jarociński & Karadi 2020) and spillovers from US monetary policy (Degasperi et al. 2020; Miranda-Agrippino & Rey 2020).

Figure 4 provides results for additional financial variables obtained from a larger BPSVAR model. Both global risk aversion and US monetary policy shocks contract US cross-border bank credit and raise EME sovereign spreads. Both shocks raise the exchange-rate adjusted price of Treasuries relative to other G10 sovereign bonds as measured by the Treasury premium of Du et al. (2018). In contrast, they do not cause flight-to-safety in terms of an increase in the measure of foreign purchases of Treasury securities of Bertaut & Tryon (2007) and Bertaut & Judson (2014, 2022); the impulse response shows the cumulated effects on foreign purchases, hence the change in the level of

Figure 3: Responses to a contractionary US monetary policy shock



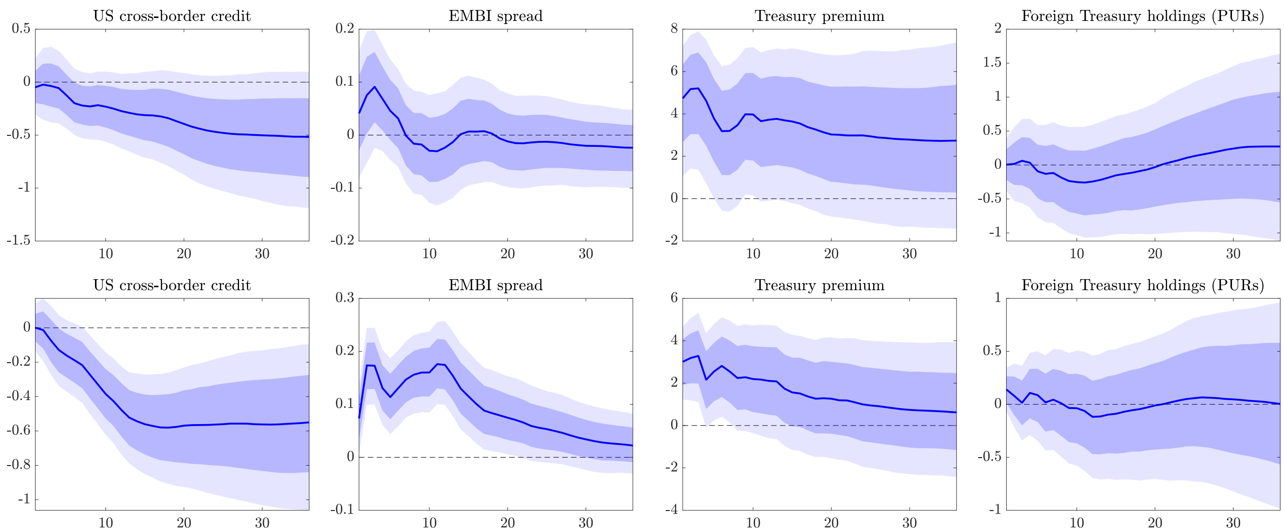
Note: See the notes to Figure 2.

foreign holdings of Treasury securities.[4] The responses of the remaining variables are very similar to the baseline (Figure A.2).

We explore several extensions and robustness checks for which we provide results in Appendix A. First, we split the RoW into AEs and EMEs. We find that EME monetary policy tightens in response to both global risk aversion and US monetary policy shocks (Figure A.3). Moreover, consumer-price responses are less clearly—if at all—contractionary in EMEs than in AEs. This suggests policy trade-offs pertain to EMEs rather than AEs. Second, results are similar when we use as proxy variable for the global risk aversion shock surprises in long-term Treasury yields or the dollar-euro bilateral exchange rate that can be calculated for narrower intra-daily windows (Figure A.4). Third, results are similar when we consider only positive gold-price surprises and thereby only use events with *adverse* global risk aversion shocks for identification (Figure A.5). Fourth, results are similar when we use the Fed-funds-futures surprises cleansed from central bank information effects

[4]This finding is inconsistent with a widespread view that when risk aversion increases investors flock to safety and purchase US Treasury securities. For example, Krishnamurthy & Lustig (2019, pp. 458) note that "purchases of Treasuries on average tend to follow a widening of the Treasury basis, as Treasuries become more expensive relative to foreign bonds. Foreign investors buy Treasuries when they are expensive." At the same time, flight-to-safety is not invariably understood to entail safe haven flows in terms of an increase in actual purchases. For example, Jiang et al. (2021a, p. 2) define their empirical "Fact 3: Flight to dollar safety. During global downturns, the dollar appreciates and the dollar bond prices rise", and Kekre & Lenel (2021, p. 1) "formalize [flight to dollar bonds] as an increase in their liquidity value". In a similar vein, recent work by Tabova & Warnock (2021) exploiting unprecedented detail on investors' Treasury holdings questions whether foreigners exhibit flight-to-safety in terms of an increase in actual purchases. They lay out why the data underpinning previous findings of flight-to-safety are faulty, and show that when using adequate data "foreigners do *not* buy Treasuries when they are expensive" (p. 1, emphasis added) and that "private foreign investors, but not foreign officials, increase their flows into US Treasuries when [the Treasury premium] *is low or has fallen* (p. 5, emphasis added). And very recent evidence suggests Treasuries were actually shedded during the COVID-19 pandemic (Vissing-Jorgensen 2021).

Figure 4: Responses of additional financial variables to contractionary global risk aversion (top row) and US monetary policy shocks (bottom row)



Note: The vertical axis deviation from pre-shock level in percent/percentage points. US cross-border credit is in logarithms multiplied by 100. Foreign holdings of Treasury securities are relative to the lag of the Hodrick-Prescott filtered trend component of US nominal GDP and multiplied by 100. The EMBI spread and the Treasury premium are in percent. The responses are estimated from a larger BPSVAR model with additional endogenous variables. See also the notes to Figure 2.

using non-publicly available Greenbook forecasts from Miranda-Agrippino & Ricco (2021) or the sum of the high-frequency-based conventional interest rate, forward guidance and LSAP surprises of Jarociński (2021) as proxy variable for the US monetary policy shock (Figure A.6).[5]

3 A structural model with dollar trinity

In what follows we set up a structural two-country model with dollar dominance in trade invoicing, cross-border credit and safe asset supply. We use the model to explore how these dimensions of dollar dominance interact to shape the role of the exchange rate in the transmission of the GFCyc to the RoW.

We first outline the structure of the model. We then show that the impulse responses to global risk aversion and US monetary policy shocks in the model with a standard calibration match well the empirical evidence from the BPSVAR model. Finally, we show that in a counterfactual version of the model without dollar trinity the GFCyc and the exchange rate are much less consequential for the RoW: Global risk aversion and US monetary policy shocks appreciate the dollar and tighten global financing conditions much less, entail much weaker contractionary effects on output and no

[5]The conventional interest rate policy, forward guidance and LSAP surprises of Jarociński (2021) are very similar to the analogues of Swanson (2021), except that they also account for the possible presence of central bank information effects. See Georgiadis & Jarocinski (forthcoming) for a detailed comparison.

trade-offs for RoW monetary policy.

3.1 Model structure

The model consists of two economies, the US denoted by U, and a RoW block denoted by R, which are linked through trade, cross-border bank lending and investment in US Treasuries. The model features standard real and nominal frictions such as sticky prices and wages, habit formation in consumption, investment adjustment costs and variable capital utilization. At the heart of the model are US and RoW banks that engage in leveraged domestic and cross-border lending and borrowing. We assume the structure of frictions is generally symmetric for the US and the RoW; the key exception is financial frictions. In particular, we assume US banks intermediate domestic dollar funds to the RoW and that US Treasuries are the global safe asset. We describe RoW and US banks in detail below. We keep the model description short and do not discuss features that are standard. We relegate most equations to Appendix C and only state those related to dollar dominance in trade invoicing, cross-border credit and safe asset supply. Figure A.7 in the Appendix provides a schematic model overview.

3.1.1 Households

Each economy is populated by households and firms indexed on the unit interval. A fraction s of agents resides in the RoW, the remaining fraction in the US. Following Erceg et al. (2000) we assume that within each country households are symmetric with the exception of the wage they receive and labor they supply. As in Gertler & Karadi (2011) we assume that within each household a fraction $1-f$ of members are workers, while the remaining fraction f are bankers. Workers supply labor, make consumption decisions and provide deposits to local banks, while bankers accumulate equity and intermediate funds from households to domestic firms. US banks additionally intermediate funds to RoW banks, and RoW banks to the US government. To ensure that bankers do not end up with enough equity to fund all investments without having to rely on domestic deposits, we assume that every period a banker has to close its bank with probability $1-\theta_b$ and transfer the accumulated equity to the household. A corresponding number of workers randomly become bankers every period, keeping the ratio of workers to bankers fixed.

3.1.2 RoW banks

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

$$Q_{R,t}K_{R,j,t} + RER_tGB_{R,j,t} = B_{R,j,t} + RER_tCBDL_{R,j,t} + N_{R,j,t}, \tag{4}$$

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

On the asset side of the RoW bank's balance sheet in Equation (4), claims on domestic capital $K_{R,j,t}$ earn the rate $R^K_{R,t}$, and—when converted to RoW currency—holdings of US Treasuries $GB_{R,j,t}$ earn the rate $D\mathcal{E}_t R^{GB}_{U,t-1}$, $D\mathcal{E}_t \equiv \mathcal{E}_t/\mathcal{E}_{t-1}$. On the liability side, deposits of domestic households $B_{R,j,t}$ cost the rate $R_{R,t-1}$—which we assume equals the RoW risk-free, central bank rate—and cross-border dollar loans from US banks $CBDL_{R,j,t}$ the rate $D\mathcal{E}_t R^{CBDL}_{U,t-1}$. The law of motion for the RoW bank's net worth is

$$N_{R,j,t} = \frac{1}{1+\pi^C_{R,t}} \Big\{ R_{R,t-1} N_{R,j,t-1} + \Big[(1-\alpha^{GB}_{R,j,t-1}) R^K_{R,t} + \alpha^{GB}_{R,j,t-1} D\mathcal{E}_t R^{GB}_{U,t-1} - (1-\ell^{CBDL}_{R,j,t-1}) R_{R,t-1} - \ell^{CBDL}_{R,j,t-1} D\mathcal{E}_t R^{CBDL}_{U,t-1} \Big] AS_{R,j,t-1} \Big\}, \tag{5}$$

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, $\alpha^{GB}_{R,j,t} \equiv RER_t GB_{R,j,t}/AS_{R,j,t}$ the share of total assets accounted for by US Treasuries, and $\ell^{CBDL}_{R,j,t} \equiv RER_t CBDL_{R,j,t}/AS_{R,j,t}$ the share of total assets funded by cross-border dollar loans.

Equation (5) shows that a RoW bank's net worth generally fluctuates with the dollar exchange rate. In particular, even when returns on US Treasuries equal the costs of cross-border dollar loans ($R^{GB}_{U,t-1} = R^{CBDL}_{U,t-1}$), if the share of assets funded by cross-border dollar loans exceeds the asset share of Treasuries ($\ell^{CBDL}_{R,j,t} - \alpha^{GB}_{R,j,t} > 0$) the bank's net worth drops when the dollar appreciates ($D\mathcal{E}_t > 0$).

The objective of a RoW bank is to maximize the discounted value of current and expected future equity streams. The bank's value function is

$$V_{R,j,t} = \max\ \mathbb{E}_t \sum_{s=0}^{\infty} (1-\theta_B)\Theta_{R,t,t+s} N_{E,j,t+1+s}, \tag{6}$$

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

In order to put a ceiling on the amount of leverage a RoW bank can take on we assume it faces a balance-sheet constraint in the spirit of Gertler & Karadi (2011). We motivate this balance-sheet constraint as an eligibility requirement the bank needs to satisfy in order for creditors to provide funding. In particular, for the bank to attract creditors and be able to leverage, the sum of its discounted current and expected future equity streams has to be larger than a risk-weighted sum of its current assets

$$V_{R,j,t} \geq \delta_{R,j,t}(Q_{R,j,t}K_{R,j,t} + \Gamma^{GB}_R RER_t GB_{R,j,t}). \tag{7}$$

We assume creditors apply two types of risk weights in the balance-sheet constraint in Equation (7). First, the *asset-specific* risk weight Γ^{GB}_R represents the perceived riskiness of Treasuries relative to claims on domestic capital (for a similar interpretation see Karadi & Nakov 2021; Coenen et al. 2018). In particular, we assume that US Treasuries are perceived to be less risky than claims on domestic capital ($\Gamma^{GB}_R < 1$). Second, the *balance-sheet-specific* risk weight $\delta_{R,j,t}$ represents the perceived riskiness of the bank's relative *asset and liability* composition. The balance-sheet constraint in Equation (7) thus shows how creditors weigh the perceived riskiness of the size and structure of the bank's asset and liability portfolio on the right-hand side against its discounted current and expected future level of equity on the left-hand side.[6] In particular, we assume the balance-sheet-specific risk weight varies with the asset and liability shares according to

$$\delta_{R,j,t}\left(\ell^{CBDL}_{R,j,t}, \alpha^{GB}_{R,j,t}\right) = \bar{\delta}_R\left[1 + \frac{\kappa_{R,\alpha,\ell}}{2}\left(\alpha^{GB}_{R,j,t} - \ell^{CBDL}_{R,j,t}\right)^2 - \epsilon_{R,\alpha}\alpha^{GB}_{R,j,t}\right] + \epsilon^{\delta_R}_t, \tag{8}$$

where $\epsilon^{\delta_R}_t$ is an exogenous shock we discuss in Section 4.

The specification of the balance-sheet-specific risk weight in Equation (8) is key for the transmission mechanisms in the model. First, cross-border dollar loan funding increases the balance-sheet-specific risk weight as long as it is not met by corresponding dollar assets in terms of holdings of US Treasuries ($\kappa_{R,\alpha,\ell} > 0$). We make this assumption because unhedged cross-border dollar borrowing exposes the RoW bank's net worth to fluctuations in the exchange rate and dollar funding shortages.[7] Second, apart from hedging funding through cross-border dollar loans, holding US Treasuries reduces the balance-sheet-specific risk weight ($\epsilon_{R,\alpha} > 0$). We make this assumption because Treasuries are viewed as the safe asset whose market price is relatively stable so that it can be sold with limited losses or even gains on its face value in times of stress in order to provide liquidity buffer in any type of funding shortage (Gorton 2017; Bianchi et al. 2021). In other words, Equation (8) incorporates a general and a dollar-specific incentive for holding Treasuries as liquidity-buffer. [8]

The remaining equations for the RoW bank are standard. In particular, we impose market clearing for domestic capital and specify the start-up funds 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 equilibrium all banks choose the same portfolio structure as they face the same returns and costs. The law of motion for aggregate net worth of the RoW banking sector is given by

$$\begin{aligned} N_{R,t} = \frac{\theta_B}{1+\pi^C_{R,t}}\Big\{ & R_{R,t-1}N_{R,t-1} + \Big[(1-\alpha^{GB}_{R,t-1})R^K_{R,t} + \alpha^{GB}_{R,t-1}D\mathcal{E}_t R^{GB}_{U,t-1} \\ & - (1-\ell^{CBDL}_{R,t-1})R_{R,t-1} - \ell^{CBDL}_{R,t-1}D\mathcal{E}_t R^{CBDL}_{U,t-1}\Big]AS_{R,t-1}\Big\} + \omega_R AS_{R,t-1} \end{aligned} \tag{9}$$

When the model is parameterized so that the balance-sheet constraint in Equation (7) binds in a

[6] The balance-sheet constraint in Equation (7) 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.

[7] 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).

[8] Note that strictly speaking Equation (8) states that also a positive net dollar exposure ($\alpha^{GB}_{R,j,t} - \ell^{CBDL}_{R,j,t} > 0$) increases the balance-sheet-specific risk weight. Thus, Equation (8) 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.

neighbourhood of the steady-state, the maximum equilibrium leverage ratio is given by

$$\phi_{R,j,t} \equiv \frac{AS_{R,j,t}}{N_{R,j,t}} = \frac{n_{R,j,t}}{\mathcal{R}_{R,j,t} - \mathcal{P}_{R,j,t}}, \tag{10}$$

where

$$\mathcal{R}_{R,j,t} \equiv \delta_{R,j,t}\left[(1-\alpha^{GB}_{R,j,t}) + \Gamma^{GB}_{R}\alpha^{GB}_{R,j,t}\right], \tag{11}$$

$$\begin{aligned}\mathcal{P}_{R,j,t} \equiv \mathbf{E}_t\Omega_{R,j,t,t+1}\Big[&(1-\alpha^{GB}_{R,j,t})R^{K}_{R,t+1} + \alpha^{GB}_{R,j,t}D\mathcal{E}_{t+1}R^{GB}_{U,t} \\ &- (1-\ell^{CBDL}_{R,j,t})R_{R,t} - \ell^{CBDL}_{R,j,t}D\mathcal{E}_{t+1}R^{CBDL}_{U,t}\Big],\end{aligned} \tag{12}$$

are the RoW bank's asset-share-weighted bank and asset-specific risk weight and its expected profitability, respectively; the terms $\Omega_{R,j,t,t+1}$ and $n_{R,j,t}$ denote the bank's stochastic discount factor and the expected discounted returns to equity defined in Appendix C, respectively. Equation (10) shows that the RoW bank's maximum leverage is pinned down by its portfolio's expected profitability and perceived riskiness in terms of risk weights. In particular, the RoW bank can attain a higher leverage ratio, thereby exploit more investment opportunities and generate more profits if (i) the perceived riskiness in terms of $\mathcal{R}_{R,j,t}$ is low, (ii) its expected profitability in terms of $\mathcal{P}_{R,j,t}$ is high, and/or (iii) expected discounted returns to equity in terms of $n_{R,j,t}$ are large.

3.1.3 US banks

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

$$Q_{U,t}K_{U,j,t} + CBDL_{U,j,t} = B_{U,j,t} + N_{U,j,t}, \tag{13}$$

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

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

$$\begin{aligned}N_{U,j,t} =& \frac{1}{1+\pi^{C}_{U,t}}\Big[(R^{K}_{U,t} - R_{U,t-1})Q_{U,t-1}K_{U,j,t-1} \\ &+ (R^{CBDL}_{U,t-1} - R_{U,t-1})CBDL_{U,j,t-1} + R_{U,t-1}N_{U,j,t-1}\Big],\end{aligned} \tag{14}$$

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

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

$$V_{U,j,t} \geq \delta_{U,j,t}(Q_{U,t}K_{U,j,t} + \Gamma^{CBDL}_{U,t}CBDL_{U,j,t}), \tag{15}$$

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

$$\Gamma_{U,t}^{CBDL} = \bar{\Gamma}_{U}^{CBDL} + \Phi_{U,\phi}\phi_{R,j,t}, \tag{16}$$

and where $\phi_{R,j,t}$ is the leverage ratio of RoW banks from Equation (10). Specifically, in Equation (16) we assume cross-border dollar lending is perceived to be more risky by a US bank's creditors when RoW banks are more leveraged. The motivation for this specification is that while RoW banks lend to the US government (the least risky borrower by assumption) and US firms (which pledge the entire return to capital), US banks also lend to leveraged and thus risky RoW banks, whos leverage also endogenously fluctuates with the state of the economy.

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

$$\delta_{U,j,t} = \overline{\delta}_{U} + \epsilon_t^{\delta_U}, \tag{17}$$

where $\epsilon_t^{\delta_U}$ is an exogenous shock we discuss in Section 4.

We assume for simplicity that the return on US Treasuries equals the risk-free, monetary policy rate: $R_{U,t}^{GB} = R_{U,t}$. 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 (15) was zero, and if the balance-sheet-specific risk weight in Equation (17) was independent of these holdings.

In equilibrium, the bank's maximum leverage ratio again reflects a risk-profitability trade-off

$$\phi_{U,j,t} \equiv \frac{AS_{U,j,t}}{N_{U,j,t}} = \frac{Q_{U,t}K_{U,j,t} + CBDL_{U,j,t}}{N_{U,j,t}} = \frac{n_{U,j,t}}{\mathcal{R}_{U,j,t} - \mathcal{P}_{U,j,t}}, \tag{18}$$

where

$$\mathcal{R}_{U,j,t} = \delta_{U,j,t}\left[(1-\alpha_{U,j,t}^{CBDL}) + \Gamma_{U,t}^{CBDL}\alpha_{U,j,t}^{CBDL}\right], \tag{19}$$

$$\mathcal{P}_{U,j,t} = \mathbf{E}_t\Omega_{U,j,t,t+1}\left[(1-\alpha_{U,j,t}^{CBDL})R_{U,t+1}^{K} + \alpha_{U,j,t}^{CBDL}R_{U,t}^{CBDL} - R_{U,t}\right], \tag{20}$$

where $\alpha_{U,j,t}^{CBDL} \equiv CBDL_{U,j,t}/AS_{U,j,t}$ and $\Omega_{U,j,t,t+1}$ and $n_{U,j,t}$ are the US bank's stochastic discount factor and the expected discounted returns to equity, respectively.

3.1.4 Implications of dollar dominance in cross-border credit and safe asset supply for financial spillovers and exchange rate determination

We first show how the RoW bank's problem gives rise to a UIP deviation that implies RoW banks hold US Treasuries even though they earn a lower direct. risk-weight-adjusted excess return than alternative assets, which we interpret as convenience yield accruing to foreign investors in the spirit of Jiang et al. (2021b).[9]

Consider the RoW bank's *asset* portfolio choice problem. The first-order conditions for the bank's problem in Equation (6) imply that optimal portfolio choice requires

$$\mathbf{E}_t \left[\Omega_{R,j,t,t+1} \left(D\mathcal{E}_{t+1} R^{GB}_{U,t} - R_{R,t}\right)\right] + CY_{R,j,t} = RP^{GB}_{R,j,t}. \tag{21}$$

The first term on the left-hand side coincides with the UIP condition in a standard model without financial frictions and safe asset demand. In particular, in a standard setup, in order to rule out arbitrage profits for RoW banks the exchange-rate-adjusted return of Treasuries—whose dollar-return equals the US risk-free rate $R^{GB}_{U,t} = R_{U,t}$ by assumption—has to equal the cost of funding through domestic deposits in terms of the risk-free rate $R_{R,t}$. Equation (21) shows that our model gives rise to two UIP deviations $CY_{R,j,t}$ and $RP^{GB}_{R,j,t}$.

The first UIP deviation is given by

$$RP^{GB}_{R,j,t} = \Gamma^{GB}_R \mathbf{E}_t \Big[\Omega_{R,j,t,t+1} \Big(R^K_{R,t+1} - R_{R,t}\Big)\Big], \tag{22}$$

and arises because optimal portfolio choice requires that in equilibrium the overall, exchange-rate-adjusted excess return of US Treasuries on the left-hand side in Equation (21) has to equal the risk-weight-adjusted excess return of the alternative investment in domestic capital on the right-hand side in Equation (21).

The second UIP deviation is given by

$$CY_{R,j,t} = -\frac{\partial \delta_{R,j,t} / \partial \alpha^{GB}_{R,j,t}}{\delta_{R,j,t}} \left[(1 - \alpha^{GB}_{R,j,t}) + \Gamma^{GB}_R \alpha^{GB}_{R,j,t}\right] \mathbf{E}_t \Big[\Omega_{R,j,t,t+1} \Big(R^K_{R,t+1} - R_{R,t}\Big)\Big], \tag{23}$$

and arises because in our setup the *overall* return of US Treasuries for a RoW bank on the left-hand side is made up of the direct component $R^{GB}_{U,t}$ and an additional, *indirect* component: Holding Treasuries loosens a RoW bank's balance-sheet constraint in Equations (7) and (8), thereby allows it to leverage more, exploit more investment opportunities and generate additional profits. In other words, because of their dominant safe asset property, holding Treasuries may be optimal for a RoW bank even if their direct, expected, exchange-rate-adjusted return is lower than the risk-weight-adjusted return of domestic capital $RP^{GB}_{R,j,t}$. We interpret this indirect return $CY_{R,j,t}$ as a convenience yield.

Equation (23) shows that the magnitude of the convenience yield is pinned down by the degree to which holding Treasuries reduces a RoW bank's balance-sheet-specific risk weight, how the freed leverage translates into additional claims on domestic capital, and the corresponding excess return. For example, when domestic credit spreads are high, holding additional Treasuries and thereby relaxing a RoW bank's balance-sheet constraint is particularly profitable, and hence the convenience yield is high.

[9] In Du et al. (2018) and Krishnamurthy & Vissing-Jorgensen (2012) the convenience yield is instead defined as the difference between the domestic risk-free and government bond rates.

As a UIP condition Equation (21) pins down the evolution of the dollar exchange rate. First, for a given RoW domestic deposit rate ($R_{R,t}$), in standard UIP logic an increase in the US risk-free rate and hence by assumption the return on Treasuries ($R^{GB}_{U,t}$) requires an expected depreciation of the dollar ($D\mathcal{E}_{t+1}$ declines), which is in part achieved by a contemporaneous appreciation. Second, for a given RoW domestic deposit rate ($R_{R,t}$) and US risk-free rate ($R^{GB}_{U,t}$), an increase in the convenience yield ($CY_{R,j,t}$) has to be accompanied by an expected depreciation of the dollar ($D\mathcal{E}_{t+1}$ declines), which is again in part achieved by a contemporaneous appreciation.

Note that Equation (21) instills a structural interpretation to the convenience yield in the UIP condition in the no-arbitrage finance framework in Krishnamurthy & Lustig (2019). Apart from the risk premium $RP^{GB}_{R,j,t}$, Equation (21) also coincides with the UIP condition in the structural model of Jiang et al. (2021a). However, in their setup the convenience yield is introduced *ad hoc* as a UIP deviation that is assumed to decline in the global stock of safe assets. In contrast, in our model the convenience yield and its relation to global financing conditions emerge endogenously from the optimal portfolio choice of RoW banks.[10]

Next we show how the US bank's problem gives rise to a global financial accelerator that operates on cross-border dollar lending. Consider the US bank's *asset* portfolio choice problem. Optimal portfolio choice requires

$$\Gamma^{CBDL}_{U,t}\mathbb{E}_t\Big[\Omega_{U,j,t,t+1}(R^K_{U,t+1} - R_{U,t})\Big] = \mathbb{E}_t\left[\Omega_{U,j,t,t+1}\Big(R^{CBDL}_{U,t} - R_{U,t}\Big)\right] - RP^{CBDL}_{U,j,t}, \tag{26}$$

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

Apart from the term $RP^{CBDL}_{U,j,t}$, Equation (26) coincides with the equilibrium condition in a standard model without financial frictions on cross-border dollar lending and borrowing. In particular, in a standard setup expected, risk-weight-adjusted returns of different assets have to equalize. In

[10] The RoW bank's problem also gives rise to another risk premium that implies the direct costs of cross-border dollar borrowing are lower than those of domestic funding. Optimal portfolio *liability* choice requires that the expected cost of domestic deposits equal the expected exchange-rate-adjusted cost of cross-border dollar loans

$$\mathbf{E}_t\left(\Omega_{R,j,t,t+1}R_{R,t}\right) = \mathbf{E}_t\left(\Omega_{R,j,t,t+1}D\mathcal{E}_{t+1}R^{CBDL}_{U,t}\right) + RP^{CBDL}_{R,j,t}, \tag{24}$$

with

$$RP^{CBDL}_{R,j,t} = \frac{\partial\delta_{R,j,t}/\partial\ell^{CBDL}_{R,j,t}}{\delta_{R,j,t}}\mathbf{E}_t\Omega_{R,j,t,t+1}\Big[(1-\alpha^{GB}_{R,j,t})(R^K_{R,t+1} - R_{R,t}) + \alpha^{GB}_{R,j,t}\left(D\mathcal{E}_{t+1}R^{GB}_{U,t} + CY_{R,j,t} - R_{R,t}\right)\Big]. \tag{25}$$

Cross-border dollar borrowing has an additional, *indirect* cost, as it tightens the RoW bank's balance-sheet constraint in Equations (7) and (8), thereby limits its leverage and thus reduces profits. This risk premium implies that in order for the RoW bank to borrow cross-border dollar funds the *direct* cost has to be lower than for domestic deposits. Thus, consistent with the data, in our model cross-border dollar borrowing is—or at least appears to be—cheap compared to domestic funding (Caramichael et al. 2021; Gutierrez et al. 2023). Analogous to the UIP condition in Equation (21), also Equation (24) provides intuition for the evolution of the dollar exchange rate. For example, when global financing conditions tighten so that domestic credit spreads rise, the risk premium on cross-border dollar loans increases. Equation (24) shows that for a given deposit rate and cross-border dollar credit rate this rise in the risk premium has to be accompanied by an expected depreciation of the dollar. This is partly accomplished by a contemporaneous appreciation. This mechanism is similar to the "two-way feedback between balance sheets and exchange rates" in Akinci & Queralto (2019, p.3).

Equation (26) this means that the expected, risk-weight-adjusted excess returns on claims on domestic capital have to equal the expected excess returns on cross-border lending. Equation (26) shows that in our model the *direct* expected excess return of cross-border dollar lending has to be higher than the risk-weight-adjusted excess return of claims on domestic capital due to a risk premium $RP^{CBDL}_{U,j,t}$.

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

$$RP^{CBDL}_{U,j,t} = \frac{\partial \Gamma^{CBDL}_{U,t}}{\partial \alpha^{CBDL}_{U,j,t}} \alpha^{CBDL}_{U,j,t} \mathbf{E}_t \Omega_{U,j,t,t+1} \Big[(1-\alpha^{CBDL}_{U,j,t})(R^K_{U,t+1} - R_{U,t}) + \alpha^{CBDL}_{U,j,t}(R^{CBDL}_{U,t} - R_{U,t}) \Big], \tag{27}$$

and arises because the US bank's cross-border dollar lending raises the RoW bank's leverage, which feeds back and raises the US bank's asset-specific risk weight (see Equation (16)) and thereby has an additional, *negative indirect* return: It tightens the US bank's balance-sheet constraint in Equations (15) and (16), thereby limits its leverage and thus reduces profits.[11]

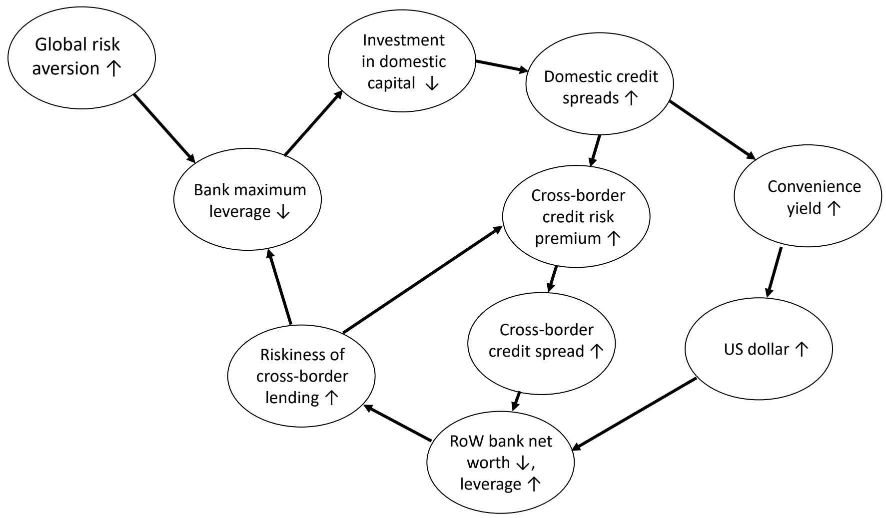
Equation (27) shows that the magnitude of this risk premium is pinned down by the degree to which cross-border dollar lending raises the US bank's asset-specific risk weight on cross-border dollar lending, how the ensuing reduction in the bank's leverage cuts into claims on domestic capital and cross-border dollar lending, and their corresponding excess returns. For example, when domestic credit spreads are high, the foregone profits implied by the tightening in the bank's balance-sheet constraint due to cross-border dollar lending are particularly high, and hence the risk premium on cross-border dollar lending is high.

Plugging Equation (27) in Equation (26) and solving for the cross-border dollar credit spread shows that it is large whenever domestic credit spreads and/or the asset-specific risk weight on cross-border dollar lending are high. The intuition is that whenever the (risk-adjusted) excess return on the alternative asset of domestic capital increases, the return of cross-border dollar lending needs to increase as well in order for the US bank to engage in this activity.

Note that Equation (26) implies a *global* financial accelerator mechanism that operates on cross-border dollar lending as laid out schematically in Figure 5. In particular, suppose there is an increase in global investors' risk aversion that reduces their willingness to provide finding for given asset holdings and balance sheet composition. As in standard domestic financial accelerator models, this reduces US and RoW banks' maximum equilibrium leverage ratio, reduces investment in physical capital and leads to an increase in domestic credit spreads. In our model, this raises the convenience yield of Treasury securities, which appreciates the dollar. As in steady state RoW banks feature a negative net dollar exposure (see the calibration in Section 3.2 below), dollar appreciation reduces RoW banks' net worth. At the same time, the increase in domestic credit spreads also increases cross-border dollar credit spreads, which reduces RoW banks' profits and hence their further reduces their net worth. The reduction in net worth raises RoW actual banks' leverage, which increases

[11] In Appendix C we show how the RoW banks' leverage ratio $\phi_{R,j,t}$ is related to the liability share of cross-border dollar loans $\ell^{CBDL}_{R,j,t}$.

Figure 5: The global financial accelerator in the trinity model



Note: The figure illustrates the global financial accelerator in the dollar trinity model.

the riskiness of cross-border dollar lending. This reduces US banks' maximum equilibrium leverage ratio, which triggers another round of amplification.

To sum up: Dollar dominance in safe asset supply and cross-border credit interact to give rise to several features that speak to key patterns between investor risk aversion, the dollar exchange rate and capital flows in the data. First, because holdings of US Treasuries reduce RoW banks' riskiness a UIP deviation emerges that is accounted for by an endogenous convenience yield. Second, when global financing conditions tighten the convenience yield rises. Third, when the convenience yield rises the dollar appreciates. Fourth, dollar appreciation triggers a global financial accelerator mechanism with a retrenchment in cross-border dollar credit and a tightening of financing conditions.

3.1.5 Production and pricing of final goods

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

In our model we go beyond DCP in bilateral trade between the US and the RoW and assume that prices of a share of domestic sales in the RoW are also sticky in dollar. In particular, Boz et al. (2022) document that a large share of trade among countries in the RoW is also priced in dollar; this is the actual meaning of a dominant—in the context of trade also often termed 'vehicle'—currency. It implies that when the dollar appreciates expenditure switching does not only affect imports from the US, but imports in general. Therefore, dollar pricing in third-country trade—in our model captured by domestic sales in the RoW—may be consequential for the effects of dollar appreciation in the context of a global risk aversion shock. To incorporate dollar pricing of a share of domestic sales in the RoW, we consider a multi-layered production structure in the spirit of Georgiadis & Schumann (2021) and laid out in Figure A.8 in the Appendix.

At the top layer, the RoW final consumption and investment good $Y^C_{R,t}$ is put together by a continuum of firms that operate under perfect competition, see Figure A.8. They combine a RoW final domestic good $Y^R_{R,t}$ and a RoW final import good $Y^R_{U,t}$ employing a constant elasticity of substitution (CES) technology

$$Y^C_{R,t} = \left[n_R^{\frac{1}{\psi_f}} Y^{R\,\frac{\psi_f - 1}{\psi_f}}_{R,t} + (1 - n_R)^{\frac{1}{\psi_f}} Y^{R\,\frac{\psi_f - 1}{\psi_f}}_{U,t} \right]^{\frac{\psi_f}{\psi_f - 1}} . \tag{28}$$

The parameter n_R governs the share of domestically produced goods and thereby the degree of home bias.[12] The parameter ψ_f corresponds to the elasticity of substitution between the final domestic good and the import good. As aggregation within the auxiliary sectors takes place using a constant elasticity of substitution (CES) production function, the first-order conditions are standard for essentially all stages of the bundling process and therefore only provided in Appendix C.

RoW final domestic good We assume markets are partly segmented and firms set different prices in different markets depending on demand conditions. We assume a fraction of RoW firms $1 - \gamma^R_R$ sets their prices for domestic sales in dollar. As in Gopinath et al. (2020), we assume firms cannot choose their pricing currency, but are assigned to it exogenously and do not change it over time.

The firms that put together the RoW final domestic good $Y^R_{R,t}$ shown on the right side in Figure A.8 operate under perfect competition and combine inputs $\widetilde{Y}^R_{R,t}$ and $\widehat{Y}^R_{R,t}$ using a CES technology. The inputs are produced by two branches of firms that also operate under perfect competition and combine RoW retail goods. The firms in the first branch combine RoW retail goods $\widehat{Y}^R_{R,t}(i)$ priced in dollar (DCP goods) into the RoW final DCP good $\widehat{Y}^R_{R,t}$; analogously, the firms in the second branch combine RoW retail goods $\widetilde{Y}^R_{R,t}(i)$ priced in the producer's currency (PCP goods) into the RoW final PCP good $\widetilde{Y}^R_{R,t}$. RoW retail-goods-producing firms buy and repackage RoW intermediate goods, operate under monopolistic competition and serve the RoW as well as the US market; for simplicity Figure A.8 only shows their domestic sales. The share of RoW retail-goods-producing firms whose domestic sales prices are sticky in dollar is given by $(1 - \gamma^R_R)$. Therefore, $(1 - \gamma^R_R)$ also reflects the degree to which movements in the dollar exchange rate cause fluctuations in the RoW aggregate producer-price index $P^R_{R,t}$.

Imports As shown on the left side in Figure A.8, the RoW import good $Y^R_{U,t}$ is produced analogously to the RoW final domestic good $Y^R_{R,t}$. In particular, RoW final import good producers use inputs from two branches of firms that operate under perfect competition and aggregate goods from US

[12]We adjust the home bias parameter in order to account for differences in country size as in Sutherland (2005). In particular, given a degree of general trade openness op_R and the relative size of the RoW s, n_R takes the value $n_R = 1 - op_R(1 - s)$ with a similar adjustment for the US counterpart.

retail goods producers. The latter operate under monopolistic competition and set prices that are either sticky in the producer's currency (PCP goods) or in the importer's currency (LCP goods). Likewise, we assume that when exporting a fraction $(1-\gamma_U^R)$ of RoW and $(1-\gamma_R^U)$ of US retailers faces prices that are sticky in the currency of the importer, while the prices of the remaining firms are sticky in the producer's currency. While not shown in Figure A.8, notice for future reference that for RoW exports to the US the resulting US import-price index expressed in dollar is (up to a first-order approximation) a weighted average of the RoW DCP and PCP good bundles. As a fraction $(1-\gamma_U^R)$ of RoW exporters sets their prices in dollar, the importance of the exchange rate $\mathcal{E}_t$ for movements in the import price depends on γ_U^R: The larger γ_U^R, the more a nominal appreciation of the dollar *ceteris paribus* causes a fall in the US import-price index and thereby an increase in the demand for import goods.

Retail-goods-firm pricing There exists a continuum of firms that operate under monopolistic competition and use intermediate goods to produce a retail good that is eventually sold to the specialized branches farther up. Each retail firm sells its product in the domestic and foreign markets; as mentioned above, for simplicity we only show sales to RoW in Figure A.8. When selling in the RoW (i.e. domestic) market, a fraction γ_R^R of RoW retail-goods-producing firms sets prices in RoW currency, while the remaining $(1-\gamma_R^R)$ share of firms sets their prices in dollar. A similar setting exists in the market for US imports, with γ_U^R indicating the fraction of RoW firms that price their exports in the producer's currency. Regardless of the pricing currency, all firms use the same production technology and face the same factor costs. Because firms are subject to Calvo-style price-setting frictions and can only change their price with a probability $(1-\theta_p^R)$ each period, the mark-up of a firm whose price is sticky in dollar fluctuates with the exchange rate. As RoW firms serving domestic and US markets, respectively, set their prices optimally and as in each market they use different pricing currencies, their profit functions differ as shown in Appendix C. As standard in Calvo-style price setting, firms choose their optimal reset price given demand and their pricing currency while taking into account that they might not be able to reset their price in the future. For instance, the optimal price $\hat{P}_{R,t}^R(i)$ for a DCP firm i for its sales in the RoW market is determined by

$$\underset{\hat{P}_{R,t}^R(i)}{max}\,\mathbb{E}_t\sum_{s=0}^{\infty}\theta_p^{E^s}\Theta_{R,t,t+s}\Big[\mathcal{E}_t\hat{P}_{R,t}^R(i)\hat{Y}_{R,t}^R(i)-MC_{R,t}\hat{Y}_{R,t}^R(i)\Big]. \tag{29}$$

3.1.6 Fiscal and monetary policy

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

$$GB_{U,t}=TRA_{U,t}+R_{U,t-1}^{GB}GB_{U,t-1}. \tag{30}$$

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

$$\hat{r}_{i,t} = \rho_{i,r}\hat{r}_{i,t-1} + (1-\rho_{i,r})(\phi_{i,\pi}\hat{\pi}^c_{i,t} + \phi_{i,z}\hat{z}_{i,t}) + \sigma^r_{i,\varepsilon}\varepsilon^r_{i,t}, \quad i \in U,\, R, \tag{31}$$

where $\pi^C_{i,t}$ is final (consumption) good inflation, $Z_{i,t}$ real GDP, $\varepsilon^r_{i,t}$ is a monetary policy shock, and hats denote deviations from steady state.

3.1.7 Balance of payments

We assume financial markets clear, which implies $GB_{U,t} = \frac{s}{1-s}GB_{R,t}$ and $CBDL_{U,t} = \frac{s}{1-s}CBDL_{R,t}$, where s is the relative country size parameter. When aggregating across budget constraints in the RoW, we recover the national accounting identity

$$RER_t\left[\left(GB_{R,t} - \frac{R^{GB}_{U,t-1}}{1+\pi^C_{U,t}}GB_{R,t-1}\right) - \left(CBDL_{R,t} - \frac{R^{CBDL}_{U,t-1}}{1+\pi^C_{U,t}}CBDL_{R,t-1}\right)\right] = \frac{P^R_{R,t}}{P^C_{R,t}}Y^R_{R,t} + \frac{\mathcal{E}_t P^F_{R,t}}{P^C_{R,t}}Y^U_{R,t} - Y^C_{R,t}. \tag{32}$$

The left-hand side represents the sum of the changes in the RoW net foreign asset position and the net financial account, while the right-hand side is the trade balance (taking into account that prices charged differ across domestically produced and exported goods). Importantly, and in contrast to Akinci & Queralto (2019), Devereux et al. (2020) and many others, we explicitly model *gross* rather than only net financial flows. We thereby break the 'triple coincidence' between production, decision-making and currency areas (Avdjiev et al. 2016). As a consequence, the national accounting identity does not dictate the evolution of all financial flows as in a net-flows model. In a net-flow model, where, for instance, RoW banks can only borrow in dollars but not hold dollar assets (i.e. gross liabilities equal net liabilities), the trade balance and costs of funds borrowed in the previous period determine uniquely the foreign banking sector's liability position in the next period. In contrast, in our model the national accounting identity only uniquely determines the *sum of the changes* in gross assets and liabilities has to equal the sum of the trade balance and the financial account.

3.2 Calibration

We generally allow parameter values to differ across the US and the RoW (see Table C.4 in the Appendix). For parameters that govern standard model elements, to the extent possible we draw on estimates from existing literature. In particular, for US parameters we rely on Justiniano et al. (2010). For the RoW it is more difficult to find suitable estimates, as it reflects an aggregate of countries. Since the euro area accounts for roughly one quarter of the RoW in the data in terms of output, we use the estimates in Coenen et al. (2018) for many of the RoW parameters. We next discuss the calibration of the parameters that govern DCP in trade and cross-border credit.

Regarding DCP in trade we first calibrate the relative country size s such that the steady-state share of US real GDP in global output is 25%. Given the country sizes, we set the general RoW openness vis-à-vis the US (op_R) such that the steady-state share of imports from the US in the aggregate RoW bundle ($1 - \eta_{ER}$) is roughly 5.1%, in line with the data over 1990-2019. In the same vein, we set US trade openness (op_U) such that the share of imports in the US bundle ($1 - \eta_U$) is roughly 14%. We set the share of RoW firms that face sticky dollar prices when exporting to the US ($1 - \gamma_U^R$) to 93%, in line with invoicing shares documented in Gopinath (2015). Based on the calculations in Georgiadis & Schumann (2021) we assume that US exporters almost exclusively face sticky prices in dollar and set γ_R^U to 3%. We set the share of intra-RoW *sales* that is priced in dollar ($1 - \gamma_R^R$) to 9%, which implies that 37.5% of intra-RoW *exports* are priced in dollar as indicated by the invoicing data in Boz et al. (2022).[13]

We almost exclusively choose the parameters that govern the endogenous portfolio choices of RoW and US banks in order to meet some steady-state targets. For both the US and the RoW banking sectors we follow Akinci & Queralto (2019) and assume a (risk weight adjusted) steady-state leverage ratio of five. Furthermore, we impose that the steady-state domestic credit spread ($R_i^K - R_i$) equals 200 basis points, which roughly corresponds to the average of the GZ-spread of Gilchrist & Zakrajsek (2012). These two assumptions imply the country specific values for the start-up fund parameter (ω_B) and the constants in balance-sheet-specific risk weights ($\bar{\delta}$) shown in Table C.4. We assume an average bank planning horizon of 7.5 years, which lies in between the 10 year of Gertler & Karadi (2011) and the one in Akinci & Queralto (2019). This implies that we set $\theta_{U,B} = \theta_{R,B}$ of 0.9667. For the parameters governing the portfolio choice of US banks we target a risk premium that is a fifth of the US domestic credit spread (a conservative choice) as well as an annualized steady-state 'exorbitant privilege' (Gourinchas & Rey 2007) of 1%, which pins down $\bar{\Gamma}_U^{CBDL}$ and $\Phi_{U,\phi}$. For RoW banks we jointly determine the parameters $\epsilon_{R,\alpha}$, $\bar{\delta}_R$ and $\kappa_{R,\alpha,\ell}$ in order to hit three steady state targets: A (risk weight adjusted) leverage ratio of five and a portfolio such that RoW banks invest 15% of their total liabilities in US Treasuries and finance 25% of their total assets using cross-border dollar loans. The latter roughly corresponds to the average liability structure of non-US, internationally active banks in the BIS Locational Banking Statistics.[14]

Finally, we impose that the US and RoW steady-state risk-free rates are 2% and 3.5%, respectively. These values roughly correspond to the averages in the data and pin down the discount factors β_U and β_R. These assumptions imply that the steady-state trade deficit to GDP ratio of the US is

[13] 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%.

[14] 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 ($\alpha_R^{TREAS} - \ell_R^{CBDL} < 0$). 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 Section 4.4.2 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.

1.8%, which is close to the average in the data. The US finances this trade deficit by a positive net financial income, which results from the US earning higher returns from cross-border dollar lending to the RoW than it pays for Treasuries held by the RoW. Therefore, the US maintains a higher steady-state per capita consumption than the RoW as a direct consequence of the exorbitant privilege.

4 Dollar trinity and the transmission of the GFCyc

4.1 Transmission of global risk aversion and US monetary policy shocks

As global risk aversion shock we consider an innovation that raises the perceived riskiness of US and RoW banks. In particular, consider the innovations $\epsilon_t^{\delta_R}$ in Equation (8) and $\epsilon_t^{\delta_U}$ in Equation (17), which increase the balance-sheet-specific risk weights for given balance-sheet size and composition. We assume that $\epsilon^{\delta_{i,B}}$ has a factor structure with a domestic component $\eta_t^{\delta_i}$ and a global component $\eta_t^{\delta_G}$ and evolves as

$$\epsilon_t^{\delta_{i,B}} = \rho_\delta \epsilon_{t-1}^{\delta_{i,B}} + \eta_t^{\delta_i} + \eta_t^{\delta_G}. \tag{33}$$

We interpret $\eta_t^{\delta_G}$ as a global shock to the risk aversion of US and RoW banks' creditors in the sense of reducing their willingness to provide funding for given balance-sheet size and composition.

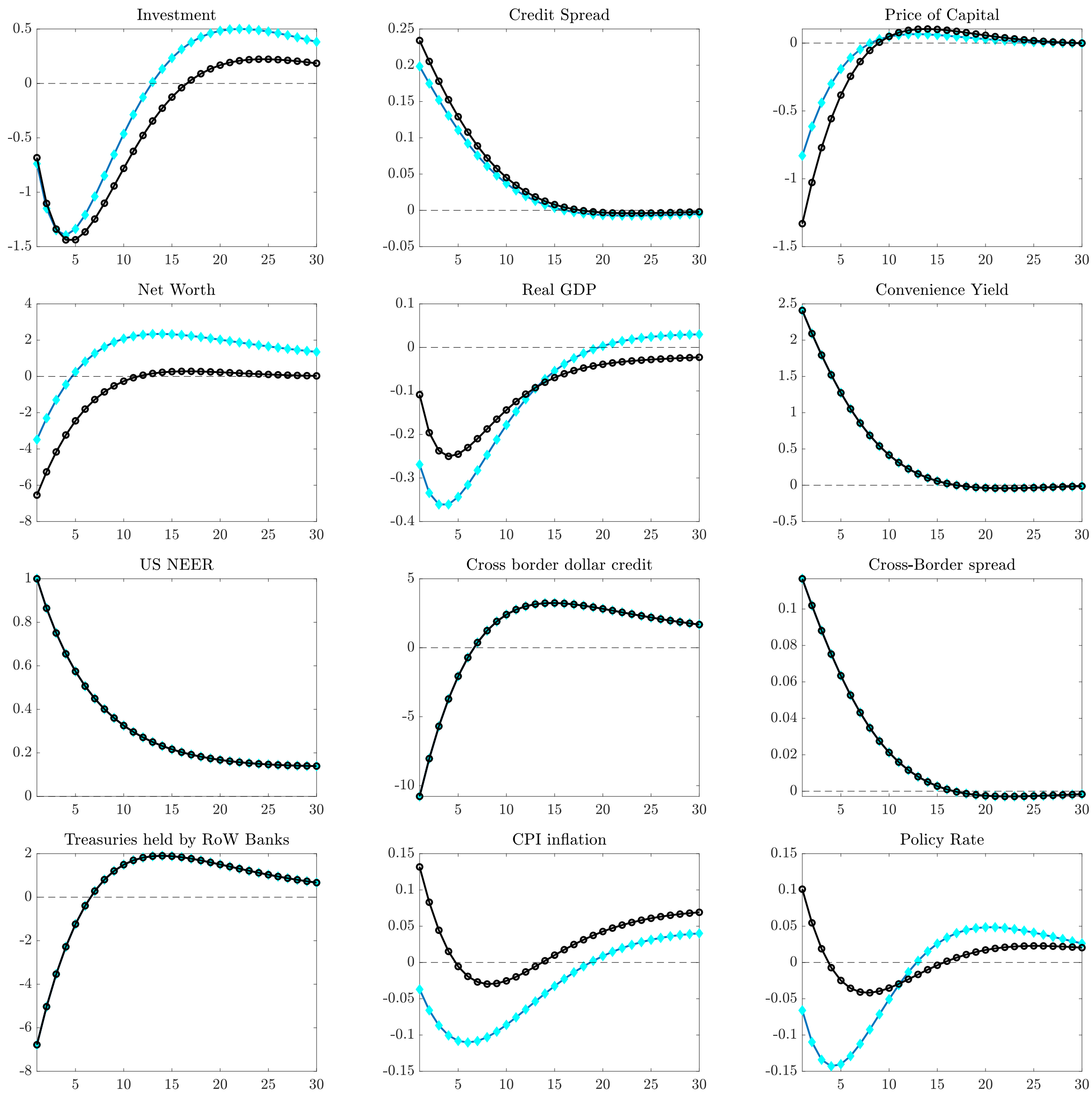
The impulse responses to such a contractionary global risk aversion shock $\eta_t^{\delta_G}$ are shown in Figure 6.[15] The shock increases the perceived riskiness of banks, which triggers adjustments as in standard domestic financial accelerator mechanisms (see Bernanke et al. 1999; Gertler & Karadi 2011). In particular, banks are forced to cut lending to domestic firms in order to shrink their balance sheets, which reduces investment in physical capital, raises domestic credit spreads and contracts the price of capital and hence banks' net worth, which triggers another round of amplification. Eventually, output contracts. However, in our model there is an additional global financial accelerator mechanism that operates on cross-border dollar credit (see Figure 5).

First, the convenience yield increases and the dollar appreciates. In particular, the increase in domestic credit spreads through standard domestic financial accelerator mechanisms implies additional leverage becomes more profitable for RoW banks. Hence, the additional, indirect return from holding Treasuries in terms of loosening balance-sheet constraints increases, manifesting in an increase in the convenience yield in Equation (23). In order to equalize the increased overall return of holding Treasuries and domestic funding costs for RoW banks, the UIP condition in Equation (21) implies that the dollar has to appreciate on impact.

Second, the dollar appreciation triggers a global financial accelerator operating on cross-border dollar credit. In particular, because of their unhedged steady-state dollar liability exposure, the net worth of RoW banks in Equation (9) drops as the dollar appreciates, raising their leverage in Equation (10), making them riskier borrowers. This raises the perceived riskiness of US banks (Equation (16)),

[15] We solve the model using a first order approximation around the deterministic steady state.

Figure 6: Responses to a global risk aversion shock for the US (cyan diamonds) and the RoW (black circles)



Note: The figure shows the impulse responses to a shock $\eta_t^{\delta_G}$ in Equation (33) to the US and RoW banks' balance-sheet-specific risk weights in Equations (8) and (17), scaled so as to cause an immediate appreciation of the dollar of 1%. Cyan (black) lines with diamonds (circles) depict the impulse responses for the US (RoW). All variables are plotted in %-deviations from steady state, except for interest rates, credit spreads, the convenience yield and inflation rates, which are plotted in annualized percentage rates.

which forces them to reduce their leverage in Equation (18) by cutting their cross-border dollar lending to RoW banks and increasing associated credit spreads. The latter further erodes the net worth of RoW banks in Equation (9), and thereby triggers another round of amplification.

Third, RoW banks shed their liquidity buffers in terms of holdings of Treasuries as they face a drop in cross-border dollar credit supply. This is the result of a trade-off RoW banks face. On the one hand, given the balance-sheet-specific risk weight in Equation (8) RoW banks have an incentive to hold additional Treasuries because the leverage this frees is more profitable given the increase in domestic credit spreads; this is the increase in the convenience yield in Equation (23). On the other hand, RoW banks face a contraction in cross-border dollar funding supply by US banks on the liability side of their balance sheet in Equation (4), which they can partly compensate by liquidating holdings of Treasuries.

Finally, RoW monetary policy tightens as the result of a trade-off between rising consumer prices and a contraction in output. In particular, because the prices of some intra-RoW sales are also sticky in dollar due to its use as a vehicle-currency, consumer-price inflation in the RoW increases despite the contraction in output. RoW monetary policy thus faces a trade-off between mitigating the contraction in output and dampening the increase in consumer prices, which is resolved by a tightening, which further amplifies the slowdown in RoW real activity. In contrast, US monetary policy does not face such a trade-off and can mitigate the drop in output and consumer-price inflation by loosening.

The effect of a global risk aversion shock on output is stronger in the US than in the RoW. This is partly due to expenditure switching away from imports from the US towards domestically produced goods in the RoW. At the same time, because it is RoW banks that feature immediate vulnerabilities in the global financial system due to the currency mismatches on their balance sheets, RoW financial variables are affected more strongly.

Figure 7 shows the impulse responses to a US monetary policy shock, which transmits in a very similar manner as the global risk aversion shock. This is noteworthy also because—unlike the global risk aversion shock—a US monetary policy shock is not a common, symmetric shock to the US and the RoW.

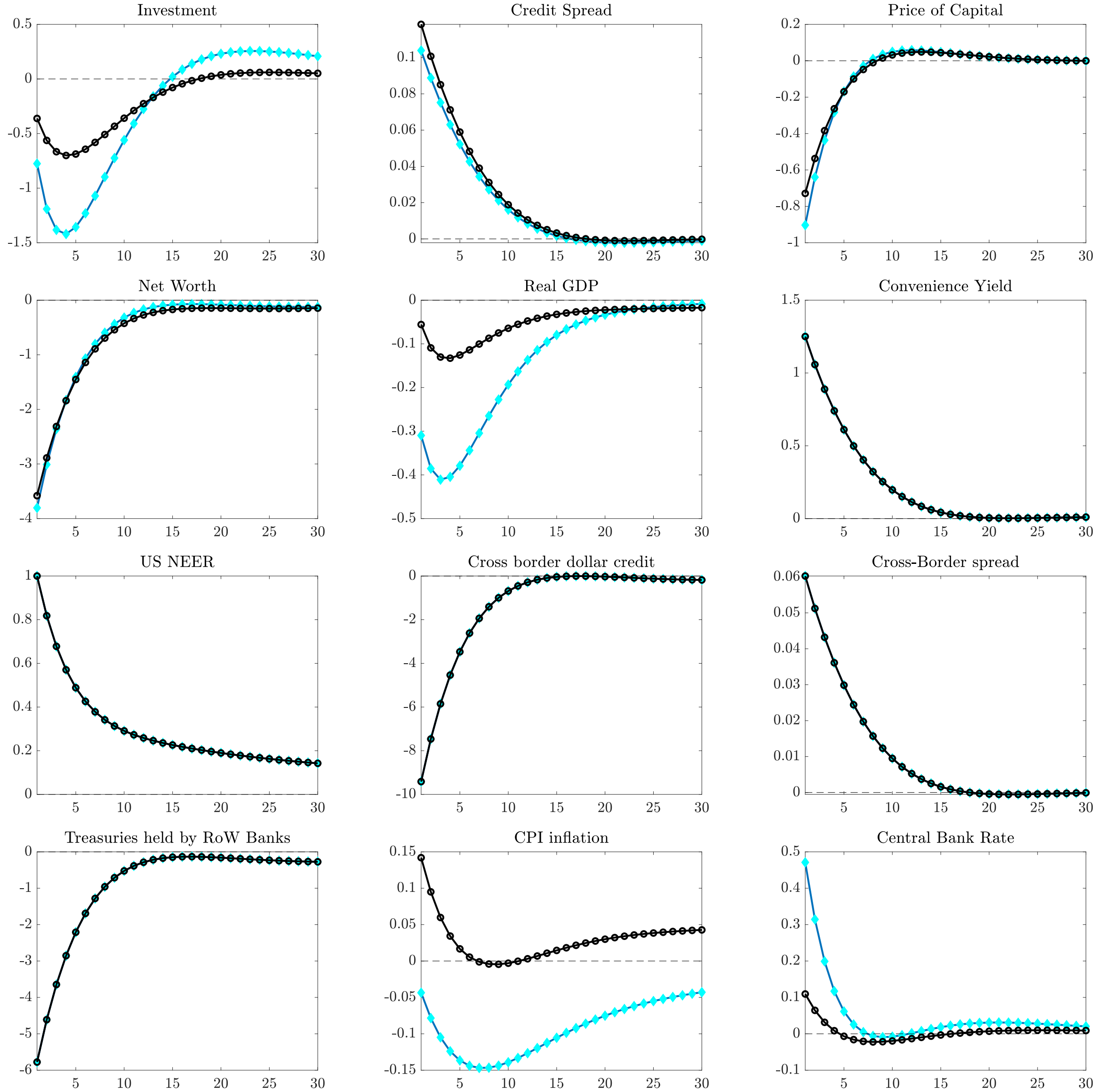
Overall, the model rationalizes the empirical patterns in terms of unconditional correlations in Figure 1 and causal effects between the GFCyc, the dollar exchange rate, other financial variables, real activity and consumer prices in Figures 2 to 4.

4.2 Empirical fit

Figures 8 and 9 compare the impulse responses to global risk aversion and US monetary policy shocks from the structural model (red dots) in Figures 6 and 7 to the corresponding empirical estimates from the BPSVAR model in Figures 2 and 3 (blue solid lines).[16]

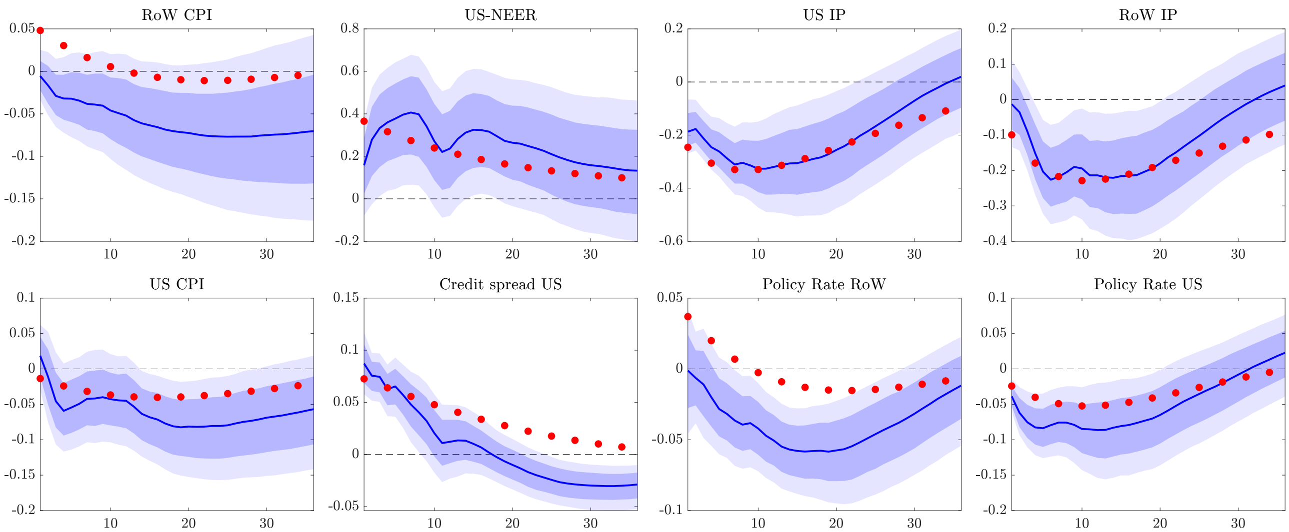
[16] We make several adjustments to render the impulse responses comparable. First, the structural model is calibrated to quarterly data, while the BPSVAR model is estimated on monthly data. Therefore, the impulse responses from the structural model in Figures 8 and 9 are plotted for the first month of each quarter. Second, while the structural model features real GDP, the BPSVAR model includes industrial production, which is about 2.5 times more volatile in

Figure 7: Responses to a US monetary policy shock for the US (cyan diamonds) and the RoW (black circles)



Note: The figure shows the impulse responses to a US monetary policy shock $\varepsilon^r_{U,t}$ in Equation (31) scaled so as to cause an immediate appreciation of the dollar of 1%. The cyan (black) lines with diamonds (circles) depict the impulse responses for the US (RoW). All variables are plotted in %-deviations from steady state, except for interest rates, credit spreads, the convenience yield and inflation rates, which are plotted in annualized percentage rates.

Figure 8: Responses to a global risk aversion shock in the structural model (red dots) and the BPSVAR model (blue solid lines)



Note: Solid blue lines show BPSVAR model responses reproduced from Figure 2. Black dots show impulse responses of the structural model. Footnote 16 provides further details on the scaling of impulse responses.

Remarkably, for most variables the impulse responses in the structural model match fairly well those estimated in the data—even though they have not been used as calibration targets. Against this background, we next use the structural model to assess how global risk aversion and US monetary policy shocks would transmit in the absence of dollar trinity.

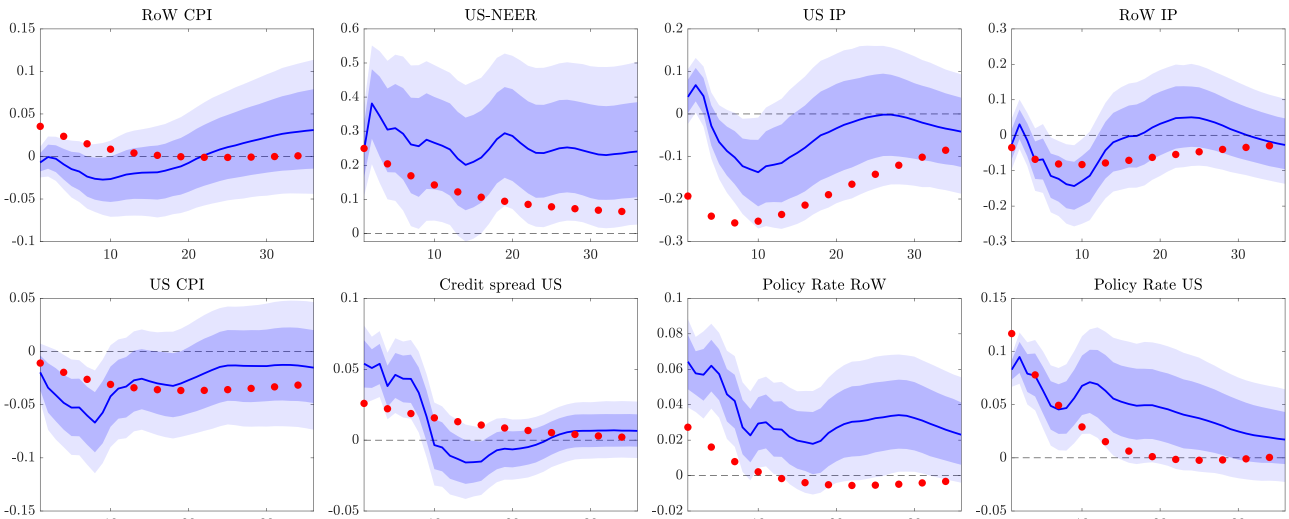
4.3 Transmission in the absence of dollar trinity

We compare the impulse responses of the structural model *with* dollar trinity to those from a counterfactual model *without any dollar dominance*. In the latter there is no cross-border dollar credit, no demand for US Treasuries as safe assets, and all US-RoW bilateral import and all intra-RoW sales prices are sticky in the producer's currency instead of the dollar.[17] The counterfactual model still features financial frictions and hence domestic financial accelerator mechanisms, but does no longer give rise to a global financial accelerator that operates on cross-border dollar lending and and is triggered by a dollar appreciation. We assume that households freely trade dollar bonds across borders, which implies a standard UIP condition.

quarterly data. We adjust the real GDP response in the structural model accordingly. Third, in order to account for differences in the size of the global risk aversion and US monetary policy shocks, we re-scale the impulse responses of the structural model so that the dollar appreciates by as much on average over four quarters as in the BPSVAR model; for the US monetary policy shock we scale the impulse responses so that the average increase in the Treasury yield over the first four quarters the is the same as in the BPSVAR model.

[17] Up to first-order this counterfactual model is numerically hardly distinguishable from a version of the baseline trinity model in which we set to zero the steady-state levels of cross-border dollar credit and the associated risk premium, RoW holdings of US Treasuries, and the convenience yield.

Figure 9: Responses to a US monetary policy shock in the structural model (red dots) and the BPSVAR model (blue solid lines)

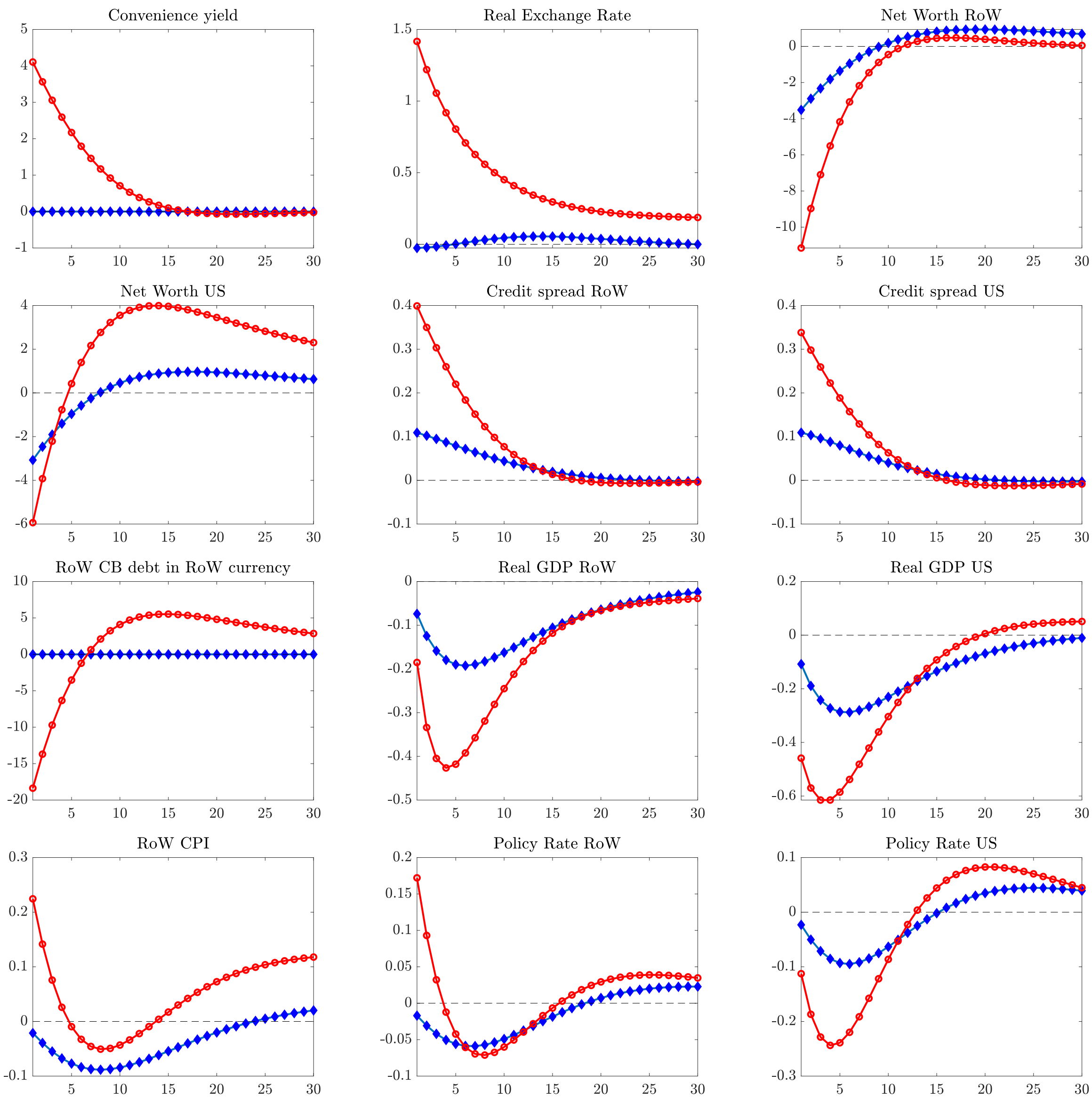


Note: Solid blue lines show BPSVAR model responses reproduced from Figure 3. Black dots show impulse responses of the structural model. Footnote 16 provides further details on the scaling of impulse responses.

To simplify the exposition, we first present results for the baseline trinity model and the counterfactual without any dollar dominance, and only then discuss in more detail the role of the individual trinity dimensions. Figure 10 shows results for variables that exemplify the role of dollar dominance in trade, cross-border credit and safe asset supply for the transmission of global risk aversion shocks. In particular, without dollar trinity there is no additional, indirect return of holding US Treasuries in terms of a convenience yield for RoW banks. As a result, the dollar does not appreciate in response to a global risk aversion shock; the small, delayed appreciation arises because the US and the RoW are not calibrated fully symmetrically. Banks' net worth falls and domestic credit spreads rise because of the domestic financial accelerators. The effects on financial variables are smaller without dollar trinity given the absence of the global financial accelerator. The lack of dollar appreciation in combination with the absence of the global financial accelerator implies the contractionary effect of a global risk aversion shock on US and RoW output is halved. It is reduced by more in absolute terms for the US because of the absence of the expenditure switching in favour of the RoW that is entailed by the dollar appreciation in the baseline model with dollar trinity. And finally, without dollar dominance in trade there is no trade-off between mitigating the contraction in output and dampening the increase in consumer price inflation for monetary policy in the RoW.

To comprehend the role of the individual trinity dimensions it is instructive to remove them sequentially instead of all at once as in Figure 12. First, the impulse responses with green dots in Figure 11 depict the effects of a global risk aversion shock when there is dollar dominance in cross-border credit and safe assets, but not in trade invoicing. In this counterfactual model, holding Treasuries still earns a convenience yield and hence the dollar still appreciates in response to a global

Figure 10: Responses to a global risk aversion shock with (red circles) and without (blue diamonds) dollar trinity



Note: The red lines with circles show the impulse responses of baseline model and the blue lines with diamonds from an alternative model in which we switch off dollar trinity. The global risk aversion shock is normalized to increase the US balance-sheet-specific risk weight by 1%.

risk aversion shock. Moreover, RoW banks still obtain funds through cross-border dollar credit and therefore experience a drop in their net worth as the dollar appreciates, which triggers a global financial accelerator. However, without dollar dominance in trade invoicing, dollar appreciation does not entail pressures on RoW import and hence consumer prices. As a result, RoW monetary policy does not face a trade-off, and so it loosens in order to mitigate the fall in output and inflation. Also, without dollar dominance in trade invoicing there is expenditure switching in the US when the dollar appreciates, further dampening the contraction in the RoW.[18]

Second, the impulse responses with black crosses in Figure 11 depict the effects of the global risk aversion shock when there is dollar dominance in safe assets, but not in cross-border credit and trade invoicing. In this counterfactual model holding Treasuries again still earns a convenience yield and hence the dollar still appreciates in response to a global risk aversion shock. However, RoW banks do not obtain funds through cross-border dollar credit, and so dollar appreciation does not cut into their net worth triggering a global financial accelerator. Because of the absence of the global financial accelerator, credit spreads rise by less, which entails that the convenience yield rises by less, and hence that the dollar appreciates by less.

Results for the US monetary policy shock shown in Figure 12 are similar in many regards. In particular, without dollar trinity RoW banks are largely shielded from a US monetary policy tightening. In contrast, the US financial sector is more heavily affected because without dollar trinity US banks do not diversify their portfolio across countries but solely hold domestic assets, whose prices are heavily affected by the monetary policy tightening. Without dollar dominance there is less pressure on RoW monetary policy to tighten because (i) intra-RoW sales prices are no longer partially sticky in dollar and (ii) the dollar appreciates by less due to the lack of a convenience yield which endogenously amplifies the appreciation in the baseline model with dollar trinity.

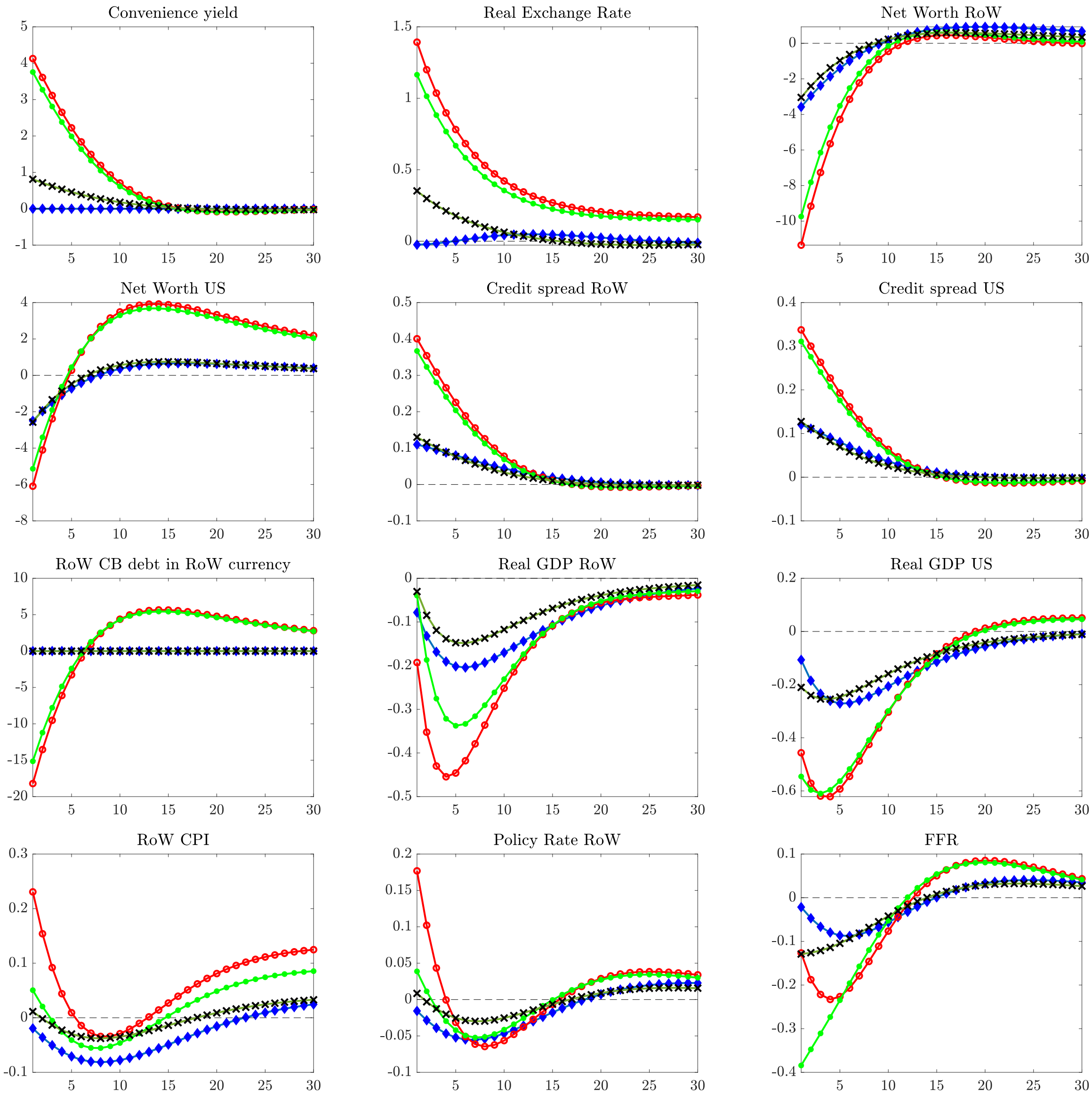
We conclude that under dollar trinity dominance in safe asset supply, cross-border credit and trade invoicing interact so that the dollar exchange rate emerges as—in the jargon of Bruno & Shin (2015)—the 'linchpin' for the transmission of the GFCyc to the world economy.

4.4 Extensions

We consider two extensions. First, we consider a different non-trinity counterfactual in which Treasuries remain the global safe asset and the dollar is the dominant currency in global trade invoicing, but in which US banks lend to RoW banks in RoW currency rather than in dollar. Second, we extend the baseline trinity model so that it replicates the empirical fact that the RoW is actually a net creditor to the US by introducing an additional, unconstrained RoW entity that can be interpreted as a foreign reserve manager, pension or sovereign wealth fund.

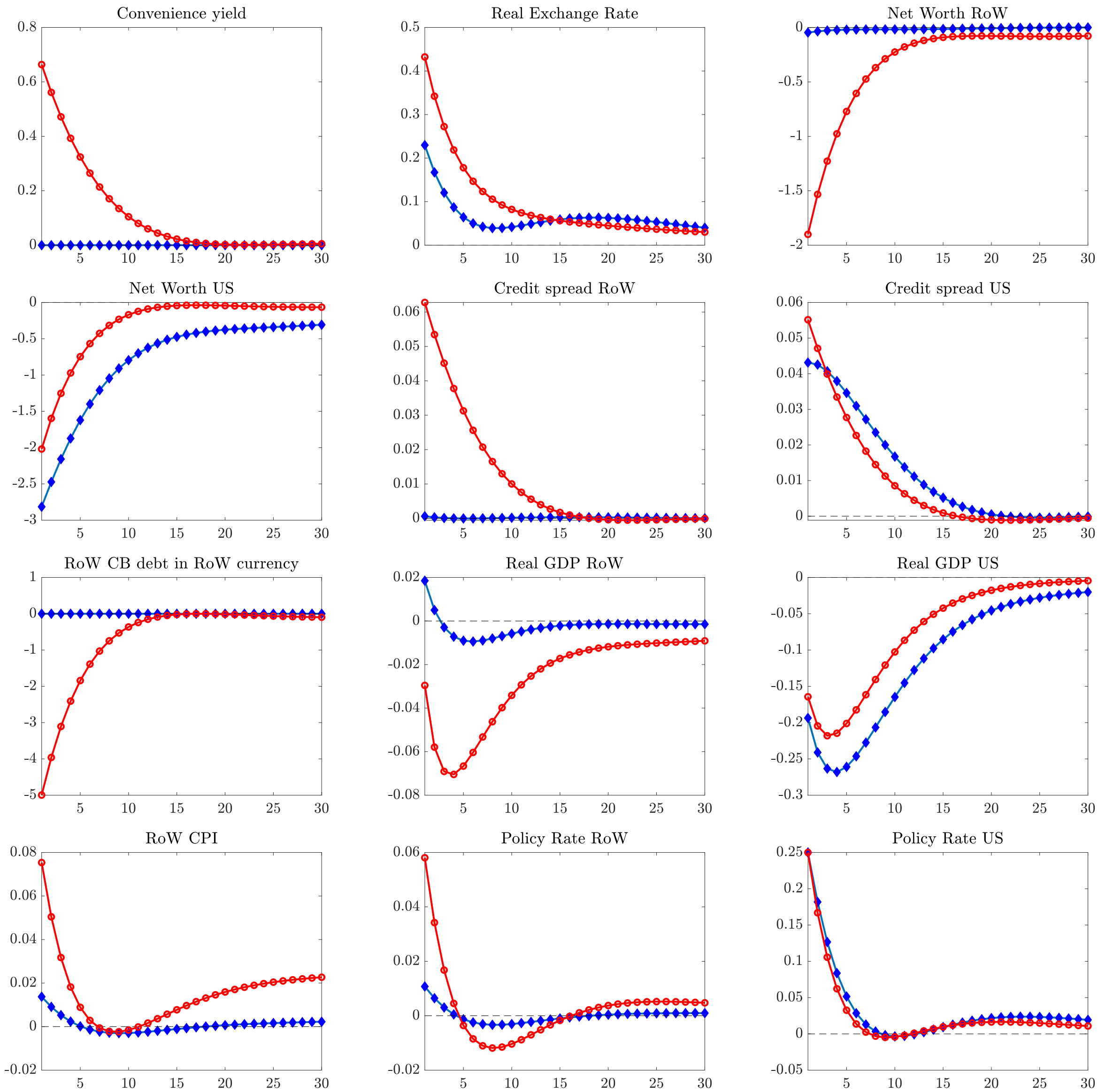
[18] In the US the additional monetary policy loosing resulting from the drop in import prices when there is no dominance in trade invoicing offsets the effect of expenditure switching on US output.

Figure 11: Responses to a global risk aversion shock in the trinity model (red circles), without DCP in trade (green dots), without DCP in trade and cross-border credit (black crosses), and without any DCP (blue diamonds)



Note: The red lines with circles show impulse responses for the baseline trinity model, the green lines show for the model without dollar dominance in trade invoicing, the black lines for the model without dollar dominance in trade invoicing and cross-border credit, the blue lines for the model without any dollar dominance.

Figure 12: Responses to a US monetary policy shock with (red circles) and without (blue diamonds) dollar trinity



Note: The red lines with circles show the impulse responses of baseline model and the blue lines with diamonds from an alternative model in which we switch off dollar trinity. The US monetary policy shock aversion shock is normalized to increase the US policy rate by 25 basis points.

4.4.1 Original sin redux

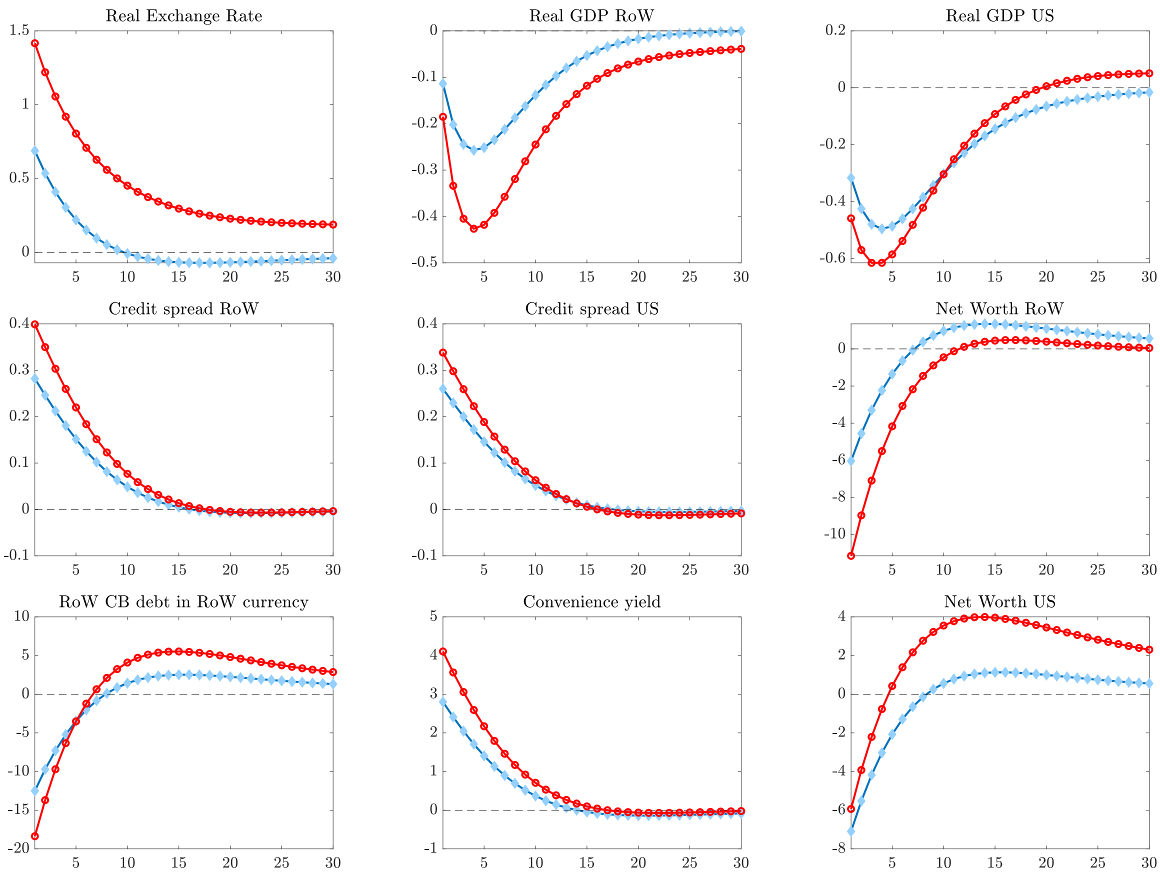
Historically, EMEs have borrowed from abroad in foreign currency, especially in dollar, which has been at the root of 'original sin' (Eichengreen & Hausmann 2005). This is reflected in our assumption in Equations (4) and (13) that US banks intermediate domestic dollar funds to RoW banks. More recently however, EMEs have been borrowing increasingly in local currency (Benetrix et al. 2020).

At the same time, overcoming 'original sin' does not necessarily lead to 'redemption'. In particular, EMEs may remain vulnerable to capital flow swings because funds are ultimately provided by foreign investors. Carstens & Shin (2019) refer to this persisting vulnerability of EMEs to external shocks as 'original sin redux'. Against this background, we consider a counterfactual in which cross-border lending by US to RoW banks is denominated in RoW currency, while RoW banks still hold a part of their portfolio in US Treasuries.[19]

Results for the global risk aversion shock are shown in Figure 13. Under 'original sin redux' the net worth of RoW banks drops by less, as they do not experience a negative exchange rate valuation effect on their balance sheets when the dollar appreciates. As a result, domestic credit spreads rise by less. At the same time, the net worth of US banks falls by more, as now the negative exchange rate valuation effect materializes on their balance sheets. As a result, while domestic credit spreads in the US also increase by less than in the baseline model with dollar trinity, the difference is smaller than for the RoW. The convenience yield increases by less as RoW domestic credit spreads do not rise as much. Hence, also the dollar appreciates by less. Cross-border lending by US to RoW banks—in RoW currency—tightens by as much as in the baseline model under dollar trinity despite the fact that the net worth of US banks falls by more under 'original sin redux'. The reason for this result lies in the ties between US and RoW banks. While in the baseline model with dollar trinity US banks do not exhibit currency mismatches and are therefore not subject to exchange rate valuation effects directly, they are affected indirectly through their exposure to RoW banks. Thus, US banks are in one way or another affected by currency mismatches in the global financial system, either indirectly under 'original sin' or directly under 'original sin redux'. Overall, under 'original sin redux' output in the RoW drops by less as RoW banks no longer exhibit vulnerabilities in terms of currency mismatches. Strikingly, and in contrast to Hofmann et al. (2022), although US banks exhibit negative valuation effects stemming from the dollar appreciation US output does not fall by more under 'original sin redux'. The reason for this result is again that RoW banks' net worth falls by less in response to the global risk aversion shock as they no longer experience negative exchange rate valuation effects, which loosens US banks' balance-sheet constraints relative to the baseline and thereby partially offsets the negative effect of a fall in US banks' net worth. The results for the US monetary policy shock are very similar (Figure A.9).

[19]Our model includes several additional features relative to that of Hofmann et al. (2022). First, we model explicitly the liability portfolio choice problem of RoW banks instead of assuming a fixed share of cross-border borrowing. Second, in our model UIP does not hold, and the dollar appreciates not only because of changes in interest rate differentials but also because of endogenous variation in the convenience yield of safe assets. Third, in our counterfactual RoW banks still hold dollar-denominated US Treasuries, which implies that their net worth is not entirely shielded from exchange rate movements as in Hofmann et al. (2022) but rather *rises* when the dollar appreciates.

Figure 13: Responses to a global risk aversion shock with dollar trinity (red circles) and 'original sin redux' (light blue diamonds)



Note: Red solid lines with circles show the impulse responses of baseline model and the light blue lines with diamonds from an alternative model in which cross-border lending is denominated in RoW currency. The global risk aversion shock is normalized to increase the US balance-sheet-specific risk weight by 1%.

These results suggests that the transmission of the GFCyc to the world economy could be mitigated if the currency of the global safe asset—which appreciates in times of a crisis—could be decoupled from the currency of cross-border bank lending.

4.4.2 Exorbitant duty

In the data the aggregate RoW has a positive net dollar position vis-à-vis the US. This partly underlies the 'exorbitant duty' (Gourinchas et al. 2012; Gourinchas & Rey 2022): When global risk aversion spikes and the dollar appreciates, the US (RoW) experiences a negative (positive) exchange rate valuation effect on its external balance sheet.[20] Taken together, when global risk aversion spikes and the dollar appreciates there is a wealth transfer that can be interpreted as the US providing

[20] According to Gourinchas & Rey (2022) the largest part of the overall valuation effect arises because the US is the 'global venture capitalist': Its foreign liabilities are tilted towards instruments whose prices increase when global risk aversion spikes—e.g. Treasury securities—while the prices of its foreign assets plummet—e.g. foreign equity.

insurance to the RoW, at least from an accounting perspective. In contrast, in the calibration of our baseline trinity model the RoW counterfactually has a *negative* net dollar position vis-à-vis the US. As a result, there is no wealth transfer from the US to the RoW due to an exchange rate valuation effect when global risk spikes and the dollar appreciates.

However, we argue the absence of this exorbitant duty in the baseline trinity model is inconsequential for the transmission of the GFCyc. In particular, the RoW's positive net dollar exposure vis-à-vis the US in the data is to a large extent accounted for by entities that are not subject to financial frictions and therefore unconstrained—for central banks, example foreign exchange reserve managers, pension and sovereign wealth funds—so that they simply absorb exchange rate valuation effects over time without contributing a global financial accelerator mechanism.[21]

In order to illustrate this, we consider an extension in which we introduce an unconstrained RoW government entity that holds dollar assets such that the *aggregate* RoW has a positive net dollar exposure vis-à-vis the US, while the RoW banking sector continues to be net short in dollar. In particular, we assume that in the RoW there exists a continuum of government entities—which we refer to as pension funds for simplicity—that in each period take on deposits $D^{PF}_{R,j,t}$ from RoW households at the rate $R_{R,t-1}$ which they use to purchase US Treasuries $GB^{PF}_{R,j,t}$. As bank deposits return the same rate as deposits with pension fund, RoW households are indifferent between the two. After each period, the pension funds transfer profits or losses from these operations to households. The balance sheet of RoW pension fund j in real terms reads as

$$RER_t GB^{PF}_{R,j,t} = D^{PF}_{R,j,t}, \tag{34}$$

and the period-by-period flow-of-funds constraint can be written as

$$\frac{R_{R,t-1}}{(1+\pi^C_{R,t})} D^{PF}_{R,t-1} + RER_t GB^{GB}_{R,j,t} = \frac{R^{GB}_{U,t-1}}{(1+\pi_{U,t})} RER_t GB_{R,j,t-1} + D^{PF}_{R,t}. \tag{35}$$

In contrast to the baseline trinity model, we assume that the supply of US Treasuries is fixed at $\overline{GB}_U$, which is calibrated to yield a (negative) US net-foreign-asset-to-GDP-ratio in line with the data.[22] Market clearing then determines the optimal amount of US Treasuries $GB_{R,t}$ held by the

[21]Sufficiently detailed data on the composition of US-RoW cross-border positions by counterparty country and sector, currency and instrument necessary to document this does not exist. However, some circumstantial evidence can be provided based on existing but less detailed data. For example, according to data from US Treasury International Capital RoW (quasi-)government holdings of US debt and equity securities—not including RoW institutional investors other than sovereign wealth funds—amounted to 28% of US annual GDP over 2005 to 2019, while according to the data from Benetrix et al. (2020) over the same period the US net foreign asset position and net foreign dollar exposure amounted to -30% and -80%, respectively. Similarly, the IMF's Currency Composition of Official Foreign Exchange Reserves (COFER) data suggest that global official dollar-denominated foreign exchange reserves amounted to 37% of US annual GDP over 1991 to 2019 (assuming the same dollar share for un-allocated as for allocated reserves), while the US net foreign asset position and net dollar exposure amounted to -20% and -60%, respectively. While not conclusive, this data suggests a non-trivial share of the RoW's holdings of US assets making up its net foreign asset position and net dollar exposure are held by unconstrained entities.

[22]While our baseline calibration implies the US has a positive net foreign asset position of 52% of GDP, here we calibrate $\overline{GB}_U$ to roughly match the average within our sample used in the empirical analysis in Section 2 at -14%.

RoW pension funds as

$$GB_{R,t}^{PF} = \frac{(1-s)}{s}\overline{GB}_U - GB_{R,t}, \tag{36}$$

where s denotes relative country size. One way to think of this set-up is that given a fixed supply of Treasuries, RoW banks purchase Treasuries to optimally manage the riskiness of their balance sheets, and RoW pension funds just absorb the residual. After imposing market clearing and aggregating across budget constraints of RoW firms and households, the aggregate RoW budget constraint (i.e. the national accounting identity) in Equation (32) includes an additional term which tracks the evolution of US Treasuries holdings of RoW pension funds.

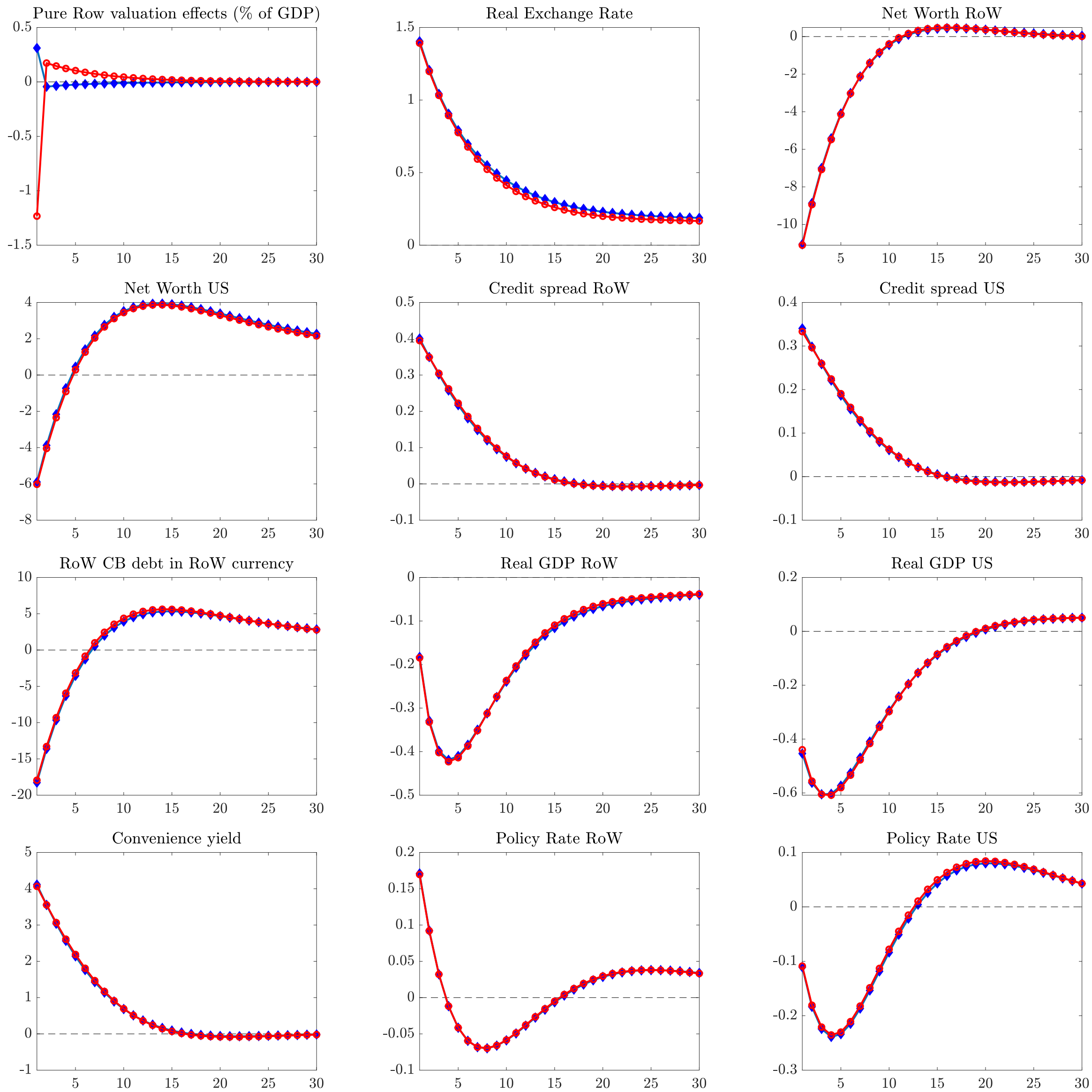
The first panel in Figure 14 shows that in this setup the RoW experiences a exchange rate valuation gain of roughly 0.4% of GDP following a dollar appreciation due to a global risk aversion shock. Most importantly, however, the responses of the remaining variables are virtually unchanged relative to the baseline trinity model.

The explanation for this outcome is that as long as the RoW entity that accounts for the positive net dollar exposure vis-à-vis the US is unconstrained and profits are distributed in a lump-sum fashion to (unconstrained) households, exchange rate valuation effects hardly affect consumption and savings choices of unconstrained households (Kaplan et al. 2018). Thus, the overall RoW net dollar exposure vis-à-vis the US is not key for the transmission of the GFCyc. What matters is the net dollar exposure of constrained RoW banks.

5 Conclusion

The dollar exchange rate is closely related to the GFCyc. While the co-movement is remarkable, it leaves open the question whether the dollar is just a 'correlate' of the GFCyc, or whether it plays a central role in its transmission to the world economy, and, if so, which features of the international monetary system account for this. We first document that in the data a dampening of the GFCyc entails an appreciation of the dollar and a contraction the US and RoW economy. Consistent with dollar trinity—dominance in trade invoicing, cross-border credit and safe asset supply—a dampening of the GFCyc furthermore is associated with an increase in the price of safe assets, a contraction in cross-border dollar credit, and monetary policy tightening in EMEs. We then present a structural two-country New Keynesian model for the US and the RoW with dollar trinity that rationalizes these empirical patterns. Our findings suggest that the three dimensions of dollar dominance interact in a way so that the dollar exchange rate emerges as the 'linchpin' for the pervasive transmission of the GFCyc to the world economy.

Figure 14: Responses to a global risk aversion shock with (red circles) and without (blue diamonds) exorbitant duty



Note: The red lines with circles show the impulse responses of baseline model and the blue lines with diamonds from an alternative model in which we add unconstrained RoW pension funds which hold enough US dollar denominated assets, such that the RoW is a net creditor to the US.

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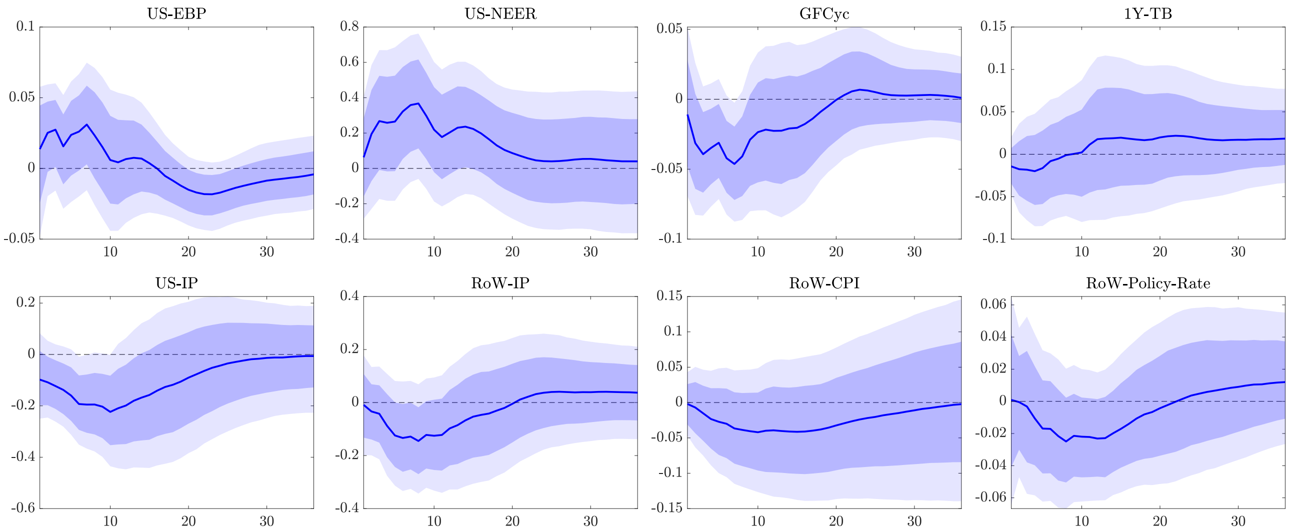
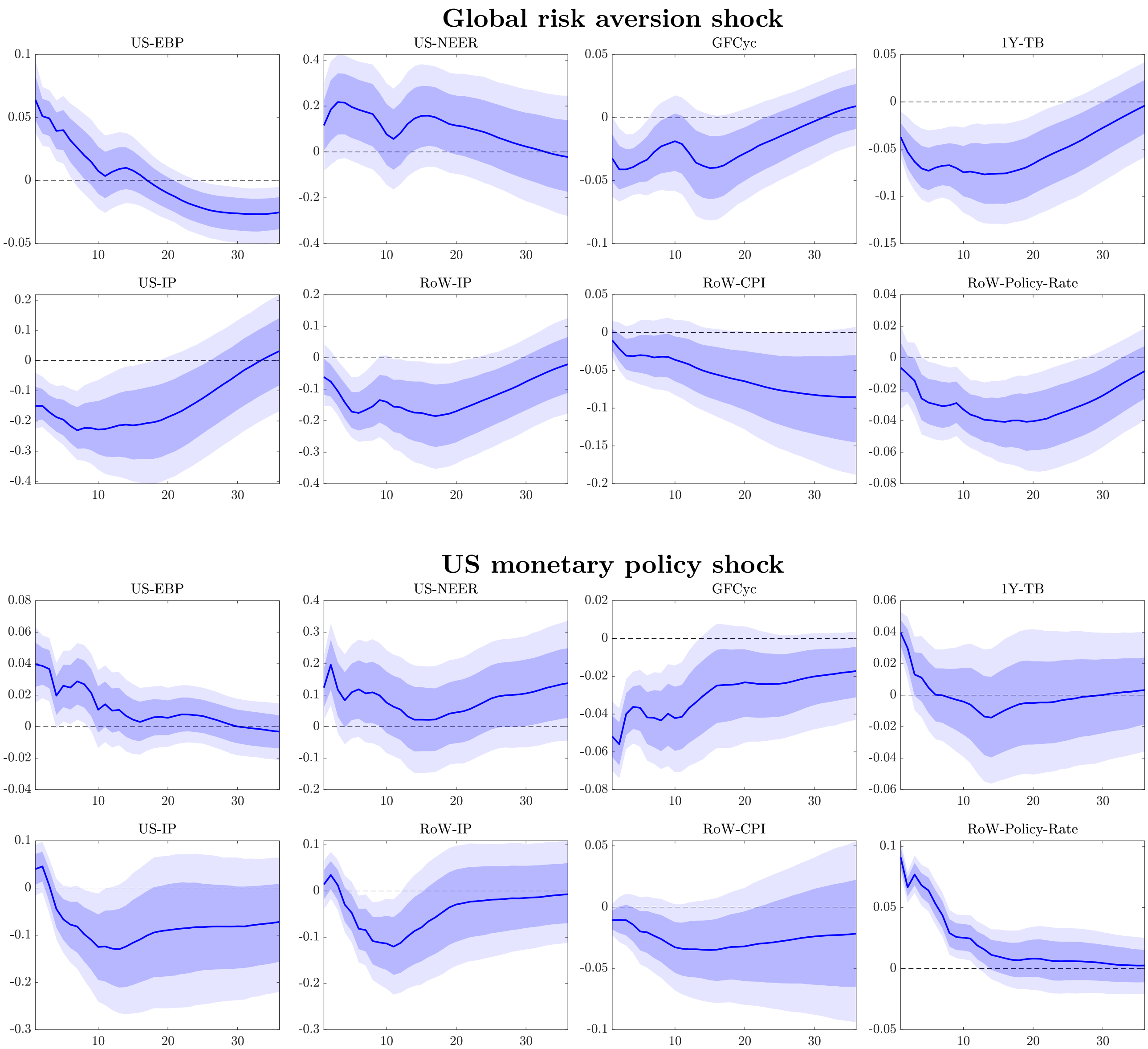
A Online appendix - Additional figures

Figure A.1: Responses to a contractionary global uncertainty shock



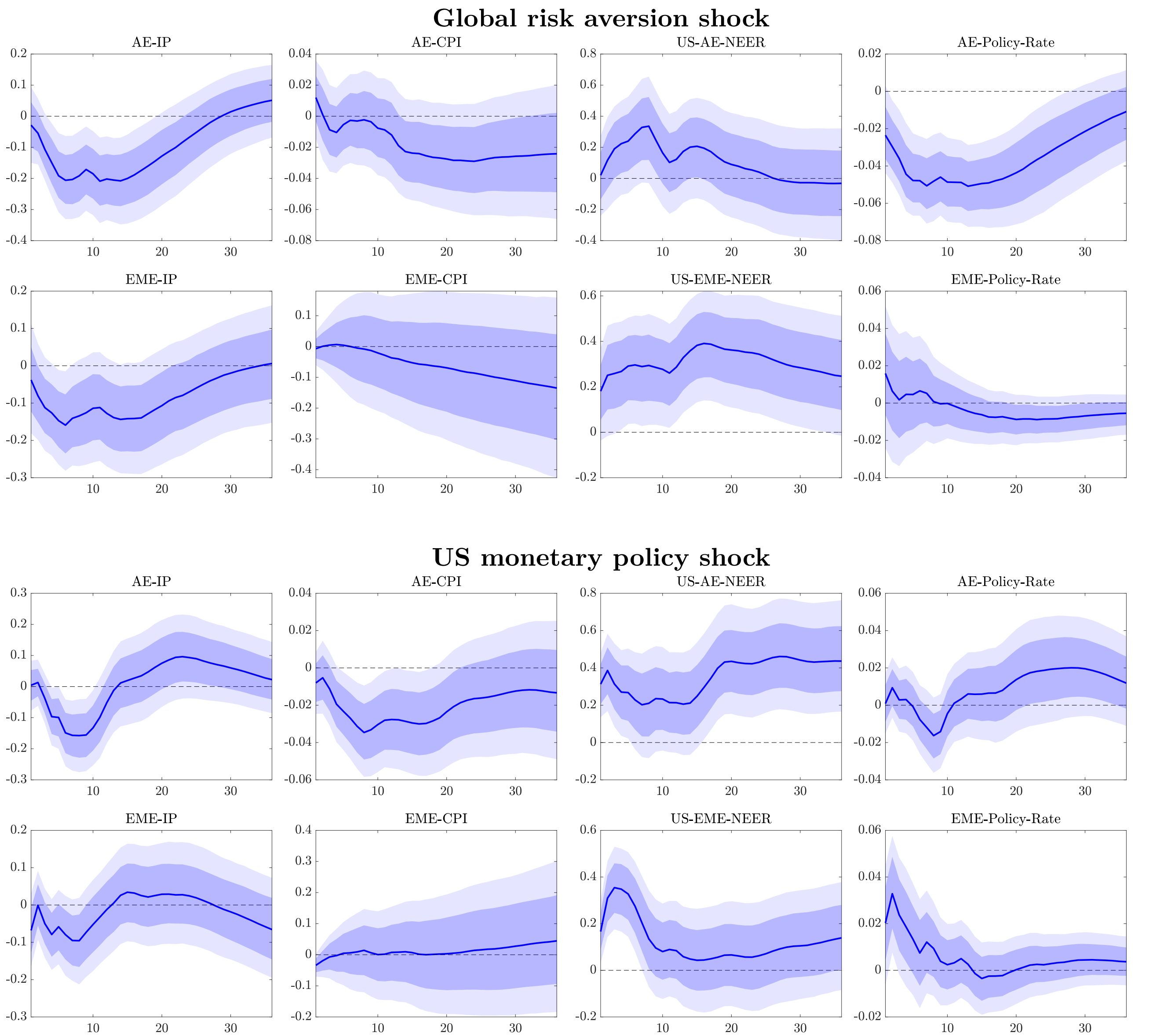
Note: See the notes to Figure 2.

Figure A.2: Results for large BPSVAR model



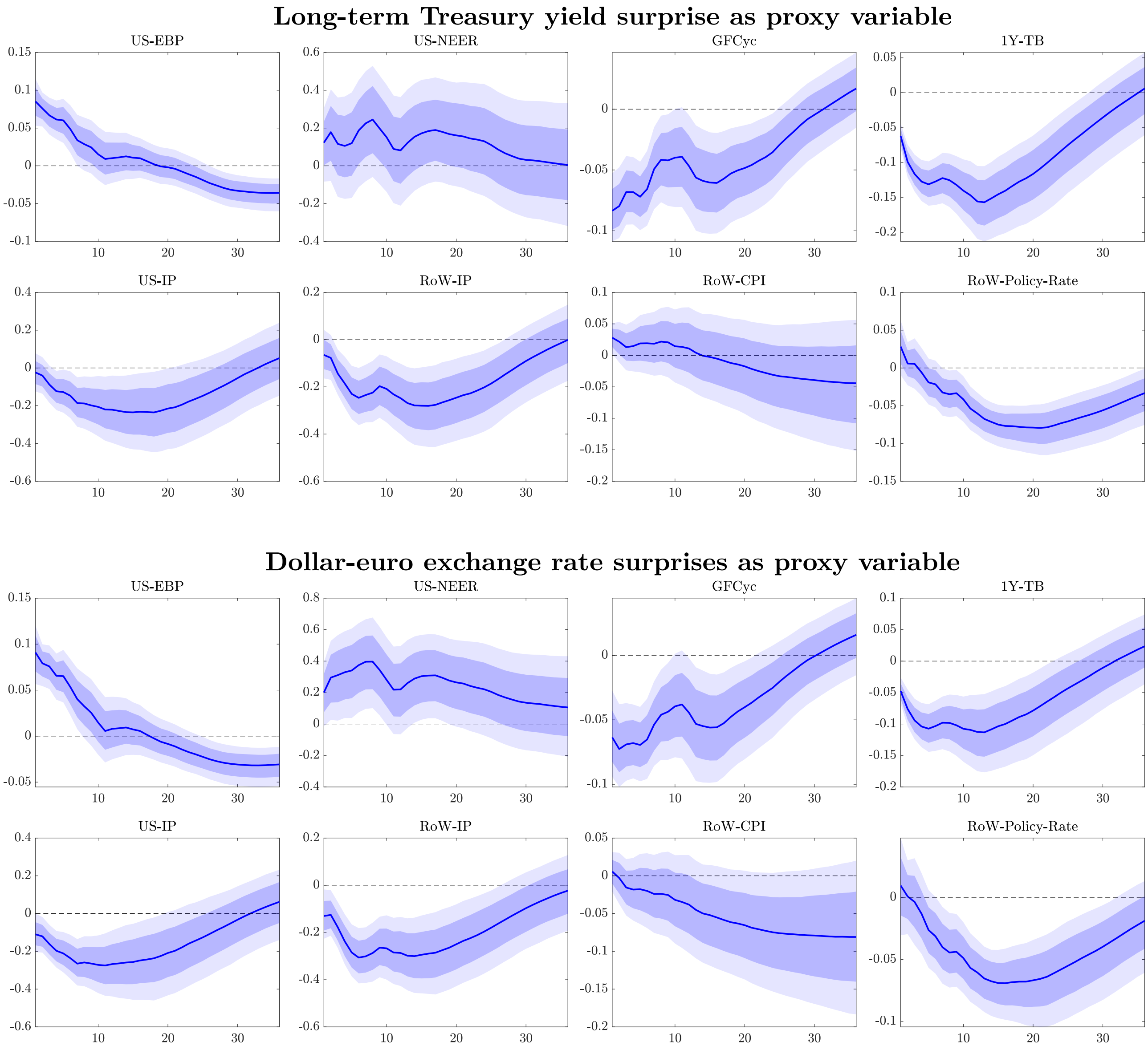
Note: See the note to Figure 2.

Figure A.3: Results for AEs and EMEs



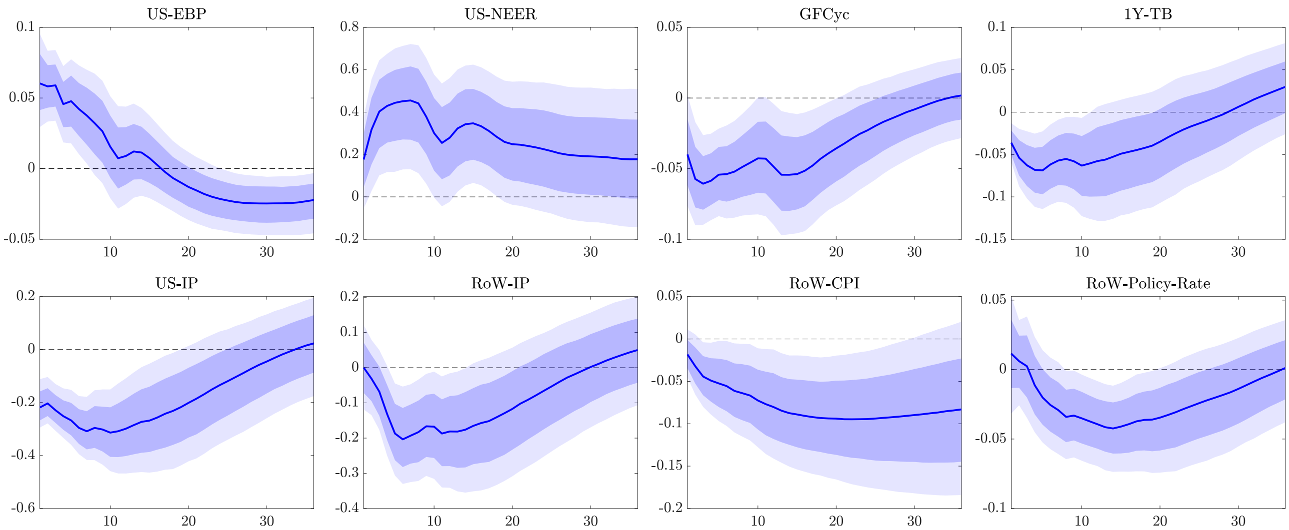
Note: See the note to Figure 2.

Figure A.4: Responses to contractionary global risk aversion shock using long-term Treasury yield or dollar-euro exchange rate surprises as proxy variable



Note: We use as proxy variable the changes in long-term Treasury yields over a -30min/+90min window or the US dollar/euro exchange rate over a -10min/+20min window. We extract Treasury futures prices and exchange rates from Reuters Tick History. Treasury futures are traded on the Chicago Board of Trade from Sunday 5pm to Friday 4pm. Exchange rates are traded 24/7 and are rather liquid. We choose different window lengths for Treasury futures and US dollar/euro exchange rate surprises due to differences in trading activity. See the note to Figure 2.

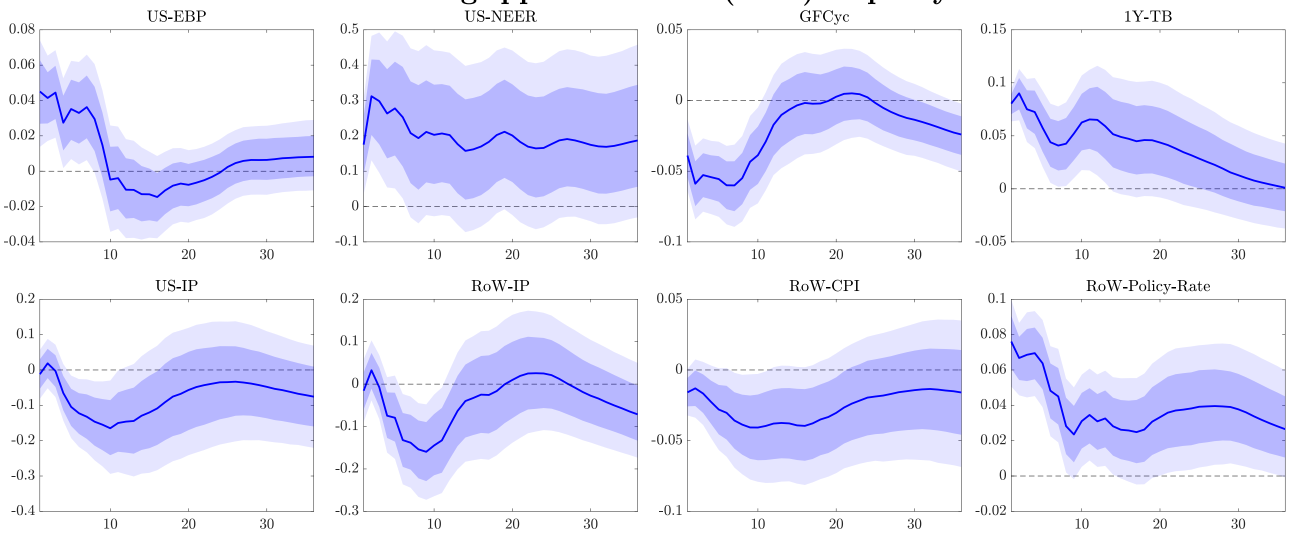
Figure A.5: Responses of contractionary global risk aversion shock using only positive gold-price surprises as proxy variable



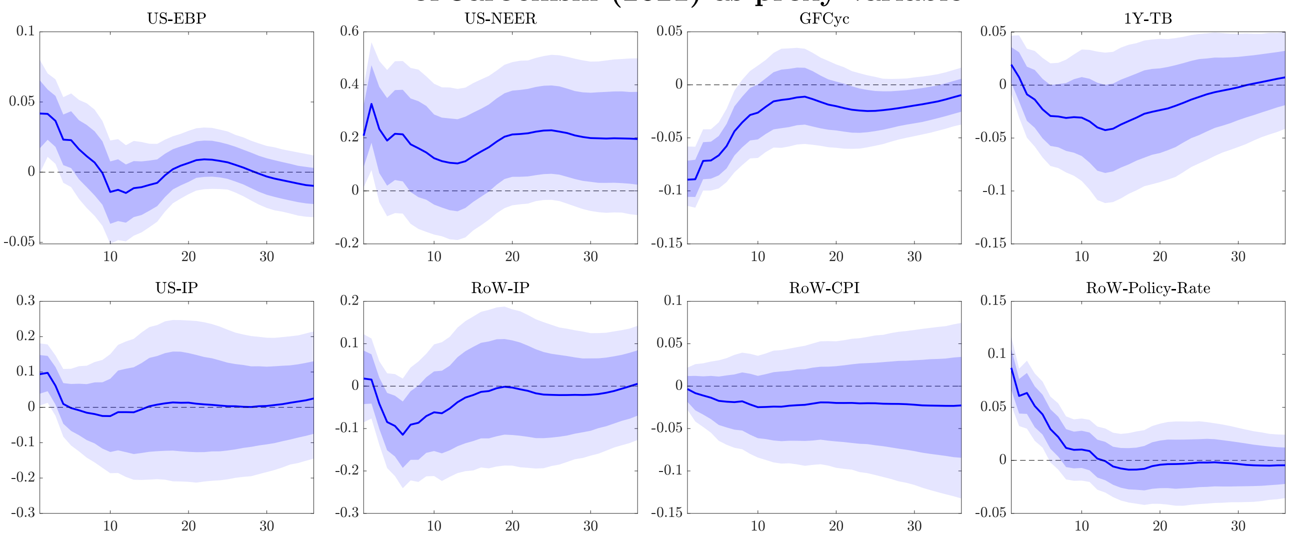
Note: See the note to Figure A.3.

Figure A.6: Responses to contractionary US monetary policy shock using Fed-funds-futures surprises of Miranda-Agrippino & Ricco (2021) or conventional interest rate, forward guidance and LSAP surprises of Jarociński (2021) as proxy variable

Cleansed Fed-funds-futures surprises of Miranda-Agrippino & Ricco (2021) as proxy variable



Conventional interest rate, forward guidance and LSAP surprises of Jarociński (2021) as proxy variable



Note: See the note to Figure 2.

Figure A.7: Schematic overview of the model

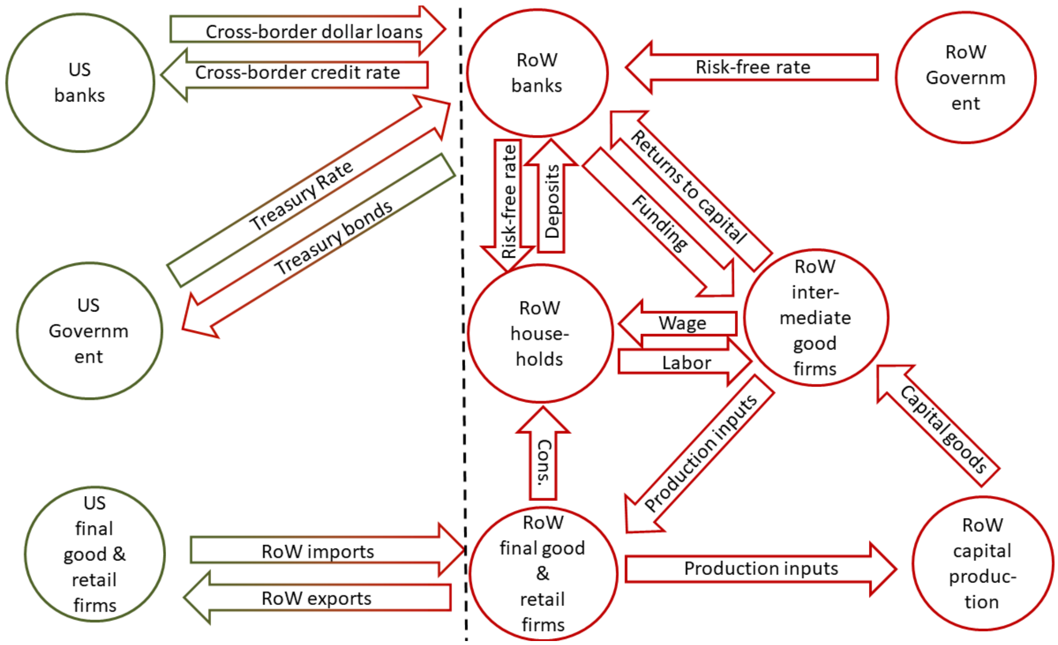
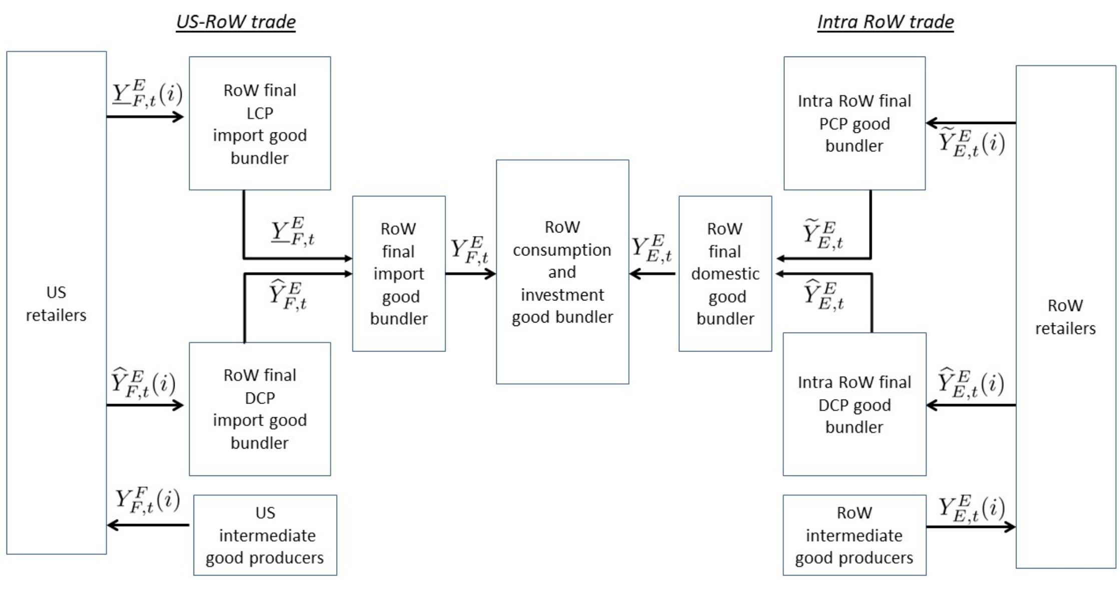
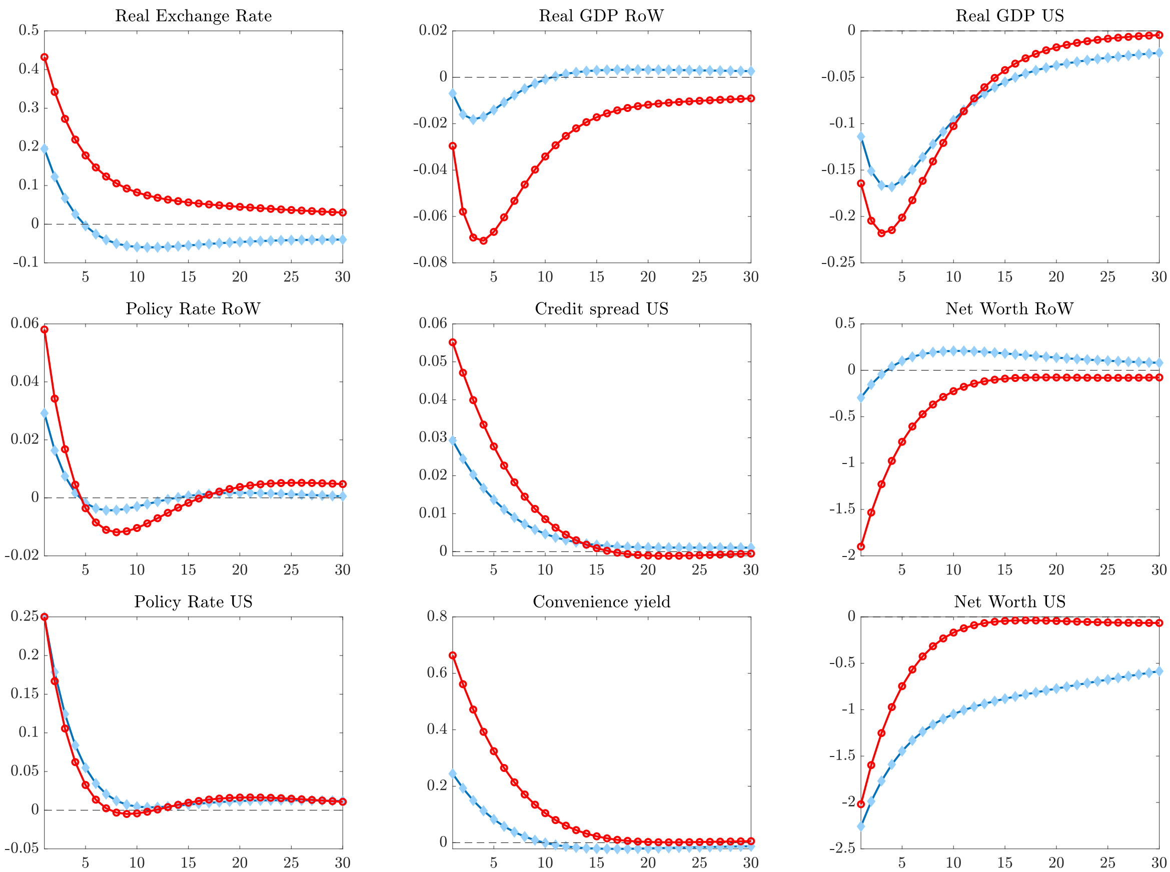


Figure A.8: Multi-layered production structure for the RoW consumption and investment good



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

Figure A.9: Responses to a US monetary policy shock with dollar trinity (red circles) and 'original sin redux' (light blue diamonds)



Note: Red solid lines with circles show the impulse responses of baseline structural model and the light blue lines with diamonds from an alternative model in which cross-border lending is denominated in RoW currency. The US monetary policy shock is normalized to 25 basis points.

B Online appendix - Additional tables

Table B.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)	
Broad, AE, EME US dollar NEER	Nominal broad trade-weighted Dollar index	FRB/Haver	1990m1-2019m12
RoW, AE, EME IP	Industrial production, see Martínez-García et al. (2015)	Dallas Fed Global Economic Indicators/Haver	1990m1 - 2019m12
RoW, AE, EME CPI	Consumer price index	Dallas Fed Global Economic Indicators/Haver (Martínez-García et al. 2015)	1990m1 - 2019m12
RoW, AE, EME policy rate	Short-term official/policy rate, see Martínez-García et al. (2015)	Dallas Fed Global Economic Indicators/Haver	1990m1 - 2019m12
US cross-border bank credit	External claims on all sectors 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	1993m12-2019m12
US Treasury premium	Deviation from covered interest parity between US and G10 government bond yields	Du et al. (2018)	1991m4-2019m12
Foreign Treasury security purchases	Estimated transactions, change in holdings cleansed from valuation effects	Bertaut & Tryon (2007), Bertaut & Judson (2014, 2022)	1990m1-2011m6, 2012m1-2019m12, interpolated for 2011m7-2011m12
Global factor in risky asset prices		Miranda-Agrippino et al. (2020)	1990m1 - 2019m4
US macroeconomic uncertainty index	One-month ahead forecast-error variance	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.

C Additional model details

C.1 Households and unions

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

$$U(C_{E,t}, L_{E,t}) = \frac{1}{1-\sigma^c}(C_{E,t} - h_E C_{E,t-1})^{1-\sigma^c} - \frac{\kappa_{E,w}}{1+\varphi} L_{E,t}^{1+\varphi}. \tag{C.1}$$

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

$$\frac{B^n_{E,t}}{P^C_{E,t}} + C_{E,t} = \frac{B^n_{E,t-1} R_{E,t-1}}{P^C_{E,t}} + \frac{W_{E,t}(h) L_{E,t}(h) + IS_{E,t}(h)}{P^C_{E,t}} + \frac{\Pi^C_{E,t}}{P^C_{E,t}} + \frac{\Pi^R_{E,t}}{P^C_{E,t}},$$

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

$$\Lambda_{E,t} = (C_{E,t} - h_E C_{E,t-1})^{-\sigma_c} - \beta h_E \mathbb{E}_t[(C_{E,t+1} - h C_{E,t})^{-\sigma_c}] \tag{C.2}$$

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

$$\Lambda_{E,t} = \mathbb{E}_t\Big[\beta \Lambda_{E,t+1} \frac{R_{E,t}}{1+\pi^C_{E,t+1}}\Big]. \tag{C.3}$$

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

$$w_{E,t}^{1-\psi_w} = (1-\theta_w)\tilde{w}_{E,t}^{1-\psi_w} + \theta_w(1+\pi_{E,t}^C)^{\psi_w-1}w_{E,t-1}^{1-\psi_w} \tag{C.4}$$

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

C.2 RoW financial intermediaries

Recall that the objective of the banker is to maximize its expected terminal wealth

$$V_{E,j,t} = max\ \mathbb{E}_t \sum_{s=0}^{\infty}(1-\theta_B)\Theta_{E_{t,t+s}}(N_{E,j,t+1+s}). \tag{C.5}$$

subject to the incentive compatibility constraint

$$V_{E,j,t} \geq \delta_{E,B,j,t}(Q_{E,j,t}S_{E,j,t} + \Gamma^{GB}RER_{E,t}^{F}GB_{E,j,t}). \tag{C.6}$$

It can be shown that the value function of a bank is linear in its components and applying a guess and verify procedure the solution to the bankers problem can be characterized by the following set of equations.

$$v_{E,t} = \mathbf{E}_t\Big(\Omega_{E,t,t+1}(R_{E,k,t+1} - R_{E,t})\Big) \geq 0 \tag{C.7}$$

$$v_{E,t}^{GB} = \mathbf{E}_t\Big(\Omega_{E,t,t+1}(\frac{\mathcal{E}_{E,t+1}^F}{\mathcal{E}_{E,t}^F}R_{F,t}^{GB} - R_{E,t})\Big) \geq 0 \tag{C.8}$$

$$n_{E,t} = \mathbf{E}_t\Big(\Omega_{E,t,t+1}(R_{E,t})\Big) \geq 1 \tag{C.9}$$

$$u_{E,t} = \mathbf{E}_t\Big(\Omega_{E,t,t+1}(\frac{\mathcal{E}_{E,t+1}^F}{\mathcal{E}_{E,t}^F}R_{E,b,t}^F - R_{E,t})\Big) \geq 0 \tag{C.10}$$

$$\Omega_{E,t,t+1} = \mathbf{E}_t\Big(\frac{\beta\Lambda_{E,t+1}}{\Lambda_{E,t}(1+\pi_{E,t+1}^c)}\Big[(1-\theta_B) \tag{C.11}$$

$$+ \theta_B((v_{E,t+1}\Psi_{E,j,t+1} + v_{E,t+1}^{GB}\Psi_{E,j,t+1}^{GB} - u_{E,t+1}\Xi_{E,j,t+1}^F)\frac{\phi_{E,B,t+1}}{\Psi_{E,j,t+1} + \Gamma^{GB}\Psi_{E,j,t+1}^{GB}} + n_{E,t+1})\Big]$$

$$AS_{E,j,t} = \frac{n_{E,t}}{(\delta_{E,B,t}\Psi_{E,j,t} + \delta_{E,B,t}\Gamma^{GB}\Psi_{E,j,t}^{GB} - v_{E,t}\Psi_{E,j,t} - v_{E,t}^{GB}\Psi_{E,t}^{GB} + u_{E,t}\Xi_{E,j,t}^T)}N_{E,j,t} = \phi_{E,B,t}N_{E,j,t} \tag{C.12}$$

Equations C.7, C.8, C.9, C.10, represent the discounted excess returns from borrowing and lending domestically, the discounted excess returns from borrowing and investing into US government bonds, the discounted excess costs of borrowing in US-$ instead of acquiring domestic deposits and the discounted marginal value of an additional unit of equity. Equation C.11 is the bankers "augmented" real stochastic discount factor, which accounts for marginal value of funds internal to the financial intermediary and the fact that the bank may have to close with a probability of $1-\theta_B$. Lastly C.12 shows that total lending is restricted to be a multiple of existing net worth, with $\phi_{E,B,t}$

as the optimal leverage ratio, which is common across all RoW banks.

C.3 US financial intermediaries

Recall that the creditors of a US bank require that the expected terminal wealth of the banker j satisfies

$$V_{F,j,t} \geq \delta_{F,B}(Q_{F,t}S_{F,j,t} + \Gamma_t B^{F\star}_{E,j,t}). \tag{C.13}$$

Defining $\xi^F_{E,j,t} = \frac{B^{F\star}_{E,j,t}}{RER^F_{E,t}Q_{F,t}S_{F,j,t}}$ as the asset ratio of interbank loans to domestic investments it can be shown that the coefficients of the value function of the banker $V_{F,j,t}$ are given

$$v_{F,t} = \mathbb{E}_t\Big(\Omega_{F,t,t+1}(R_{k,F,t+1} - R_{F,t})\Big) \tag{C.14}$$

$$u^F_{E,b,t} = \mathbb{E}_t\Big(\Omega_{F,t,t+1}(\Big[\frac{\mathcal{E}^F_{E,t}}{\mathcal{E}^F_{E,t+1}}\Big]R^F_{E,b,t} - R_{F,t})\Big) \tag{C.15}$$

$$n_{F,t} = \mathbb{E}_t\Big(\Omega_{F,t,t+1}(R_{F,t})\Big) \tag{C.16}$$

$$AS_{F,j,t} = \frac{n_{F,t}}{\delta_{F,B}\Psi^F_{F,t} + \delta_{F,B}\Gamma\Psi^E_{F,t} - v_{F,t}\Psi^F_{F,t} + u^F_{E,b,t}\Psi^E_{F,t}}N_{F,j,t} \tag{C.17}$$

$$\Omega_{F,t,t+1} = \Big(\frac{\Theta_{F,t,t+1}}{(1+\pi^c_{F,t+1})}\Big[(1-\theta^F_B) + \theta^F_B\Big(\frac{v_{F,t+1} + u^F_{E,b,t+1}\xi^F_{E,j,t+1}}{1+\Gamma_t\xi^F_{E,j,t+1}}\phi_{F,B,t+1} + n_{F,t+1}\Big)\Big]\Big). \tag{C.18}$$

with $v_{F,t}, n_{F,t}$ and $\Omega_{F,t,t+1}$ are slightly different versions of their RoW counterparts touched up on the previous section.

Lastly we can show that the optimal portfolio choice of the US bank, which determines the required dollar returns charged to RoW banks for cross border lending, is given by

$$\Gamma^F_{E,t}\mathbb{E}_t\Big(\Omega_{F,t,t+1}\big[R_{K,F,t+1} - R_{F,t}\big]\Big) + RP^F_{E,b,t} = \mathbb{E}_t\left(\Omega_{F,t,t+1}\Big[R^F_{E,b,t} - R_{F,t}\Big]\right). \tag{C.19}$$

with $RP^F_{E,b,t}$ defined as

$$RP^F_{E,b,t} = \mathbf{E}_t\Omega_{F,t,t+1}\Big[(R_{k+1} - R_F)\Psi^F_{F,j,t} + (R^F_{E,b,t} - R_F)\Psi^{E\star}_{F,j,t}\Big]\Psi^{E\star}_{F,j,t}\frac{\partial\Gamma^F_{E,t}}{\partial\Psi^{F\star}_{E,j,t}}. \tag{C.20}$$

Using the market clearing conditions alongside the balance sheets of the two banks it can be shown that

$$\frac{\partial\Gamma^F_{E,t}}{\partial\Psi^{F\star}_{E,j,t}} = \Phi^F_{\Gamma,E}\frac{\frac{1-s}{s}RER^F_{E,t}\alpha^{CBDL}_{F,t}AS_{F,t}}{N_{E,t}} \tag{C.21}$$

C.3.1 Intermediate good firms

In each economy there exists a continuum of perfectly competitive intermediate goods firms that sell their output to domestic retailers. We assume that at the end of period t but before the realization of shocks the intermediate good firm acquires capital for use in next period's production. To do so, the intermediate good firm i issues $S_{E,i,t}$ claims equal to the number $K_{E,i,t}$ of units of capital acquired, and prices each claim at the real price of a unit of capital $Q_{E,t}$.[23] The production function is

$$Z_{E,i,t} = \Big(U_{E,i,t}K_{E,i,t-1}\Big)^{\alpha} L_{E,i,t}^{(1-\alpha)}, \tag{C.22}$$

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

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

$$MC^{r}_{E,t} = \frac{w_{E,t}^{1-\alpha}\tau_{E,t}(U_{E,t})'^{\alpha}}{(1-\alpha)^{(1-\alpha)}\alpha^{\alpha}}. \tag{C.23}$$

$$\frac{w_{E,t}}{\tau_{E,t}(U_{E,t})'} = \frac{1-\alpha}{\alpha}\frac{(U_{E,t}K_{E,t-1})}{L_{E,t}}, \tag{C.24}$$

where $MC^{r}_{E,t}$ denote the real marginal costs of the intermediate good firms deflated by the RoW final good price $P^{C}_{E,t}$ and $\tau_{E,t}(U_{E,t})'$ as the derivative of the adjustment cost function, which maps a change in utilization rate into a change in the depreciation rate[24]. The optimal choice of capital gives the resulting gross nominal returns on capital, which are transferred to the bank in exchange for funding

$$R_{K,E,t} = (1+\pi^{c}_{E,t})\frac{\Big(MC^{r}_{E,t}\alpha\frac{Z_{E,t}}{K_{t-1}}\Big) + (Q_{E,t} - \tau_{E,t}U_{E,t})}{Q_{E,t-1}}. \tag{C.25}$$

C.4 Capital producers

Capital producing firms buy and refurbish depreciated capital from the intermediate goods firm at price $P^{C}_{E,t}$ and also produce new capital using the RoW final good, which consists of domestically produced and imported retail goods, as an input. Furthermore we assume that they face quadratic adjustment costs on net investment[25] and that profits, which arise outside of the steady state, are distributed lump sum to the households. The optimal choice of investment yields the familiar *Tobins Q* relation for the evolution of the relative price of capital

$$\begin{aligned} Q_{E,t} = 1 + \frac{\Psi}{2}\Big(\frac{In_{E,t}+Iss_E}{In_{E,t-1}+Iss_E} - 1\Big)^2 + \Psi\Big(\frac{In_{E,t}+Iss_E}{In_{E,t-1}+Iss_E} - 1\Big)\frac{In_{E,t}+Iss_E}{In_{E,t-1}+Iss_E} \\ - \beta\frac{\Lambda_{E_{t+1}}}{\Lambda_{E_t}}\Psi\Big(\frac{In_{E,t+1}+Iss_E}{In_{E,t}+Iss_E} - 1\Big)\Big(\frac{In_{E,t+1}+Iss_E}{In_{E,t}+Iss_E}\Big)^2 \end{aligned} \tag{C.26}$$

[23] As the market for claims is frictionless, arbitrage requires that the value of capital installed and used in next period's production has to equal the value of claims on capital ($Q_{E,t}S_{E,t} = Q_{E,t}K_{E,t}$).

[24] The adjustment cost function is given by $\tau_{E,t}(U_{E,t}) = \tau_{E,ss,scale} + \zeta_{E,1}\frac{U_t^{1+\zeta_2}}{1+\zeta_2}$ with $\tau_{E,ss,scale}$ as an exogenous scale parameter in order to normalize utilization in the steady state.

[25] 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 $Q_{E,t}$

alongside the law of motion for capital

$$K_{E,t} = K_{E,t-1} + In_{E,t} \tag{C.27}$$

C.5 Goods bundling and pricing

C.5.1 Final consumption and investment good

They combine a final domestically produced good $Y^E_{E,t}$ and a final import good $Y^E_{F,t}$ into a combined final good, employing the following CES technology

$$Y^C_{E,t} = \Big[n_E^{\frac{1}{\psi_f}} Y^{E\,\frac{\psi_f-1}{\psi_f}}_{E,t} + (1-n_E)^{\frac{1}{\psi_f}} Y^{E\,\frac{\psi_f-1}{\psi_f}}_{F,t}\Big]^{\frac{\psi_f}{\psi_f-1}}. \tag{C.28}$$

The parameter n_E governs the share of domestically produced goods and thereby the degree of home bias in the assembling process[26]. The parameter ψ_f on the other hand corresponds to the elasticity of substitution between the final domestic and import good.

Taking the prices of the domestic final good $P^E_{E,t}$ and the price of the final import good expressed in domestic currency $(\mathcal{E}^F_{E,t} P^E_{F,t})$[27] as well as total demand from consumers and capital producers as given, the optimal demand for goods produced domestically and abroad is governed by

$$Y^E_{E,t} = n_E \Big(\frac{P^E_{E,t}}{P^C_{E,t}}\Big)^{-\psi_f} Y^C_{E,t} \tag{C.29}$$

$$Y^E_{F,t} = (1-n_E)\Big(\frac{\mathcal{E}^F_{E,t} P^E_{F,t}}{P^C_{E,t}}\Big)^{-\psi_f} Y^C_{E,t}. \tag{C.30}$$

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

$$P^c_{E,t} = \Big[n_E P^{E\,1-\psi_f}_{E,t} + (1-n_E)(\mathcal{E}^F_E P^E_{F,t})^{1-\psi_f}\Big]^{\frac{1}{1-\psi_f}}. \tag{C.31}$$

C.5.2 RoW domestically produced and sold final good

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

[26] 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_E and the relative country size of the RoW s, the parameter n_E takes the value $n_E = 1 - op_E(1-s)$ with a similar adjustment for the US counterpart

[27] Note that because of the pricing-to-market assumption the price for US exports expressed in US-\$ $P^E_{F,t}$ will in general be different from the price charged for US goods sold in the US $P^F_{F,t}$.

Table C.1: RoW domestic sales bundling

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

Table C.2: US import good bundling

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

C.5.3 Import good bundling

Table C.2 provides an overview of the core equations and first order conditions for the multistage bundling process of the final import good.

C.6 Retail good pricing

C.3. The optimal price choice of a DCP firm i for its sales in the RoW market, taking into account the fact that it may not be able to reset its US-\$ denominated price $\hat{P}^E_{E,t}(i)$, can be written as

$$\max_{\hat{P}^E_{E,t}(i)} \mathbb{E}_t \sum_{s=0}^{\infty} \theta_p^{E^s} \Theta_{E_{t,t+s}} \left[\mathcal{E}^E_{E,t}\hat{P}^E_{E,t}(i)Y^E_{E,t}(i) - MC_{E,t}Y^E_{E,t}(i)\right]. \qquad \text{(C.32)}$$

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

Type of firm and market	Profit function
[.510pt] RoW market PCP firm	$\tilde{\Pi}^E_{E,t}(i) = \tilde{P}^E_{E,t}(i)\tilde{Y}^E_{E,t}(i) - MC_{E,t}\tilde{Y}^E_{E,t}(i)$
[.510pt] RoW market DCP firm	$\hat{\Pi}^E_{E,t}(i) = \mathcal{E}^F_{E,t}\hat{P}^E_{E,t}(i)\hat{Y}^E_{E,t}(i) - MC_{E,t}\hat{Y}^E_{E,t}(i)$
[.510pt] US import market PCP firm	$\tilde{\Pi}^F_{E,t}(i) = \tilde{P}^F_{E,t}(i)\tilde{Y}^F_{E,t}(i) - MC_{E,t}\tilde{Y}^F_{E,t}(i)$
[.510pt] US import market DCP firm	$\hat{\Pi}^F_{E,t}(i) = \mathcal{E}^F_{E,t}\hat{P}^F_{E,t}(i)\hat{Y}^F_{E,t}(i) - MC_{E,t}\hat{Y}^F_{E,t}(i)$

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

$$\frac{\hat{P}^E_{E,t}(i)}{\hat{P}^E_{E,t}} = \hat{p}^E_{E,t} = \frac{\psi_i}{(\psi_i - 1)}\frac{\hat{x}^E_{E,1,t}}{\hat{x}^E_{E,2,t}}. \tag{C.33}$$

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

$$\hat{x}^E_{E,1,t} = \Lambda_{E,t}\Big(\frac{\mathcal{E}^F_{E,t}\hat{P}^E_{E,t}}{P^E_{E,t}}\Big)^{-\psi_i} Y^E_{E,t}\frac{P^E_{E,t}}{P^C_{E,t}}MC^{rp}_{E,t} + \beta\theta_p\mathbb{E}_t\hat{x}^E_{E,1,t+1}(1+\hat{\pi}^E_{E,t+1})^{\psi_i} \tag{C.34}$$

$$\hat{x}^E_{E,2,t} = \Lambda_{E,t}\Big(\frac{\mathcal{E}^F_{E,t}\hat{P}^E_{E,t}}{P^E_{E,t}}\Big)^{-\psi_i} Y^E_{E,t}\Big(\frac{\mathcal{E}^F_{E,t}\hat{P}^E_{E,t}}{P^C_{E,t}}\Big) + \beta\theta^E_p\mathbb{E}_t\hat{x}^E_{E,1,t+1}(1+\hat{\pi}^E_{E,t+1})^{\psi_i-1}, \tag{C.35}$$

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

$$1 = (1-\theta_p)\hat{p}^{E^{1-\psi_i}}_{E,t} + \theta_p(1+\hat{\pi}^E_{E,t})^{(\psi_i-1)}, \tag{C.36}$$

where $\hat{p}^E_{E,t}$ denotes the ratio of the optimal reset price relative to the aggregate price index. Very similar equations hold for the optimal price of RoW retail firms that set their prices in the US import market in US-\$ as well as, with slight adaptions, for PCP firms.

C.7 Market clearing and the aggregate budget constraint

Turning to the market clearing conditions, aggregate demand for the domestic consumption good $Y^C_{E,t}$ is given by the sum of individual demand from all sources that either consume the good or use it as an input in production

$$Y^C_{E,t} = C_{E,t} + I_{E,t} + \frac{\Psi}{2}\Big(\frac{In_{E,t} + Iss_E}{In_{E,t-1} + Iss_E} - 1\Big)^2 (In_{E,t} + Iss_E). \tag{C.37}$$

Aggregating across all intermediate and retail goods firms and imposing market clearing yields the aggregate production function of the economy

$$Z_{E,t} = (U_{E,t}K_{E,t-1})^{\alpha} L_{E,t}^{(1-\alpha)} = \delta^E_{E,t}Y^E_{E,t} + \delta^F_{E,t}Y^F_{E,t}, \tag{C.38}$$

with $\delta^E_{E,t}$ and $\delta^F_{E,t}$ as price dispersion terms which are zero up to a first order approximation. $Y^E_{E,t}$ corresponds to the aggregate domestic demand for the final *domestically produced* RoW good given by

$$Y^E_{E,t} = n_E\Big(\frac{P^E_{E,t}}{P^C_{E,t}}\Big)^{-\psi_f} Y^C_{E,t}, \tag{C.39}$$

with $Y^C_{E,t}$ as the households and firms demand for the final good. Furthermore the aggregate demand for RoW goods produced for exports reads as

$$Y^F_{E,t} = \frac{1-s}{s}(1-n_F)\Big(\frac{\mathcal{E}^F_{E,t}P^F_{E,t}}{P^C_{F,t}}\Big)^{-\psi_f} Y^C_{F,t}, \tag{C.40}$$

where it it is important to note that variables are expressed in per capita terms and therefore, following Sutherland (2005), the relative population size has to be taken when aggregating across countries as indicated by the ratio $\frac{1-s}{s}$.

Imposing double-entry bookkeeping i.e. that some RoW bank's interbank market liability $B^F_{E,j,t}$ has to always be an asset of a some US bank $B^{F\star}_{E,j,t}$ and taking into account the fact that population sizes differ yields a market clearing condition for the US-$ interbank loan market

$$\int_0^s B^F_{E,j,t}dj = \int_s^1 B^{F\star}_{E,j,t}dj. \tag{C.41}$$

This can be translated into a solution for the aggregate ratio of interbank lending to domestic funding $\xi^F_{E,t}$ as a function of the share of RoW investments funded by US-$ loans $\Xi^F_{E,t}$ given by

$$\xi^F_{E,t} = \frac{\frac{s}{1-s}\Xi^F_{E,t}Q_{E,t}K_{E,t}}{RER^F_{E,t}Q_{F,t}K_{F,t}}. \tag{C.42}$$

After aggregating the joint budget constraints of bankers and households and consolidating profits from all types of retail firm sales and the capital producing firms, one arrives at the familiar open-economy budget constraint we show in the main part of the paper

C.8 Calibration

Table C.4: Parameter values used in the simulations

Param.	Val.	Description	Source
		Households	
h_R	0.620	Habit persistence in consumption RoW	CKSW(2018) [a]
h_U	0.790	Habit persistence in consumption US	JPT(2010)
σ_c	1.002	Intertemporal elasticity of substitution	$\approx$ log utility
φ	2.000	Inverse Frisch elasticity of labor	CKSW(2018)
β_U	0.995	Discount factor US	2% ann. US rate
β_R	0.9913	Discount factor ROW	3.5% ann. RoW rate
		RoW financial intermediaries	
ω_B^U	0.00036	Start up funds RoW	endogenous in SS
θ_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
Γ_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	
ω_B^U	0.00026	Start-up funds parameter US	endogenous in SS
θ_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 Γ_U^{CBDL} wrt $\phi_{R,t}$	endogenous in SS
ρ_δ	0.95	Common persistence of global risk shock	VAR dynamics
		Wage decision	
ψ_w	6.000	Elasticity of substitution labor services	20% wage mark up
θ_w^R	0.780	Calvo parameter wages RoW	CKSW(2018)
θ_w^U	0.840	Calvo parameter wages US	JPT(2010)
		International trade	
ψ_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	
α	0.333	Share of capital in production	AQ(2019)
ζ_2	5.800	Elasticity of depreciation wrt. to utilization	JPT(2010)
$\tau_{R,ss}$	0.020	Normalization parameter depreciation RoW	endogenous in SS

Table C.4 –			
Param.	**Val.**	**Description**	**Source**
ζ_1^R	0.035	Normalization of utilization parameter RoW	endogenous in SS
ζ_1^U	0.035	Normalization of utilization parameter US	endogenous in SS
$\tau_{U,ss}$	0.020	Normalization parameter depreciation US	endogenous in SS
Retail good pricing			
ψ_i	6.000	Elasticity of substitution retail goods	20% mark up
θ_P^R	0.820	Calvo parameter retail firms RoW	CKSW(2018)
θ_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.
$\gamma_{U^R} \widehat{= 1 -} \gamma_U^R$	0.97	Share of RoW export to US DCP firms	≈ G(2015) invoicing
$\widetilde{\gamma_R^U} = 1 - \gamma_R^U$	0.05	Share of US export LCP firms	≈ G(2015) invoicing
Capital goods production			
Ψ_R	5.770	Investment adjustment costs RoW	CKSW(2018)
Ψ_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)
U_{ss}	1.000	SS utilization rate target RoW and US	JPT(2010)
τ_{ss}	0.025	SS depreciation rate target RoW and US	JPT(2010)
$S_{R,ss}$	0.005	SS credit spread target RoW (quarterly)	≈ CKSW(2018)
$S_{U,ss}$	0.005	SS credit spread target US (quarterly)	≈ 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)
$\ell_{R,j,t}^{CBDL}$	0.25	SS dollar debt portfolio share RoW	≈ LBS avg.
$\alpha_{R,j,t}^{GB}$	0.15	SS US treasuries portfolio share RoW	≈ LBS avg.
$R_{U,ss}^{CBDL} - R_{U,ss}^{GB}$	0.0025	SS Exorbitant priviledge	1% annualized
$CY_{R,ss}$	0.0115	SS convenience yield	≈ JKL(2012)
$RP_{U,ss}^{CBDL}$	0.001	SS interbank risk premium	1/5 of credit spread

[a] 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.