

International Portfolio Rebalancing and Fiscal Policy Spillovers*

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Abstract

We theoretically and empirically evaluate the spillover effects of debt-financed fiscal policy interventions of the United States on other economies. We first consider a two-country dynamic stochastic general equilibrium model with international portfolio rebalancing effects arising from an imperfect substitutability between short- and long-term domestic and foreign bonds. The model shows that US fiscal expansions financed by long-term debt issuance would, on net, hinder economic activity in the rest of the world (ROW). This is despite the standard trade channel's net positive effect on the ROW economy given the depreciation in the ROW currency. The fall in ROW output occurs mainly due to the increase in the ROW term premia and long-term rates through the portfolio rebalancing channel, as the relative demand for ROW long-term bonds decreases following the increase in the supply of US long-term bonds accompanying the fiscal expansion. Testing the predictions of our theoretical model by using panel regressions and vector autoregressions, we find empirical support for the negative relationship between ROW output and US fiscal spending. The data also confirm the positive relationship between ROW term spreads and US fiscal spending.

Keywords: International portfolio rebalancing, international spillover effects of fiscal policy, preferred habitat, DSGE.

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*All remaining errors are our own. The views expressed in this paper are those of the authors. No responsibility should be attributed to the Bank of Canada.

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1 Introduction

Following the Coronavirus crisis, the US government engaged in an unprecedented degree of fiscal stimulus, financed primarily by long-term debt creation. The fiscal measures, along with the conventional and unconventional monetary policy actions of the Federal Reserve, were likely critical in avoiding worse macroeconomic outcomes in the US during and after the crisis; however, the nature of the spillover effects of these fiscal measures on other countries is far from certain. On the one hand, currencies of other countries felt significant depreciation pressures during this period due to capital outflows. This may have helped increase net export demand on their goods and services, but at a time when these effects were likely more limited due to disruptions in international supply chains, travel restrictions, and the decline in incomes in export markets. On the other hand, these countries' long-term yields increased along with the increase in US yields following the fiscal expansion in the US. In this paper, we argue that the latter effect is due to international portfolio rebalancing, and has helped reverse the potentially positive impact of the US fiscal expansion on other economies, especially for those with significant holdings of US government bonds.

To entertain this idea, we theoretically and empirically evaluate the spillover effects of debt-financed fiscal policy interventions in the US on other economies. We first consider a two-country New Keynesian dynamic stochastic general equilibrium (DSGE) model with nominal and real frictions and international portfolio rebalancing effects, similar to Alpanda and Kabaca (2020). The portfolio rebalancing effects arise in the model from imperfect substitutability between short- and long-term bond portfolios in each country, as well as between domestic and foreign bonds within these subportfolios. In particular, an increase in the relative supply of US long-term bonds leads to a decrease in long-term bond prices and a corresponding increase in long-term yields in the US, and this occurs even when short-term rates remain constant, since bond supplies directly affect the term premium component of long-term rates.¹

The model shows that US fiscal expansions, primarily financed by long-term debt issuance, would hinder economic activity in the rest of the world (ROW) due to the increase in the ROW term premia through the portfolio rebalancing channel. This occurs as the relative demand for ROW long-term bonds decreases following a large-scale fiscal expansion and the resulting increase in the supply of long-term bonds in the US. In addition, the depreciation of ROW currencies in response to a US fiscal expansion causes an increase in their inflation due to exchange rate pass-through. This mechanism prompts an increase in short-term rates as well in ROW economies. The increase in both short- and long-term interest rates in turn, suppresses spending and output. For a reasonable calibration, we find that these two negative effects of US fiscal policy spillover dominate the standard fiscal spillovers operating through trade and, on net, US fiscal expansions are contractionary for the ROW. We also find that negative GDP spillovers remain when we limit monetary policy reaction to

¹This is consistent with the empirical evidence presented by Gagnon et al. (2011) and Greenwood and Vayanos (2010, 2014) regarding the relationship between relative bond supplies and the relative returns on government bonds of different maturities. Note that if all bonds were perfectly substitutable, then exogenous changes in the relative bond supplies would not affect the relative bond prices and yields (Curdia and Woodford, 2011).

inflation, reflecting that our results are not driven mainly because of tighter conventional monetary policy in the ROW.

Our DSGE model also has interesting implications for the *domestic* effects of fiscal policy, since the increase in long-term rates attenuates the stimulatory effects of fiscal policy in the domestic economy as well. This is similar to the standard “crowding out” effects of fiscal policy, but here the crowding out effects are due to higher long-term rather than short-term interest rates, and are relevant even when the economy is operating at the zero lower bound (ZLB). The model also points out the importance of coordination between monetary and fiscal authorities when it comes to the implementation of large-scale asset purchases or large scale fiscal expansions. For example, a central bank’s quantitative easing (QE) policy is rendered less robust if the government decides to take advantage of the resulting lower long-term interest rates and bias its fiscal financing towards the issuance of long-term debt. This has indeed happened to some degree in past QE episodes in the US, indicating that the effects of QE would have been larger in the absence of this endogenous type of response from the fiscal authority. Finally, a “helicopter drop” type of policy, which combines a long-term debt financed fiscal expansion with central bank purchases of long-term government bonds (in exchange for bank reserves, which, in a world with interest on reserves, is synonymous with issuing short-term government debt), can have more robust effects on the economy. We show that this type of coordination avoids the “crowding out” effects of fiscal policy as the QE policy of the central bank pacifies the increase in long-term interest rates. More critical for our paper, we find that the spillover effects of a helicopter drop policy is also expansionary on the ROW economy as the crowding out effects of the portfolio rebalancing channel is muted.

In the second part of our paper, we empirically test the main prediction of our DSGE model. Specifically, we estimate both panel data and vector autoregression (VAR) models using data from G-20 countries (excluding the European Union as a bloc) to determine whether US fiscal spending is negatively related to foreign output. It is important to note that in this analysis, we deliberately avoid imposing structure and allow the data to inform us on the relationship between US fiscal policy and foreign economic activity. We follow this strategy to determine how the inferences from our structural model stack up against the data. In our panel regressions, we include variables that capture the extent of countries’ bilateral trade with the US and their holdings US government bonds to incorporate the two conflicting mechanisms in our DSGE model (trade versus the portfolio rebalancing channels). Results from our estimations, consistent with the DSGE model results, generally demonstrate a negative relationship between US fiscal expansions and foreign output. These negative effects are observed, not only for total government expenditure but also its two main subcategories, government consumption and government investment. We also find that countries’ US bond holdings can affect their sensitivity to US fiscal spending, but this effect is not quantitatively large. The extent of bilateral trade, in contrast, does not have a significant effect on this sensitivity. Contrary to government consumption and investment, we find that US transfer spending is positively related to foreign output. This is consistent with the results from our DSGE model under the calibration with high levels of bilateral trade. These results are robust to using various measures of

fiscal spending in the estimations.

Further, panel data analyses provide support for the trade and portfolio channels of fiscal spillover in the DSGE model. We find that countries experience a real exchange rate depreciation, an increase in trade, and an increase in the term premium when there is a US fiscal expansion. The results are reversed if there is a fiscal contraction. These results are also robust to using alternative fiscal policy measures. Finally, we find, consistent with our model's prediction, that the negative fiscal spillover is smaller in magnitude during ZLB episodes in the G-20.

Next, we reconfigure our dataset to conduct a time series analysis. We use both country-specific VAR and panel VAR models and find similarly that US fiscal spending most often generates a negative response for foreign output. The inference is the same when we use alternative US fiscal policy measures and a panel VAR model with exogenous variables. The results from both the panel data regressions and the VAR analysis suggest that a one percent increase (decrease) in US fiscal spending is related to a 0.25 percent decrease (increase) in foreign output. This quantitative relationship is similar to, albeit slightly larger than, that implied by our DSGE model.

In summary, having taken a very agnostic perspective on structure, and after conducting a battery of robustness tests, we conclude from our empirical analysis that US fiscal spending is inversely related to output growth in the G-20.

1.1 Related literature

Our paper is related to the literature on the portfolio balancing channel, which dates at least back to Tobin (1969). Andres et al. (2004) incorporate Tobin's ideas into a DSGE model, generating imperfect substitution between assets through transaction costs on long-term bonds and segmented asset markets, whereby a subset of agents cannot smooth consumption through the use of short-term bonds. Chen et al. (2012a) and Alpanda and Kabaca (2020) use this kind of a set-up to study the domestic and international effects of QE policy in closed- and open-economy contexts, respectively.² Hau and Rey (2004) find evidence in support of the portfolio balance channel affecting exchange rates using a VAR framework. Also, Valchev (2015) shows that imperfect substitutability between domestic and foreign short-term bonds helps solve the interest rate parity puzzle.³ In our paper, we find that the international dimension of this portfolio channel is stronger than any positive effects of US fiscal spending that operates through trade. Specifically, we find that the reliance on long-term US bond issuance after fiscal expansion results in an increase in the term premium, suppressing economic activity abroad.

On the effects of fiscal spending spillovers from a large open economy, empirical findings in the literature are mixed. While studies such as Auerbach and Gorodnichenko (2013), Carmignani (2015), Beetsma and Giuliodori (2011), Beetsma et al. (2006) find positive international spillover effects using data from OECD countries, Blanchard et al. (2016), Gadatsch et al. (2016), Arce et

²Also see Priftis and Vogel (2016) who analyze the effects of QE in the Euro Area using a similar approach.

³See also Benes et al. (2013a), Blanchard et al. (2005) and Kumhof (2010), who investigate the portfolio balance channel in open economy models.

al. (2016), Benassy-Quere (2006), Arin and Koray (2009), Arin (2012) draw the opposite inference from their empirical analysis.⁴ We should note that the literature mostly focuses on fiscal spillovers among EU economies or pairs of neighbouring countries. Our empirical work by contrast investigates the broader and more widespread spillover effects of fiscal policy.

While the theoretical mechanism of Mundell-Fleming linking fiscal expansion to exchange rate appreciation and a worsening trade balance in the originating country is long-standing, the empirical literature here also offers mixed evidence. Studies such as Kim and Roubini (2008), Monacelli and Perotti (2010); Ravn et al. (2012), for example, find that local currency depreciates in response to a fiscal expansion. Our empirical findings and the responses from our DSGE model are consistent with empirical evidence that support the standard Mundell-Fleming theory, indicating local currency appreciation (e.g., Auerbach and Gorodnichenko, 2016). Similarly our findings are consistent with Monacelli and Perotti (2010), Ravn et al. (2012) and Garcia-Solanes et al. (2011), while Corsetti and Müller (2006) and Kim and Roubini (2008) offer contrary evidence. While the literature is mixed on the effects of US fiscal policy on exchange rates, it agrees that a debt-financed (especially through long-term debt) US fiscal expansions generate higher term premia in foreign economies (see, Cardarelli and Kose, 2004). The empirical literature on the effects of US policies on portfolio balancing and foreign term premia offer evidence, for both emerging market and advanced economies, that is consistent with the mechanisms in our model (see, Fratzscher et al., 2016; Lim et al., 2014; Tillman, 2016; Chari et al., 2017; Bluwstein and Canova, 2016; Chen et al., 2012b, 2016; Haberis and Lipinska, 2012; Bhattarai et al., 2017).

The decline in foreign yields during this period suggests that a portfolio rebalancing by international investors was under way, as the fall in US long-term yields increased the attractiveness of rest-of-the-world (ROW) assets. In their survey of the literature on US unconventional policy, Bhattarai and Neely (2016) note that the portfolio balance channel appears to be an important conduit of unconventional policy, and event studies and VARs have identified, on net, positive international spillover effects from these policies. Similarly, Fratzscher et al. (2016) analyze the effects of the Federal Reserve's QE on portfolio flows in the US and in 52 other countries using high frequency data, and find that the policy announcements and asset purchases related to QE2 and QE3 have resulted in portfolio rebalancing towards non-US assets. Similarly, Lim et al. (2014), Tillman (2016), and Chari et al. (2017) find a sizeable role for US unconventional policies in generating capital inflows to emerging markets and appreciation in their currencies. Also see Bluwstein and Canova (2016), who find significant international spillover effects from the unconventional policies of the European Central Bank. There are also other studies that find significant international spillover effects from unconventional policies in major advanced economies. See for example, Chen et al. (2012b, 2016),

⁴It should be noted here that the magnitude and the direction of the spillover in these papers depend on factors such as geographical proximity, the stage of the business cycle, monetary responsiveness, institutional factors such as openness to trade. We do not include these factors in our empirical analysis and simply find a negative relationship between US fiscal policy and output growth rates of G-20 countries. Similarly, in the DSGE model, we are silent about the monetary reaction of G-20 economies to US fiscal expansion and various other factors that may impact the degree of the fiscal spillover.

Haberis and Lipinska (2012), Bhattarai et al. (2017).

The remainder of the paper proceeds as follows. The next section introduces the DSGE model, and Section 3 discusses the parameterization of model parameters and key results obtained from the model. Section 4 presents the empirical tests we conduct based on the implications of our theoretical framework, and Section 5 concludes.

2 Open Economy DSGE Model

In this section, we build a two-country, large open-economy DSGE model with portfolio balancing effects similar to Alpanda and Kabaca (2020). Each country in the model is populated by two types of households (unrestricted and hand-to-mouth), capital producers, final-goods aggregators, domestic producers, and importers, as well as fiscal and monetary policy rules. As a medium-scale DSGE model, our set up also features various nominal and real rigidities such as price and wage stickiness, indexation of prices and wages to past inflation, habit formation in consumption, adjustment costs in investment, and costs of capital utilization, which are important for capturing the key properties of business cycle dynamics (Christiano et al., 2005; Smets and Wouters, 2007; Adolfson et al., 2008; Justiniano and Preston, 2010).

In what follows, we focus on the features of the model that are related to fiscal policy as well as the portfolio balancing channel and the associated transmission mechanism of fiscal and monetary policy shocks to the domestic and the foreign economies through the long-term interest rates and the exchange rate. The description of the more standard features of the model, such as production and nominal rigidities, are deferred to Appendix A. Note that we only describe the agents in the *domestic* economy below, but the *foreign* economy is analogous in our set-up. When variables from the foreign economy are necessary in the description, we denote them with a (*) superscript.⁵

2.1 Unrestricted households

The economy is populated by a unit measure of infinitely-lived unrestricted households indexed by i , whose intertemporal preferences over consumption, $c_{U,t}$, bond portfolio, a_t , and labor supply, $n_{U,t}$, are described by the following expected utility function:

$$E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left(\log [c_{U,\tau}(i) - \zeta c_{U,\tau-1}] + \xi_a \log a_{\tau}(i) - \xi_n \frac{n_{U,\tau}(i)^{1+\vartheta}}{1+\vartheta} \right), \quad (1)$$

where t indexes time, $\beta < 1$ is the time-discount parameter, ζ is the external habit parameter for consumption, ϑ is the inverse of the Frisch-elasticity of labor supply, and ξ_a and ξ_n are level parameters that determine the relative importance of the bond portfolio and labor in the utility function.

⁵In our policy experiments using the DSGE model in Section 4, we treat the US as the *foreign* economy where fiscal shocks originate, and the ROW as the *domestic* economy, which is affected by the spillover effects of these policies.

The bond portfolio term in the utility function, a_t , is a CES aggregate of subportfolios consisting of short-term government bonds, $a_{S,t}$, and long-term government bonds, $a_{L,t}$:

$$a_t(i) = \left[\gamma_a^{\frac{1}{\lambda_a}} a_{S,t}(i)^{\frac{\lambda_a-1}{\lambda_a}} + (1 - \gamma_a)^{\frac{1}{\lambda_a}} a_{L,t}(i)^{\frac{\lambda_a-1}{\lambda_a}} \right]^{\frac{\lambda_a}{\lambda_a-1}}, \quad (2)$$

where γ_a determines the share of short-term bonds in the aggregate portfolio, and λ_a is the elasticity of substitution between short- and long-term bonds. Introducing government bonds in the utility function is motivated by the liquidity and safety benefits provided by these securities relative to holding less liquid and riskier assets, similar to Krishnamurthy and Vising-Jorgensen (2012), Valchev (2015), and Alpanda and Kabaca (2020). Imperfect substitution among the various types of government bonds capture the differential convenience benefits generated by these assets, as well as financial institutions' relative portfolio preferences with respect to the different types of government bonds.⁶

The short-term bond subportfolio is a CES aggregate of short-term *domestic* government bonds, $B_{HS,t}$, and short-term *foreign* government bonds, $B_{FS,t}$:

$$a_{S,t}(i) = \left[\gamma_S^{\frac{1}{\lambda_S}} \left(\frac{B_{HS,t}(i)}{P_t} \right)^{\frac{\lambda_S-1}{\lambda_S}} + (1 - \gamma_S)^{\frac{1}{\lambda_S}} \left(\frac{e_t B_{FS,t}(i)}{P_t} \right)^{\frac{\lambda_S-1}{\lambda_S}} \right]^{\frac{\lambda_S}{\lambda_S-1}}, \quad (3)$$

where P_t is the aggregate price level, e_t is the nominal exchange rate (in units of domestic currency per unit of foreign currency), γ_S determines the share of domestic bonds in the short-term bond subportfolio, and λ_S is the elasticity of substitution between domestic and foreign short-term bonds. Similarly, the long-term bond subportfolio is a CES aggregate of long-term domestic government bonds, $q_{L,t} B_{HL,t}$, and long-term foreign government bonds, $q_{L,t}^* B_{FL,t}$:

$$a_{L,t}(i) = \left[\gamma_L^{\frac{1}{\lambda_L}} \left(\frac{q_{L,t} B_{HL,t}(i)}{P_t} \right)^{\frac{\lambda_L-1}{\lambda_L}} + (1 - \gamma_L)^{\frac{1}{\lambda_L}} \left(\frac{e_t q_{L,t}^* B_{FL,t}(i)}{P_t} \right)^{\frac{\lambda_L-1}{\lambda_L}} \right]^{\frac{\lambda_L}{\lambda_L-1}}, \quad (4)$$

where $q_{L,t}$ and $q_{L,t}^*$ denote the relative prices of real domestic and foreign long-term bonds, respec-

⁶We impose imperfect substitution across the various government bonds of different maturities and currencies using a nested CES structure as in Alpanda and Kabaca (2020). Valchev (2015) features portfolio adjustment costs with a CES specification that enter the budget constraint of households, while Chen et al. (2012a) use a segmented markets approach to generate imperfect substitutability between bonds. Alpanda and Kabaca (2020) show that these approaches yield similar dynamics with respect to a QE shock in a closed economy setup. Our choice of using the “bonds-in-utility” approach here is also partly for convenience, since a segmented markets approach in our model would require introducing multiple types of “restricted agents” in order to adequately capture the imperfect substitutability among the four types of government bonds available. Also see Harrison (2011) and Chin et al. (2015), who capture imperfect asset substitutability in the objective function of portfolio managers who sell mutual fund shares backed by bonds to households, instead of within the utility function of households directly. Vitek (2014) follows a similar strategy to ours for capturing portfolio balance effects in households' utility, but focuses on portfolio balancing between government bonds and equity.

tively.⁷ Note that long-term bonds are modeled as perpetuities that pay a coupon payment of 1 unit in the first period after issuance, and their coupon payments decay by a factor of κ in each period after that, as in Woodford (2001).⁸ Thus, the nominal yields on the long-term bonds, $R_{L,t}$ and $R_{L,t}^*$, are related to the relative bond prices as

$$R_{L,t} = \frac{1}{q_{L,t}} + \kappa, \text{ and } R_{L,t}^* = \frac{1}{q_{L,t}^*} + \kappa. \quad (5)$$

In the long-term bond subportfolio, γ_L determines the share of domestic bonds, and λ_L is the elasticity of substitution between domestic and foreign long-term bonds.

The unrestricted households' period budget constraint is given by

$$\begin{aligned} c_{U,t}(i) + q_t [k_t(i) - (1 - \delta)k_{t-1}(i)] + \frac{B_{HS,t}(i)}{P_t} + \frac{e_t B_{FS,t}(i)}{P_t} + \frac{q_{L,t} B_{HL,t}(i)}{P_t} + \frac{e_t q_{L,t}^* B_{FL,t}(i)}{P_t} \quad (6) \\ \leq (1 - \tau_n) \frac{W_{U,t}(i)}{P_t} n_{U,t}(i) + (1 - \tau_k) r_{k,t} k_{t-1}(i) + \tau_k \delta k_{t-1}(i) + \frac{R_{t-1} B_{HS,t-1}(i)}{P_t} \\ + \frac{e_t R_{t-1}^* B_{FS,t-1}(i)}{P_t} + \frac{(1 + \kappa q_{L,t}) B_{HL,t-1}(i)}{P_t} + \frac{e_t (1 + \kappa q_{L,t}^*) B_{FL,t-1}(i)}{P_t} \\ + \frac{\Pi_{h,t}}{P_t} + \frac{\Pi_{f,t}}{P_t} + tr_{U,t} - \frac{\kappa_w}{2} \left(\frac{W_{U,t}(i)/W_{U,t-1}(i)}{\pi_{t-1}^{\zeta_w} \pi^{1-\zeta_w}} - 1 \right)^2 \frac{W_{U,t}}{P_t} n_{U,t}, \end{aligned}$$

where k_t is the capital stock, q_t is the relative price of capital, $W_{U,t}$ is the nominal wage rate of unrestricted households, and $r_{k,t}$ is the rental rate of capital. τ_n and τ_k denote the tax rates on labor and capital income, where depreciation is deductible from the latter. Short-term domestic and foreign bonds pay pre-determined interest rates of R_{t-1} and R_{t-1}^* , respectively. Long-term bonds are tradable each period, which allows us to write them in a recursive format in the budget constraint above.⁹ $\Pi_{h,t}$ and $\Pi_{f,t}$ denote the profits of monopolistically-competitive domestic producers and importers, while $tr_{U,t}$ is real lump-sum transfers from the government to unrestricted households.

Unrestricted households possess market power in the labor market and supply heterogeneous labor services, which are aggregated into a homogeneous labor service by perfectly-competitive labor intermediaries, who in turn rent these labor services to goods producers. Households face quadratic adjustment costs when changing nominal wages à la Rotemberg (1982), which introduces nominal wage stickiness into the model. In the wage adjustment cost specification described above (the last term in the budget constraint), κ_w is a scale parameter, $\pi_t = P_t/P_{t-1}$ refers to the aggregate inflation factor, and ζ_w determines the degree of indexation of wage adjustments to past inflation.

⁷For the notation related to long-term bonds, we follow the convention in Chen et al. (2012a). In particular, the price and quantity of bonds are denoted by $q_{L,t}$ and $B_{L,t}$, respectively, where the former is a *relative* price while the latter is denoted in *nominal* terms. This is without loss of generality, and one can define the bond price in nominal terms and the quantity in real terms. See the Online Appendix of Alpana and Kabaca (2020) for more on this issue.

⁸Note that there are no coupon payments in the period of the bonds' issuance, and the coupon payments in the subsequent periods occur *before* the bonds are traded among agents. Thus, the prices of long-term bonds in the model represent *ex coupon*, and not *cum coupon*, prices.

⁹See the online Appendix of Alpana and Kabaca (2020) for more on this issue.

We provide further details on the model features regarding labor intermediaries and wage rigidities in Appendix A.

The unrestricted households' objective is to maximize utility subject to the budget constraint, the labor demand curve of labor intermediaries, and appropriate no-Ponzi conditions.

2.1.1 Term premium and long-term interest rates

The unrestricted agents' optimality conditions with respect to domestic short- and long-term bonds are given by

$$\lambda_{U,t} = \beta E_t \left[\lambda_{U,t+1} \frac{R_t}{\pi_{t+1}} \right] + \frac{\xi_a}{a_t} \frac{\partial a_t}{\partial a_{S,t}} \frac{\partial a_{S,t}}{\partial b_{HS,t}}, \quad (7)$$

$$q_{L,t} \lambda_{U,t} = \beta E_t \left[\lambda_{U,t+1} \frac{R_{L,t+1} q_{L,t+1}}{\pi_{t+1}} \right] + \frac{\xi_a}{a_t} \frac{\partial a_t}{\partial a_{L,t}} \frac{\partial a_{L,t}}{\partial b_{HL,t}}, \quad (8)$$

where $\lambda_{U,t}$ is the Lagrange multiplier on the budget constraint, and real domestic bond holdings are defined as $b_{HS,t} = B_{HS,t}/P_t$ and $b_{HL,t} = B_{HL,t}/P_t$. The corresponding optimality conditions for their foreign short- and long-term bond holdings are

$$rer_t \lambda_{U,t} = \beta E_t \left[\lambda_{U,t+1} rer_{t+1} \frac{R_t^*}{\pi_{t+1}^*} \right] + \frac{\xi_a}{a_t} \frac{\partial a_t}{\partial a_{S,t}} \frac{\partial a_{S,t}}{\partial b_{FS,t}}, \quad (9)$$

$$rer_t q_{L,t}^* \lambda_{U,t} = \beta E_t \left[\lambda_{U,t+1} rer_{t+1} \frac{1 + \kappa q_{L,t+1}^*}{\pi_{t+1}^*} \right] + \frac{\xi_a}{a_t} \frac{\partial a_t}{\partial a_{L,t}} \frac{\partial a_{L,t}}{\partial b_{FL,t}}, \quad (10)$$

where the real exchange rate is defined as $rer_t = e_t P_t^*/P_t$, and real foreign bonds are defined as $b_{FS,t} = B_{FS,t}/P_t^*$, and $b_{FL,t} = B_{FL,t}/P_t^*$.

The first two of these expressions above can be log-linearized and combined to generate a recursive expression for the yield on long-term bonds as

$$\widehat{R}_{L,t} = \frac{\kappa}{R_L} \widehat{R}_{L,t+1} + \left(1 - \frac{\kappa}{R_L} \right) \left(\widehat{R}_t + \widehat{T}_t \right), \quad (11)$$

where the term, \widehat{T}_t , is given by

$$\widehat{T}_t = \left(\frac{\pi}{\beta R} - 1 \right) \left\{ \frac{1}{\lambda_a} (\widehat{a}_{L,t} - \widehat{a}_{S,t}) - \frac{1}{\lambda_L} \left[\widehat{a}_{L,t} - (\widehat{q}_{L,t} + \widehat{b}_{HL,t}) \right] + \frac{1}{\lambda_S} (\widehat{a}_{S,t} - \widehat{b}_{HS,t}) \right\}. \quad (12)$$

Iterating on (11), one can show that the yield on long-term bonds depends on current and expected future short-term rates (expectations hypothesis), plus a term premium term as

$$\widehat{R}_{L,t} = \left(1 - \frac{\kappa}{R_L} \right) E_t \sum_{s=0}^{\infty} \left(\frac{\kappa}{R_L} \right)^s \widehat{R}_{t+s} + \widehat{t}p_t, \quad (13)$$

where the term premium, \widehat{tp}_t , is given by

$$\widehat{tp}_t = \left(1 - \frac{\kappa}{R_L}\right) E_t \sum_{s=0}^{\infty} \left(\frac{\kappa}{R_L}\right)^s \widehat{T}_{t+s}. \quad (14)$$

Thus, within the context of our model, the term premium is the discounted sum of the \widehat{T}_t terms, with the individual \widehat{T}_t 's capturing the contribution of each period's relative bond holdings to the overall term premium.¹⁰

The equations above imply that, even when the short rate is kept constant (e.g., at the ZLB), the long rate can be altered by changing the maturity composition of the bonds outstanding. In particular, long-term rates would tend to increase if expansionary fiscal policy is financed primarily through the issuance of long-term bonds, while they would decrease if fiscal policy is financed by short-term bond issuance.

How does the foreign term premium affect the domestic term premium? First, let us log-linearize and combine equations 9 and 10 to obtain a recursive expression for the foreign yield on long-term bonds as

$$\widehat{R}_{L,t}^* = \frac{\kappa}{R_L} \widehat{R}_{L,t+1}^* + \left(1 - \frac{\kappa}{R_L}\right) \left(\widehat{R}_t^* + \widehat{T}_t^*\right), \quad (15)$$

where the term, \widehat{T}_t^* , is given by

$$\widehat{T}_t^* = \left(\frac{\pi}{\beta R} - 1\right) \left\{ \frac{1}{\lambda_a} (\widehat{a}_{L,t} - \widehat{a}_{S,t}) - \frac{1}{\lambda_L} \left[\widehat{a}_{L,t} - (r\widehat{er}_t + \widehat{q}_{L,t}^* + \widehat{b}_{FL,t}) \right] + \frac{1}{\lambda_S} \left(\widehat{a}_{S,t} - (r\widehat{er}_t + \widehat{b}_{FS,t}) \right) \right\}. \quad (16)$$

We can obtain a relationship between domestic and foreign premia by combining equations 12 and 16 as in the following:

$$\widehat{T}_t = \widehat{T}_t^* + \left(\frac{\pi}{\beta R} - 1\right) \left\{ \frac{1}{\lambda_L} \left(\widehat{q}_{L,t} + \widehat{b}_{HL,t} - (r\widehat{er}_t + \widehat{q}_{L,t}^* + \widehat{b}_{FL,t}) \right) + \frac{1}{\lambda_S} \left(\widehat{b}_{HS,t} - (r\widehat{er}_t + \widehat{b}_{FS,t}) \right) \right\}. \quad (17)$$

Above equation suggests that term premium spillovers from foreign to domestic yields will depend on the substitution between home and foreign assets in both short- and long-term maturities. Domestic premium moves in-tandem with foreign premium when home and foreign bonds are perfectly substitutable in both maturities ($\lambda_S = \lambda_L = \infty$).

¹⁰Note also that if the elasticity of substitution across the different assets are equal to each other (i.e., $\lambda_a = \lambda_S = \lambda_L$), the expression for the long-term bond in (13) reduces to

$$\widehat{R}_{L,t} = \left(1 - \frac{\kappa}{R_L}\right) E_t \sum_{s=0}^{\infty} \left(\frac{\kappa}{R_L}\right)^s \left[\widehat{R}_{t+s} + \left(\frac{\pi}{\beta R} - 1\right) \frac{1}{\lambda_a} \left(\widehat{q}_{L,t+s} + \widehat{b}_{HL,t+s} - \widehat{b}_{HS,t+s} \right) \right],$$

which is similar to the expression in the closed economy set up of Chen et al. (2012a).

2.1.2 Exchange rate determination

The exchange rate is determined through arbitrage between home and foreign assets. Equations 7 and 9 can be log-linearized and combined to yield a short term (modified) uncovered interest parity (UIP) condition:

$$\widehat{R}_t - \widehat{R}_t^* = E_t \widehat{d}_{t+1} + \left(\frac{\pi}{\beta R} - 1 \right) \frac{1}{\lambda_S} \left[\widehat{b}_{HS,t} - \left(r \widehat{e}r_t + \widehat{b}_{FS,t} \right) \right], \quad (18)$$

where $\widehat{d}_t = \widehat{e}_t - \widehat{e}_{t-1}$ denotes the nominal depreciation rate of the ROW currency. The above condition implies that the country risk premium is determined by the relative holdings of short-term domestic and foreign bonds. In the case of a fiscal shock financed by issuing long-term debt, this premium will not affect the exchange rate much as the short-term debt remains fixed. However, if the fiscal shock is financed by short-term debt, the country risk premium will have appreciatory pressures on the home currency as the stock of foreign bonds increase in portfolios relative to home bonds. We will examine the difference in maturity of debt financing further in section 3.2.5.

Note that the exchange rate has to also hold between long-term home and foreign assets as well. We can combine the short-term UIP condition with equation 17 to obtain a long-term (modified) UIP condition:

$$\widehat{R}_t + \widehat{T}_t - \left(\widehat{R}_t^* + \widehat{T}_t^* \right) = E_t \widehat{d}_{t+1} + \left(\frac{\pi}{\beta R} - 1 \right) \frac{1}{\lambda_S} \left[\widehat{q}_{L,t} + \widehat{b}_{HL,t} - \left(r \widehat{e}r_t + \widehat{q}_{L,t}^* + \widehat{b}_{FL,t} \right) \right], \quad (19)$$

Above equation implies that the one-period holding return differential between home and foreign long-term bonds has to be equal to the expected depreciation plus the premium agents require depending on their relative holdings of these bonds.

2.1.3 Bond yields and consumption demand

Changes in the long-term interest rates also affect consumption demand in our setup. To see this, observe that the unconstrained households' first-order conditions with respect to the four types of bonds can be log-linearized and combined to yield an "IS" curve equation of the form:

$$\widehat{\lambda}_{U,t} = \beta \frac{R}{\pi} \left(E_t \widehat{\lambda}_{U,t+1} + \widehat{R}_t^a - E_t \widehat{\pi}_{t+1} \right) - \left(1 - \beta \frac{R}{\pi} \right) \widehat{a}_t, \quad (20)$$

where \widehat{R}_t^a is the return on the bond portfolio given by

$$\begin{aligned} \widehat{R}_t^a &\equiv \gamma_a \gamma_S \widehat{R}_t + (1 - \gamma_a) \gamma_L \left(\widehat{R}_t + \widehat{T}_t \right) \\ &+ \gamma_a (1 - \gamma_S) \left(\widehat{R}_t^* + E_t \widehat{d}_{t+1} \right) + (1 - \gamma_a) (1 - \gamma_L) \left(\widehat{R}_t^* + \widehat{T}_t^* + E_t \widehat{d}_{t+1} \right), \end{aligned} \quad (21)$$

with the nominal depreciation rate defined as $\widehat{d}_t = \widehat{e}_t - \widehat{e}_{t-1}$. Note that, in the absence of imperfect substitutability between the four types of bonds, we would have

$$\widehat{R}_t = \widehat{R}_t + \widehat{T}_t = \widehat{R}_t^* + E_t \widehat{d}_{t+1} = \widehat{R}_t^* + \widehat{T}_t^* + E_t \widehat{d}_{t+1}, \quad (22)$$

and thus, the *IS* curve would reduce to:

$$\widehat{\lambda}_{U,t} = \beta \frac{R}{\pi} \left(E_t \widehat{\lambda}_{U,t+1} + \widehat{R}_t - E_t \widehat{\pi}_{t+1} \right) - \left(1 - \beta \frac{R}{\pi} \right) \widehat{a}_t, \quad (23)$$

with \widehat{a}_t appearing in the *IS* curve as a result of the bonds-in-utility assumption.¹¹ With imperfect substitutability however, the relevant interest rate in the *IS* equation is a function of not only the domestic short rate, but also of the domestic long rate as well as the foreign interest rates. Furthermore, the importance of each interest rate for consumption demand is linked to the portfolio share of the related bonds.

As we shall see in Section 4, an expansionary fiscal policy shock in the US economy results in an increase in short-term interest rates, since inflation and aggregate output increases, similar to a standard international DSGE setup *without* portfolio balance effects. But here, even when short-term interest rates are constrained at the ZLB, both US and ROW term premia increase and the consumption demand of unconstrained agents is adversely affected, when the fiscal expansion is financed primarily by long-term debt issuance. There is a moderating effect on consumption demand based on the net increase in the portfolio size, a_t , but this effect is relatively small since $1 - \beta R/\pi$ is slightly above, but very close to, 0, given our calibration.

The expansionary fiscal shock also leads to currency appreciation for the US economy similar to a standard setup, which reduces US net exports. Despite these adverse effects from unrestricted households' consumption and net exports, the US aggregate output increases due to the direct impact of the expansionary government expenditure as well as the positive response of hand-to-mouth households' consumption. Unlike the standard setup however, aggregate output in the ROW economy declines, since the increase in their net export demand is not enough to reverse the adverse effects of the shock on their consumption demand through the short- and long-term interest rates.

2.2 Restricted households

The economy is also populated by a unit measure of infinitely-lived restricted (i.e., hand-to-mouth) households, who do not own any bonds and whose intertemporal preferences over consumption, $c_{R,t}$,

¹¹In the absence of utility benefits of bonds, the real interest rate at the steady state would be equal to $R/\pi = 1/\beta$, and the above expression would reduce to the standard *IS* curve in the New Keynesian literature. Since $R/\pi < 1/\beta$ in our model, signaling short-term interest rate changes in the future by the central bank do not affect current demand as much. Thus, this extra discounting generated by the bonds-in-utility specification can partly help solve the “forward guidance puzzle” (Michaillat and Saez, 2021).

and labor supply, $n_{R,t}$, are described by the following expected utility function:

$$E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left(\log [c_{R,\tau}(i) - \zeta c_{R,\tau-1}] - \xi_n \frac{n_{R,\tau}(i)^{1+\vartheta}}{1+\vartheta} \right). \quad (24)$$

The restricted households' period budget constraint is given by

$$c_{R,t}(i) \leq (1 - \tau_n) \frac{W_{R,t}(i)}{P_t} n_{R,t}(i) + tr_{R,t} - \frac{\kappa_w}{2} \left(\frac{W_{R,t}(i) / W_{R,t-1}(i)}{\pi_{t-1}^{\zeta_w} \pi^{1-\zeta_w}} - 1 \right)^2 \frac{W_{R,t}}{P_t} n_{R,t}, \quad (25)$$

where $W_{R,t}$ is the nominal wage rate of restricted households, $tr_{R,t}$ is their real lump-sum transfers from the government, and the last term is their quadratic wage adjustment costs. The first-order conditions of hand-to-mouth agents are standard, and are relegated to Appendix A.

2.3 Fiscal policy

Government expenditure, g_t , is composed of two components: $g_t = g_{c,t} + g_{i,t}$, where $g_{c,t}$ is government consumption, and $g_{i,t}$ is government investment.¹² Both components are assumed to follow exogenous AR(1) processes as

$$\log g_{c,t} = (1 - \rho_{gc}) \log g_c + \rho_{gc} \log g_{c,t-1} + \varepsilon_{gc,t}, \quad (26)$$

$$\log g_{i,t} = (1 - \rho_{gi}) \log g_i + \rho_{gi} \log g_{i,t-1} + \varepsilon_{gi,t}, \quad (27)$$

where ρ_{gc} and ρ_{gi} are persistence parameters and $\varepsilon_{gc,t}$ and $\varepsilon_{gi,t}$ are *i.i.d.* shock innovations.

The law of motion linking government investment to the stock of government capital, $k_{g,t}$, is given by

$$k_{g,t} = (1 - \delta_g) k_{g,t-1} + g_{i,t}, \quad (28)$$

where δ_g is the depreciation rate for government capital. As explained further in Appendix A, the productivity term in the firms' production function is affected by the stock of government capital as in Leeper et al. (2010). In particular, firm j 's production function is given by

$$y_t(j) = (z_t k_{g,t-1}^{\Psi}) [u_t(j) k_{t-1}(j)]^{\alpha} \left[n_{H,t}(j)^{\Phi} n_{L,t}(j)^{1-\Phi} \right]^{1-\alpha} - f, \quad (29)$$

where the total factor productivity (TFP) term has two components: z_t , which follows an exogenous AR(1) process, and lagged government capital, $k_{g,t-1}$, which affects TFP with parameter Ψ determining the strength of the impact of government capital on TFP.¹³

¹²Without loss of generality, one can assume that government consumption enters the households' utility in a separable manner and is treated as an externality by households.

¹³The firm also uses private capital, k_{t-1} , and labor services of the two types of agents, $n_{U,t}$ and $n_{R,t}$, as inputs in production, with α and Φ denoting share parameters. u_t denotes the utilization rate of capital, while f denotes the fixed costs in production. See Appendix A for more details on the production side of the model.

The (consolidated) government budget constraint is given by

$$\frac{P_{h,t}}{P_t} g_t + \frac{R_{t-1}}{\pi_t} b_{S,t-1} + \frac{R_{L,t}}{\pi_t} q_{L,t} b_{L,t-1} + tr_t = tax_t + b_{S,t} + q_{L,t} b_{L,t}, \quad (30)$$

where $P_{h,t}$ is the price of domestic goods, $tr_t = tr_{U,t} + tr_{R,t}$ denotes aggregate transfers from the government to households, and tax_t is aggregate taxes given by

$$tax_t = \tau_n (w_{U,t} n_{U,t} + w_{R,t} n_{R,t}) + \tau_k (r_{k,t} - \delta) k_{t-1}, \quad (31)$$

with real wages of each agent given by $w_{U,t} = W_{U,t}/P_t$ and $w_{R,t} = W_{R,t}/P_t$.

Transfers to the individual types of households are given by

$$tr_{m,t} = \Xi_m y \left(\frac{y_t}{y} \right)^{-\varrho_y} \left(\frac{b_{S,t-1} + q_{L,t-1} b_{L,t-1}}{b_S + q_L b_L} \right)^{-\varrho_b} \tilde{\varepsilon}_{tr,t} \text{ for } m \in \{U, R\}, \quad (32)$$

where Ξ_U and Ξ_R determine the steady state value of transfers-to-output ratio for each household, $b_{S,t}$ and $b_{L,t}$ refer to the total amount of real government bonds outstanding (held both by domestic and foreign households), ϱ_y and ϱ_b are parameters regulating the elasticity of transfers with respect to the output gap and the government debt gap, respectively, and $\tilde{\varepsilon}_{tr,t}$ is an exogenous shock which follows an AR(1) process.¹⁴ In our baseline case, we let transfer shocks affect both types of households, but we also run an alternative scenario in the next section with transfer shocks being targeted to restricted households only.

Note that the term that gets determined residually in the government budget constraint is the change in total government bonds; hence, budget deficits are debt financed in the model. However, the relative financing of deficits through short- versus long-term bond issuance is so far undetermined. In our baseline exercises, we assume that fiscal deficits are financed by long-term debt, which requires that short-term debt stays constant over time at its steady-state value:

$$b_{S,t} = \bar{b}_S. \quad (33)$$

Above equation ensures that the government' budget constraint equation in (30) is satisfied on the margin by issuing long-term bonds only.

2.4 Monetary policy

The central bank targets the nominal short-term interest rate using a Taylor rule of the form

$$\log R_t = \rho \log R_{t-1} + (1 - \rho) \left(\log R + r_\pi \log \frac{\pi_t}{\pi} + r_y \log \frac{y_t}{y} \right) + \varepsilon_{r,t}, \quad (34)$$

¹⁴Lump-sum transfers adjust with the level of government debt to rule out a Ponzi scheme for the government.

where R is the steady-state value of the (gross) nominal policy rate, y_t denotes domestic output, y is the steady-state level of output, and $\varepsilon_{r,t}$ is an *i.i.d.* monetary policy shock. ρ determines the extent of interest rate smoothing in the Taylor rule, while the parameters r_π and r_y determine the long run responses of the interest rate to inflation and the output gap, respectively.

We do not explicitly model the balance sheet of the central bank and its holdings of government bonds following Chen et al. (2012a) and Alpanda and Kabaca (2020); thus, the government bonds outstanding in the government’s budget constraint in (30) refer to the quantity of bonds available to the general public (i.e., both domestic and foreign households in the model economy), net of purchases by the central bank.¹⁵

2.5 Production and market clearing conditions

The production side of the model is relatively standard, and is described in more detail in Appendix A. The model features domestic producers and importers in each country, which produce differentiated products in monopolistically-competitive markets. Both domestic producers and importers face adjustment costs when changing prices, and both index their price changes partly to trend inflation and partly to their respective past inflation rates. These nominal rigidities result in non-neutralities in the effects of conventional monetary policy shocks, and lead to partial pass-through from exchange rates to inflation, which are standard features in open-economy New Keynesian models (Adolfson et al., 2008; Justiniano and Preston, 2010b).

The differentiated domestic and imported products are aggregated by final goods producers, which operate in perfectly-competitive markets. The domestically-produced final goods, y_t , can be used as the “home” component of the consumption and investment aggregates, or as government expenditure or export goods as

$$c_{h,t} + i_{h,t} + g_t + y_{f,t}^* = y_t, \tag{35}$$

where $c_{h,t}$ and $i_{h,t}$ denote the home components of the consumption and investment aggregates, while $y_{f,t}^*$ denotes the foreign country’s imports, hence the domestic country’s exports.¹⁶ Similarly, the imported final goods in the domestic country, $y_{f,t}$, can be used as the “foreign” component of the consumption and investment aggregates:

$$c_{f,t} + i_{f,t} = y_{f,t}. \tag{36}$$

The final consumption and investment goods are then constructed as a CES aggregate of their respective home and foreign components described above.

¹⁵Note that we have denoted the government’s budget constraint in (30) as the “consolidated budget constraint,” implying that it can effectively be viewed as combining the flow constraints of both the fiscal and the monetary authorities, while treating the monetary base created by the central bank and the short-term bonds issued by the fiscal authority as perfectly substitutable. This consolidated representation of the flow constraints also captures the notion that the net cash flow of the central bank ultimately accrues to the fiscal authority in the real world.

¹⁶Note that all adjustment costs are assumed to accrue to households in lump-sum fashion, and therefore do not enter the feasibility condition.

The model also features perfectly-competitive capital producers, who face adjustment costs in the change in investment levels, which helps generate a relative price between investment and consumption goods.¹⁷ The market clearing conditions for short- and long-term bonds issued by the ROW economy are given by

$$\frac{B_{S,t}}{P_t} = \frac{B_{HS,t}}{P_t} + \frac{B_{FS,t}^*}{P_t}, \text{ and } \frac{q_{L,t}B_{L,t}}{P_t} = \frac{q_{L,t}B_{HL,t}}{P_t} + \frac{q_{L,t}B_{FL,t}^*}{P_t}, \quad (37)$$

where $B_{FS,t}^*$ and $B_{FL,t}^*$ refer to US holdings of ROW short- and long-term bonds, respectively.¹⁸ The balance-of-payments identity in the model is given by

$$\begin{aligned} & \left(\frac{e_t B_{FS,t}}{P_t} - \frac{e_t R_{t-1}^* B_{FS,t-1}}{P_t} \right) + \left(\frac{e_t q_{L,t}^* B_{FL,t}}{P_t} - \frac{e_t R_{L,t}^* q_{L,t}^* B_{FL,t-1}}{P_t} \right) \\ & - \left(\frac{B_{FS,t}^*}{P_t} - \frac{R_{t-1} B_{FS,t-1}^*}{P_t} \right) - \left(\frac{q_{L,t} B_{FL,t}^*}{P_t} - \frac{R_{L,t} q_{L,t} B_{FL,t-1}^*}{P_t} \right) = \frac{P_{h,t}}{P_t} y_{f,t}^* - \frac{e_t P_{h,t}}{P_t} y_{f,t}, \end{aligned} \quad (38)$$

where the right hand side denotes the trade balance, while the left hand side captures the corresponding change in bond holdings, net of interest payments, across borders. The model's equilibrium is defined as prices and allocations such that households maximize the discounted present value of utility and all firms maximize the discounted present value of profits, subject to their constraints, and all markets clear.

3 Quantitative Analysis using the DSGE Model

In this section, we first describe the calibration of model parameters, and then present impulse responses of key variables for the US and ROW economies to fiscal policy shocks originating in the US. In particular, we consider three types of fiscal shocks: (i) government consumption, (ii) government investment, and (iii) government transfers.

3.1 Calibration

Table 1 lists the parameter values used in our baseline calibration, while Table 2 presents the implied steady state of the model based on these parameters. In what follows, we describe the calibration of some of the key parameters of the model, including those related to fiscal policy and the bond portfolio, relegating the relatively standard parts of the calibration to Appendix B. Most parameter values are similar to those used in Alpanda and Kabaca (2020).

The steady-state level of the exogenous part of TFP in the US, z^* , is set to 1 without loss of generality, while the ROW's z is calibrated so that the steady-state output in the ROW economy is

¹⁷Note that different import shares in the investment and consumption aggregates would also generate differences in the price of these final goods, although we assume equal import shares for both of these goods in our parameterization in Section 3.

¹⁸The F subscript here denotes the fact that these are foreign bonds from the perspective of the US economy.

2.5 times as large as the US economy, based on the average of the export-to-GDP and the import-to-GDP ratios in the US between 1990-2007 (12.1%) and the corresponding measure for the ROW economies (4.9%), similar to Sutherland (2005).

We set the share of unconstrained households in total composite labor, Φ , to 0.8, implying a hand-to-mouth share of 20%, similar to Campbell and Mankiw (1991). The steady-state government expenditure level is set to ensure that its share in output, g/y , is 20% in each country. The depreciation rate for government capital, δ_g , is set to 2% to match a government investment-to-GDP ratio of 5%, while government consumption-to-GDP is 15%. The elasticity of government capital to TFP, Ψ , is set to 0.1, close to estimates in Leeper et al. (2010). The tax rates on labor and capital income, τ_n and τ_k , are set to 0.3 and 0.2, respectively. The elasticity of transfers to output gap and government debt gap, τ_y and τ_b , are set to 1, and Ξ_R is set to 0.01 in both countries, while the steady-state transfer level parameter for unconstrained agents in the two countries, Ξ_U and Ξ_U^* , are set to ensure that each government's budget constraint is satisfied given the bond ratios and interest rates at the steady state.

To calibrate the portfolio share parameters for the US and the ROW, we combine data targets on the supply of short- and long-term bonds in each economy, as well as data on foreign bond holdings provided by the Treasury International Capital (TIC) database of the US Treasury. For the US, the short- and long-term government bonds outstanding relative to annual GDP are 0.114 and 0.186, respectively, over the 2001-2007 period. The corresponding government bond supply-to-GDP ratios for the ROW economy are given by 0.127 and 0.353, when we consider the sample of countries we used to construct a ROW measure.¹⁹ These constitute our bond supply targets.²⁰ For bond holdings, TIC data indicate that the foreign holdings of short- and long-term US Treasuries, as a ratio to world GDP excluding the US, are given by 0.017 and 0.044, respectively, for the 2001-2007 period.²¹ TIC data also indicates that the US residents' holdings of short- and long-term foreign government bonds, as a ratio to US GDP, are given by 0.002 and 0.025, respectively. These constitute our targets for the foreign holdings of each bond. The differences in the bond supplies and these figures can then be used to construct data targets for domestic holdings of these bonds.

We calibrate the portfolio share parameters in the CES aggregates to match the bond supply and bond holding data targets mentioned above. In particular, we set the share of short-term bonds in the US portfolio, γ_a^* , to 0.42, while the shares of domestic bonds in the US short- and long-term portfolios, γ_S^* and γ_L^* , are set to 0.98 and 0.75, respectively. Similarly, for the ROW portfolio, the share of short-term bonds, γ_a , is set to 0.27, while the shares of domestic bonds in their short- and

¹⁹The aggregate ROW series are constructed using the weighted average of data from Australia, Canada, China, the Euro Area, Japan, Norway, Sweden, Switzerland, and the United Kingdom as in Alpanda and Kabaca (2020).

²⁰The short-term bond supply series are constructed as the sum of the monetary base and government bonds with a maturity of less than one year at issuance. The measure for the US long-term bonds includes only Treasury bonds, but not debt issued by Government-sponsored Enterprises (GSEs).

²¹The figure for the short-term holdings also includes foreign holdings of US currency, reported by the Flow of Funds of the Federal Reserve Bank. In general, our short-term bond measures include the monetary base, since it is a close substitute for short-term government bonds when the policy rate is at the ZLB or when the central bank pays interest on reserves.

long-term portfolios, γ_S and γ_L , are 0.88 and 0.89. For both countries, the elasticity of substitution between short- and long-term bonds, λ_a , is set to 1.5, while the elasticity of substitution between domestic and foreign bonds in the short and long subportfolios, λ_S and λ_L , are relatively higher at 12.5 and 4.5, respectively.

3.2 Results

In this section, we start off by describing the effects of fiscal shocks in the US on both the US and the ROW economies. We then analyze how these baseline results would be altered under alternative scenarios, such as the absence of portfolio rebalancing effects. For these, we focus more on the government consumption shock, and defer the results for the other fiscal shocks to Appendix C.

3.2.1 Impact of fiscal shocks on the US and ROW

We start by considering the impulse responses of the US and ROW economies to fiscal shocks originating in the US. We consider all three fiscal shocks; namely, government consumption, government investment, and transfers. All three shocks are assumed to have a persistence of 0.9, and the size of the shocks is scaled to 1% of the steady-state annual US output.

Figure 1 shows the impulse responses of US variables after each of the three fiscal policy shocks originating in the US. Similar to a standard setup, government consumption shocks act as expansionary demand shocks, leading to an increase in both output and inflation, while the central bank raises the short-term interest rate given its Taylor rule. The US long-term rate increases as well, both due to the expectations hypothesis and due to the increase in the term premium component. In particular, due to imperfect substitution between short- and long-term bonds, the term premium on long-term rates in the US increase by about 25 basis points (bps). Note that unconstrained agents increase their holdings of US (and foreign) long-term bonds relatively more than their US (and foreign) short-term bond holdings. The fiscal shock crowds out not only private investment, but also consumption of unconstrained agents. Aggregate consumption increases however due to the response of hand-to-mouth agents, who increase their labor supply and consumption as a result of the increased aggregate demand in the economy. On the trade side, the fiscal expansion leads to an appreciation of the US currency, which results in a decline in US exports and an increase in US imports. Thus, the fiscal expansion also crowds out the net export component of demand. Nevertheless, the government consumption shock overall acts as a standard expansionary demand shock in the economy.

The effects of an expansionary government investment shock on the US economy are similar to those from a government consumption shock, except for the former's effects on inflation and interest rates. In particular, government investment increases the stock of government capital, and acts similar to a positive productivity shock given the externality effect of government capital on private production. The higher levels of supply then increase overall output and curb inflation. The latter effect is associated with a decline in the short-term rate via the central bank's Taylor rule, which also

leads to a decline in the long-term rate through the expectations hypothesis despite the increase in the term premium component. The decline in interest rates also moderates the appreciation effects on the US currency, which mitigates trade effects relative to government consumption. Also, the increase in effective productivity incentivizes private investment, which recovers much faster than it does after a government consumption shock. As a result, the expansionary impact on US output is higher with government investment relative to government consumption.

The baseline results with transfer shocks are also similar to those from a government consumption shock, except consumption and imports increase relatively more with transfer shocks. This is because the transmission of transfer shocks to the economy is primarily through households' consumption, and consumption goods require imported intermediate goods in their production process, unlike government consumption goods, which only require domestically produced intermediates. As a result of higher spending on imported goods, output also increases less than under government consumption or investment shock.

Note that the appreciation of the US dollar following those fiscal shocks is consistent with the short-term UIP condition (see equation 18). Fiscal stimulus in the US generates a short-term rate differential, appreciating the currency. In addition, the portfolio term in the short-term UIP condition does not play a significant role on the currency since the fiscal stimulus does not move short-term debt supply. The appreciation of the US dollar is also consistent with the long-term UIP condition (see equation 19). Here, term premium differential generates additional appreciation pressures on the dollar, which is then offset by increased US long-term debt. The latter is because the fiscal stimulus is financed by issuing long-term debt, increasing the holdings of US long-term bonds in portfolios. And higher US debt in long-term portfolios generates depreciation pressures on the dollar.

Figure 2 plots the corresponding impulse responses for ROW variables to the expansionary fiscal shocks originating in the US. The spillover effects of US government consumption shocks on ROW output is on net negative. We observe that the inflation rate picks up due to the depreciation of ROW currency and this causes short-term interest rates to rise. The increase in the US term premium partially passes through to the ROW term premium as ROW agents increase their holdings of US long-term bonds and reallocate their portfolios away from local long-term bonds. This causes a further increase in long-term interest rates, depressing consumption demand in the ROW economy. Coupled with the reduction in private investment, aggregate output falls despite the positive impact of the currency depreciation on ROW net exports.

The spillover effects of US government investment and transfer shocks to the ROW economy are by and large similar. As noted, the transfer shock in the US leads to a larger positive impact on ROW net exports, which results in ROW output to slightly increase on impact rather than decrease. Figures C.4 and C.5 in Appendix C repeats the transfer experiment described above, but allocates the transfers only to hand-to-mouth agents (instead of both types of agents as in the baseline case). These results illustrate that both the expansionary impact of transfers on the US economy as well as the positive spillover effects on the ROW economy are rendered significantly larger if the transfers

are targeted towards the hand-to-mouth agents, which have a much larger marginal propensity to consume.

In Appendix C, Figures C.1 and C.2 repeat the above exercises in the absence of hand-to-mouth agents in both countries. The results both for the US and ROW economies are virtually the same, except for the response of the aggregate consumption variable in the US, which now becomes negative at impact for government consumption and investment shocks. As a result, the stimulatory impact of these fiscal stimuli on aggregate output is also slightly less positive in the US. These results are consistent with the literature, and one of the main reasons hand-to-mouth agents are now routinely added in models considering the effects of fiscal shocks (Campbell and Mankiw, 1991).²²

3.2.2 The case without portfolio balancing

Portfolio balancing is a key mechanism in our model that drives the spillover of US fiscal to ROW economies. To identify the contribution of this mechanism more precisely, we shut-off the mechanism and compare the degree of spillover to the baseline scenario with portfolio balancing. Figure 3 illustrates this comparison. To shut-off the mechanism, we set all the elasticity parameters in the portfolio specification, λ_a , λ_S , and λ_L to infinity. Figure 3 plots the impulses for government consumption shocks only, while the corresponding figures for government investment and transfer shocks are deferred to Appendix C.

In the absence of portfolio rebalancing effects, the term premium stays constant in response to a government consumption shock, resulting in a smaller increase in the long-term rate in the US. The expansionary shock, therefore, generates a slightly higher increase in output and inflation. While short-term rates increase in response to higher inflation, long-term rates in the US increase less than they do under the baseline calibration given the non-responsiveness of the term premium component.

For the ROW economy, both output and inflation is higher in the absence of portfolio rebalancing effects. The term premium does not change in this case, implying a lower portfolio return in real terms, and higher spending. The higher level of spending in turn fuels inflation despite the lower degree of depreciation in the ROW currency, demonstrating that the impact of lower import prices are dominated by higher domestic-good prices in determining total inflation. Finally, the higher inflation rates lead to higher short-term rates through the Taylor rule. As a result, long-term rates increase despite a stable term premium.

Figures C.6 and C.7 in Appendix C present the corresponding impulse responses from government investment and transfer shocks, respectively. The results are qualitatively quite similar to those from the government consumption shocks described above. In particular, US and ROW inflation rates increase by more and the level of ROW output is higher in the absence of portfolio rebalancing.

²²Unlike government consumption and investment shocks, we observe an increase in aggregate consumption following the transfer shock. The main reason why consumption increases following the transfer shock is because the exchange rate appreciation increases imports more in the case of the transfer shock relative to other fiscal shocks. When we assume the economy is closed, the consumption demand no longer depends on the exchange rate, and the transfer shock does not move the aggregate demand as in the stylized New-Keynesian models with Ricardian equivalence.

Here we should note that while the level of ROW GDP is higher in the absence of portfolio balancing, it still falls following a positive US fiscal policy shock. This is at odd with the standard textbook description of the positive fiscal spillovers to foreign GDP through trade. The reason why GDP falls in our model even in the absence of portfolio balancing effects is because monetary policy responds to higher inflation, increasing the real short-term rates. We should however mention that it is possible for foreign monetary authorities to keep policy rates unchanged if they perceive the rise in import prices and depreciation of their currency as a temporary response. It is also possible that ROW might face constraints on monetary policy such as ZLB, as was the case during the recent coronavirus crisis. Figure 4 shows the results when ROW monetary policy does not respond to higher inflation over eight quarters for either of the two reasons mentioned above. In the absence of portfolio balancing effects, GDP spillovers are now positive due to positive trade effects. This highlights the importance of ROW monetary policy reaction, or the lack thereof, for the spillovers from US fiscal policy.

3.2.3 Trade openness and fiscal spillovers

We now investigate how trade openness affect the domestic and the international spillover impact of fiscal shocks. In particular, we consider a case where we increase the degree of international trade openness by considering $\gamma_i^* = \gamma_c^* = 0.3$, implying a home bias for goods in the foreign economy closer to its country size. While doing this, we keep the steady-state portfolio ratios the same as in our baseline case.²³ The results for government consumption shocks are presented in Figure 5. Figures C.8 and C.9 in Appendix C present the corresponding impulse responses from government investment and transfer shocks, respectively.

The results show that the domestic and the international GDP spillover effects of fiscal shocks are not highly sensitive to import shares. On the other hand, inflation is quite sensitive to import shares as the contribution of import prices to headline inflation increases. In particular, higher import shares leads to US inflation to fall despite a lower degree of US dollar appreciation. Lower inflation also prompts a lower level of US short-term and long-term rates relative to the baseline scenario. In the ROW economy however, the positive response of inflation is larger in magnitude. This surge in inflation, despite a small increase in the term premium, generates higher short- and long-term interest rate responses in the ROW. Thus, both rate differentials across regions become smaller, consistent with a lower degree of US dollar appreciation.

The insensitivity of GDP spillovers are mainly an outcome of offsetting effects on GDP through domestic demand and trade. On the positive side, higher trade volumes increases the contribution of exports to ROW GDP, making US fiscal policy shocks appealing from the ROW perspective. However, a lower degree of depreciation offsets this positive trade spillover. In addition, higher policy rates as a reaction to higher inflation have contractionary effects on ROW domestic demand. As a result, ROW GDP does not change much with higher trade openness. In order to identify

²³The portfolio ratios and the difference in country size implies $\gamma_i = \gamma_c = 0.72$ for the Home region.

the contribution of the monetary policy rule, we shut down the reaction function for eight quarters and recalculate the responses (displayed in Figure 6). Higher trade openness now implies positive spillovers to ROW GDP from the US fiscal shock without a prompt monetary policy reaction. Similar to the previous subsection, this highlights the importance of ROW monetary policies on the spillover effects from the US fiscal policy.

3.2.4 Financial openness and fiscal spillovers

We next analyze the sensitivity of our baseline results to financial openness. In particular, we consider a case where we increase the degree of international financial openness by considering $\gamma_S^* = \gamma_L^* = 0.3$, implying a home bias for bonds in the foreign economy closer to its country size.²⁴ Again, the results for government consumption shocks are presented in the main text in Figure 7, while Figures C.10 and C.11 in Appendix C present the corresponding impulse responses from government investment and transfer shocks, respectively.

The effect of the US fiscal shock on the US term premium is smaller in this case because smaller home bias in portfolios make term premiums to be affected less by the domestic factors such as asset supply. Lower term premium, in turn, implies slightly lower appreciation of the US dollar, which further amplifies the effect of expansionary shock on inflation. As a result, policy rates increase more leading to a stable long-term rate despite a lower term premium. With stable portfolio returns (lower term premium and higher real short rates), total aggregate spending does not move much, leaving output unchanged in the US.

Higher financial openness, however, makes ROW term premium to be affected more by external factors such as US asset supply. As a result, the same fiscal shock leads to a higher term premium, generating higher long-term rates resulting in a larger negative spillover effect on the ROW output from the US fiscal expansion. In addition, trade contributes to the negative spillovers here. As a result of smaller term premium differential, the exchange rate depreciates slightly less, leading to a smaller gain from trade spillovers.

Both term premium and exchange rate pulls down ROW output; however, quantitatively, the impact is small. This is mainly because, policy rates increase less in the ROW, preventing a bigger recession. A smaller policy rate mostly a reaction of smaller exchange rate passthrough from a smaller depreciation. Similar to the previous subsections, to identify the contribution of the monetary policy rule, we shut down the reaction function for eight quarters and recalculate the responses (displayed in Figure 8). The negative spillover effects from higher term premium is more visible now without a prompt monetary policy reaction.

3.2.5 Maturity of debt financing and fiscal spillovers

We proceed by considering a short-term debt financed US fiscal expansion and comparing the results with the baseline scenario (with funding through long-term debt). This is akin to the case of

²⁴The goods ratios and the difference in country size implies $\gamma_S = 0.74$ and $\gamma_L = 0.84$ for the Home region.

helicopter money under the assumption that money and short-term government bonds are perfectly substitutable. Figure 9 in the main text presents the related results for government consumption shocks, while Figures C.12 and C.13 in Appendix C present the corresponding results for government investment and transfer shocks, respectively.

Short-term financing of the fiscal shock, or equivalently a helicopter drop policy which combines a long-term debt financed fiscal expansion with central bank purchases of long-term government bonds in exchange for bank reserves, increases the supply of US short-term bonds in the market. Due to imperfect substitutability, the higher amount of US short-term bonds, decreases the demand for ROW short bonds and a relative increase in the demand for both US and ROW long-term bonds. As a result, term premia in both countries decline. The international spillover effects of the US fiscal shock are, therefore, smaller on the ROW output. In particular, the decrease in the term premium leads to a smaller increase in the long-term interest rate, with less impact on ROW demand. Nevertheless, the US long-term rate increases by more relative to the baseline case given higher inflation and short-term interest rates.

4 Empirical Analysis

Simulations of the model showed that the financial spillover effects feeding through the term premium and exchange rate dominated the trade spillover effects so that an expansionary (contractionary) US fiscal policy generated a decrease (an increase) in foreign output. In this section, we describe the methodology and the data that we use to test whether these spillover predictions are consistent with data. We discuss our main results and those obtained from various sensitivity tests. Before we begin, we should mention that the main objective of this section is to draw inferences from data in the absence of any substantial structural restrictions. By letting the data speak, we check whether the general relationships between macroeconomic variables are consistent with our results above.

4.1 Methodology

We begin by determining whether the financial and trade spillover predictions from our model are consistent with cross-country data. Specifically we test whether a US fiscal policy expansion is consistent with a US dollar appreciation, an increase in their term premium, and an increase in countries' bilateral trade surplus with the US. To infer these relationships we estimate different forms of the following model:

$$\begin{aligned}
 x_{i,t} = & \beta^X x_{i,t-1} + \sum_{k=1}^4 \beta_k^F g_{t-k}^{US} + \sum_{k=1}^4 \beta^T bts_y_{i,t-k} + \sum_{k=1}^4 \beta^{TI} bts_y_{i,t-k} * g_{t-k}^{US} \\
 & + \sum_{k=1}^4 \beta^B bhs_y_{i,t-k} + \sum_{k=1}^4 \beta^{BI} bhs_y_{i,t-k} * g_{t-k}^{US} + \beta^{TD} v_t + \beta^{CD} u_i + \varepsilon_{i,t}
 \end{aligned} \tag{39}$$

where subscripts i and t index countries and time, respectively, and v_t and u_i are vectors of dummy variables that represent time and time invariant country fixed effects, respectively. This equation, similar to our theoretical predictions, relates exchange rates, countries' trade balance and their term premium (denoted by $x_{i,t}$) to US fiscal spending, g_{t-k}^{US} . In equation (39), $bts_{i,t-k}$ and $bhs_{i,t-k}$ represent the growth rate of country i 's bilateral trade surplus with the US and her US bond holdings as a share of her GDP, respectively. The former variable is approximated by the growth rate of bilateral exports to GDP ratio minus the growth rate of bilateral imports to GDP ratio. Incorporating these variables, and their interaction with US fiscal spending, into our empirical analysis allows us to test whether the strength and the nature of the spillover mechanisms in our model depend on the direction of trade and the degree of financial integration through government bond holdings.

To estimate equation (39), we use a panel fixed effects estimator that accounts for both country and time fixed effects. In doing so, we use country clusters to account for the possibility that observations could be correlated within countries. The main reason we use a fixed effects approach over a dynamic panel estimator is that, dynamic panel estimators such as Blundell and Bond (1998) are designed for panels with a large cross sectional dimension and short time dimension. In our panel, the number of time periods exceed the number of countries. We should also point out here that we use 4 lags of the independent variables to account for the impact lags of fiscal policy. While there is no clear indication of the appropriate number of lags in the literature, especially in a panel setting (e.g., Alesina et al., 2012; Alesina and Adagna, 2013), there is evidence that long term effects of fiscal policy could be much smaller in magnitude compared to its short term effects (see, Gemmel et al., 2011). This is why we choose 4 quarters in our baseline specification.²⁵

4.2 Data

To estimate our empirical models, we use quarterly data from 19 of the G-20 economies that span the 2000:Q1 to 2020:Q4 period. Since we include the largest economies in the Euro Area, we exclude EU as a bloc. The data are mainly obtained from 4 sources. Nominal and real exchange rates, seasonally adjusted real GDP growth rates, and the term premium variable, measured as the spread between government bond rates and deposit rates, are obtained from the International Financial Statistics database. The reason we use the two series to measure the term premium is that they were the only indicators of long-term and short-term interest rates that were available for every country and each period in our sample.

The bilateral trade statistics (imports and exports) of the 18 countries with the US are from the Census Bureau. These data are in US dollars. To gauge the significance of US trade on the three dependent variables in our model, we first convert bilateral exports and imports to local currency and we divide by the nominal GDP of countries. We then calculate the growth rates (growth over the previous period) of these ratios and subtract the growth rate of the imports to GDP ratio from

²⁵We did check the robustness of our results to using 8 and 12 quarter lags. While the results were qualitatively similar, the fiscal policy coefficients were insignificant relatively more often.

the growth rate of exports to GDP ratio. Including this measure of trade surplus/deficit growth then allows us to determine whether the spillover effects of US fiscal policy depend on countries' direction of trade with the US. Naturally, we exclude this variable when we are estimating the relationship between US fiscal policy and bilateral trade.

The holdings of US securities are obtained from the Treasury International Capital (TIC) System. The TIC data date back to 2000 and this is the reason why our sample starts from this year. The historical TIC data shows the stock of total US security holdings by country and they are available at the monthly frequency. We convert these data to the quarterly frequency by taking averages. Finally, various indicators of the stance of US fiscal policy are obtained from the Federal Reserve Bank of St. Louis, FRED database. One concern we have when measuring the sensitivity of foreign macroeconomic variables to US fiscal spending is that this spending is linked to US output through automatic and discretionary mechanisms. The panel estimation results, therefore, could reflect foreign variable responses to US output, and not necessarily to US fiscal policy. While it is true that overall US fiscal spending, whether its related to US output or not, is what matters for foreign economies, given the scope of our paper it is useful to identify the component of fiscal policy that is independent of US output and to measure its relationship with foreign economic activity. To this end, we first estimate a Vector Autoregressive (VAR) model, with real US government spending growth and real US GDP growth, ordered as such in a Cholesky decomposition to identify the component of US government spending that is orthogonal to US real GDP growth (hereafter, referred to as orthogonal government spending). In this VAR estimation, we use 4 lags of the two variables. We then incorporate this component into our panel estimations as the main independent variable to measure its relationship with foreign macroeconomic variables. Using this measure also allows us to neutralize any automatic stabilizer features of fiscal policy as the main focus in our paper is on large scale bond issuance that provides funding for discretionary policies. We do, however, use fiscal spending growth (without orthogonalizing) and distinguish between government consumption and investment spending, investigate the effects of government transfers and tax revenue in further analysis.

4.3 Results

In this section, we report the suggestive evidence obtained from the estimation of equation (39). We investigate the relationship between US fiscal policy and foreign output. We determine if or how the spillover effects on output are altered at the zero lower bound. Finally, we use a vector autoregression (VAR) analysis to measure the foreign output responses to the changes in US fiscal spending.

4.3.1 Baseline results

The results reported in Table 3 show the relationship between US fiscal policy (growth of real US government spending orthogonal to US real GDP growth) and the three key variables in our model.

Overall the results, consistent with our model predictions, indicate that there is a real US dollar appreciation, and an increase in the trade surplus (in bilateral trade with the US) and term premium of foreign economies when there is a US fiscal expansion.

It is not straightforward to interpret the coefficient of the exchange rate variable given that the G-20 sample includes a diverse group of currencies and our baseline measure of fiscal spending is a generated regressor but the coefficient value of 0.0102 in the first column implies that if there is a one standard deviation change in US fiscal spending in the past 4 quarters, the real dollar exchange rate appreciates by roughly 0.5 standard deviations in the ensuing period. Both the magnitude and the sign of the coefficient value are similar when we add the growth rate of countries' trade balance with the US as a share of their GDP (results in the second column) and its interaction with US fiscal policy. This is also true when we add countries' US bond holdings as a share of their GDP (results in the third column). The significant positive coefficients of bilateral trade balance and bond holdings suggest that the dollar tends to appreciate in real terms against currencies of countries that have a bilateral trade surplus with the US and hold large amounts of US bonds (relative to their GDP).

The real appreciation of the dollar ensuing a US fiscal expansion is consistent with the results displayed in column 4. Specifically, the results imply that countries experience an improvement (deterioration) in their bilateral trade balance with the US when there is a fiscal expansion (contraction). In these estimations, the dependent variable is the countries' trade balance with the US as a share of their GDP and hence the trade balance variable is not included on the right hand side. We similarly omit the bond holdings variable as trade balance directly affects the denominator of US bond holdings as a share of countries' GDP. The coefficient value of 0.0248 implies that countries' trade surplus with the US, relative to their GDP, increases by roughly 2.5 percentage points when there is a 1 percent increase in US fiscal spending (0.249 percent increase in 4 consecutive quarters). More generally, the results in the first four columns are consistent with the trade mechanism in our model such that a real US dollar appreciation prompted by a US fiscal expansion can have spillover effects on other countries through trade.

Our model projected that an expansionary bond-financed US fiscal policy can decrease the price of long-term bonds in the US and abroad, increasing term premiums which in turn further depresses foreign economic activity. In our estimations, reported in the last three columns of Table 3, we find a positive relationship between US fiscal policy and term premium in foreign economies. Using our measure of term premium as the dependent variable in equation (39), we find that the growth rate of US government spending, orthogonal to US output growth, is positively related to the change in foreign term premiums. The coefficient value of 0.0829 implies that there is roughly an 8 basis points increase in the term premium of G-20 countries when there is a 1 percent change in US fiscal spending evenly spread across 4 quarters. The positive significant coefficient of the interactive term in the last column suggest that this sensitivity to US fiscal policy is higher for countries that have a trade surplus with the US.

Table 4 reports alternative measures of fiscal policy. The numbers (1), (2) and (3) in column 2 correspond to the specifications displayed in Table 3. The results in the first row of each panel, for

example, correspond to the specification with only the lagged values of the fiscal policy measure and the dependent variable on the right hand side. To obtain the results in the first four columns, we use the growth rates of total government spending, government consumption spending, government investment spending and transfers as the independent variable in equation (39). The results in panel A, with the exception of column three, support the baseline relationship between real dollar exchange rates and US fiscal policy. We find that the relationship is reversed for investment. This finding is consistent with the DSGE model responses to government investment shocks as these shocks, similar to TFP shocks, generate a less negative and even positive responses in exchange rates. These results are similar across the three specifications. The results reported in the first four columns of panel C also support our baseline findings that there is positive link between US fiscal spending and foreign term premiums with the exception of government consumption spending and transfers in the first specification. By contrast, we do not detect a significant relationship between the four fiscal policy measures and bilateral trade balance as reported in the first four columns of panel B.

Next, we follow a similar approach to identify the components of real government consumption, investment and transfer spending growth that are orthogonal to real GDP growth and use these as our measures of fiscal policy variable in equation (39). In addition, we use the Ramey (2009) news shock series, a commonly used fiscal shock variable in the literature that tracks the changes in the expectations of US government military/political spending, in an alternative test. The results in the last 5 columns of each panel display the results that correspond to these measures of fiscal policy. These results in panel A are qualitatively identical to the results in the first four columns. When the growth of trade balance to GDP ratio is used as the dependent variable, the significant coefficients are now consistent with the earlier results. The coefficients of investment and transfers growth remain insignificant. Turning to panel C, we observe that all significant coefficients, consistent with the predictions of our model are positive.

4.3.2 US fiscal policy and foreign output

While the three variables mentioned above are key to our analysis, the main inference from the first part of the paper is that a US fiscal expansion, contrary to common wisdom, can have a negative effect on foreign output. In this section, we test whether this prediction of the model is consistent with data. To conduct the test, we use the real GDP growth rate of the G-20 economies as our dependent variable in equation (39). Since this variable is directly related to our baseline measures of bilateral trade and bond holdings, we reconfigure the two independent variables. For the trade variable, we add the bilateral exports and imports for a country and convert this trade volume statistic to local currency, and then express it as a share of total trade volume of US with the G-20 countries. We follow a similar approach and measure a countries US bond holdings as a share of all holdings by G-20 countries. Doing so, allows us to test whether US fiscal policy has a bigger or smaller impact on its main trade partners and bondholders. We incorporate these variables and their interaction with US fiscal spending into equation (39). One potential caveat here is that some

of the main trade partners of the US are also her main bondholders. To avoid multicollinearity, we include our trade volume and bond holdings variables in separate regressions. In doing so, we use all of the alternative measures of fiscal policy mentioned in the previous section.

The results obtained from the estimation of equation (39) with only the trade volume variables are reported in Table 5. The main inference is that US fiscal spending is, in general, negatively related to foreign economic activity. A US fiscal expansion, for example, is associated with a decline in the growth rate of G-20 economies. To visualize the quantitative significance of this negative sensitivity, suppose initially that a country, say country x , does not trade with the US nor does it hold her bonds and real US government expenditures, for 4 consecutive quarters, increase by 1 percent relative to the previous quarter. The coefficient value of 1.0366 reported in the first column then implies that the real GDP of country x decreases by roughly 1 percent in the next quarter. The positive coefficient of transfers, by contrast to the other coefficients, indicates that a growth in US transfer payments is positively related to foreign economic activity. The negative coefficient of the interactive term does not change this inference as the mean value of the bilateral trade variable (countries' share of US trade) is 0.034 in our sample.

The magnitude of the negative relationship mentioned above is not significantly altered by the degree of trade that country x has with the US as the interactive variable coefficient is statistically insignificant throughout most estimations. The results do, however, show that more important trade partners of the US grow slower relative to those who trade less with the US. This relationship albeit is not as strong as the relationship between US fiscal policy and foreign output growth. The coefficient value of -0.054 in column 1 implies that if country x 's US trade as a share of her GDP goes up by 1 percentage point for 4 consecutive quarters, its GDP grows 0.054 percentage points slower in the ensuing quarter.

The remaining columns display the results that we obtained by using alternative measures for the stance of US fiscal policy. The results suggest that investment (measured as the growth rate of real government investment) is the component of government spending that is most negatively related to foreign economic activity. It is important to note here that our results do not imply any casual relationships and that they only offer suggestive evidence to bring perspective to our model results.

The results in columns 5 to 8 also reveal a negative relationship, albeit smaller in magnitude, between orthogonal spending variables and foreign output growth. The positive relationship between growth in US transfer payments and foreign output growth is robust to using our alternative approach. The results displayed in the last column that correspond to the Ramey (2009) news shock variable similarly point to a negative relationship between US government spending and foreign output.

We proceed by estimating equation (39) with bond holdings variables to determine whether holdings of US bonds changes countries' sensitivity to US fiscal policy. Similar to our earlier results, the results displayed in Table 6 demonstrate a significant and negative relationship between US government spending and foreign output for all variables except transfers. One noticeable difference

here is that the growth in total spending is not significantly related to foreign output in this model. Also, unlike earlier results, the coefficients of the interactive term are generally significant. The magnitude of these coefficients, however, are not large enough to change our main inference that US fiscal spending is negatively related to foreign output (the average share of US bond holdings across time and countries is 3.5% in our sample). It should be noted, however, that the negative effects of orthogonal government total spending, consumption and investment are larger when countries hold a larger share of US bonds.

4.3.3 Sensitivity to US fiscal policy at the zero lower bound

Policy rates in some of the countries in our sample, especially in the second half of our sample period, are at the zero lower bound (ZLB). It is well-known that output's sensitivity to changes in demand, whether fiscal in nature or not, is much higher at the ZLB. Any potential positive effects of US fiscal policy on the demand for foreign goods then could be stronger at this threshold. To check for this possibility, we estimate equation (39) by including a variable that captures the interaction between the US fiscal policy variables and the time periods characterized by ZLB. Specifically, we construct a dummy variable that takes the value 1 if short term deposit rates are less than 0.5% and 0 otherwise.²⁶ We then interact this variable with the measures of US fiscal policy and include it in equation (39). The results obtained from this estimation are reported in Table 7. As indicated by the results in the first two rows, the relationship between US fiscal policy and foreign output is generally more positive (less negative) at the zero lower bound as all significant coefficients except those of orthogonal consumption and transfers is positive. The sign and significance of the fiscal policy measures are similar to those in our baseline results. Same can be said about the coefficients of lagged output and the bilateral trade variable which are omitted for brevity.

4.3.4 VAR evidence

In this section we use panel country-specific data in simple VAR models to investigate the response of foreign output to the changes in and shocks to US government spending. To do so, we first use a panel VAR model (PVAR) with three variables and a Cholesky ordering in which the three variables are ordered as follows: the growth rate of US real government spending, country-specific real GDP growth rate, and the growth rate of the real US dollar exchange rate. Our sample similarly includes quarterly data from 2000:Q1 to 2020:Q4. To estimate the model we use the first lags of the variables and we cluster standard errors by country.

The response of foreign output (orthogonalized impulse responses) to the growth rate of real US government spending in our estimated PVAR model is displayed at the top of Figure 10. Consistent with the main inference from our panel regressions, we find a negative response. The 90% level confidence bands indicate that this negative response is significant for the first 3 quarters. The amplitude of the response implies that a one standard deviation change in the growth rate of real

²⁶We tried alternative thresholds and obtained qualitatively similar results.

US government spending generates roughly a 25 basis point decrease in the growth rate of foreign real GDP. This one-to-four ratio is consistent with our panel regressions.

Next, we use two alternative measures of US fiscal policy stance to check the robustness of the negative relationship mentioned above. First, we use the component of real US government spending that is orthogonal to real US output. Second, we include the widely-used Blanchard-Perotti (2002) government shock series in our PVAR model to represent the stance of US fiscal policy. The reason we use this series instead of the Ramey (2009) news shock series is that it is a continuous measure that allows us to use a sufficient number of observations in our estimation.²⁷ The impulse responses to these alternative measures of fiscal policy also reveal a negative relationship between US fiscal spending and foreign output. Unlike the initial result, however, the significant spillover effects of fiscal policy now appear to be more long-lived.

We proceed by using our VAR analysis to determine whether the negative relationship that we have uncovered so far is also observed at the country level. In doing so, we use the growth rate of real US government spending and its component that is orthogonal to US GDP as the two measures of fiscal policy. The orthogonalized output responses to a one standard deviation change in these variables are displayed in Figures 11 and 12, respectively. In both graphs, the fiscal policy variable for the US is the Blanchard-Perotti (2002) government shock series. The responses generally support the negative relationship observed at the panel level. The responses, however, are less significant and there are countries, other than the US, for which a US fiscal expansion generates a positive output response.

The VAR identification strategy that we have used so far assumes that foreign variables can affect US fiscal policy measures, albeit with a lag. As a final robustness check, we use a Panel Vector Autoregressive X (PVARX) model that incorporates US fiscal policy measures as exogenous variables. The model, therefore, allows US shocks to affect foreign variables (contemporaneously and with a lag) but not the other way around. Figure 13 displays the responses to the two US fiscal policy measures, the Blanchard-Perotti spending shock and the component of US fiscal spending that is orthogonal to US real GDP growth. Both responses, consistent with our baseline results, point to negative international spillover effects of US fiscal policy.

5 Conclusion

In this paper, we study the international spillover effects of fiscal policies in a calibrated two-country, open-economy model with portfolio balance effects. Portfolio balance effects arise from imperfect substitutability between short- and long-term bonds in portfolio preferences, which we introduce into an otherwise stylized two-country DSGE model with nominal and real rigidities. This imperfect substitution leads to higher long-term yields in the US economy as a response to a fiscal expansion

²⁷Both the Ramey and Blanchard-Perotti series are obtained from Valery Ramey's website and they are available quarterly upto 2015:Q4. The Ramey news shock variable is positive for only 15 periods in our sample. It is zero otherwise.

financed by long-term bond issuance, generating depreciation pressures on the ROW currency, but also leads to higher bond yields in the ROW. The latter spillover effect on the ROW long-term yields contracts the ROW economy, despite the improvement in their trade balance.

Our model also suggests that the stimulatory effects of fiscal policy in the domestic economy can be attenuated if fiscal expansions are financed primarily through long-term bond issuance, given the increase in long-term interest rates. Similarly, the stimulatory effects of QE policies adopted by the central bank can also be attenuated if the government decides to take advantage of the resulting lower long-term interest rates and bias its fiscal financing towards the issuance of long-term debt. This points to the importance of potential coordination between the central bank and the government in deep recessions, which require large fiscal stimuli by the government and/or large scale asset purchases by the central bank. Finally, our model indicates that a “helicopter drop” type of policy, which combines a long-term debt financed fiscal expansion with central bank purchases of long-term government bonds can have more robust effects on the economy. The spillover effects of a helicopter drop policy is also more expansionary on the ROW economy as the crowding out effects of the portfolio rebalancing channel is muted.

In the second half of the paper, we find empirical evidence supporting the key mechanisms in our model and indicating that US fiscal expansions can be contractionary for ROW economies. Specifically, we use panel estimations and find that countries’ trade surplus with the US grows, their currencies depreciate in real terms, and their term premia increase when there is a US fiscal expansion. Investigating the relationship between foreign output and US fiscal policy, we infer that domestic demand effects through higher term premia could be more important than trade effects as we find that US fiscal expansions are contractionary abroad.

While our empirical analysis provides suggestive evidence, future research could corroborate our findings by investigating the behavior of bondholders (by using entity level data) in response to a US fiscal policy shock. This research could identify and measure the significance of portfolio balancing effects associated with US fiscal policies.

References

- [1] Adjemian, S., H. Bastani, M. Juillard, F. Karamé, F. Mihoubi, G. Perendia, J. Pfeifer, M. Ratto, and S. Villemot (2011). “Dynare: Reference Manual, Version 4,” Dynare Working Papers, 1, CEPREMAP.
- [2] Adolfson, M., S. Laséen, J. Lindé, and M. Villani (2007). “Bayesian estimation of an open economy DSGE model with incomplete pass-through,” *Journal of International Economics*, 72, 481-511.
- [3] Adolfson, M., S. Laséen, J. Lindé, and M. Villani (2008). “Evaluating an estimated new Keynesian small open economy model,” *Journal of Economic Dynamics and Control*, 32, 2690-2721.

- [4] Alpanda, A., and U. Aysun (2014). “International transmission of financial shocks in an estimated DSGE model,” *Journal of International Money and Finance*, 47, 21-55.
- [5] Alpanda, S., G. Cateau, and C. Meh (forthcoming). “A Policy Model to Analyze Macroprudential Regulations and Monetary Policy,” *Canadian Journal of Economics*.
- [6] Amador, M., J. Bianchi, L. Bocola, and F. Perri (2016). “Reverse speculative attacks,” *Journal of Economic Dynamics and Control*, 72, 125-137.
- [7] An, S., and F. Schorfheide (2007). “Bayesian Analysis of DSGE Models,” *Econometric Reviews*, 26, 211-219.
- [8] Andres, J., J. D. Lopez-Salido, and E. Nelson (2004). “Tobin’s imperfect asset substitution in optimizing general equilibrium,” *Journal of Money, Credit and Banking*, 36, 665-690.
- [9] Bansal, R., and J. W. Coleman II (1996). “A Monetary Explanation of the Equity Premium, Term Premium, and Risk-Free Rate Puzzles,” *Journal of Political Economy*, 104, 1135-1171.
- [10] Bauer, M. D., and C. J. Neely (2014). “International channels of the Fed’s unconventional monetary policy,” *Journal of International Money and Finance*, 44, 24-46.
- [11] Baumeister, C., and L. Benati (2013). “Unconventional Monetary Policy and the Great Recession: Estimating the Macroeconomic Effects of a Spread Compression at the Zero Lower Bound,” *International Journal of Central Banking*, 9, 165-212.
- [12] Benes, J., A. Berg, R. A. Portillo, and D. Vavra (2013a). “Modeling sterilized interventions and balance sheet effects of monetary policy in a New-Keynesian framework,” IMF Working Paper No. 13/11.
- [13] Benes, J., M. K. Johnston, and S. Plotnikov (2013b). IRIS Toolbox Release 20130208 (Macroeconomic modeling toolbox), software available at <http://www.iris-toolbox.com>.
- [14] Benigno, P., and S. Nistico (2012). “International Portfolio Allocation under Model Uncertainty,” *American Economic Journal: Macroeconomics*, 4, 144-189.
- [15] Bernanke, B. S. (2012). “Monetary Policy Since the Onset of the Crisis,” Speech at the Federal Reserve Bank of Kansas City Economic Symposium, Jackson Hole, Wyoming, 31 August.
- [16] Bhattarai, S., and C. Neely (2016). “A Survey of the Empirical Literature on US Unconventional Monetary Policy,” Federal Reserve Bank of St. Louis Working Paper 2016-021A.
- [17] Blanchard, O., F. Giavazzi, and F. Sa (2005). “The US current account and the dollar,” NBER Working Paper No. 11137.
- [18] Blundell, R., and T. MaCurdy (1999). “Labor supply: A review of alternative approaches,” in *Handbook of Labor Economics*, O. Ashenfelter and D. Card (eds.), vol. 3, 1559-1695.

- [19] Bluwsteina, K., and F. Canova (2016). “Beggar-Thy-Neighbor? The International Effects of ECB Unconventional Monetary Policy Measures,” *International Journal of Central Banking*, 12, 69-120.bs
- [20] Bluedorn, J., Bowdler, C. (2011). ”The open economy consequences of U.S. Monetary Policy,” *J. Int. Money Finance* 30 (2), 309–336.
- [21] Bruno, V., and H. S. Shin (2015). “Capital flows and the risk-taking channel of monetary policy,” *Journal of Monetary Economics*, 71, 119-132.
- [22] Campbell, J. Y., and N. G. Mankiw (1991). “The response of consumption to income: A cross-country investigation,” *European Economic Review*, 35, 723-756.
- [23] Chang, C., K. Chen, D. Waggoner, and T. Zha (2015). “Trends and Cycles in China’s Macroeconomy,” NBER Working Paper No. 21244.
- [24] Chen, H., V. Curdia, and A. Ferrero (2012a). “The Macroeconomic Effects of Large-Scale Asset Purchase Programmes,” *Economic Journal*, 122, F289-F315.
- [25] Chen, Q., A. Filardo, D. He, and F. Zhu (2012b). “International spillovers of central bank balance sheet policies,” in *Are central bank balance sheets in Asia too large?*, BIS Papers No. 66, 230-274.
- [26] Chen, Q., A. Filardo, D. He, and F. Zhu (2016). “Financial crisis, US unconventional monetary policy and international spillovers,” *Journal of International Money and Finance*, 67, 62-81.
- [27] Chin, M., T. Filippeli, and K. Theodoridis (2015). “Cross-country co-movement in long-term interest rates: a DSGE approach,” Bank of England Working Papers No. 530.
- [28] Chung, H., J. P. Laforte, D. Reifschneider, and J. C. Williams (2012). “Have We Underestimated the Likelihood and Severity of Zero Lower Bound Events?,” *Journal of Money, Credit and Banking*, 44, 47-82.
- [29] Coeurdacier, N., and H. Rey (2013). “Home Bias in Open Economy Financial Macroeconomics,” *Journal of Economic Literature*, 51, 63-115.
- [30] Cole, H., D. Neuhann, and G. Ordóñez (2016). “Debt Crises: For Whom the Bell Tolls,” NBER Working Paper No. 22330.
- [31] Curdia, V., and M. Woodford (2011). “The Central Bank Balance Sheet as an Instrument of Monetary Policy,” *Journal of Monetary Economics*, 58, 54-79.
- [32] Dahlhaus, T., K. Hess, and A. Reza (2014). “International Transmission Channels of US Quantitative Easing: Evidence from Canada,” *Journal of Money, Credit and Banking*, forthcoming.

- [33] D’Amico, S., W. English, D. López-Salido, and E. Nelson (2012). “The Federal Reserve’s Large-scale Asset Purchase Programmes: Rationale and Effects,” *Economic Journal*, 122, F415-F446.
- [34] Dedola, L., P. Karadi, and G. Lombardo (2013). “Global Implications of National Unconventional Policies,” *Journal of Monetary Economics*, 60, 66-85.
- [35] Doh, T. (2010). “The efficacy of large-scale asset purchases at the zero lower bound,” Federal Reserve Bank of Kansas City *Economic Review*, 95, 5-34.
- [36] Dominguez, K. M., and J. A. Frankel. ”Does foreign-exchange intervention matter? The portfolio effect.” *The American Economic Review* 83, no. 5, 1356-1369.
- [37] Dorich, J., R. Mendes, and Y. Zhang (2012). “Quantitative Easing at the Zero Lower Bound,” mimeo, Bank of Canada.
- [38] Engel, C. (2014). “Exchange Rate and Interest Parity,” in *Handbook of International Economics*, G. Gopinath, E. Helpman, and K. Rogoff (eds.), vol. 4, 453-522.
- [39] Engen, E. M., T. Laubach, D. L. Reifschneider (2015). “The Macroeconomic Effects of the Federal Reserve’s Unconventional Monetary Policies,” Finance and Economics Discussion Series No. 2015-5, Board of Governors of the Federal Reserve System.
- [40] Fagan, G., J. Henry, and R. Mestre (2001). “An Area-Wide Model (AWM) for the Euro Area,” European Central Bank Working Paper No. 42.
- [41] Fernández-Villaverde, J. (2010). “The Econometrics of DSGE Models,” *SERIEs*, 1, 3-49.
- [42] Fratzscher, M., M. Lo Duca, and R. Straub (2016). “On the international spillovers of US quantitative easing,” *The Economic Journal*, 128, 330-377.
- [43] Gagnon, J., M. Raskin, J. Remache, and B. Sack (2011). “The financial market effects of the Federal Reserve’s large-scale asset purchases,” *International Journal of Central Banking*, 7, 3-43.
- [44] Gambacorta, L., B. Hofmann, and G. Peersman (2014). “The Effectiveness of Unconventional Monetary Policy at the Zero Lower Bound: A Cross-Country Analysis,” *Journal of Money, Credit and Banking*, 46, 615-642.
- [45] Georgiadis, G. (2016). “Determinants of global spillovers from US monetary policy,” *Journal of International Money and Finance*, 67, 41-61.
- [46] Gertler, M., S. Gilchrist, and F. M. Natalucci (2007). “External Constraints on Monetary Policy and the Financial Accelerator,” *Journal of Money, Credit and Banking*, 39, 295-330.
- [47] Geweke, J. (1999): “Using simulation methods for Bayesian econometric models: Inference, development and communication,” *Econometric Reviews*, 18, 1-73.

- [48] Greenwood, R., and D. Vayanos (2010). “Price pressure in the government bond market,” *American Economic Review*, 100, 585-590.
- [49] Greenwood, R., and D. Vayanos (2014). “Bond supply and excess bond returns,” *Review of Financial Studies*, 27, 663-713.
- [50] Gust, C., E. Herbst, D. López-Salido, and M. E. Smith (2017). “The Empirical Implications of the Interest-Rate Lower Bound,” *American Economic Review*, 107, 1971-2006.
- [51] Haberis, A., and A. Lipinska (2012). “International policy spillovers at the zero lower bound,” Bank of England Working Paper No. 464.
- [52] Hamilton, J. D., and J. C. Wu (2012). “The effectiveness of alternative monetary policy tools in a zero lower bound environment,” *Journal of Money, Credit and Banking*, 44, 3-46.
- [53] Harrison, R. (2011). “Asset purchase policies and portfolio balance effects: a DSGE analysis,” in *Interest rates, prices and liquidity*, Chadha, J. and Holly, S. (eds.). Cambridge University Press.
- [54] Harrison, R. (2012). “Asset purchase policy at the effective lower bound for interest rates,” Bank of England Working Paper No. 444.
- [55] Hau, H., and H. Rey (2004). “Can portfolio rebalancing explain the dynamics of equity returns, equity flows, and exchange rates?,” NBER Working Paper No. 10476.
- [56] Ilzetzki, E., Jin, K., 2013. ”The Puzzling Change in the International Transmission of U.S. Macroeconomic Policy Shocks”. Mimeo, LSE.
- [57] International Monetary Fund (2011). *The United States, Spillover Report - 2011 Article IV Consultation*, IMF Country Report No. 11/203.
- [58] IMF (2013). *Dancing Together? Spillovers, Common Shocks, and the Role of Financial and Trade Linkages*. World Economic Outlook. Chapter 3.
- [59] Justiniano, A., and B. Preston (2010a). “Can structural small open-economy models account for the influence of foreign disturbances?,” *Journal of International Economics*, 81, 61-74.
- [60] Justiniano, A., and B. Preston (2010b). “Monetary policy and uncertainty in an empirical small open-economy model,” *Journal of Applied Econometrics*, 25, 93-128.
- [61] Kabaca, S. (2016). “Quantitative Easing in a Small Open Economy: An International Portfolio Balancing Approach,” Bank of Canada Staff Working Paper No. 2016-55.
- [62] Karnizova, L. (2010). “The spirit of capitalism and expectations-driven business cycles,” *Journal of Monetary Economics*, 57, 739-752.

- [63] Keen, B., and Y. Wang (2007). “What is a realistic value for price adjustment costs in New Keynesian models?” *Applied Economics Letters*, 14, 789-793.
- [64] Kim, S. (2001). “International transmission of U.S. monetary policy shocks: Evidence from VAR’s,” *Journal of Monetary Economics*, 48, 339-372.
- [65] Krishnamurthy, A., and A. Vissing-Jorgensen (2011). “The effects of quantitative easing on interest rates: channels and implications for policy,” NBER Working Paper No. 17555.
- [66] Krishnamurthy, A., and A. Vissing-Jorgensen (2012). “The Aggregate Demand for Treasury Debt,” *Journal of Political Economy*, 120, 233-267.
- [67] Kumhof, M. (2010). “On the theory of sterilized foreign exchange intervention,” *Journal of Economic Dynamics and Control*, 34, 1403-1420.
- [68] Leeper, E. M., T. B. Walker, and S. C. S. Yang (2010). “Government investment and fiscal stimulus,” *Journal of Monetary Economics*, 57, 1000-1012.
- [69] Lewis, K. K. (1995). “Puzzles in international financial markets,” in *Handbook of International Economics*, G. M. Grossman and K. S. Rogoff (eds.), vol. 3, 1913-1971.
- [70] Lim, J. J., S. Mohapatra and M. Stocker (2014). “Tinker, Taper, QE, Bye? The Effect of Quantitative Easing on Financial Flows to Developing Countries,” World Bank Policy Research Working Paper No. 6820.
- [71] Lo Duca, M., G. Nicoletti, A. V. Martínez (2016). “Global corporate bond issuance: What role for US quantitative easing?,” *Journal of International Money and Finance*, 60, 114-150.
- [72] Lombardo, G. and D. Vestin (2008). “Welfare implications of Calvo vs. Rotemberg-pricing assumptions,” *Economics Letters*, 100, 275-279.
- [73] Meaning, J., and F. Zhu (2011). “The Impact of Recent Central Bank Asset Purchase Programmes,” *BIS Quarterly Review*, December, 73-83.
- [74] Michailat, P., and E. Saez. “Resolving New Keynesian anomalies with wealth in the utility function,” *Review of Economics and Statistics* 103, no. 2 (2021): 197-215.
- [75] Neely, C. J. (2015). “Unconventional monetary policy had large international effects,” *Journal of Banking & Finance*, 52, 101-111.
- [76] Obstfeld, M. (2015). “Trilemmas and trade-offs: living with financial globalisation,” BIS Working Paper No. 480.
- [77] Priftis, R., and L. Vogel, (2016). “The Portfolio Balance Mechanism and QE in the Euro Area,” *The Manchester School*, 84, 84-105.

- [78] Rajan, R. (2015). "Competitive monetary easing: is it yesterday once more?," *Macroeconomics and Finance in Emerging Market Economies*, 8(1-2), 5-16.
- [79] Rogers, J. H., C. Scotti, and J. H. Wright (2014). "Evaluating Asset-Market Effects of Unconventional Monetary Policy: A Cross-Country Comparison," *International Finance Discussion Papers No. 1101*, Board of Governors of the Federal Reserve System.
- [80] Rogers, J. H., C. Scotti, and J. H. Wright (2016). "Unconventional Monetary Policy and International Risk Premia," *International Finance Discussion Papers No. 1172*, Board of Governors of the Federal Reserve System.
- [81] Rotemberg, J. J. (1982). "Monopolistic Price Adjustment and Aggregate Output," *Review of Economic Studies*, 49, 517-31.
- [82] Smets, F., and R. Wouters (2003). "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area," *Journal of the European Economic Association*, 1, 1123-1175.
- [83] Smets, F., and R. Wouters (2007). "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach," *American Economic Review*, 97, 586-606.
- [84] Sutherland, A. (2005). "Incomplete pass-through and the welfare effects of exchange rate variability," *Journal of International Economics*, 65, 375-399.
- [85] Tobin, J. (1969). "A general equilibrium approach to monetary theory," *Journal of Money, Credit and Banking*, 1, 15-29.
- [86] Valchev R. (2015). "Exchange Rates and UIP Violations at Short and Long Horizons," mimeo, Duke University.
- [87] Vayanos, D., and J. L. Vila (2009). "A preferred-habitat model of the term structure of interest rates," NBER Working Paper No. 15487.
- [88] Vitek F. (2014). "Policy and Spillover Analysis in the World Economy: A Panel Dynamic Stochastic General Equilibrium Approach," IMF Working Paper No. 14/200.
- [89] Wang, P., and C. K. Yip (1992). "Alternative Approaches to Money and Growth," *Journal of Money, Credit, and Banking*, 24, 553-562.
- [90] Woodford, M. (2001). "Fiscal requirements for price stability," NBER Working Paper No. 8072.
- [91] Wright, J. H. (2012). "What does Monetary Policy do to Long-term Interest Rates at the Zero Lower Bound?" *Economic Journal*, 122, F447-F466.

Table 1: Parameter Values

Parameter	Value	Parameter	Value
<i>Portfolio</i>		<i>Preferences</i>	
Home share (short), γ_S, γ_S^*	0.88, 0.98	Discount factor, β	0.99
Home share (long), γ_L, γ_L^*	0.89, 0.75	Cons. habit, ζ	0.70
Short share, γ_a, γ_a^*	0.27, 0.42	Labor elasticity (inverse), ϑ	2
Elasticity, λ_a	1.5	Portfolio coeff., ξ_a, ξ_a^*	0.08, 0.03
Elasticity, λ_S, λ_L	4.5, 12	Labor coefficient, ξ_n, ξ_n^*	85.23, 86.00
Coupon, κ	0.98		
<i>Technology</i>		<i>Taylor Rule and Gov't</i>	
Home bias cons., γ_c, γ_c^*	0.94, 0.85	R persistence, ρ	0.80
Home bias inv., γ_i, γ_i^*	0.94, 0.85	Inflation sensitivity, r_π	1.5
Elas. H and F cons., λ_c	1	Output gap sensitivity, r_y	0.125
Elas. H and F inv., λ_i	1	Tax coefficient (unconstrained), Ξ_U, Ξ_U^*	0.03, 0.02
Mark-up, $\theta_w, \theta_h, \theta_f$	1.25	Tax coefficient (constrained), Ξ_R	0.01
Indexation, $\varsigma_w, \varsigma_h, \varsigma_f$	0.50	Elasticities in tax policy, τ_y, τ_b	1
Calvo rigidity, $\kappa_{ph}^{est}, \kappa_{pf}^{est}, \kappa_w^{est}$	0.90	Tax rate (labor income), τ_n	0.30
Private capital exponent, α	0.34	Tax rate (capital income), τ_k	0.20
Gov't capital exponent, Ψ	0.10	Fiscal shock persistence, ρ_b	0.90
Share of unconstrained, Φ	0.80		
Depreciation rate, δ, δ_g	0.02		
Inv. adj. cost, φ	5		
Utilization elasticity, ϖ	1		

Notes: The parameter values are equal across regions, except otherwise noted.

Table 2: Model steady-state ratios

(relative to output)	Symbol	ROW	US
Consumption	c/y	0.606	0.602
Investment	i/y	0.195	0.195
Gov't expenditure	g/y	0.20	0.20
Gov't consumption	g_c/y	0.15	0.15
Gov't investment	g_i/y	0.05	0.05
Transfers	tr/y	0.038	0.034
Tax revenue	tax/y	0.227	0.227
Exports ^a	y_f^*/y	0.048	0.122
Imports ^a	y_f/y	0.049	0.120
Wage share in income	$1 - \alpha$	0.66	0.66
Priv. capital stock / GDP (ann.)	k/y	2.5	2.5
Gov't Capital stock / GDP (ann.)	k_g/y	0.6	0.6
Bond supply / GDP (ann.)			
short	b_S/y	0.1270	0.1139
long	$q_L b_L/y$	0.3530	0.1864
Bond holdings / GDP (ann.)			
short home	b_{HS}/y	0.1264	0.0724
long home	$q_L b_{HL}/y$	0.3428	0.0764
short foreign	b_{FS}/y	0.0166	0.0016
long foreign	$q_L^* b_{FL}/y$	0.0440	0.0254

Notes: (a) In the model, ROW exports is equal to US imports, and ROW imports is equal to US exports by construction. The differences in the figures above reflect the relative size of the two economies at the steady state (i.e., $y/y^* = 2.5$).

Table 3: US fiscal policy, exchange rates, term premium and trade

	Real exchange rates			Bilateral Trade Balance	Term premium		
	(1)	(2)	(3)	(1)	(1)	(2)	(3)
U.S. fiscal policy stance	-0.0107 (0.0098)***	-0.0102 (0.024)**	-0.0162 (0.061)*	0.0248 (0.069)*	0.0829 (0.000)***	0.1803 (0.018)**	0.1210 (0.005)***
Bilateral trade balance		0.0574 (0.076)*	0.2672 (0.089)*				0.4267 (0.158)
Bilateral trade balance* U.S. fiscal policy stance		0.0381 (0.644)	-0.0882 (0.616)				2.2913 (0.087)*
Bond holdings			0.1405 (0.055)*			-0.2191 (0.546)	0.4771 (0.256)
Bond holdings * U.S. fiscal policy stance			-0.0054 (0.266)			-5.3047 (0.468)	-6.0535 (0.160)
Dependent variable lag	0.073 (0.049)**	0.083 (0.028)**	0.107 (0.055)*	-0.254 (0.000)***	-0.0050 (0.927)	0.028 (0.691)	-0.096 (0.051)*
# of observations	996	973	727	1,003	529	357	357
Adj-R2	0.056	0.052	0.094	0.048	0.107	0.013	0.068

Notes: This table reports the results obtained from a fixed effects estimation of equation (39). The growth rates of real exchange rate, the bilateral trade surplus with the U.S., and term premium are the dependent variables, for the estimation results displayed in the first three columns, the fourth column and the last three columns, respectively. U.S. fiscal spending is the component of real government spending growth that is orthogonal to U.S. real GDP growth. *, **, *** significant at 10%, 5%, 1%, respectively. The numbers reported in parentheses for every variable except the lagged dependent variable are F statistics.

Table 4: Alternative measures of fiscal spending

		Government spending	Government consumption	Government investment	Government transfers	Orthogonal government spending	Orthogonal government consumption	Orthogonal government investment	Orthogonal government transfers	Ramey news shock
<i>Panel A</i>										
Real exchange rate	(1)	-1.155	-1.061	0.229	-0.144	-0.011	-0.017	0.020	-0.004	-0.278
		(0.019)**	(0.029)**	(0.020)**	(0.006)***	(0.0098)***	(0.002)***	(0.009)***	(0.002)***	(0.001)***
	(2)	-1.042	-1.008	0.308	-0.236	-0.010	-0.018	0.022	-0.007	-0.274
		(0.047)**	(0.023)**	(0.016)**	(0.008)***	(0.024)**	(0.002)***	(0.000)***	(0.003)***	(0.002)***
	(3)	-2.496	-2.329	-0.460	-0.401	-0.016	-0.022	0.019	-0.015	-0.388
		(0.004)***	(0.056)*	(0.452)	(0.000)***	(0.061)*	(0.008)***	(0.027)**	(0.001)***	(0.027)**
<i>Panel B</i>										
Trade balance	(1)	4.000	3.976	1.670	-1.611	0.025	0.023	0.022	-0.052	0.042
		(0.347)	(0.334)	(0.716)	(0.245)	(0.069)*	(0.043)**	(0.870)	(0.447)	(0.051)*
<i>Panel C</i>										
Term Premium	(1)	6.309	-3.757	1.104	-0.597	0.083	0.004	0.085	0.096	0.376
		(0.000)***	(0.000)***	(0.281)	(0.039)**	(0.000)***	(0.004)***	(0.077)*	(0.018)**	(0.012)**
	(2)	13.348	16.266	3.514	7.275	0.180	0.190	0.051	0.121	1.109
		(0.028)**	(0.076)*	(0.102)	(0.068)*	(0.018)**	(0.014)**	(0.761)	(0.498)	(0.022)**
	(3)	13.295	9.291	3.620	6.511	0.121	0.079	0.102	0.097	0.568
		(0.027)**	(0.007)***	(0.047)**	(0.062)*	(0.005)***	(0.011)**	(0.601)	(0.034)**	(0.033)**

Notes: This table reports the results obtained from a fixed effects estimation of equation (39). For the estimations reported in panels A, B and C the growth rates of real exchange rate, the bilateral trade with the U.S., and term premium are the dependent variables, respectively. Column headers show the fiscal spending measures that are used as independent variables. *, **, *** significant at 10%, 5%, 1%, respectively. The numbers reported in parentheses for every variable except the lagged dependent variable are F statistics.

Table 5: Foreign output growth, US fiscal policy and trade volume

	Government spending	Government consumption	Government investment	Government transfers	Orthogonal government spending	Orthogonal government consumption	Orthogonal government investment	Orthogonal government transfers	Ramey news shock
U.S. fiscal policy stance	-0.952 (0.344)	-0.554 (0.021)**	-1.383 (0.000)***	0.782 (0.000)***	-0.506 (0.729)	-0.170 (0.000)***	-1.053 (0.000)***	2.488 (0.000)***	-0.057 (0.001)***
Bond holdings	-0.056 (0.364)	-0.056 (0.292)	-0.057 (0.221)	-0.012 (0.141)***	-0.054 (0.464)	-0.051 (0.367)	-0.052 (0.347)	-0.046 (0.159)	-0.049 (0.035)**
Bond holdings * U.S. fiscal policy stance	0.353 (0.137)	0.587 (0.074)*	0.248 (0.000)***	-1.648 (0.219)***	-0.355 (0.045)**	-0.230 (0.046)**	-0.990 (0.009)***	-3.030 (0.066)*	0.977 (0.019)**
Lag of GDP	-0.422 (0.001)***	-0.425 (0.001)***	-0.421 (0.001)***	-0.395 (0.007)***	-0.418 (0.001)***	-0.420 (0.001)***	-0.422 (0.001)***	-0.395 (0.006)***	-0.373 (0.007)***
# of observations	969	969	969	969	969	969	969	969	712
Adj-R2	0.180	0.177	0.206	0.311	0.179	0.180	0.191	0.305	0.161

Notes: This table reports the results obtained from a fixed effects estimation of equation (39). For each estimation, real GDP growth rate is the dependent variable. *, **, *** significant at 10%, 5%, 1%, respectively. The numbers reported in parentheses for every variable except the lagged dependent variable are F statistics.

Table 6: Foreign output growth, US fiscal policy and bond holdings

	Government spending	Government consumption	Government investment	Government transfers	Orthogonal government spending	Orthogonal government consumption	Orthogonal government investment	Orthogonal government transfers	Ramey news shock
U.S. fiscal policy stance	-1.037 (0.084)*	-0.552 (0.092)*	-1.472 (0.000)***	0.818 (0.000)***	-0.445 (0.259)	-0.079 (0.004)***	-1.133 (0.000)***	2.731 (0.000)***	-0.029 (0.045)**
Bilateral trade	-0.054 (0.017)**	-0.051 (0.014)**	-0.054 (0.057)*	0.004 (0.386)***	-0.078 (0.026)**	-0.080 (0.008)***	-0.072 (0.035)**	-0.032 (0.389)	0.007 (0.635)
Bilateral trade * U.S. fiscal policy stance	-2.798 (0.593)	-3.194 (0.47)	-1.458 (0.368)	-2.022 (0.456)***	-2.305 (0.409)	-1.634 (0.322)	-3.170 (0.38)	-5.407 (0.349)	0.743 (0.707)
Lag of GDP	-0.349 (0.002)***	-0.345 (0.003)***	-0.354 (0.002)***	-0.310 (0.01)***	-0.345 (0.002)***	-0.346 (0.002)***	-0.356 (0.002)***	-0.311 (0.009)***	-0.292 (0.011)**
# of observations	1,213	1,213	1,213	1,213	1,213	1,213	1,213	1,213	914
Adj-R2	0.136	0.134	0.161	0.260	0.136	0.136	0.147	0.251	0.095

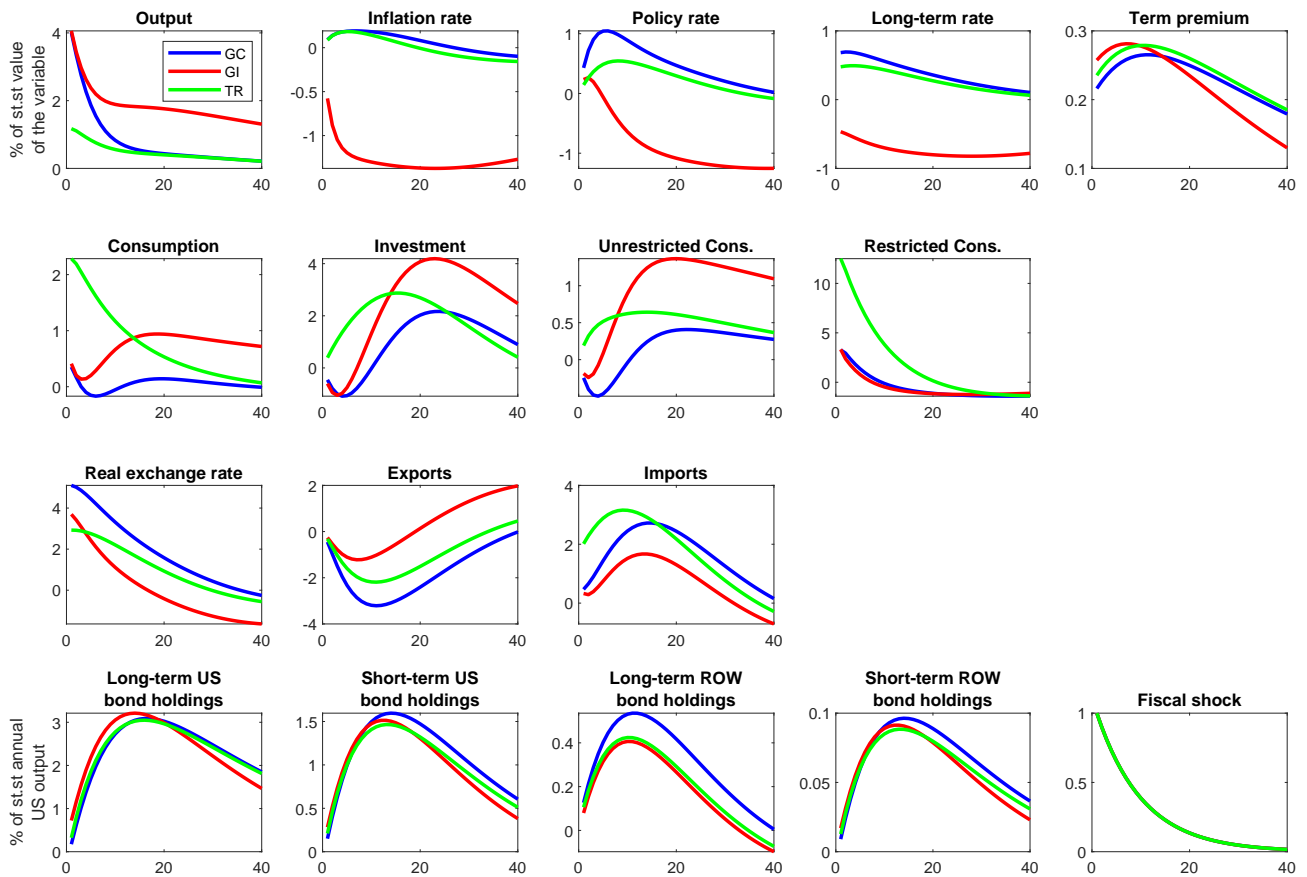
Notes: This table reports the results obtained from a fixed effects estimation of equation (39). For each estimation, real GDP growth rate is the dependent variable. *, **, *** significant at 10%, 5%, 1%, respectively. The numbers reported in parentheses for every variable except the lagged dependent variable are F statistics.

Table 7: Sensitivity to U.S. fiscal policy at the zero lower bound

	Government spending	Government consumption	Government investment	Government transfers	Orthogonal government spending	Orthogonal government consumption	Orthogonal government investment	Orthogonal government transfers	Ramey news shock
ZLB *									
U.S. fiscal policy stance	0.253	0.201	0.264	-0.055	0.085	-0.066	0.218	-0.068	0.206
	(0.000)***	(0.001)***	(0.004)***	(0.024)**	(0.001)***	(0.000)***	(0.006)***	(0.173)	(0.000)***
U.S. fiscal policy stance	-1.040	-0.544	-1.480	0.820	-0.444	-0.073	-1.134	2.741	-0.034
	(0.065)*	(0.092)*	(0.006)***	(0.000)***	(0.241)	(0.004)***	(0.001)***	(0.000)***	(0.045)**
Bilateral trade *									
U.S. fiscal policy stance	-2.932	-3.323	-1.489	-2.301	-0.024	-0.018	-0.034	-0.068	0.756
	(0.428)	(0.538)	(0.391)	(0.401)	(0.260)	(0.215)	(0.320)	(0.202)	(0.868)

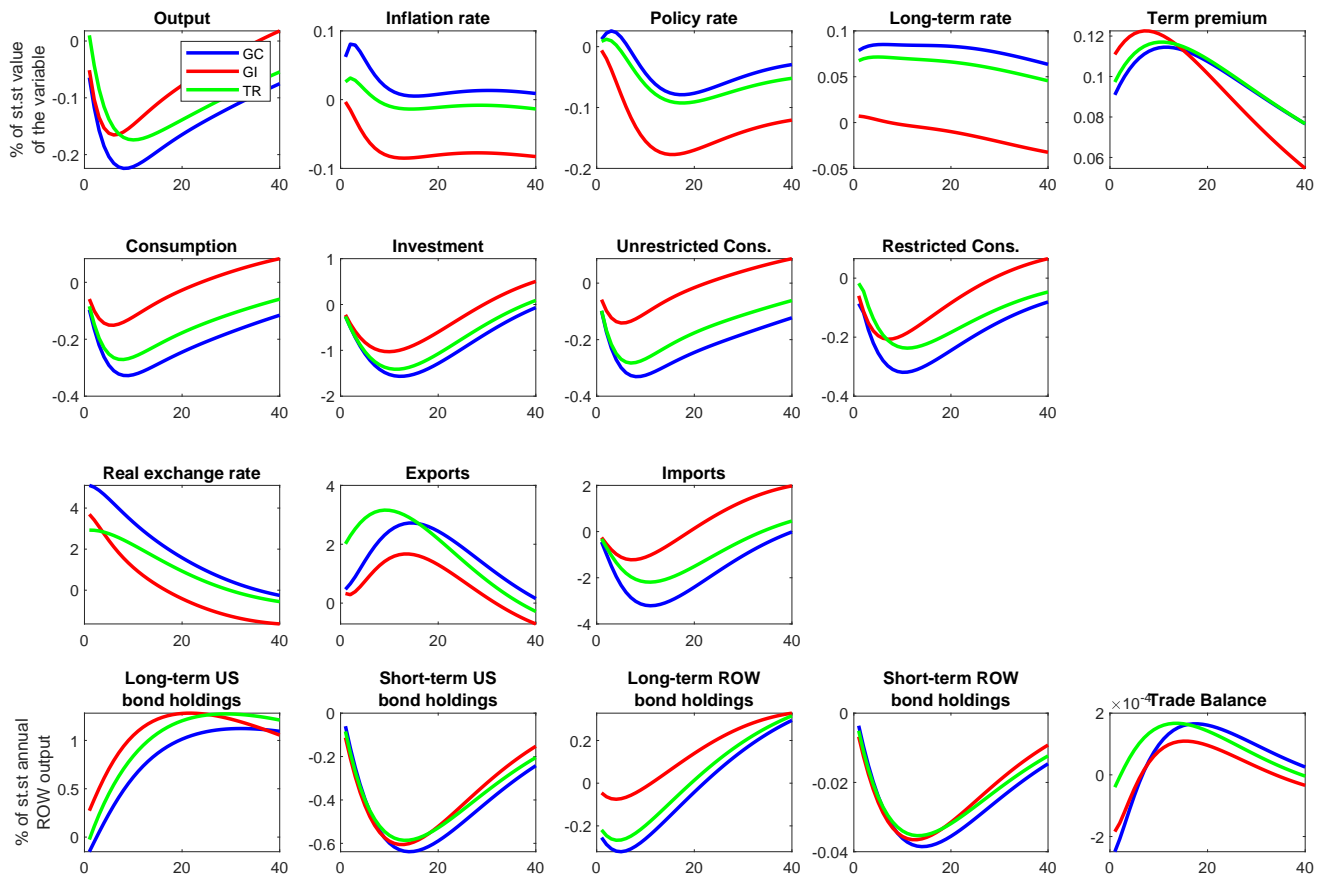
Note: This table reports the results obtained from a fixed effects estimation of equation (39) when the interactive variable displayed in the first row is added as an additional independent variable. For each estimation, real GDP growth rate is the dependent variable. *, **, *** significant at 10%, 5%, 1%, respectively. The numbers reported in parentheses for every variable except the lagged dependent variable are F statistics.

Figure 1: US responses to 1% fiscal shock in the United States as a fraction of steady-state annual US output



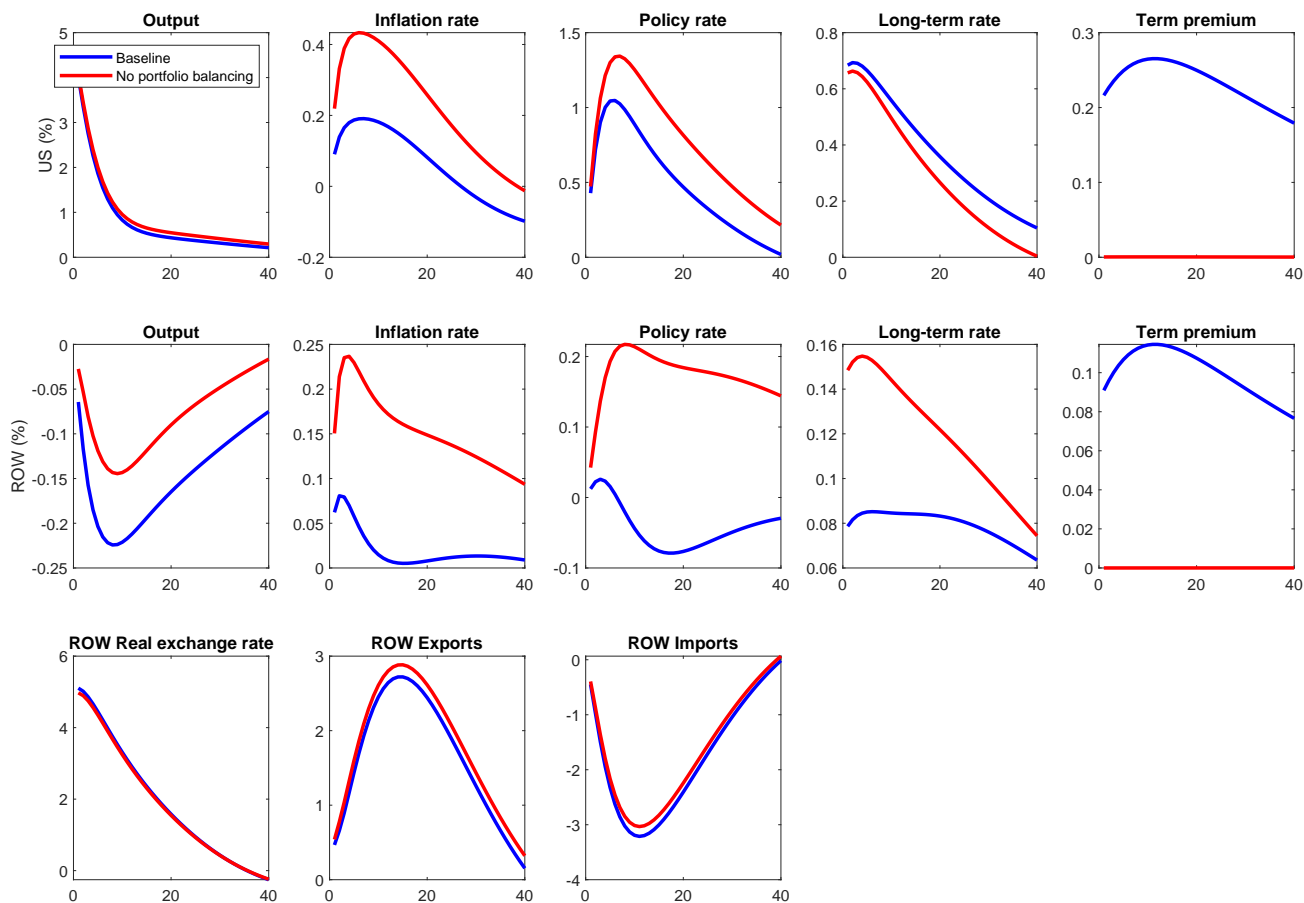
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in a few cases, policy rate, long-term rate, term premium and bond-holdings-to-GDP ratios, for which deviations are presented in percentage points.

Figure 2: ROW responses to 1% fiscal shock in the United States as a fraction of steady-state annual US output



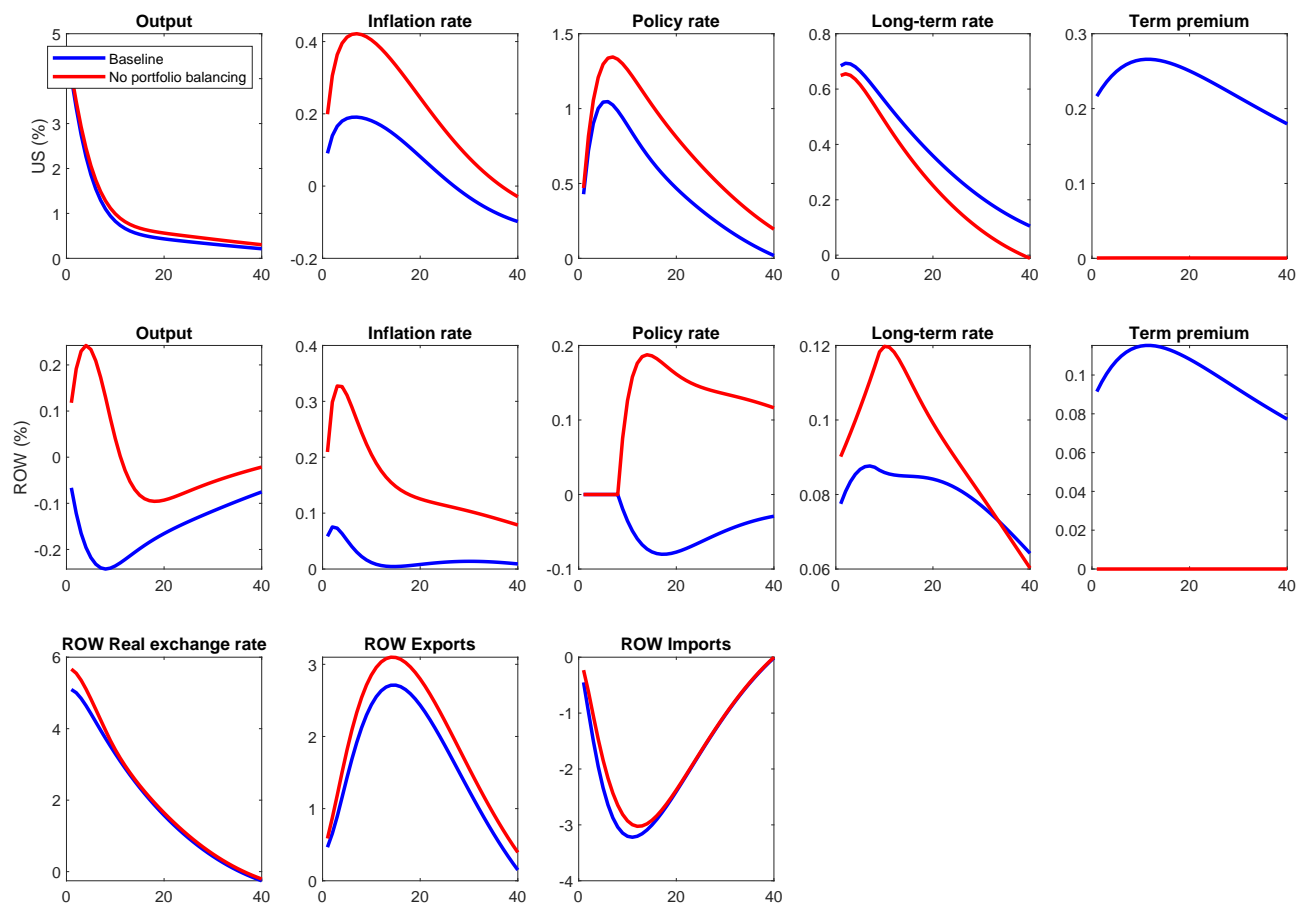
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in a few cases, policy rate, long-term rate, term premium and bond-holdings-to-GDP ratios, for which deviations are presented in percentage points.

Figure 3: Fiscal spillovers in the absence of portfolio balancing



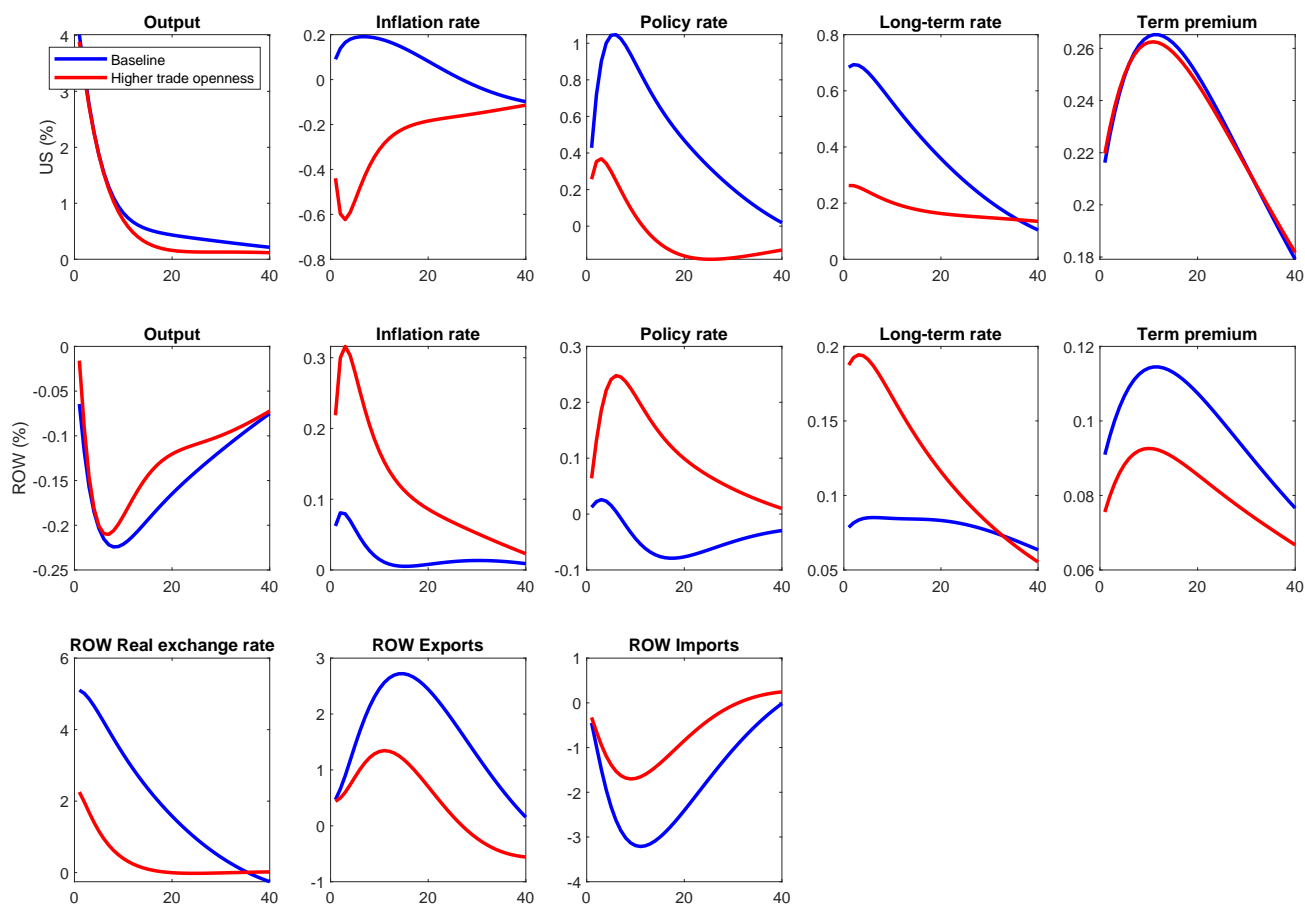
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in ation, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure 4: Fiscal spillovers in the absence of portfolio balancing - No monetary policy reaction over eight quarters at ROW



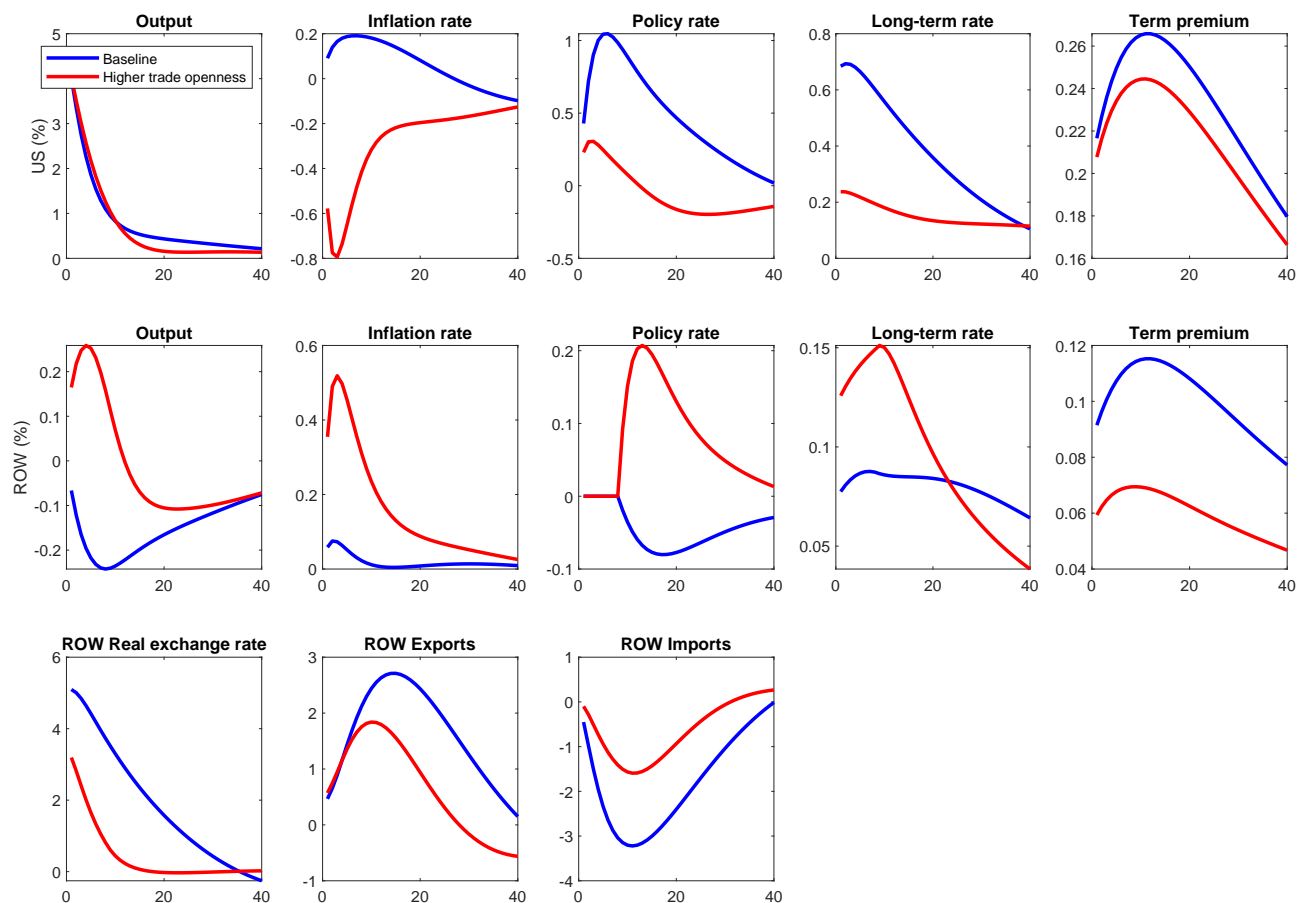
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in action, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure 5: Fiscal spillovers under higher trade openness



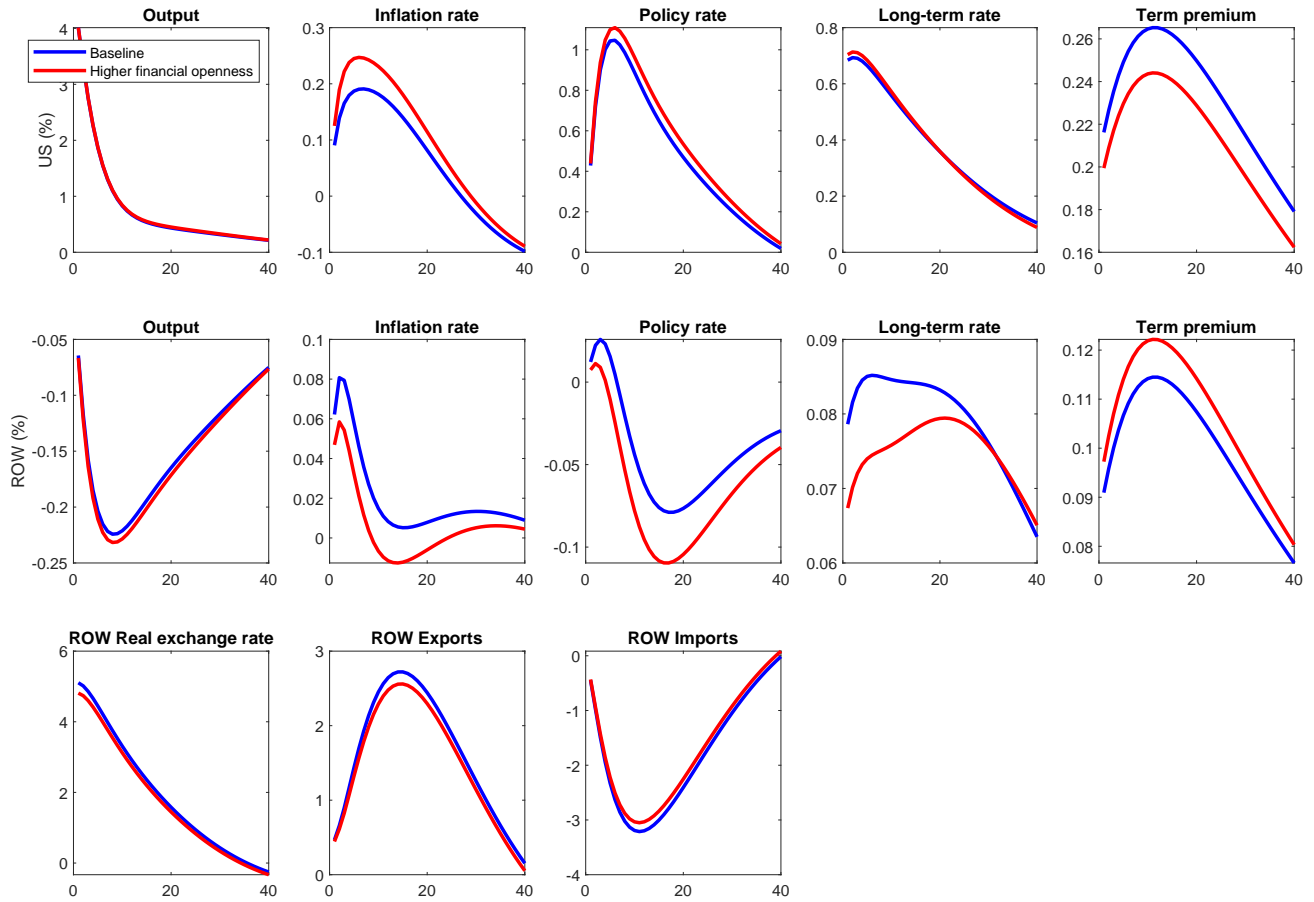
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in ation, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure 6: Fiscal spillovers under higher trade openness - No monetary policy reaction over eight quarters at ROW



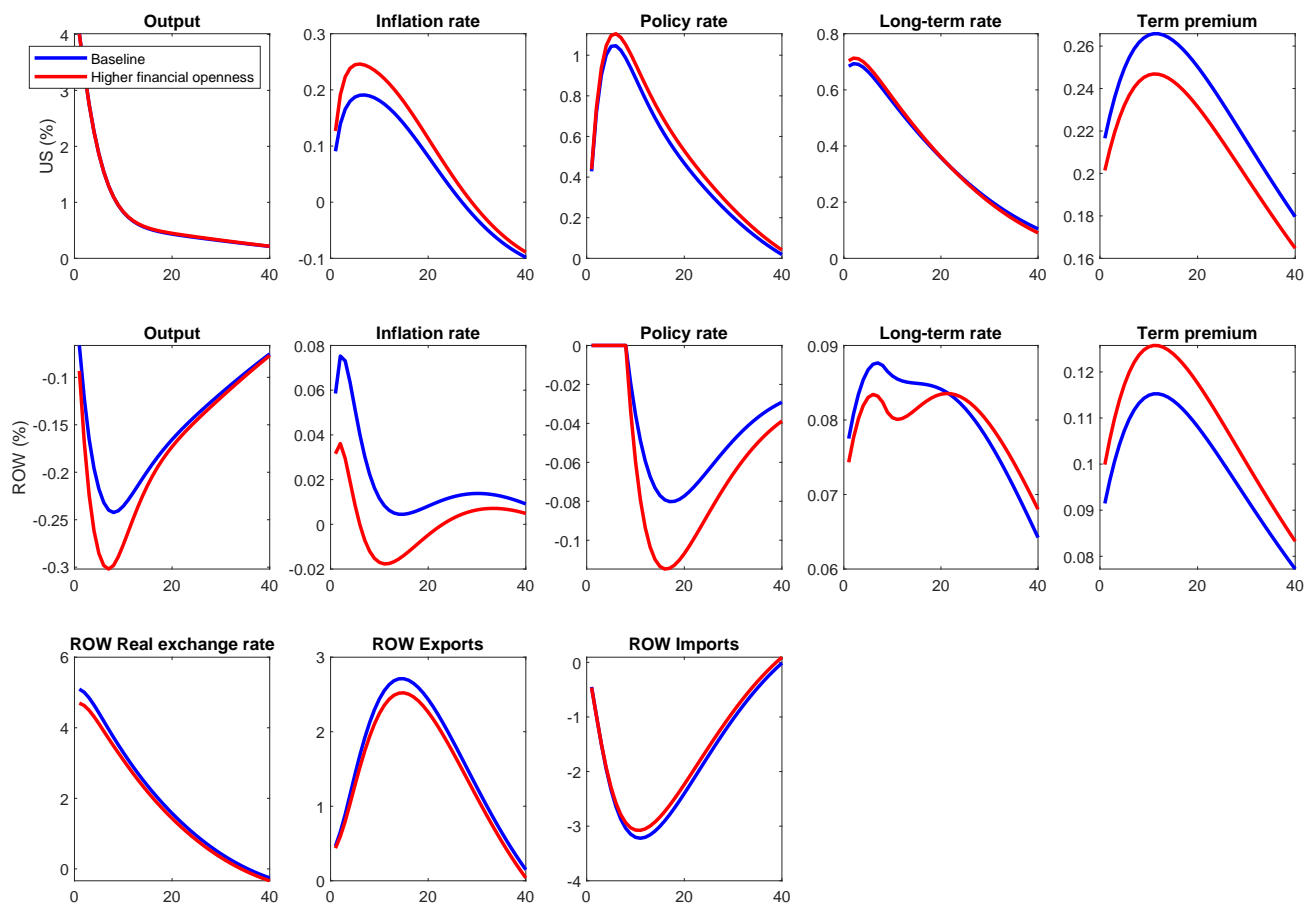
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in action, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure 7: Fiscal spillovers under higher financial openness



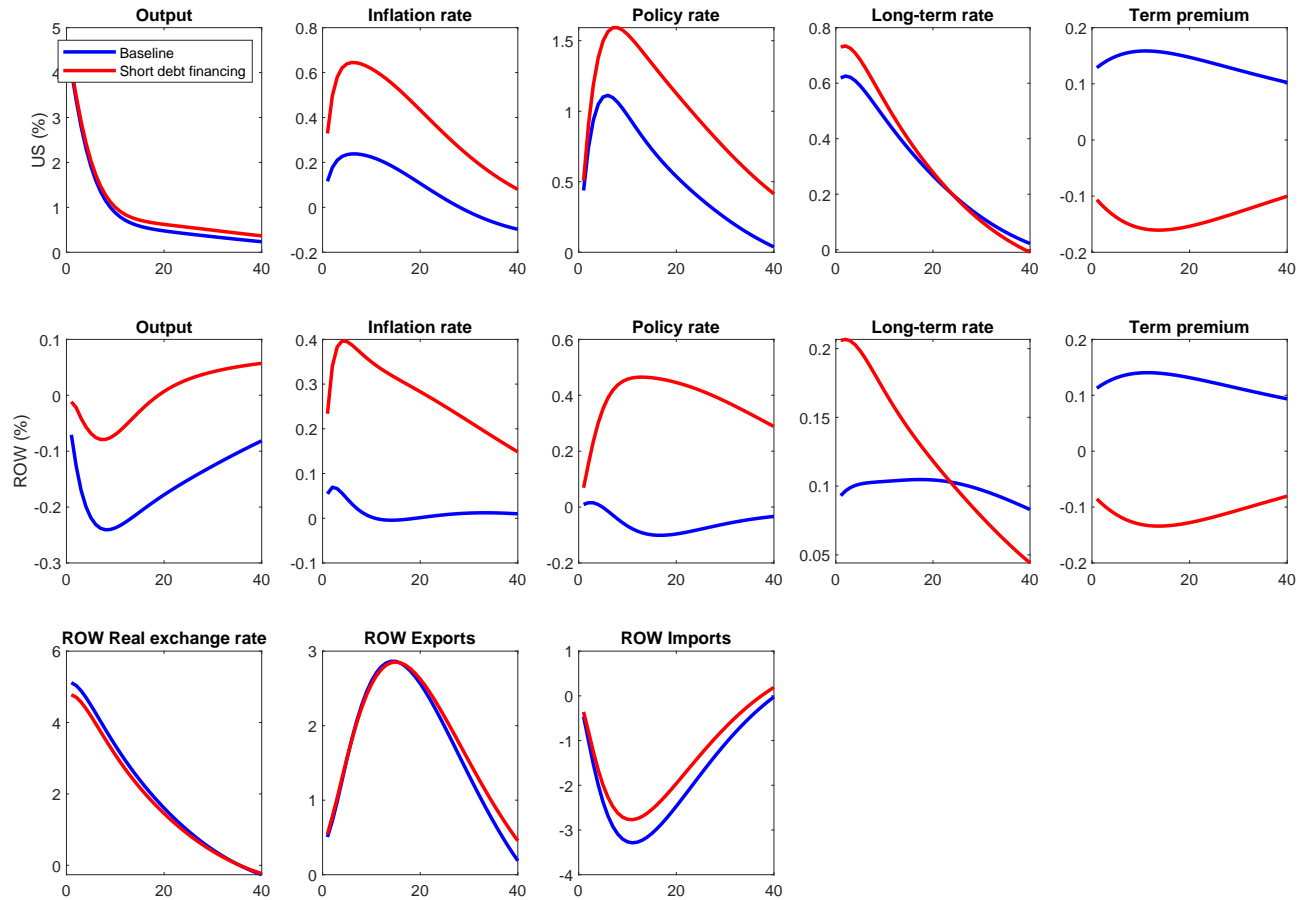
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in ation, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure 8: Fiscal spillovers under higher financial openness - No monetary policy reaction over eight quarters at ROW



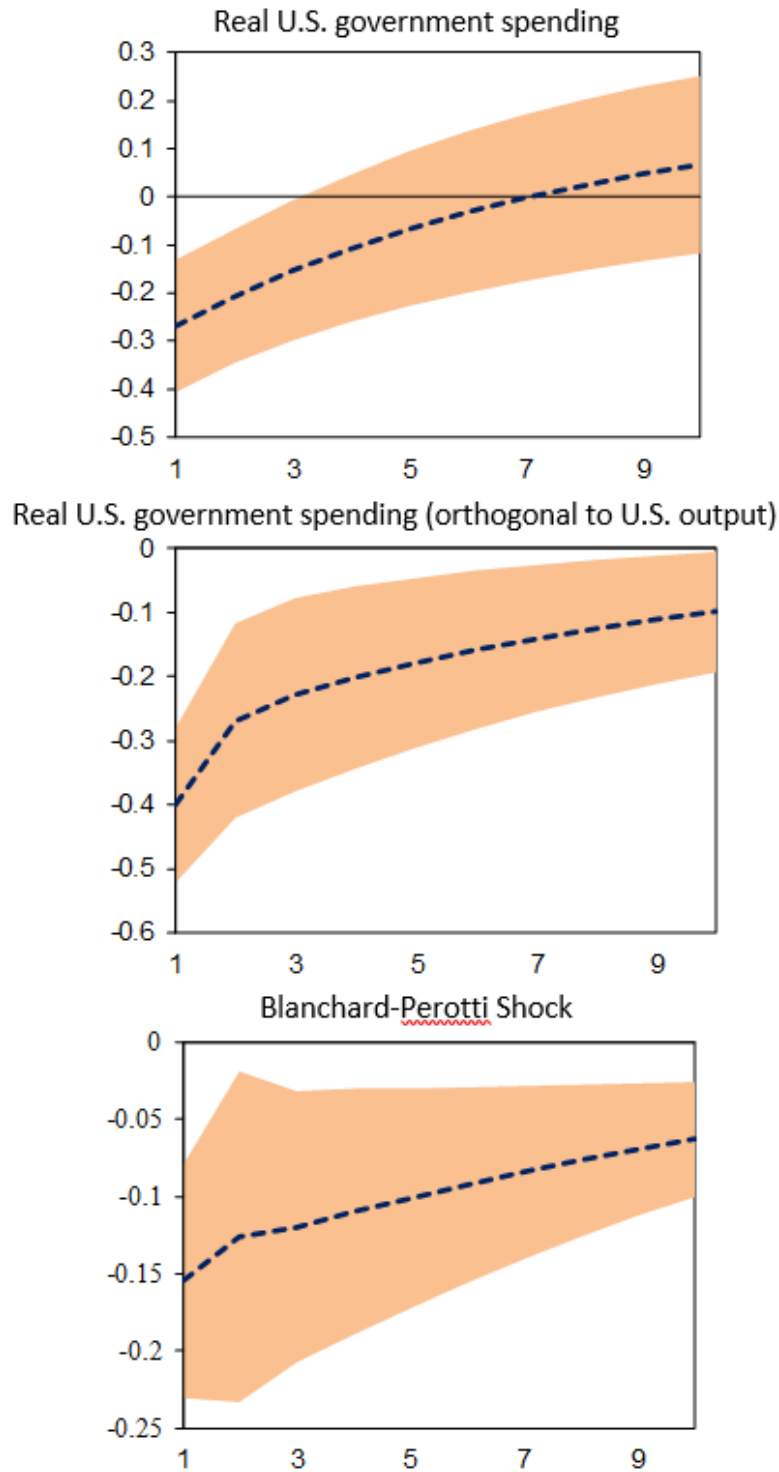
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in action, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure 9: Fiscal spillovers in the case of short-term debt financing



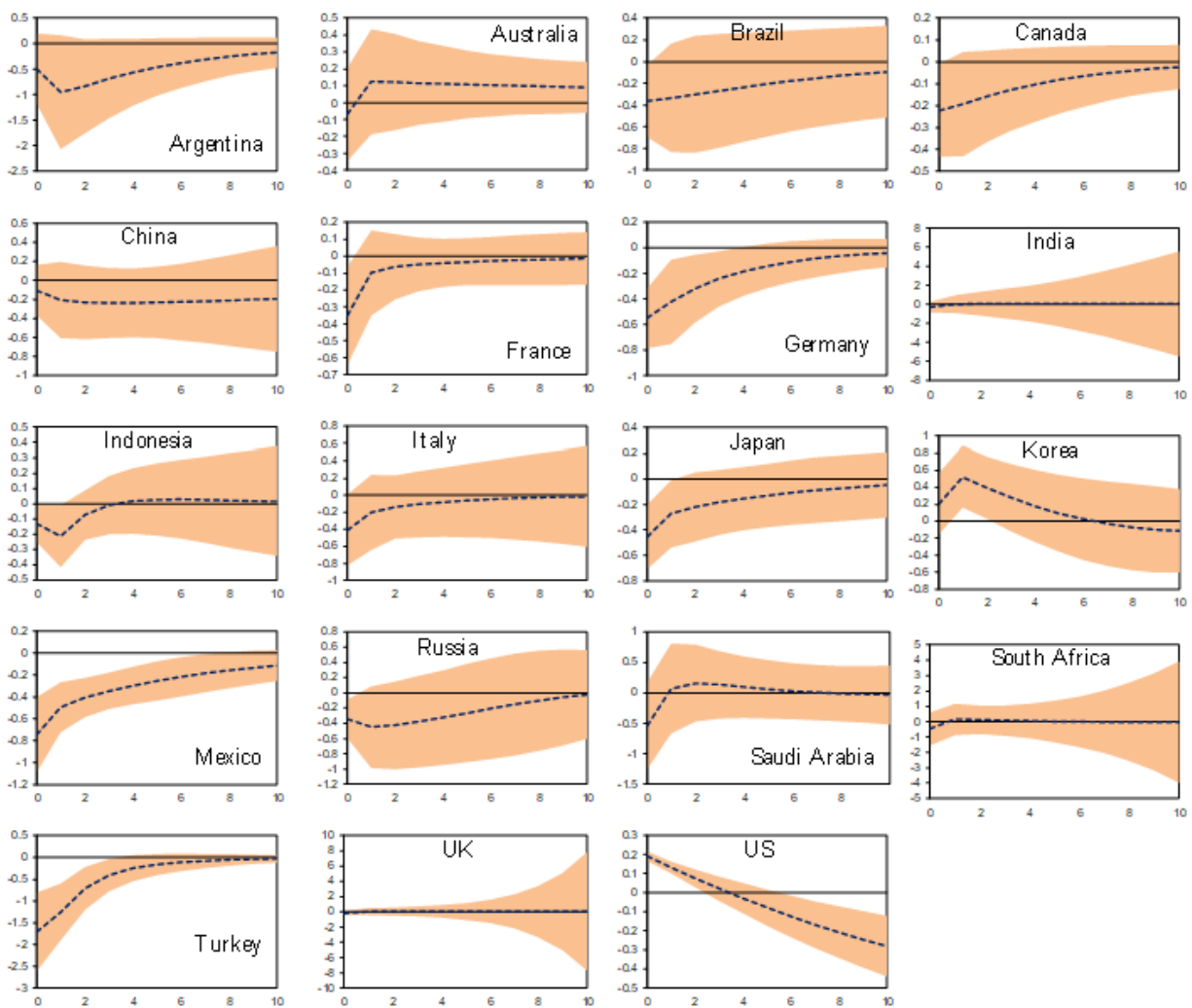
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in ation, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure 10: Foreign output responses to U.S. fiscal policy in a simple VAR model



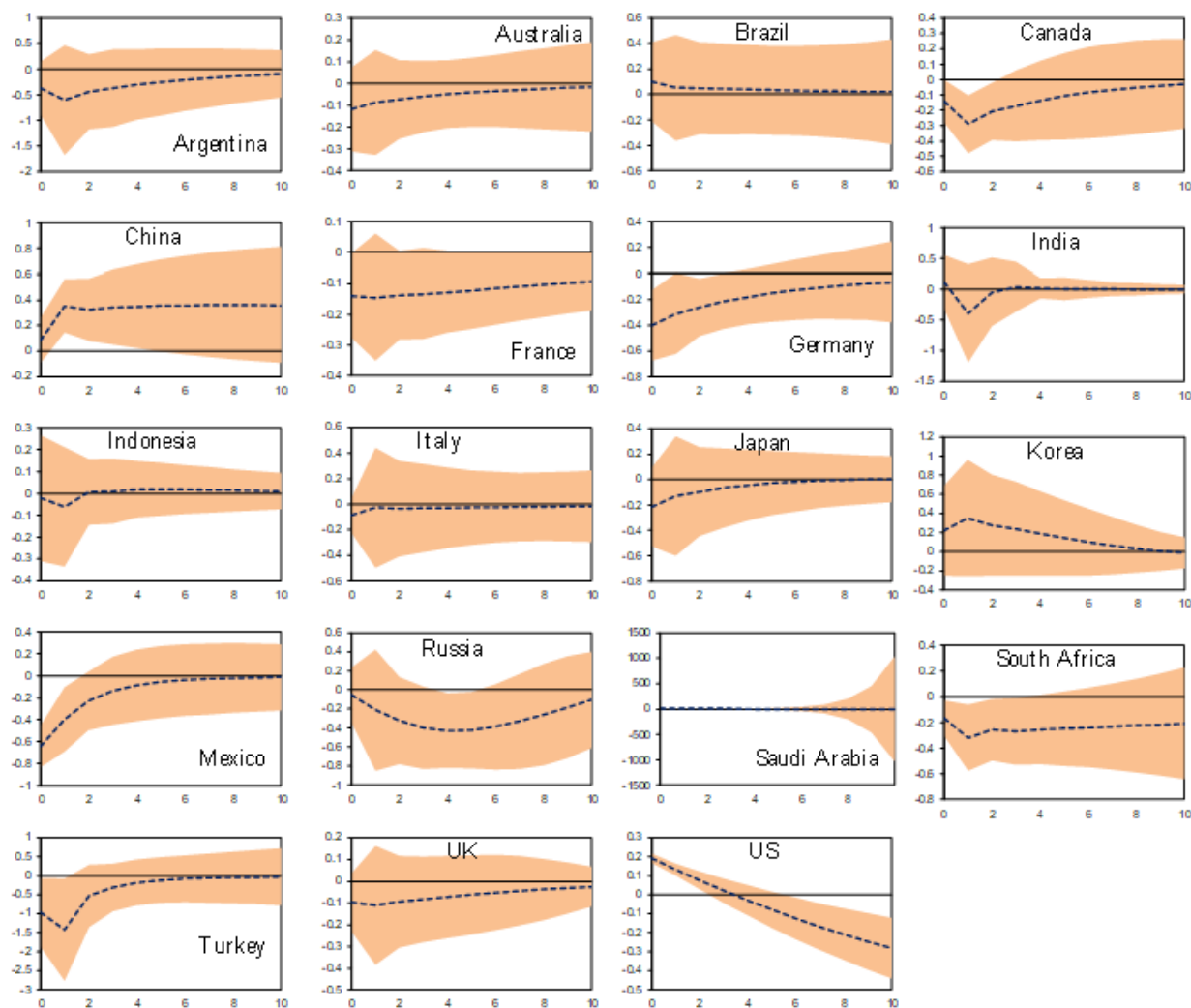
Notes: The figure displays the real GDP growth responses to three U.S. fiscal policy shocks obtained from a panel VAR model estimated using G-20 data. The confidence intervals are at the 90 percent level.

Figure 11: Output responses in country specific VAR models (responses to the changes in real U.S. government spending)



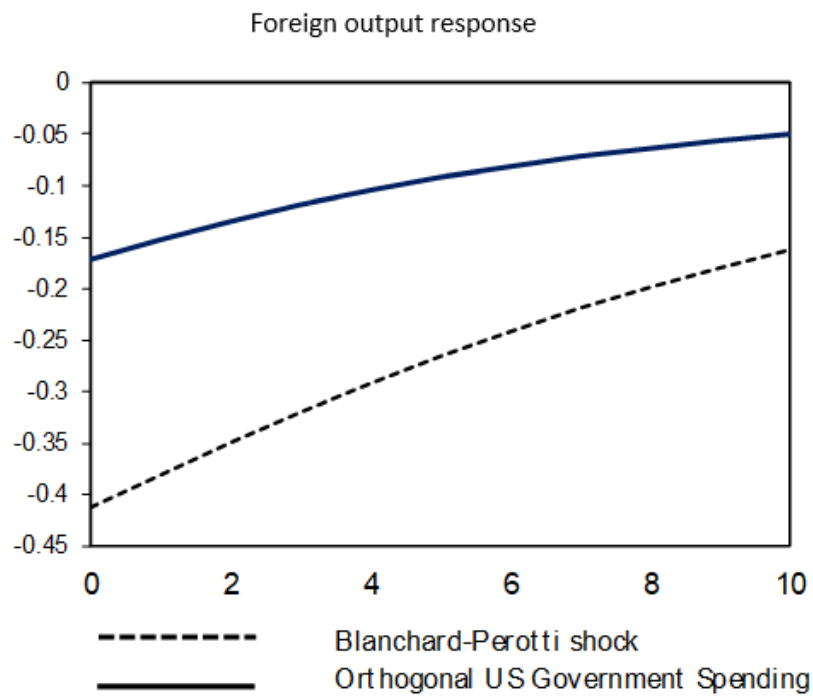
Notes: The figure displays the real GDP growth responses to a real U.S. government spending shock. The responses are obtained from country-specific VAR models. The confidence intervals are at the 90 percent level. The policy shock in the estimations with U.S. is the Blanchard-Perotti spending shock.

Figure 12: Output responses in country specific VAR models (responses to changes in the orthogonal component of U.S. government spending)



Notes: The figure displays the real GDP growth responses to a real U.S. fiscal policy shock where the fiscal policy measure is the component of real U.S. government spending that is orthogonal to U.S. real output. The responses are obtained from country-specific VAR models. The confidence intervals are at the 90 percent level. The policy shock in the estimations with U.S. is the Blanchard-Perotti spending shock.

Figure 13: G-20 output responses in a VAR-X model



Notes: The figure displays the G-20 real GDP growth response to two U.S. fiscal policy shocks obtained from a panel VAR model estimated using G-20 data. In this model, U.S. fiscal policy measures are incorporated as exogenous variables.

A Details on the DSGE Model

In this Appendix, we describe in more detail some of the model features that were only briefly described in the main text.

A.1 Unrestricted households

Labor services supplied are heterogeneous across households, and are aggregated into a homogeneous labor service by perfectly-competitive labor intermediaries, who in turn rent these labor services to goods producers. The labor intermediaries use a standard Dixit-Stiglitz aggregator; therefore, the labor demand curve facing each household is given by

$$n_t(i) = \left(\frac{W_t(i)}{W_t} \right)^{-\Theta_n} n_t, \quad (40)$$

where W_t and n_t are the aggregate nominal wage rate and labor services of households, respectively, and Θ_n is the elasticity of substitution between the differentiated labor services.

The first-order conditions of unrestricted households with respect to consumption and capital are respectively given by

$$\frac{1}{c_{U,t} - \zeta c_{U,t-1}} = \lambda_{U,t}, \quad (41)$$

$$q_t \lambda_{U,t} = \beta E_t [\lambda_{U,t+1} ((1 - \delta) q_{t+1} + r_{k,t+1})]. \quad (42)$$

The optimality conditions with respect to labor and wages can be combined to derive a New Keynesian Phillips curve for wages, which after log-linearization can be written as

$$\widehat{\pi}_{wU,t} - \varsigma_w \widehat{\pi}_{t-1} = \beta E_t [\widehat{\pi}_{wU,t+1} - \varsigma_w \widehat{\pi}_t] - \frac{(\eta_n - 1)(1 - \tau_n)}{\kappa_w} \left(\widehat{w}_{U,t} - \frac{1}{1 - \zeta} (\widehat{c}_{U,t} - \zeta \widehat{c}_{U,t-1}) - \vartheta \widehat{n}_{U,t} \right), \quad (43)$$

where the nominal wage inflation, $\widehat{\pi}_{wU,t}$, and the real wage rate, $\widehat{w}_{U,t}$, of unrestricted households are related as

$$\widehat{\pi}_{wU,t} - \widehat{\pi}_t = \widehat{w}_{U,t} - \widehat{w}_{U,t-1}. \quad (44)$$

A.2 Restricted households

The restricted (hand-to-mouth) households' first-order conditions with respect to consumption is given by

$$\frac{1}{c_{R,t} - \zeta c_{R,t-1}} = \lambda_{R,t}.$$

Similar to unrestricted agents, the optimality conditions of restricted households with respect to labor and wages can also be combined to derive a New Keynesian Phillips curve for their wages,

which after log-linearization can be written as

$$\widehat{\pi}_{wR,t} - \varsigma_w \widehat{\pi}_{t-1} = \beta E_t [\widehat{\pi}_{wR,t+1} - \varsigma_w \widehat{\pi}_t] - \frac{(\eta_m - 1)(1 - \tau_n)}{\kappa_w} \left(\widehat{w}_{R,t} - \frac{1}{1 - \zeta} (\widehat{c}_{R,t} - \zeta \widehat{c}_{R,t-1}) - \vartheta \widehat{\pi}_{R,t} \right), \quad (45)$$

where the nominal wage inflation, $\widehat{\pi}_{wR,t}$, and the real wage rate, $\widehat{w}_{R,t}$, of restricted households are related as

$$\widehat{\pi}_{wR,t} - \widehat{\pi}_t = \widehat{w}_{R,t} - \widehat{w}_{R,t-1}. \quad (46)$$

A.3 Final goods aggregators

There are two types of final goods aggregators; for consumption goods, c_t , and for investment goods, i_t . In what follows, we mainly describe the consumption goods aggregators, but investment goods aggregators are modeled in an analogous fashion.

Consumption aggregators are perfectly competitive, and they produce the final goods as a CES aggregate of home and foreign goods, $c_{h,t}$ and $c_{f,t}$:

$$c_t = \left[\gamma_c^{\frac{1}{\lambda_c}} c_{h,t}^{\frac{\lambda_c-1}{\lambda_c}} + (1 - \gamma_c)^{\frac{1}{\lambda_c}} c_{f,t}^{\frac{\lambda_c-1}{\lambda_c}} \right]^{\frac{\lambda_c}{\lambda_c-1}}, \quad (47)$$

where γ_c denotes the share of domestic goods, and λ_c is the elasticity of substitution between home and foreign goods, in the consumption aggregate. For any level of aggregate consumption, the aggregators' optimal demand for the domestic and imported consumption goods is given by

$$c_{h,t} = \left(\frac{P_{h,t}}{P_t} \right)^{-\lambda_c} \gamma_c c_t, \text{ and } c_{f,t} = \left(\frac{P_{f,t}}{P_t} \right)^{-\lambda_c} (1 - \gamma_c) c_t, \quad (48)$$

where $P_{h,t}$ and $P_{f,t}$ are the prices of the home and foreign goods, respectively. The aggregate price index for consumption goods is given by

$$P_t = \left[\gamma_c P_{h,t}^{1-\lambda_c} + (1 - \gamma_c) P_{f,t}^{1-\lambda_c} \right]^{\frac{1}{1-\lambda_c}}. \quad (49)$$

The analogous expressions for investment goods aggregators are given by

$$i_t = \left[\gamma_i^{\frac{1}{\lambda_i}} i_{h,t}^{\frac{\lambda_i-1}{\lambda_i}} + (1 - \gamma_i)^{\frac{1}{\lambda_i}} i_{f,t}^{\frac{\lambda_i-1}{\lambda_i}} \right]^{\frac{\lambda_i}{\lambda_i-1}}, \quad (50)$$

$$i_{h,t} = \left(\frac{P_{h,t}}{P_{i,t}} \right)^{-\lambda_i} \gamma_i i_t \text{ and } i_{f,t} = \left(\frac{P_{f,t}}{P_{i,t}} \right)^{-\lambda_i} (1 - \gamma_i) i_t, \quad (51)$$

$$P_{i,t} = \left[\gamma_i P_{h,t}^{1-\lambda_i} + (1 - \gamma_i) P_{f,t}^{1-\lambda_i} \right]^{\frac{1}{1-\lambda_i}}, \quad (52)$$

where $P_{i,t}$ denotes the price of the aggregate investment good.

A.4 Domestic intermediate goods firms

There is a unit measure of monopolistically competitive domestic firms indexed by j . As noted in the main text, their technology is described by the following production function:

$$y_t(j) = (z_t k_{g,t-1}^\Psi) [u_t(j) k_{t-1}(j)]^\alpha \left[n_{H,t}(j)^\Phi n_{L,t}(j)^{1-\Phi} \right]^{1-\alpha} - f, \quad (53)$$

where z_t refers to the exogenous part of TFP and follows an exogenous AR(1) process. Note that we capture the relative economic size of the domestic versus the foreign economy by their relative levels of z_t .

Domestic goods produced are heterogeneous across firms, and are aggregated into a homogeneous domestic good by perfectly-competitive final-goods producers using a standard Dixit-Stiglitz aggregator. The demand curve facing each firm is given by

$$y_t(j) = \left(\frac{P_{h,t}(j)}{P_{h,t}} \right)^{-\Theta_h} y_t, \quad (54)$$

where y_t is aggregate domestic output, and Θ_h is the elasticity of substitution between the differentiated goods. Thus, $\theta_h = \Theta_h / (\Theta_h - 1)$ is the gross markup of price over marginal cost at the steady state.²⁸

Firm j 's profits at period t are given by

$$\begin{aligned} \frac{\Pi_{h,t}(j)}{P_t} &= \frac{P_{h,t}(j)}{P_t} y_t(j) - \frac{W_{U,t}}{P_t} n_{U,t}(j) - \frac{W_{R,t}}{P_t} n_{R,t}(j) - r_{k,t} k_{t-1}(j) \\ &\quad - \frac{\kappa_u}{1+\varpi} \left[u_t(j)^{1+\varpi} - 1 \right] k_{t-1}(j) - \frac{\kappa_h}{2} \left(\frac{P_{h,t}(j)/P_{h,t-1}(j)}{\pi_{h,t-1}^{\varsigma_h} \pi^{1-\varsigma_h}} - 1 \right)^2 \frac{P_{h,t}}{P_t} y_t, \end{aligned} \quad (55)$$

where κ_u and ϖ are the level and elasticity parameters for the utilization cost. Similar to wage stickiness, price stickiness is introduced via quadratic adjustment costs with level parameter κ_h , and ς_h captures the extent to which price adjustments are indexed to past inflation.

A domestic firm's objective is to choose the quantity of inputs and output, and the price of its output each period, to maximize the present value of profits (using the households' stochastic discount factor) subject to the demand function it is facing with respect to its individual output from the aggregators. The first-order conditions of the domestic intermediate goods firm with respect to the two types of labor and capital imply

$$\widehat{w}_{U,t} + \widehat{n}_{U,t} = \widehat{w}_{R,t} + \widehat{n}_{R,t} = \widehat{r}_{k,t} + \widehat{u}_t + \widehat{k}_{t-1}. \quad (56)$$

²⁸The fixed-cost parameter f is set equal to $\theta_h - 1$ times the steady-state level of output, to ensure that pure economic profits are zero at the steady state; hence, there is no incentive for firm entry and exit in the long run.

Similarly, the first-order conditions for capital and utilization can be combined to yield

$$\widehat{u}_t = \frac{1}{\varpi} \widehat{r}_{k,t}. \quad (57)$$

Finally, the first-order condition with respect to price yields the New Keynesian Phillips curve for domestic prices as

$$\begin{aligned} \widehat{\pi}_{h,t} - \varsigma_h \widehat{\pi}_{h,t-1} &= \beta E_t [\widehat{\pi}_{h,t+1} - \varsigma_h \widehat{\pi}_{h,t}] \\ &\quad - \frac{\Theta_h - 1}{\kappa_h} \left(\widehat{p}_{h,t} + \widehat{z}_t + \Psi \widehat{k}_{g,t-1} + (1 - \alpha) \left[\Phi \widehat{n}_{U,t} + (1 - \Phi) \widehat{n}_{R,t} - (\widehat{u}_t + \widehat{k}_{t-1}) \right] - \widehat{r}_{k,t} \right), \end{aligned} \quad (58)$$

where $p_{h,t} = P_{h,t}/P_t$ is the relative price of home goods.

A.5 Importers

There is also a unit measure of monopolistically competitive importers indexed by j . They import foreign goods from abroad, differentiate them and markup their price, and then sell these heterogeneous goods to perfectly competitive import aggregators, who aggregate these into a homogeneous import good using a standard Dixit-Stiglitz aggregator. The demand curve facing each importer is given by

$$y_{f,t}(j) = \left(\frac{P_{f,t}(j)}{P_{f,t}} \right)^{-\Theta_f} y_{f,t}, \quad (59)$$

where $y_{f,t}$ is aggregate imports, and Θ_f is the elasticity of substitution between the differentiated goods.

Importers maximize the present value of profits (using the households' stochastic discount factor) subject to the demand function they are facing from the aggregators with respect to their own output. The importer's profits at period t are given by

$$\frac{\Pi_{f,t}(j)}{P_t} = \frac{P_{f,t}(j)}{P_t} y_{f,t}(j) - \frac{e_t P_{h,t}^*}{P_t} y_{f,t}(j) - \frac{\kappa_f}{2} \left(\frac{P_{f,t}(j)/P_{f,t-1}(j)}{\pi_{f,t-1}^{\varsigma_f} \pi^{1-\varsigma_f}} - 1 \right)^2 \frac{P_{f,t}}{P_t} y_{f,t}, \quad (60)$$

where κ_f and ς_f are the price adjustment cost and indexation parameters, respectively. These import price-stickiness features ensure that exchange rate movements do not immediately pass through to the domestic price of imported goods.

The first-order condition of importers with respect to price yields the import-price New Keynesian Phillips curve, which, after log-linearization, can be written as:

$$\widehat{\pi}_{f,t} - \varsigma_f \widehat{\pi}_{f,t-1} = \beta E_t [\widehat{\pi}_{f,t+1} - \varsigma_f \widehat{\pi}_{f,t}] - \frac{\Theta_f - 1}{\kappa_f} (\widehat{p}_{f,t} - \widehat{r} e r_t - \widehat{p}_{h,t}^*), \quad (61)$$

where $\pi_{f,t} = P_{f,t}/P_{f,t-1}$ is the import price inflation factor, and $p_{f,t} = P_{f,t}/P_t$ is the relative price of imported goods.

A.6 Private capital producers

Private capital producers are perfectly competitive. After goods production takes place, these firms purchase the undepreciated part of the installed capital from entrepreneurs at a relative price of q_t , and the new capital investment goods, i_t , from final-goods firms at a price of $P_{i,t}$, and produce the capital stock to be carried over to the next period. This production is subject to adjustment costs in the change in investment, and is described by the following law of motion for capital:

$$k_t = (1 - \delta) k_{t-1} + \left[1 - \frac{\varphi}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 \right] i_t, \quad (62)$$

where φ is the adjustment cost parameter.

After capital production, the end-of-period installed capital stock is sold back to entrepreneurs at the installed capital price of q_t . The capital producers' objective is thus to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left[q_t k_t - q_t (1 - \delta) k_{t-1} - \frac{P_{i,t}}{P_t} i_t \right], \quad (63)$$

subject to the law of motion for capital, where future profits are discounted using the patient households' stochastic discount factor. The first-order condition of capital producers with respect to investment yields the following investment demand equation (after log-linearization):

$$\widehat{i}_t - \widehat{i}_{t-1} = \beta E_t \left[\widehat{i}_{t+1} - \widehat{i}_t \right] + \frac{1}{\varphi} (\widehat{q}_t - \widehat{p}_{i,t}), \quad (64)$$

where $p_{i,t} = P_{i,t}/P_t$ is the relative price of investment goods.

B Details on the Calibration

The trend inflation factor, π , is set to 1.005 in both countries, corresponding to 2% annual inflation. Following Chen et al. (2012a), the decay parameter for the coupon payments of long-term bonds, κ , is calibrated to imply a duration of 30 quarters, similar to the average duration in the secondary market for 10-year US Treasury bonds.

We calibrate the time discount factor, β , to match a target capital-output ratio of 10 (i.e., 2.5 with annualized output), using the optimality condition for household's capital decision at the steady state. Traditionally, the discount factor is calibrated to match the steady-state interest rate using the first-order condition on short-term bonds. We instead use this condition to calibrate the portfolio level coefficients, ξ_a and ξ_a^* , in preferences using the ratio of government bond holdings to GDP in each country, a/y and a^*/y^* ; thus, we set the portfolio level coefficients to 0.03 and 0.08 in the US and the ROW economies, respectively. The labor level parameters, ξ_n and ξ_n^* , are calibrated to match the working hours of the economically active population as a ratio of total non-sleeping hours of 32%. The habit parameter in the utility function, ζ , is set to 0.7, helping capture the high

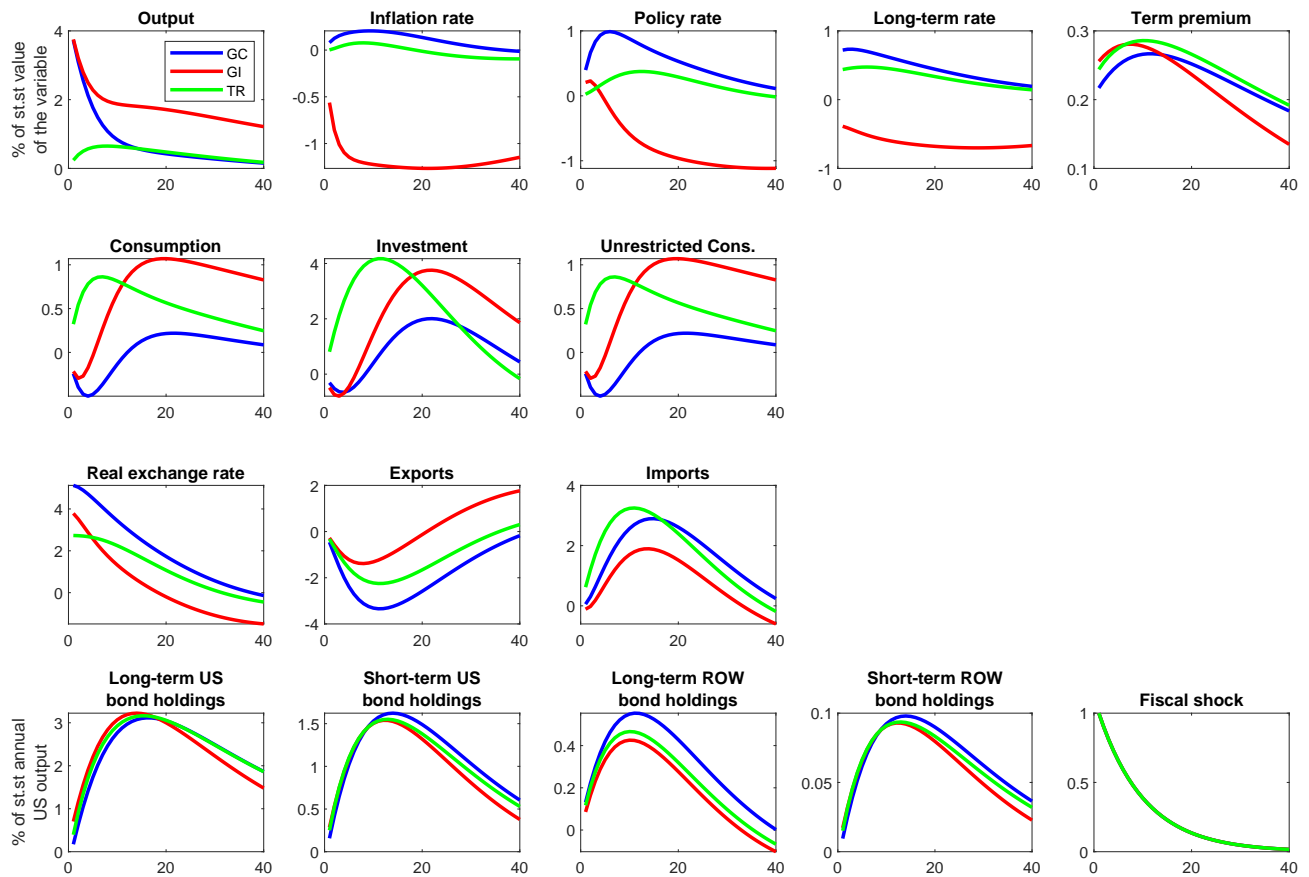
levels of persistence in the consumption data. ϑ is set to 2, implying that the labor supply elasticity is 0.5, largely consistent with the estimates presented in Blundell and MaCurdy (1999).

We calibrate the capital share in home-goods production, α , to 0.34 in both countries in order to match a labor income share of 66%. The depreciation rate of private capital, δ , is calibrated to 0.02 in both countries to match investment-output ratio of 19.5%. The capital utilization cost level parameter, κ_u , is calibrated to imply, without loss of generality, a unit utilization rate at the steady state. Home-bias parameters in the consumption and investment aggregators in the US, γ_c^* and γ_i^* , are both set to 0.85, reflecting a 12% import share, while in the ROW, the corresponding parameters, γ_c and γ_i , are set to 0.94 given the relative size of 2.6 of the ROW economy relative to the US. ϖ is set to 1, implying a unit elasticity of capacity utilization with respect to the rental rate of capital, while the investment adjustment cost parameter, φ , is set to 5. The elasticity of substitution between domestic and imported goods in the consumption and investment aggregators, λ_c and λ_i , are set to 1.

The price and wage adjustment cost parameters, κ_h , κ_f and κ_w , are set to 90, corresponding to Calvo parameters of around 0.9 and indicating significant levels of price and wage stickiness, while the indexation parameters, ς_h , ς_f and ς_w , are set to 0.5. The markup parameters, θ_h , θ_f , and θ_w , are calibrated to reflect a 25 percent steady-state markup in prices and wages in both countries. Finally, the Taylor rule on the short-term interest rate is fairly persistent with ρ set to 0.8, while the long-run reaction coefficients, r_π and r_y are set to 1.5 and 0.125, which are standard values in the literature. close to values found in the literature.

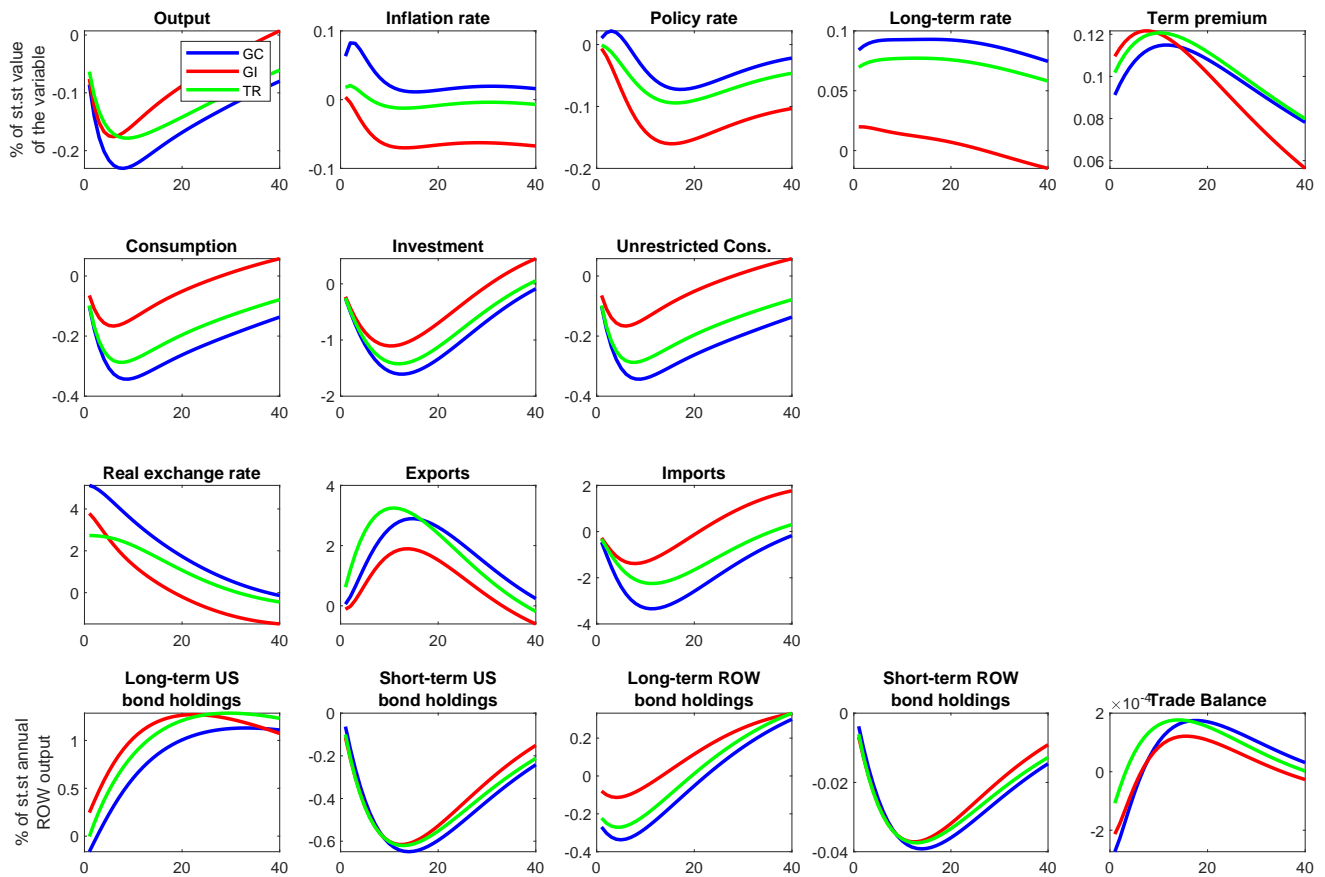
C Details on the Sensitivity Analysis

Figure C.1: US responses to 1% fiscal shock in the United States as a fraction of steady-state annual US output: The case of no-restricted agents



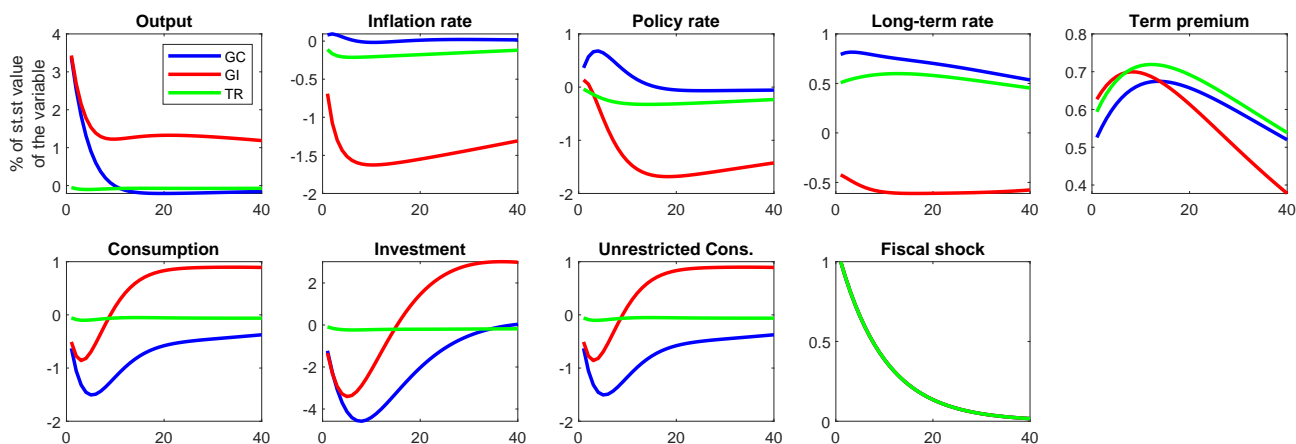
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in a)tion, policy rate, long-term rate, term premium and bond-holdings-to-GDP ratios, for which deviations are presented in percentage points.

Figure C.2: ROW responses to 1% fiscal shock in the United States as a fraction of steady-state annual US output: The case of no-restricted agents



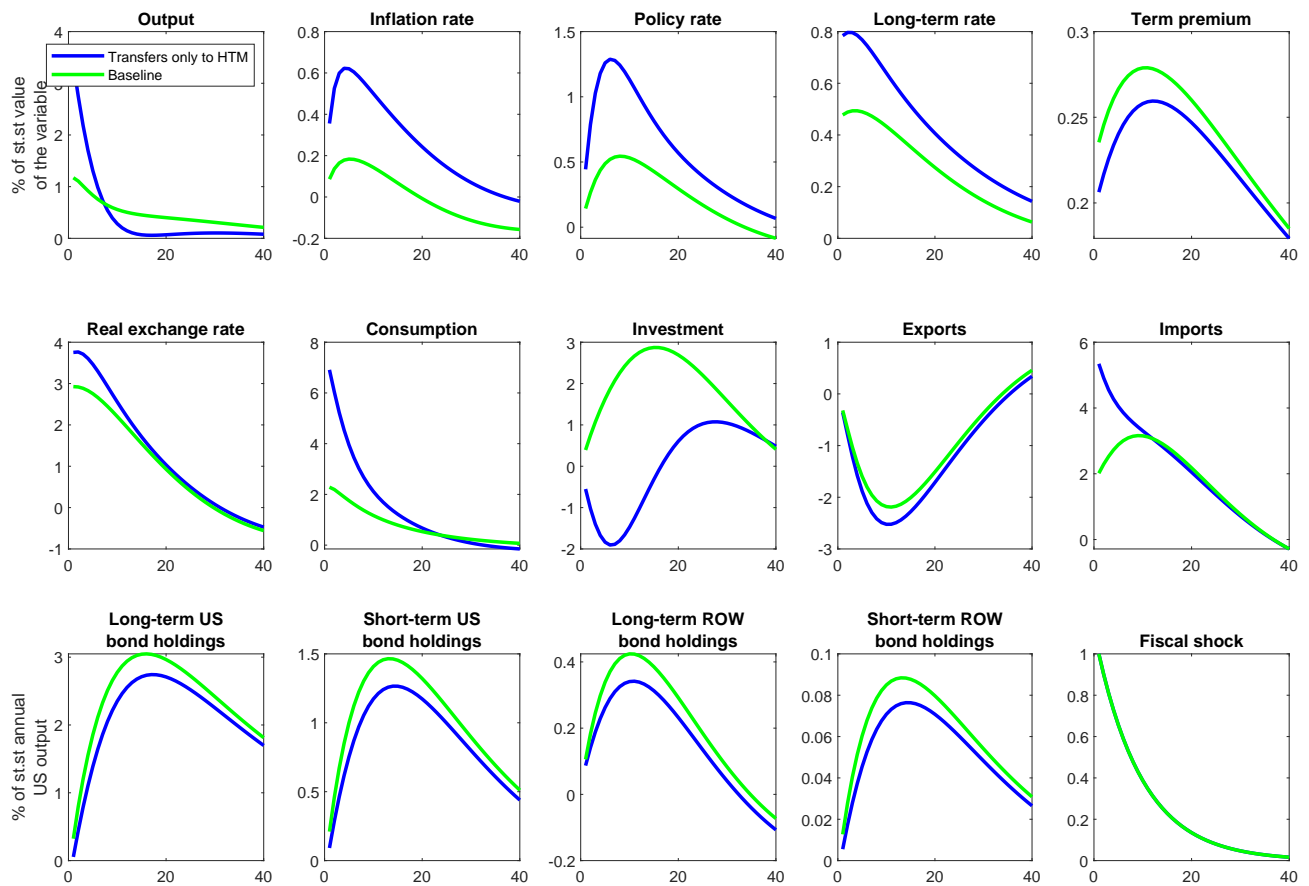
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in ation, policy rate, long-term rate, term premium and bond-holdings-to-GDP ratios, for which deviations are presented in percentage points.

Figure C.3: US responses to 1% fiscal shock in the United States as a fraction of steady-state annual US output: The case of no-restricted agents and closed-economy



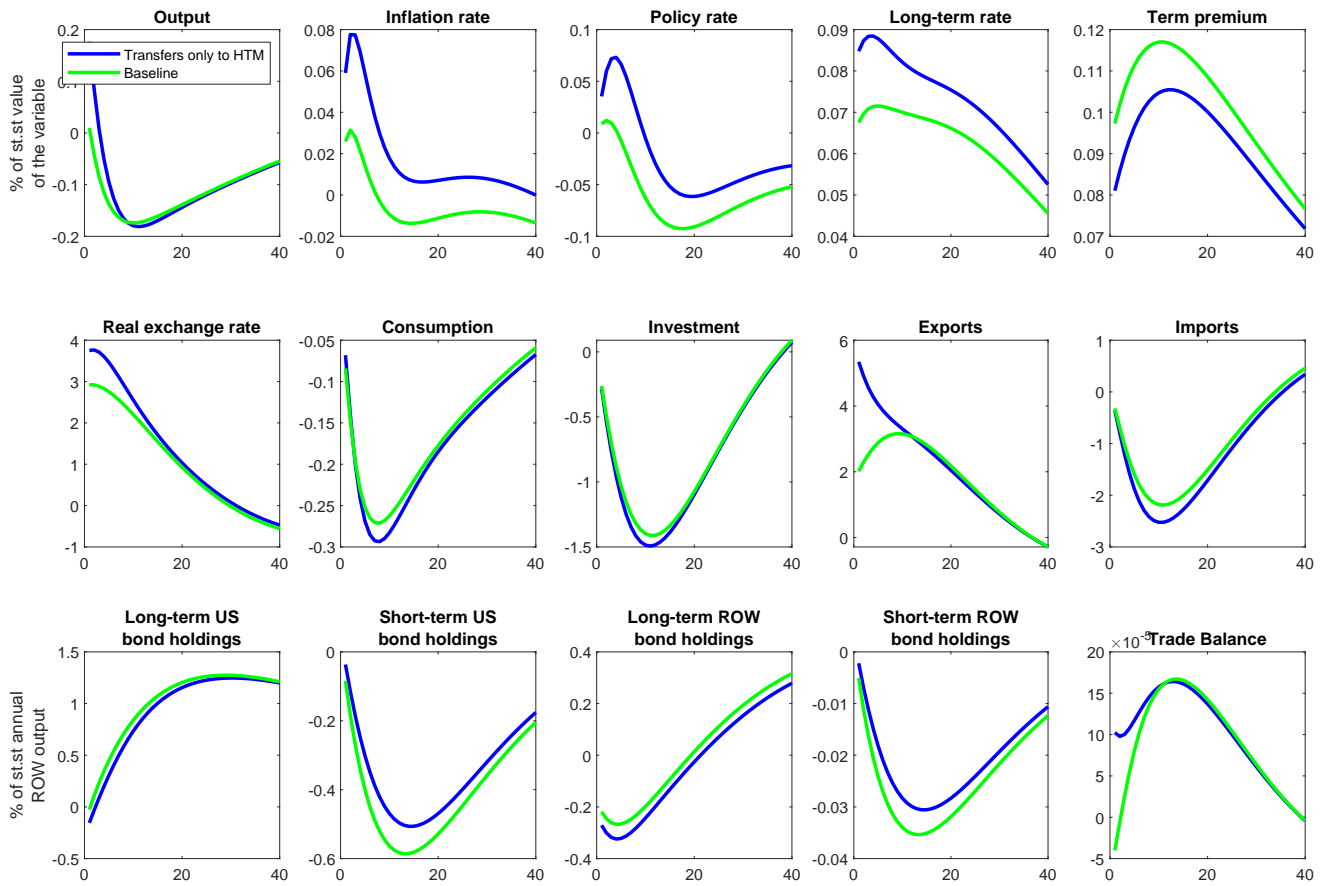
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in ation, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure C.4: US responses to 1% fiscal shock in the United States as a fraction of steady-state annual US output: The case where transfers are sent only to restricted agents



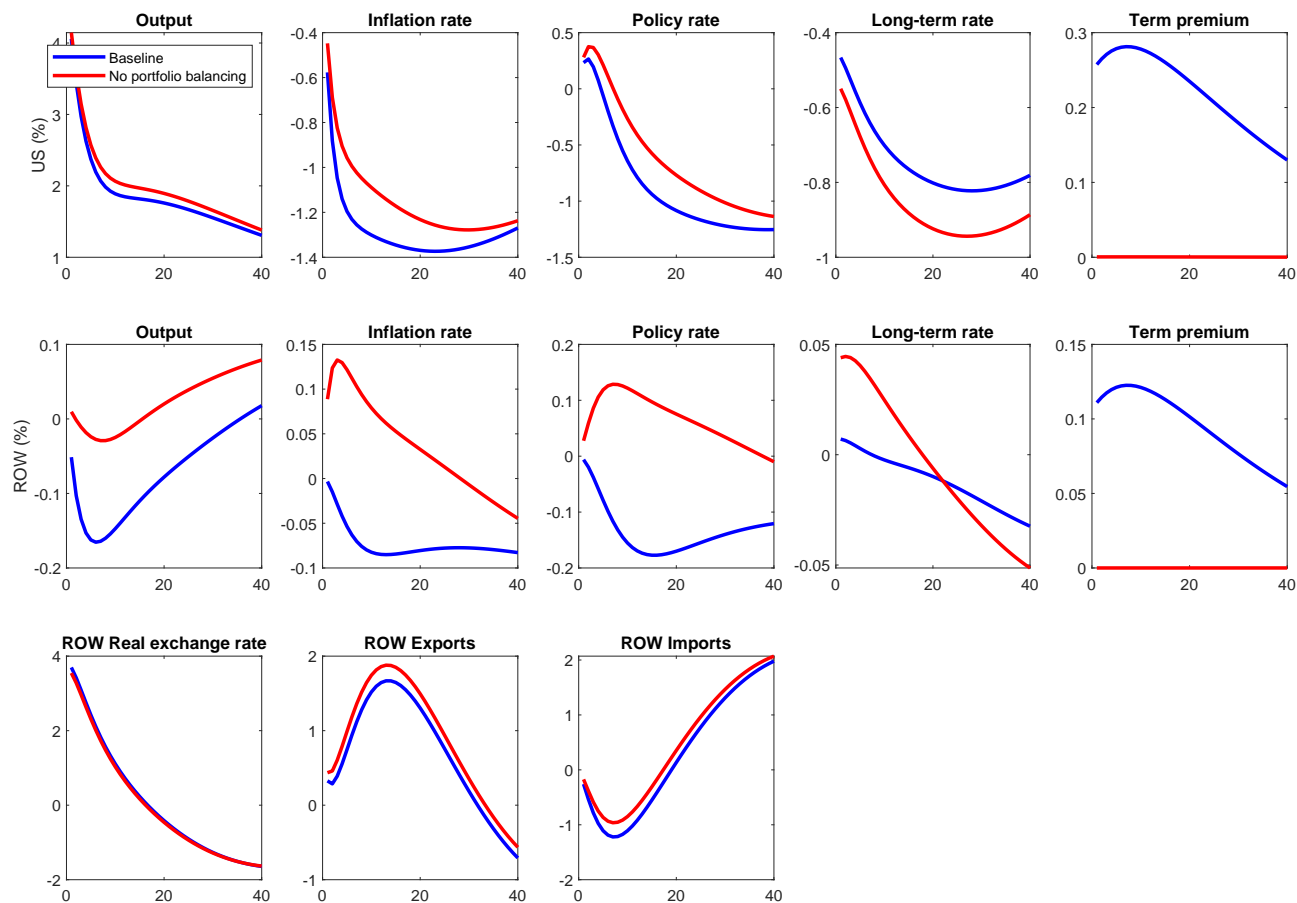
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in a few cases, policy rate, long-term rate, term premium and bond-holdings-to-GDP ratios, for which deviations are presented in percentage points.

Figure C.5: ROW responses to 1% fiscal shock in the United States as a fraction of steady-state annual US output: The case where transfers are sent only to restricted agents



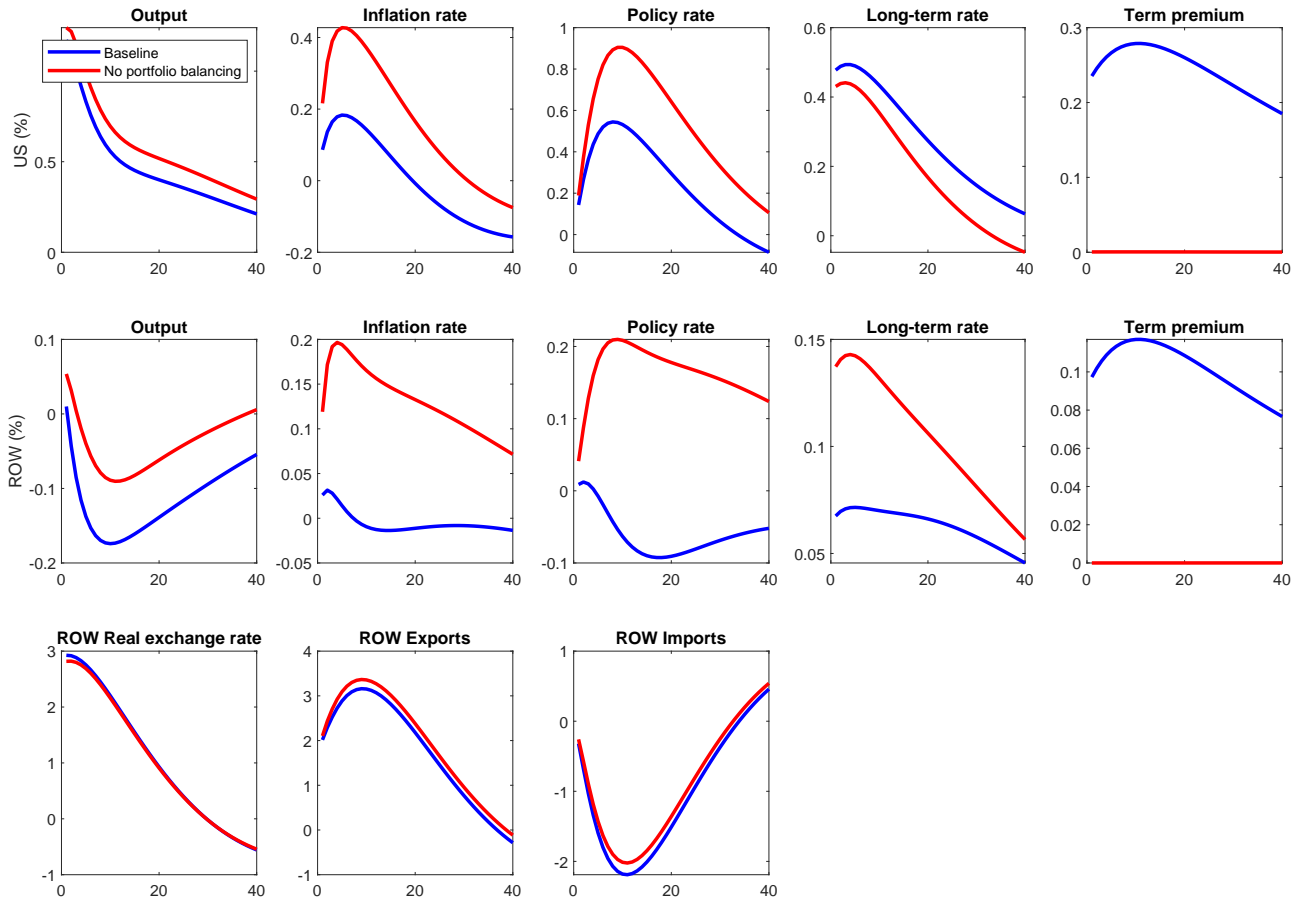
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in a few cases, policy rate, long-term rate, term premium and bond-holdings-to-GDP ratios, for which deviations are presented in percentage points.

Figure C.6: Fiscal spillovers in the absence of portfolio balancing: Government investment shock



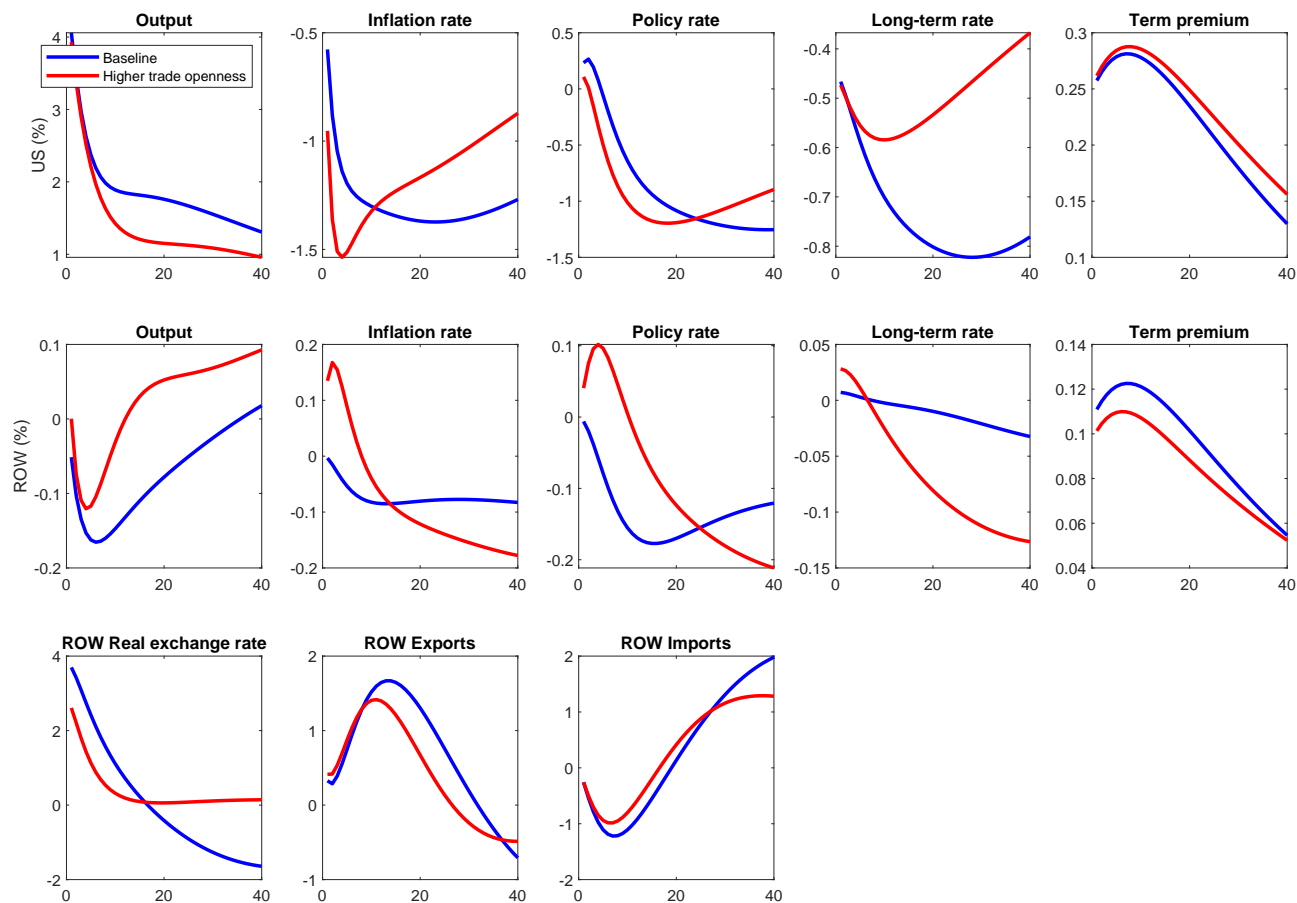
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in ation, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure C.7: Fiscal spillovers in the absence of portfolio balancing: Transfer shock



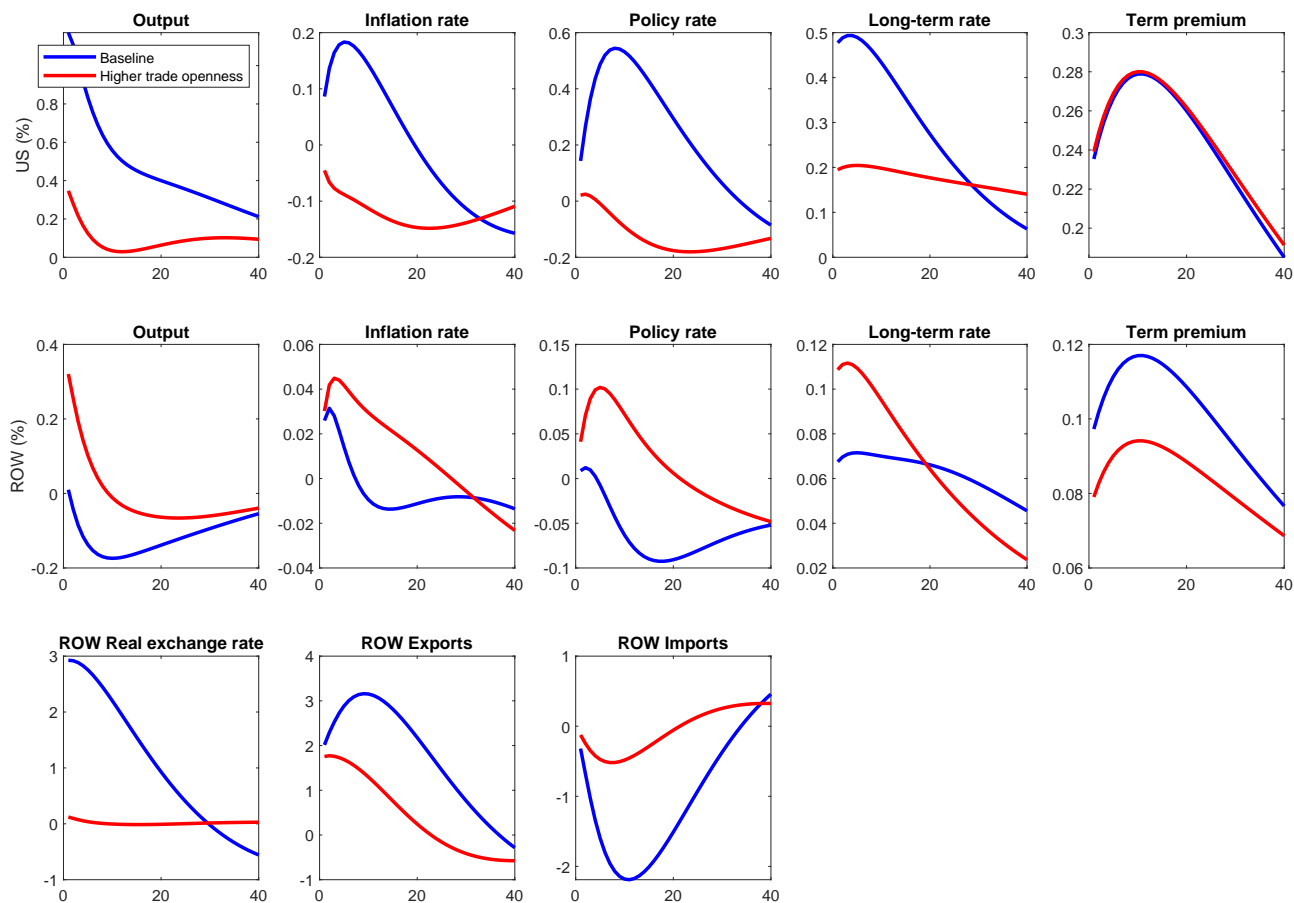
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in ation, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure C.8: Fiscal spillovers under higher trade openness: Government investment shock



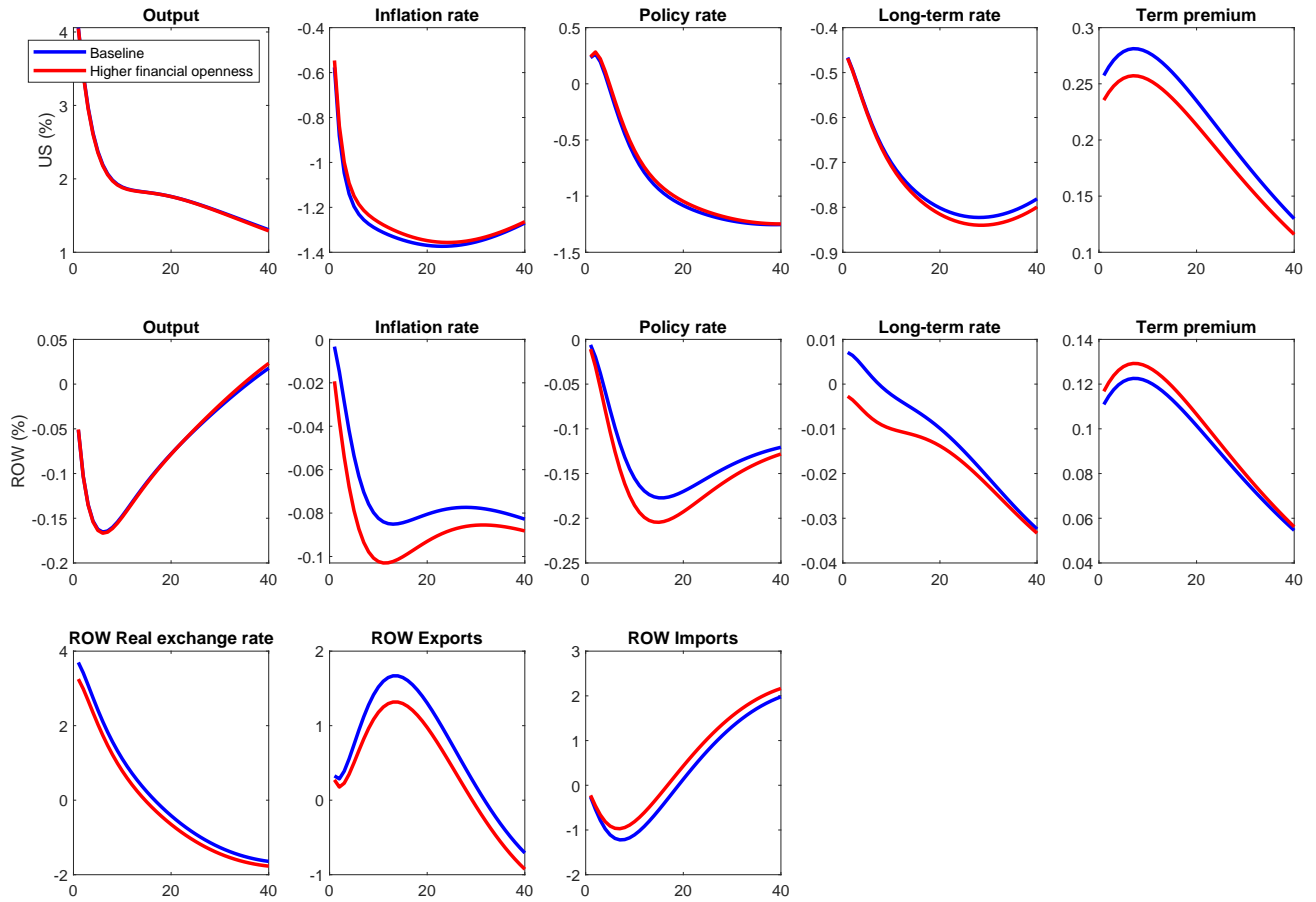
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in ation, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure C.9: Fiscal spillovers under higher trade openness: Transfer shock



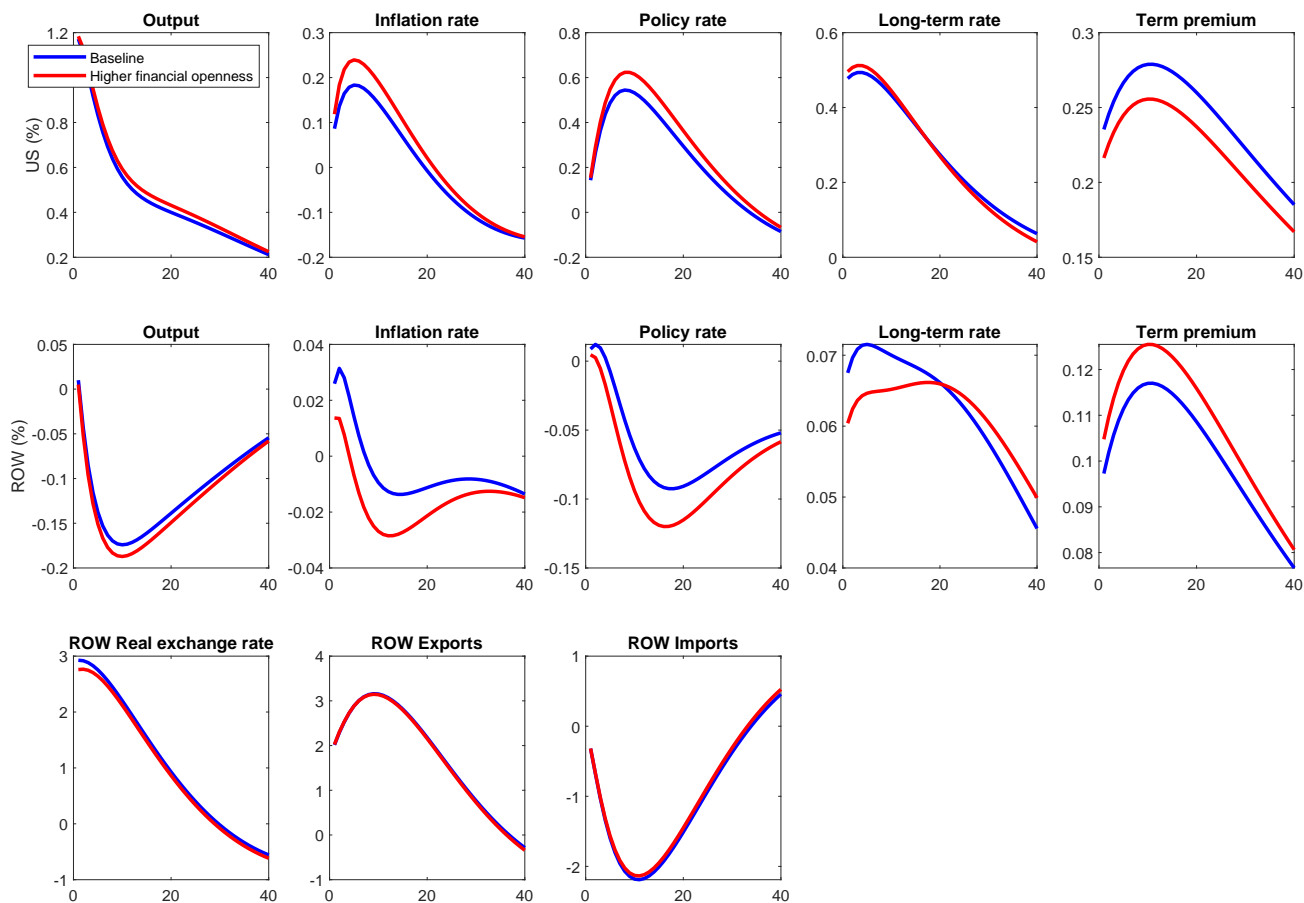
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in ation, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure C.10: Fiscal spillovers under higher financial openness: Government investment shock



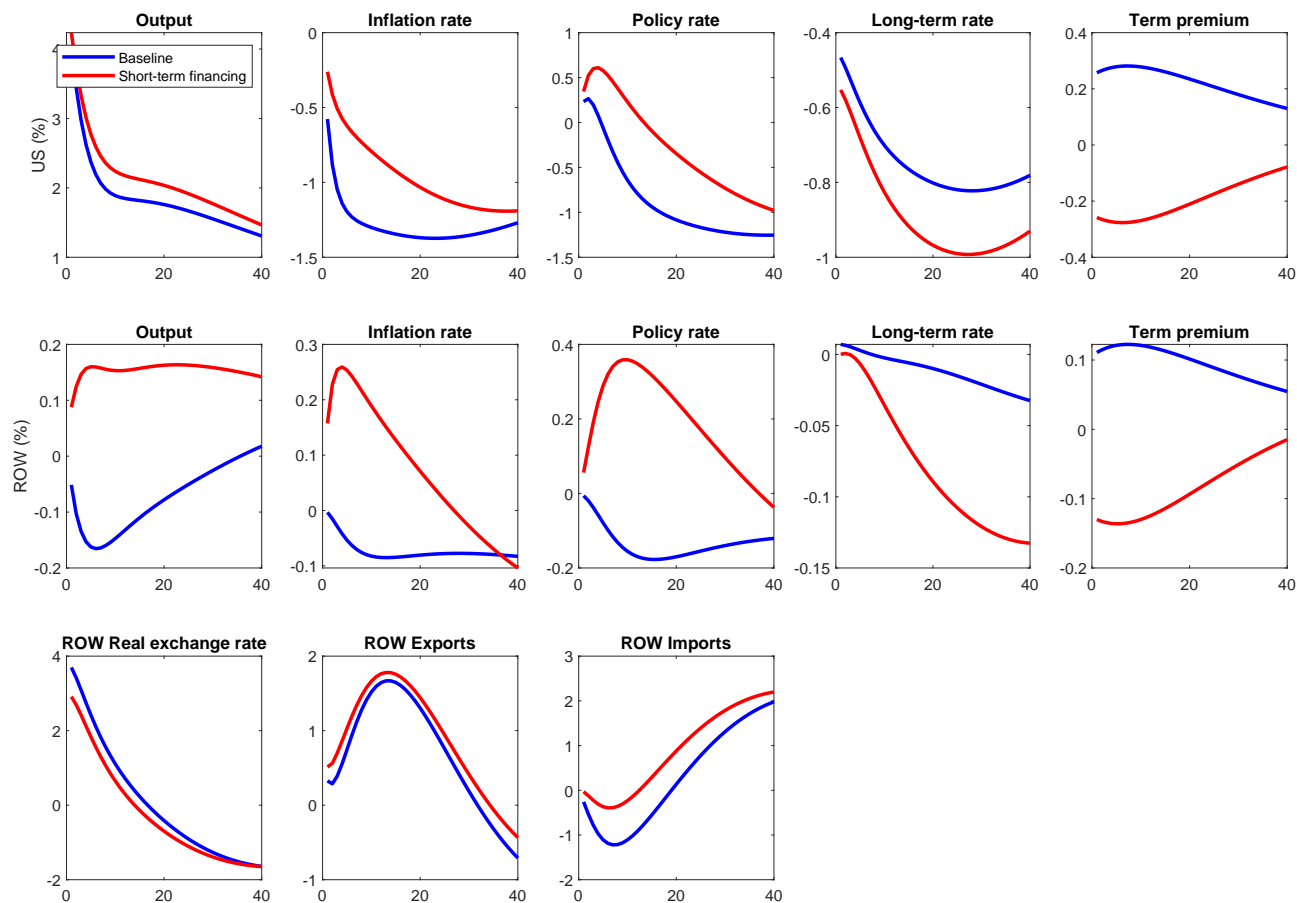
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in ation, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure C.11: Fiscal spillovers under higher financial openness: Transfer shock



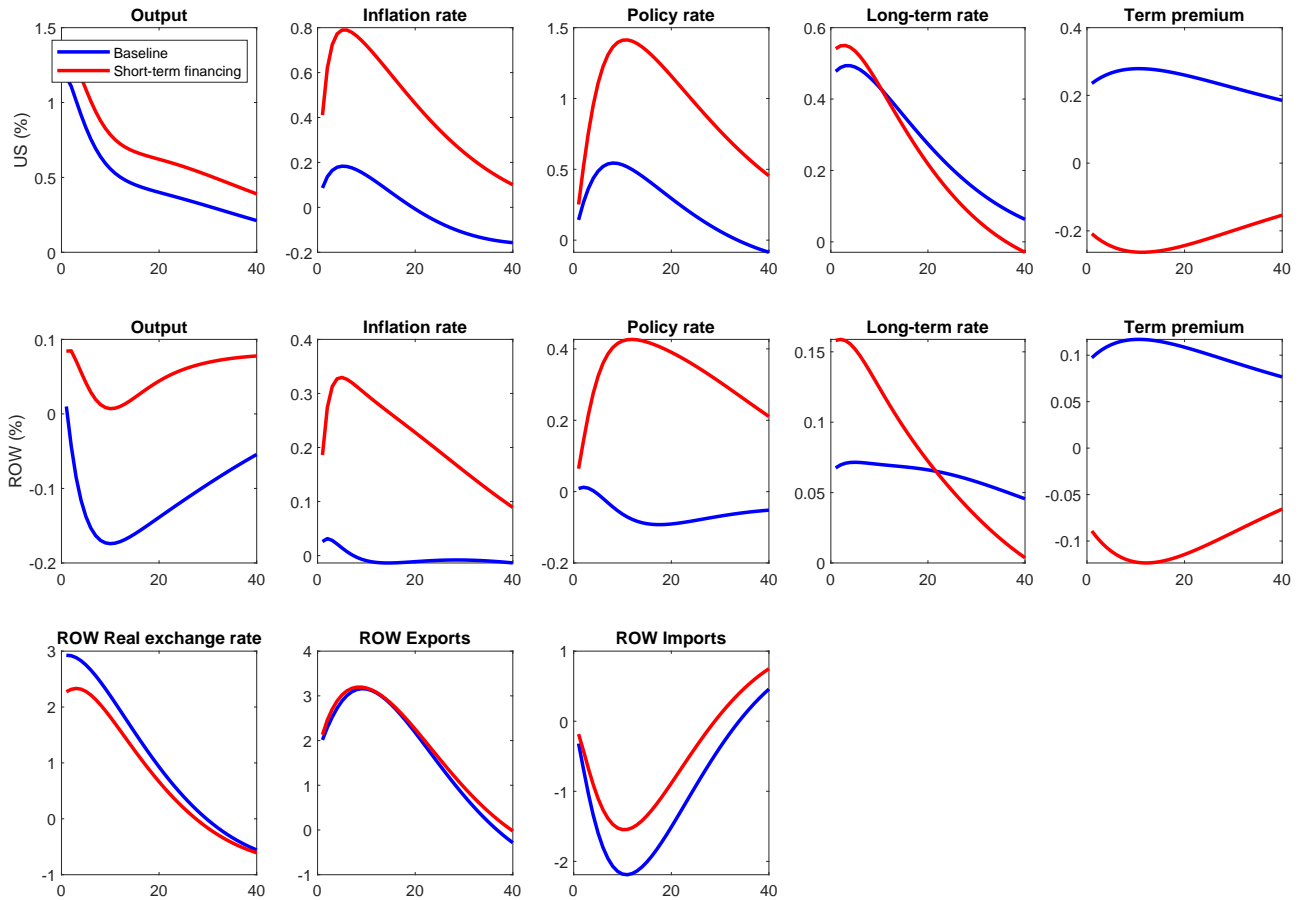
Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in ation, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure C.12: Fiscal spillovers in the case of short-term debt financing: Government investment shock



Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in ation, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.

Figure C.13: Fiscal spillovers in the case of short-term debt financing: Transfer shock



Notes: Impulse responses are presented as percentage deviations (%) from steady-state level for each variable except in ation, policy rate, long-term rate and term premium, for which deviations are presented in percentage points.