Rethinking Multilateral Policy Cooperation in the XXI Century: What do we Know about Cross-border Effects of Fiscal Policy?*

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1 Introduction

There seems little doubt among policymakers that fiscal policy measures are likely to have sizeable international spill-over effects. A least, such a notion seems to have motivated calls for joint fiscal efforts in the context of the global financial crisis—at first to provide fiscal stimulus to a failing global demand, then stressing the need for debt and deficit consolidation measures.[1] Yet, to date, the evidence on the size of international spillovers arising from fiscal measures taken at the national level is in short supply.[2] Moreover, quantitative exercises based on standard models typically predict that cross-border effects are quite contained (see Cwik and Wieland 2010 and Corsetti et al. 2010d). In this paper, we reconsider cross-border spill-overs from fiscal policy from both an empirical and a theoretical perspective. Our empirical analysis allows us to quantify spill-over effects in actual time-series data, but is limited to the extent that we focus on average effects. Our theoretical analysis, instead, allows us to account for varying economic circumstances, and the specific mechanisms through which they operate. Shedding light on these issues is a precondition for rethinking the international dimension of national fiscal policy, and the desirability of cooperative stabilization

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[1] "Our highest priority in Toronto must be to safeguard and strengthen the recovery... We worked exceptionally hard to restore growth; we cannot let it falter or lose strength now. This means that we should reaffirm our unity of purpose to provide the policy support necessary to keep economic growth strong."(US President Obama in a letter to the G20 meeting in June 2010). On the occasion the EU called for unity in retrenchment: "Even though the timing, sequencing and scope of exit measures have to be tailored to conditions prevailing in the individual G20 members, coordination between governments can help to take into account possible spill-over effects."(EU letter to G20)

[2] In an early contribution, Canzoneri et al. (2003) study the effects of US fiscal expansions on selected European countries. Beetsma et al. (2006) provide estimates for spill-over effects within Europe.

strategies.[3]

The first part of the paper is devoted to the empirical analysis. In conducting our study, we take the US as the base country by virtue of their size and role in the world economy, as well as for reasons of data availability. Building on time-series studies on the effects of government spending shocks, we analyze the transmission of fiscal policy innovations originating in the US, on economic activity abroad. We estimate a vector autoregression (VAR) model on quarterly time-series data for the period 1980–2007. As the identification of exogenous shocks to spending in time series models is subject to an ongoing debate, we actually adopt two different identification schemes. The first identification scheme, following Blanchard and Perotti (2002), posits that government spending is predetermined relative to the other variables in the VAR. The second scheme, which follows Ramey (2010), identifies spending shocks by using forecast errors computed on the basis of the Survey of Professional Forecasters. A notable result of our analysis is that, under both schemes, we find similar effects of US government spending shocks on US variables such as output and public debt, which increase significantly. We also find that the identified expansionary shocks are followed by a decline of government spending below trend after the initial increase has been phased out.

Our main result is as follows. Focusing on the EA and the UK as trading partners, our estimates suggest that an increase in US government spending by one percent of US GDP raises output by about 0.5 percent in the EA and by about 1 percent in the UK—with these peak effects occurring after about 2 years. To shed further light on the international transmission, we include in the VAR model variables capturing bilateral trade with the US. In response to an increase in US government spending, the US real exchange rate depreciates strongly irrespectively of which trading partner is considered. While this result conflicts with the received wisdom, it has been documented for the US real effective exchange rate by Kim and Roubini (2008) and a number of other studies. Similarly, we find that net exports in the US tend to rise in response to US spending increases if the trading partner in the analysis is the EA. Against the UK, however, the trade balance initially declines.[4] These findings, robust across identification schemes, pose a challenge to widely held views of how fiscal policy measures are transmitted internationally. At the same time, however, they suggest that sizeable cross-border effects of fiscal interventions—as envisioned in the policy debate—cannot not be ruled out.

In the second part of the paper, we provide a detailed analysis of the international transmission of fiscal policy measures. To this end, we reconsider the workhorse two-country model, borrowed from

[3]Relative to earlier work in Corsetti et al. (2010d), our present contribution is twofold. First, we now provide VAR evidence and perform model simulations with a view towards accounting for the evidence, notably on spill-overs. Second, we provide additional simulation results, notably by considering a crisis scenario captured by a binding zero lower bond on policy rates.

[4]Further VAR analyses of the response of the trade balance in response to fiscal shocks include Kim and Roubini (2008), Corsetti and Müller (2006), Müller (2008) and Beetsma et al. (2008).

the new Keynesian literature. In this model, each country specializes in the production of a specific set of intermediate goods which are consumed by private households and the government. While households act so as to maximize their welfare subject to constraints on prices and wage setting, monetary and fiscal policy are characterized by feedback rules. The specification of the monetary rule is a standard Taylor-type rule. As regards fiscal policy, we model a budget rule allowing for a systematic response of taxes *and* government spending to public debt. In response to an exogenous, debt-financed increase in government spending, this feedback channel induces a spending reversal, i.e., a decline of government spending below trend after the initial increase. In related work of ours, Corsetti et al. (2011), we have already stressed the importance of this modelling approach, providing a detailed analysis of a richer variant of this model with a focus on the domestic repercussions of fiscal innovations in the presence of spending reversals. In the present paper, instead, we are particularly concerned with their international spill-over effects.

Solving the model numerically, we consider two cases which are meant to capture, in a stylized manner, the US-EA and US-UK trade scenario, respectively. For both specifications of the model, we study the dynamic adjustment to an exogenous increase in government spending in the domestic economy. In general, the model does not have an easy time to generate spill-over effects on foreign output which come close to the magnitudes implied by the point estimates obtained from the VAR. Qualitatively, the model predictions align well with the evidence mainly in the presence of spending reversals. Only in this case, we do find the real exchange rate depreciates, and a gradual build-up of foreign activity, in line with our VAR results.

The mechanism through which spending reversals affect demand actually sheds light on a key transmission channel, via changes in financial market conditions triggered by expectations of future fiscal contraction. Specifically, given the monetary and fiscal feedback rules in place, an increase in current government spending triggers expectations of a future spending reversal and reduced real interest rates. Expectations of lower future real rates reduce, all else equal, current long term real rates and progressively so, as the time of the reversal approaches. This stimulates private demand globally and accounts for sizeable international spill-over effect of the fiscal expansion.

As emphasized by recent contributions, the size of the multiplier is significantly larger when monetary policy is constrained at the zero lower bound (ZLB), see e.g. Christiano et al. (2009). We thus extend our analysis of spillovers allowing for the possibility that policy rates in the domestic and/or the foreign economy may not be adjusted for a considerable time period, possibly as a result of binding ZLB constraint. In line with results of Bodenstein et al. (2010), we find that spill-over effects are particularly large if both the domestic and the foreign policy rate may not be adjusted.

These results emphasize the notion that the effects of fiscal policy cannot be ascertained independently of the economic and policy environment in which it is carried out. The implications for policy

design are apparent. For once, the impact on global demand from national fiscal policies, depends not only on the resources mobilized by the government in the short run. It can be boosted by sustainable budget policies aiming at a rapid stabilization of debt dynamics with both tax and spending adjustment can sustain private demand. Moreover, the financial channel through which anticipation of budget stability after expansions operates is active becomes more powerful in large recessions, where the economy is at the zero lower bound (see Corsetti et al. 2010b). The model thus suggests that possible cooperative fiscal policies should focus on both short-run measures and budget consolidation strategies, as joint determinant of the success of stabilization policy.[5]

Of course, even when accounting for the zero lower bound constraint, the workhorse model we use in our analysis does not allow us to explore the fiscal transmission mechanism in the presence of financial and banking crisis — recent evidence suggests that multipliers are large in these specific economic conditions (see e.g. Auerbach and Gorodnichenko (2010) and Corsetti et al. (2010e)). This defines a demanding, but promising area for further research. By the same token, the global financial crisis has shifted the focus towards the assessment and design of design of macro-prudential policies aimed at preventing the emergence of large imbalances and misalignment in goods and assets prices. Currently, most studies focus on the implications for optimal monetary policy design.[6] Similar analyses may be extended to fiscal policy.[7]

2 Time-Series Evidence

In this section we provide time-series evidence on the effects of fiscal shocks. We are primarily interested in the international repercussions of an exogenous change in government spending. In the following we consider shocks to US government spending only, as this allows us to compare results from conceptually distinct identification schemes (see also our discussion in Corsetti et al. (2011)). We focus on the effect of bilateral US trade with the EA and the UK and on output spill-overs in these currency areas in order to contrast the effects for regions which differ substantially in size relative to the US.

[5] While we abstract from default risk considerations in the present paper, the closed economy analysis in Corsetti et al. (2010c) suggests that similar conclusions apply when large deficits raise sovereign risk with spillover effects on private creditors.

[6] Imbalances and misalignment can be ascribed to different types of economic distortions, especially to financial frictions and imperfections. Recent contributions have indeed stressed the consequences of these imperfections for the design of optimal monetary policy (Cúrdia and Woodford 2009 and Woodford 2010). In open economies, cooperative monetary rules, in the form of coordinated flexible inflation targeting rules, trade off domestic objective (inflation and unemployment) with external objectives (see Corsetti et al. 2010a as well as Woodford 2010).

[7] Relative to monetary policy, fiscal policy studies are arguably more complex, in view of the multiplicity of instruments (see Correia et al. (), and/or the relevance of spending on public goods for utility and production.

2.1 Identification and specification

During the last decade, a large number of studies has attempted to characterize the fiscal transmission mechanism through VAR models. Following the seminal paper by Blanchard and Perotti (2002), most studies assume that government spending is predetermined relative to the other variable in the VAR. Under this assumptions innovations to government spending represent exogenous innovations in a recursively estimated VAR model with government spending ordered first. The assumption that government spending is predetermined appears plausible to the extent that government spending does not include transfers and that decisions lags prevent policy makers to respond instantaneously to the state of the economy.

Yet this approach to the identification of government spending innovations is subject to the criticism that changes in government spending, while unrelated to the state of the economy, may still be anticipated by economic agents. This point has been forcefully made, among others, by Ramey (2010). She therefore develops an alternative approach, whereby government spending shocks are identified on the basis of forecast errors. Specifically, Ramey computes the forecast error of quarterly government spending growth on the basis of the survey of professional forecasters maintained at the Philadelphia Fed and includes this measure in the VAR model (ordered first). Its dynamic effects are computed on the basis of impulse response functions implied by a recursively estimated VAR model.

In the following we report results obtained under both identification schemes. We estimate variants of a VAR model on quarterly time series for the period 1980:1–2007:4. Under the Blanchard-Perotti identification scheme the VAR model includes, in each case, four time series: in logs of real, per capita terms, government spending and output, a measure of long-term real interest rates (quarterly percentage points) and public debt (scaled by quarterly GDP). In addition, we include, in each case, the bilateral real exchange rate and, in order to economize on the degrees of freedom, we rotate in a sixth variable. For this we consider, in turn, exports, imports, the trade balance and foreign output. We always consider bilateral data for either the EA or the UK. The VAR model also includes a constant and a linear time trend.

2.2 Results

Results for both identification schemes are displayed in figure 1: the left column ('VAR innovation') shows the results for the Blanchard-Perotti identification scheme, the right column ('Forecast error') shows result for the alternative identification scheme due to Ramey (2010).[8] In both cases, the size of the shock is normalized so that government spending increases by one percent of GDP on impact. The solid lines display point estimates, while the shaded areas indicate 90 percent confidence

[8] In this figure we show results pertaining to US variables obtained from a six-variable VAR which also includes the US-EA exchange rate and EA output.

bounds obtained by bootstrap sampling. The horizontal axis measure quarters. Output and government spending are measured in output units, so that the response of output provides a direct measure of the government spending multiplier on output. The long term real interest rate is measured in quarterly percentage points, while public debt is measured relative to quarterly GDP.

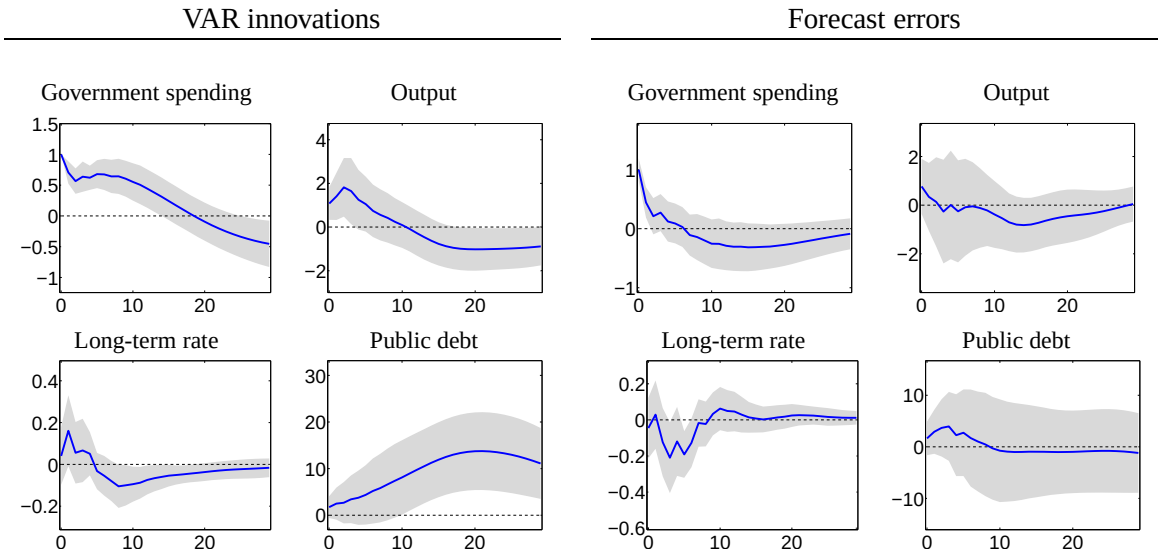

Figure 1: Effects of US government spending shock on US variables. Notes: left column shows results for Blanchard-Perotti identification scheme, right column shows results for forecast error identification scheme. Shock is normalized so that government spending increases by one percent of GDP on impoact. Horizontal axis measures quarters. Solid lines display point estimates, shaded areas indicate 90 percent confidence bounds. Output and government spending are measured in percent of trend output, long-term rate measures the long-term real interest rate in quarterly percentage points, public debt is measured relative to quarterly GDP.

A first observation concerns differences across identification schemes: although the responses differ quantitatively, the overall pattern in remarkably similar.[9] Government spending, displayed in the first row, increases on impact, but the increase shows limited persistence. Moreover, under both identification schemes, government spending tends to undershoot is long-run trend, although this happens early under the identification scheme based on forecast errors (see Corsetti et al. 2011). The responses of output are positive on impact under both identification schemes. However, while output displays a hump-shaped adjustment path under the identification scheme based on VAR innovations, its response is much more short-lived in case we use forecast errors to identify government spending shocks. Regarding long-term real interest rates, we find a decline in the medium term following the shock. Finally, we find that public debt rises strongly under both identification schemes, although the response is barely significant under the forecast error approach.

[9]Ramey (2010) stresses differences, notably in the responses of consumption and the real wage. We do not include these variables in our model. Corsetti et al. (2011) provide a more detailed discussion of similarities and differences across both

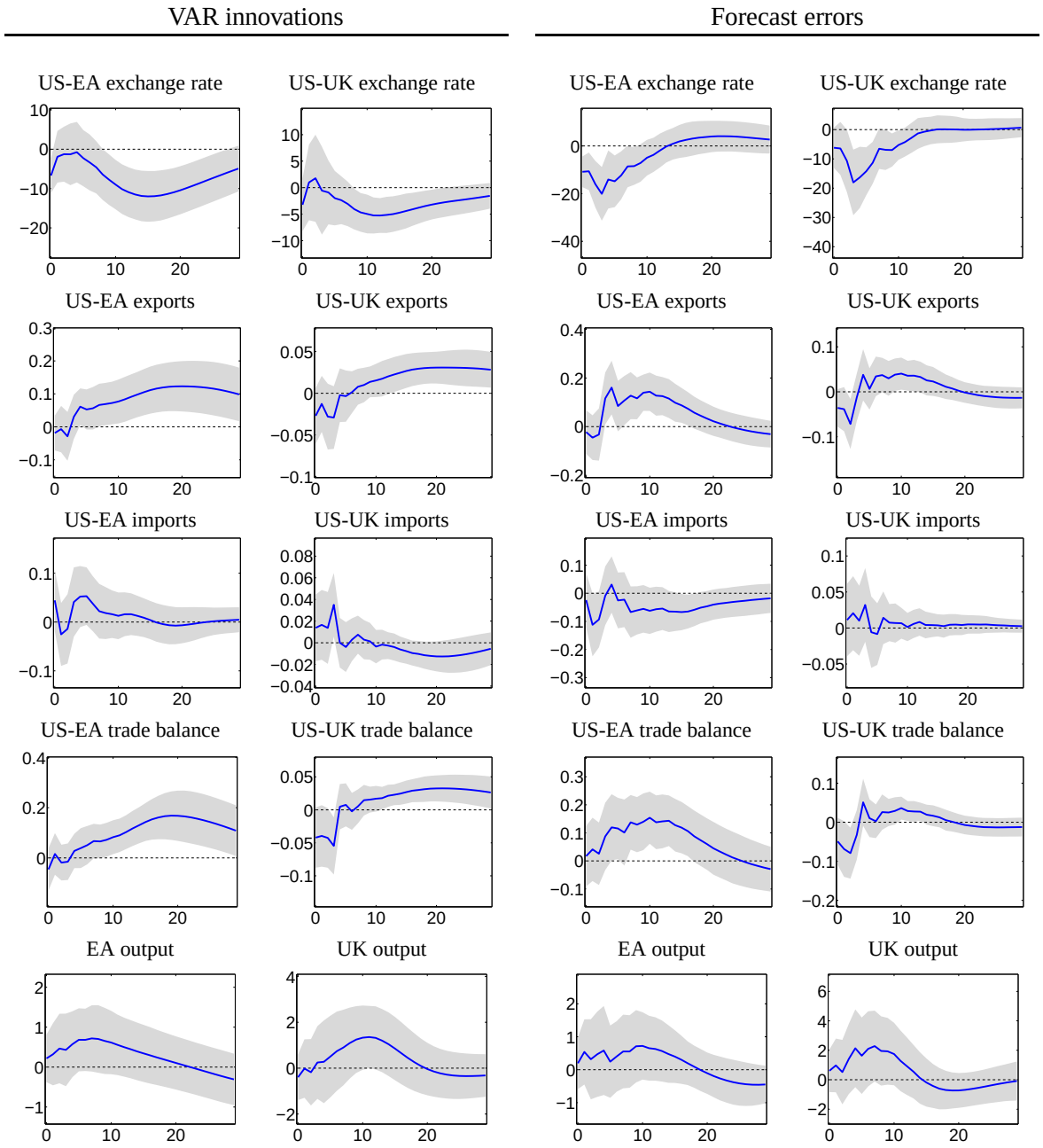

Figure 2: Effects of US government spending shock on bilateral trade with EA and UK and with EA and UK output. Notes: see figure 1; except for EA and UK output (measured in percentage deviation from trend), variables pertain to the US and are measured in bilateral terms in percent of US trend output.

Figure 2 shows results for variables which are meant to capture the effect of the US government spending innovation on bilateral trade with both the EA and the UK. Note that these responses have

identification schemes.

been computed, for each of the two trading partners, by rotating-in as sixth variable, one variable at a time, while the real exchange rate has been included in the VAR model throughout. The trade variables pertain to bilateral US variables and are measured in percent of US trend output. Output for the EA and the UK are measured in percentage deviation from trend. The first row shows the response of the bilateral real exchange rate, which depreciates sharply and strongly, showing a hump-shaped adjustment path. Although puzzling in light of the received wisdom, similar results have been documented for the US real effective exchange rate by Kim and Roubini (2008) and several subsequent studies.

The second row displays the dynamics of US exports. They hardly move on impact, but start to increase subsequently. Overall, the increase is moderate, reaching a peak of about 0.15 and 0.05 percent of US output for the EA and UK as trading partner, respectively. The response of imports is shown in the third line. Here the sign of the responses differs somewhat across identification schemes, but the responses are quite contained and barely significant in both cases. The US trade balance with the EA, in turn, shown in the fourth row, moves quickly into surplus after an initial period of one or two quarters. This finding, while again in conflict with the received wisdom on "twin deficits", is in line with earlier studies (see Kim and Roubini (2008), but also Corsetti and Müller (2006) and Monacelli and Perotti (2006) for different findings for alternative specifications and different samples). Finally in the last row of figure 2, we display the impulse response of EA and UK output. It shows it shows a gradual, but sizable build-up reaching at least 0.5 and 1 percent of EA and UK output, respectively, although the response is only marginally significant.[10]

Note that, by and large, we find very similar results, both across identification schemes and irrespectively of whether we consider bilateral US-EA or US-UK trade. Some country differences appear notably, though: the response of US imports from the UK is positive on impact. Also, the responses of exports and imports, as well as the trade balance are smaller in the UK case. UK output, in contrast, responds more strongly to the increase in US government spending. Yet it displays an adjustment patter which is quite similar to that of EA output.

3 Theory

In the following, we outline a standard two-country business cycle model to analyze key features of the international transmission mechanism. The model is a simplified version of the model developed in Corsetti et al. (2011), as we do not distinguish explicitly between private consumption and investment demand. We now turn to a brief description of the model, followed by a discussion of

[10] In an early VAR analysis, Canzoneri et al. (2003) while employing a variant of the Blanchard-Perotti identification scheme, also find a delayed, but sizeable increase in French, Italian and British output in response to US fiscal expansions. Beetsma et al. (2006) combine a VAR model with an estimated trade equation for European countries and find sizeable output spillovers from shocks to German and French government spending.

the equilibrium relationships which are pivotal to the international transmission mechanism. We also provide a brief discussion of the model parameterization before discussing simulation results.

3.1 Model outline

There are two countries, referred to as H (Home) and F (Foreign), each producing a variety of country-specific intermediate goods, with the number of intermediate good producers normalized to unity. A fraction n of firms is located in Home, the remaining firms $(n, 1]$ is located in Foreign. Analogously, Home accounts for a fraction $n \in [0, 1]$ of the global population. Intermediate goods are traded across borders, while final goods, which are bundles of intermediate goods, are not. Prices of intermediate goods are sticky in producer-currency terms. Households supply labor services only within the country where they reside, but trade a complete set of state-contingent assets internationally. Like prices, wages are also adjusted infrequently. Below, we focus our exposition on Home. When necessary, we refer to foreign variables by means of an asterisk.

3.1.1 Household and firms

Households supply differentiated labor services. Within each country, they are indexed according to labor types on the unit interval as in Erceg et al. (2000). Households engage in monopolistic competition, but their ability to set wages is restricted: in each period only an exogenously determined fraction $(1 - \xi_W)$ of households may adjust their wage. Differentiated labor services $H_t(h), \in [0, 1]$ are bundled into aggregate labor services according to the following technology

$$H_t = \left(\int_0^1 H_t(h)^{\frac{\nu-1}{\nu}} dh \right)^{\frac{\nu}{\nu-1}}. \tag{1}$$

Letting $W_t(h)$ denote the wage rate for labor services of type h, the unit cost of domestic labor services, i.e. the aggregate wage index, is given by

$$W_t = \left(\int_0^1 W_t(h)^{1-\nu} dh \right)^{\frac{1}{1-\nu}}. \tag{2}$$

Optimal bundling of differentiated labor services implies the demand function

$$H_t(h) = \left(\frac{W_t(h)}{W_t} \right)^{-\nu} H_t. \tag{3}$$

Households consume a bundle of intermediate goods, which are assembled in order to minimize expenditures given an a specific aggregation technology. Let A_t and B_t denote bundles of domestically produced and imported intermediate goods, respectively, the consumption bundle is defined as follows

$$C_t = \left[(1 - (1-n)\omega)^{\frac{1}{\sigma}} A_t^{\frac{\sigma-1}{\sigma}} + ((1-n)\omega)^{\frac{1}{\sigma}} B_t^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{1-\sigma}}, \tag{4}$$

$$C_t^* = \left[(n\omega)^{\frac{1}{\sigma}} (A_t^*)^{\frac{\sigma-1}{\sigma}} + (1 - n\omega)^{\frac{1}{\sigma}} (B_t^*)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{1-\sigma}}, \tag{5}$$

where σ measures the terms of trade elasticity of the relative demand for domestically produced goods, and $\omega \in [0,1]$ provides a measure for home bias.[11]

The bundles of domestically produced and imported intermediate goods, in turn, are defined as follows

$$A_t = \left[\left(\frac{1}{n}\right)^{\frac{1}{\epsilon}} \int_0^n A_t(j)^{\frac{\epsilon-1}{\epsilon}} dj\right]^{\frac{\epsilon}{\epsilon-1}}, \quad B_t = \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\epsilon}} \int_n^1 B_t(j)^{\frac{\epsilon-1}{\epsilon}} dj\right]^{\frac{\epsilon}{\epsilon-1}}, \tag{6}$$

where $A_t(j)$ and $B_t(j)$ denote intermediate goods produced in H and F, respectively, and ϵ measures the elasticity of substitution between intermediate goods produced within the same country.

Letting $P(j)$ denote the price of an intermediate good expressed in domestic currency and $\mathcal{E}_t$ the nominal exchange rate (the price of domestic currency in terms of foreign currency) we assume that the law of one price holds, so that $P^*(j) = \mathcal{E}_t P(j)$. Price indices are given by

$$P_{At} = \left[\frac{1}{n}\int_0^n P_t(j)^{1-\epsilon} dj\right]^{\frac{1}{1-\epsilon}}, \quad P_{Bt} = \left[\frac{1}{1-n}\int_n^1 P_t(j)^{1-\epsilon} dj\right]^{\frac{1}{1-\epsilon}}, \tag{7}$$

$$P_t = \left[(1-(1-n)\omega)P_{At}^{1-\sigma} + ((1-n)\omega)P_{Bt}^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \tag{8}$$

$$P_t^* = \left[n\omega\left(P_{At}^*\right)^{1-\sigma} + (1-n\omega)\left(P_{Bt}^*\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \tag{9}$$

and $Q_t = P_t\mathcal{E}_t/P_t^*$ measures the real exchange rate.

Given the above definitions and results, the household's utility functional is given by

$$E_t \sum_{s=0}^{\infty} \beta^s \left(\ln C_{t+s}(h) - \vartheta \frac{H_{t+s}(h)^{1+\varphi}}{1+\varphi}\right), \tag{10}$$

where β is the discount factor, ϑ is a constant determining labor supply in steady state, and φ is the inverse of the Frisch elasticity of labor supply.

For the baseline scenario, we assume that households trade a complete set of state-contingent securities. Let $\Xi_{t+1}(h)$ denote the payoff in units of currency H in period $t+1$ of the portfolio held by household h at the end of period t. With $\rho_{t,t+1}$ denoting the stochastic discount factor, the budget constraint of the household is given by

$$W_t(h)H_t(h) + R_tK_t(h) + \Upsilon_t - T_t - P_t(C_t(h) + X_t(h)) = E_t\left\{\rho_{t,t+1}\Xi_{t+1}(h)\right\} - \Xi_t(h), \tag{11}$$

where T_t and Υ_t denote lump-sum taxes and profits of intermediate good firms, respectively. Both are levied/distributed equally across households.

[11] This specification follows Sutherland (2005) and De Paoli (2009). With $\omega = 1$, there is no home bias: if the relative price of foreign and domestic goods is unity, the fraction of domestically produced goods which ends up in the consumption bundle is equal to n, while imports account for a share of $1-n$. Importantly, consumption goods are identical across countries in this case. A lower value of ω implies that the fraction of domestically produced goods in consumption goods exceeds the share of domestic production in the world economy. If $\omega = 0$, there is no trade in goods across countries.

Under complete financial markets, households fully insure against the idiosyncratic income risk that results from their limited ability to adjust wages in each period. Households are, therefore, homogeneous with respect to consumption and asset holdings. By contrast, households are heterogeneous with respect to labor supply as a result of infrequent wage adjustments. Given the household's marginal utility of nominal income, Λ_t, a household that is allowed to reoptimize its wage sets $\tilde{W}_t(h)$ to meet the following objective

$$\max E_t \sum_{s=0}^{\infty} (\beta \xi_W)^s \left[\Lambda_{t+s} H_{t+s}(h) \tilde{W}_t(h) - \vartheta \frac{H_{t+s}(h)^{1+\varphi}}{1+\varphi} \right], \tag{12}$$

subject to the demand for its labor service (3).

Producers of differentiated intermediate goods engage in monopolistic competition. The production function is given by $Y_t(j) = H_t(j)$, where $H_t(j)$ denotes domestic labor services employed by firm $j \in [0, n]$ in period t. We assume that prices are set in the currency of the producer and that price setting is constrained exogenously à la Calvo, so that in each period only a fraction of intermediate good producers $(1 - \xi_P)$ may adjust its price. When firm j has the opportunity, it sets $\tilde{P}_t(j)$ to maximize the expected discounted value of net profits:

$$\max E_t \sum_{s=0}^{\infty} \frac{\xi_P^{t+s} \rho_{t,t+s} Y_{t+s}^D(j)}{P_{t+s}} \left[\tilde{P}_t(j) - W_{t+s} \right] \tag{13}$$

subject to demand $Y_t^D(j)$.

3.1.2 Fiscal and monetary policy

Government consumption is financed either through lump-sum taxes, T_t, or through the issuance of nominal debt, D_t, denominated in domestic currency. The period budget constraint of the government reads as follows

$$\frac{D_{t+1}}{1+i_t} + T_t = D_t + G_t, \tag{14}$$

where $(1 + i_t)$ is the gross return on a one-period nominally riskfree bond, which is equal to $1/E_t \rho_{t,t+1}$; G_t denotes government spending which, under the baseline scenario, is a bundle isomorphic to private consumption, except that it falls only on domestically produced goods—reflecting the observation that the import content in government spending is considerably lower than in private spending (e.g. Corsetti and Müller 2006).

Define $D_{Rt} = D_t/P_{t-1}$ as a measure for real beginning-of-period debt, and $T_{Rt} = T_t/P_t$ as taxes in real terms. Letting variables without time subscript refer to steady-state values, we specify the following feedback rules

$$G_t = (1-\rho)G + \rho G_{t-1} - \psi_G D_{Rt} + \varepsilon_t, \;\; T_{Rt} = \psi_T D_{Rt}, \tag{15}$$

where ε_t represents an exogenous iid shock to government spending. The ψ-parameters, which we posit to be non-negative throughout, capture a systematic feedback of public debt on government spending (negative) and taxes (positive). We assume that either parameter is sufficiently large to ensure the non-explosiveness of public debt. For instance, if $\psi_G = 0$ we posit that taxes are raised sufficiently strongly in response to higher outstanding debt. Note, however, that $\psi_G = 0$ implies Ricardian equivalence, so the specific time path of taxes, for a given time path of government spending, is irrelevant for the real allocation in the economy. This assumption is frequently made in analyses of fiscal transmission; by relaxing the assumption and allowing for a feedback channel from debt to government spending, we allow for richer and more realistic dynamics in the model economy.

Turning to monetary policy, we assume flexible exchange rates and specify policymaking by means of an interest rate feedback rule:

$$\ln(1 + i_t) = \phi_{\Pi} \Pi_{At}, \tag{16}$$

where $\Pi_{At} = P_{At}/P_{At-1}$ measures domestic (producer price) inflation.

3.2 Useful equilibrium relationships

In what follows, we consider a linear approximation of the model's equilibrium conditions around a deterministic steady state in which government debt and inflation are zero and trade is balanced. We use small letters to denote deviations from steady state. In this subsection, we highlight a few equilibrium relationships which are critical in shaping the international transmission mechanism. First, private expenditure is governed by the Euler equation, which, solving forward and assuming a stationary economy, implies

$$c_t = \frac{1}{\gamma} \sum_{k=0}^{\infty} \underbrace{(r_{t+k} - \pi_{t+1+k})}_{\equiv rr_{t+k}}, \tag{17}$$

i.e., the current level of consumption demand (in terms of deviations from steady state) depends on the entire path of future short-term real interest rates. The latter is, by the expectations hypothesis, equivalent to the real rate of return on a bond of infinite duration (see, for example, Woodford 2003, p. 244).

As stressed in Corsetti et al. (2011), movements in long-term interest rates are at the heart of the transmission mechanism through which fiscal and monetary policy influence aggregate demand. Long-term rates reflect not only the current stance of policies, but also expectations about their future course. As such, they telescope anticipated future policy stances into today's financial conditions, unfolding immediate macroeconomic effects. By way of example, if households come to expect tight fiscal policy over the medium run, they anticipate correspondingly lower future policy rates. These translate, all else equal, into an upfront drop in long-term rates, boosting current consumption.

The opposite is true if households anticipate a combination of loose fiscal and tight monetary policy. Moreover, the differential of long-term real interest rate is tightly linked to the behavior of the real exchange rate: the price for Home consumption is appreciated relative to Foreign consumption, whenever long-term rates at home exceed those abroad (see Corsetti et al. 2011).
For our discussion below, is will turn to be instructive to rewrite the short-term real interest rate as follows

$$\begin{aligned} rr_t &= i_t - E_t\pi_{t+1} = i_t - ((1-(1-n)\omega)E_t\pi_{A,t+1} + (1-n)\omega E_t\pi_{B,t+1}) \\ &= (1-(1-n)\omega)(i_t - E_t\pi_{A,t+1}) + (1-n)\omega\left(i_t^* - E_t\pi_{B,t+1}^*\right). \end{aligned} \tag{18}$$

The short-term real interest rate is thus a weighted average of the difference between the Home policy rate and Home domestic inflation relative to the same difference in Foreign. This relationship illustrates to what extent the monetary policy stance abroad feeds into short-term real interest rate. By the same token, future monetary and fiscal policy abroad may play an important role for domestic long-term real interest rates. The relative weight of foreign policy on domestic rates is determined by $(1-n)\omega$, which reflects the average import share in consumption and thus the openness of the economy.

3.3 Parameterization

In order to solve the model numerically, we assign parameter values. A period in the model corresponds to one quarter. Accordingly, we set $\beta = 0.99$. For the Frisch elasticity of labor supply we assume a value of one-third by setting $\varphi = 3$; see Domeij and Flodén (2006) for recent evidence. Given these assumptions, we set ϑ to ensure that agents spend on average one-third of their time endowment working. The trade price elasticity σ is set equal to 0.5 in the baseline scenario, a value in the (admittedly wide) range considered in the recent macroeconomic literature; see Corsetti et al. (2008) for further discussion. Regarding γ, the coefficient of relative risk aversion, we assume a value of 0.26, in line with the estimates of Amato and Laubach (2003), but somewhat higher than the estimates by Rotemberg and Woodford (1997). This implies nevertheless a fairly high value for the intertemporal elasticity of substitution (IES) of private expenditure, as we do not model private investment explicitly. Nominal rigidities play a key role in the transmission of government spending shocks. We assume that $\xi_P = 0.66$, implying an average price duration of three quarters—within the range of values discussed, for example, by Nakamura and Steinsson (2008). Regarding wage rigidities we set $\xi_W = 0.75$ so that the average wage duration is four quarters. For monetary policy we assume $\phi_\pi = 1.5$.
The steady-state output share of government spending is assumed to be 20 percent. The parameter ρ is set to 0.9, capturing the persistence of government spending deviations from trend documented

by many VAR studies on US data. In our baseline scenario we set $\psi_G = \psi_T = 0.02$, implying a systematic feedback from higher public debt to government spending and taxes. These parameter values not only ensure debt-stabilizing fiscal policy over time, but also assign some role in this to spending restraint. Specifically, an initial increase in government spending would be followed after some time by a fall in spending below trend, in line with the VAR evidence.[12]

Finally, we consider two distinct trade scenarios which are meant to capture bilateral trade relationships between the Home, say the US, and a slightly smaller Foreign, say the EA; in this case we set $n = 0.57$. On the other hand, we consider the possibility of trade with a much smaller foreign country, say the UK; in this case we set $n = 0.85$. In both cases, we set ω to target the import share of the foreign country, i.e., 19 and 28 percent, respectively (this implies an import share in Home of 14 and 4 percent, respectively).[13]

3.4 Simulation results

Figure 3 shows results for the baseline scenarios, displaying the impulse responses of selected variables to an exogenous increase in government spending in Home. Time is measured on the horizontal axis in quarters. The responses of quantities are measured in percent of domestic output. An exception is foreign output, which measured is in percent of foreign output. The real exchange rate is measured in percentage deviations from steady state. The lines with circles (blue) reflect results for the US-EA trade scenario ($n = 57$ and an import share in Foreign of 19 percent). Lines with crosses reflect results for the US-UK trade scenario ($n = 85$ and an import share in Foreign of 28 percent).

Overall, the predictions of the model are broadly in line with the VAR evidence discussed above. Government spending increases initially, but tends to undershoot its long-run (steady-steady) state level considerably (spending reversals). Meanwhile there is a sizeable and hump-shape build-up of public debt in Home. Home output increases sizably, with an impact response of somewhat below unity. Home consumption, instead, shows a hump-shaped increase with a peak response after about 0.3 percent of output after about 8 quarters.

Conversely, the real exchange rate declines (depreciates) on impact and continuous to decline for an

[12] Using annual observations to estimate spending and tax rules, Galí and Perotti (2003) report estimates for the coefficient on debt ranging from -0.04 to 0.03 for government spending, and from 0 to 0.05 for taxes, in a panel of OECD members (no breakdown by country provided). For the U.S., Bohn (1998) reports estimates for the response of the *surplus* to debt in a range from 0.02 to 0.05. To see that our parameter choice ensures the solvency of the government—fiscal policy is 'passive' in the sense of Leeper (1991)—consider a linear approximation of the equilibrium conditions around the steady state: abstracting from autocorrelation of government spending and assuming an 'active monetary policy', debt stability holds if $1 - \psi_G - \psi_T < \beta$.

[13] Under these assumptions spill-overs will turn out to be fairly large. An alternative approach would be to set the import share in home country so as to account for EA and UK imports in the US (about 2 and 1 percent, respectively). In this case, spill-over effects are virtually zero and possibly understate the actual effect, as spill-overs from the US to the EA or the UK are likely to be transmitted through third countries such that the overall openness of the EA and the UK seems necessary to be accounted for.

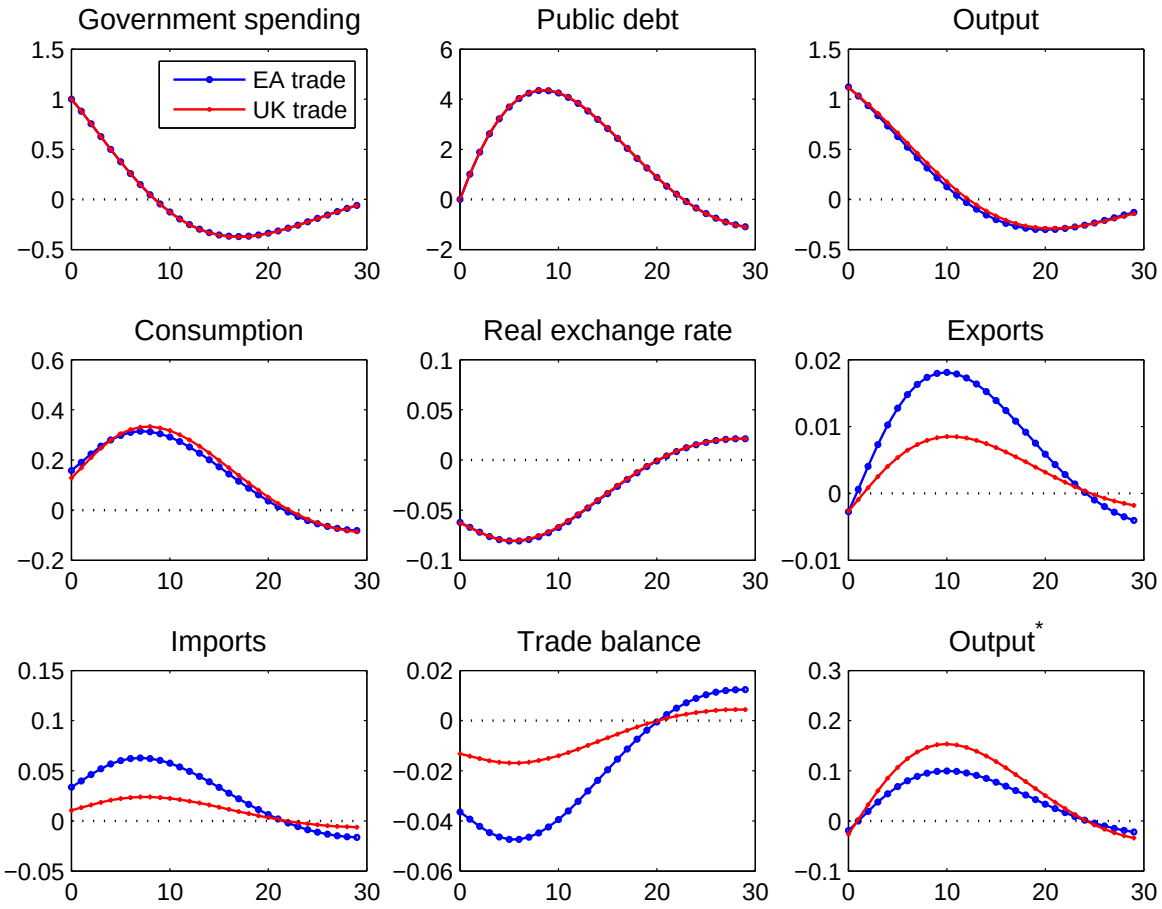

Figure 3: Effects of government spending shock in Home: baseline scenario (for given country size n, ω is set to target import share of EA (19 percent) and UK (28 percent), see blue lines with circles and red line with crosses, respectively). Notes: all variables pertain to Home (US) and are measured in output units, except for Output*. The real exchange rate is measured in percentage deviations from steady state.

extended period. Quantitatively, its decline is contained relative to what we found in the VAR model. Home exports fall briefly in response to the innovation, but then move gradually into positive territory. Quantitatively, the responses are quite moderate. Home imports, in turn, increase sizably on impact and return gradually to steady state. The Home trade balance moves into a deficit for the first ten quarters, but improves quickly. A small trade surplus emerges in Home after about 4-5 years. Finally, there while on impact Foreign output is basically flat, it starts to rise gradually and reaching a peak after about 10 quarters.

A few comments are in order. First, the responses pertaining to domestic developments in Home are virtually identical in both trade scenarios. There are differences in the response of trade variables, however. Home exports and imports, as well as the trade balance tend to respond more strongly in the US-EA trade scenario. Foreign output, in contrast, increases more strongly in the US-UK scenario. These findings line up rather well with the time-series evidence provided above. We note, however, that international spill-overs on foreign activity are small relative to what we found in the VAR model (as far are peak responses are concerned). Also the pattern of the Home trade balance in case the EA is considered as a trading partner is quite distinct from what we documented within the VAR model.

In a first step towards understanding these results, we consider, in figure 4, the impulse responses of the same variables, but contrast the responses for the US-EA trade scenario (blue lines with circles) with the responses obtained under the assumption that government spending falls on domestic and foreign produced goods (black lines with diamonds) and under the assumption that the import share in Home is 2 percent only, corresponding to the average import share of EA imports in US GDP; the import share in Foreign is 2.6 percent in this case (red line with crosses).

Under these alternative assumptions trade variables respond quite differently, at least from a quantitative point of view. Consider first the case of a lower import share. In this case there is virtually no effect of in Home trade, once it is measured in terms of Home output. Foreign output also appears basically unaffected from the fiscal expansion in Home. If, instead, the import share is left unchanged relative to the baseline scenario, but we assume that government spending falls on goods produced in Home *and* Foreign, spill-over effects are quite a bit stronger. Notably, the impact response of Home imports, the Home trade balance and Foreign output is much stronger than in the baseline scenario. Clearly, this reflects the direct effect of increased government spending in Home on goods produced abroad.

As we are particularly interested in the determinants of international spill-overs, it is appropriate to provide a more detailed account on the adjustment process in Foreign in response to the Home fiscal expansion under our baseline scenario. Figure 5 thus shows, in addition to Foreign output, the response of foreign consumption and the foreign trade balance. As our baseline scenario assumes a relatively small value for the trade price elasticity, we also report responses assuming higher values for

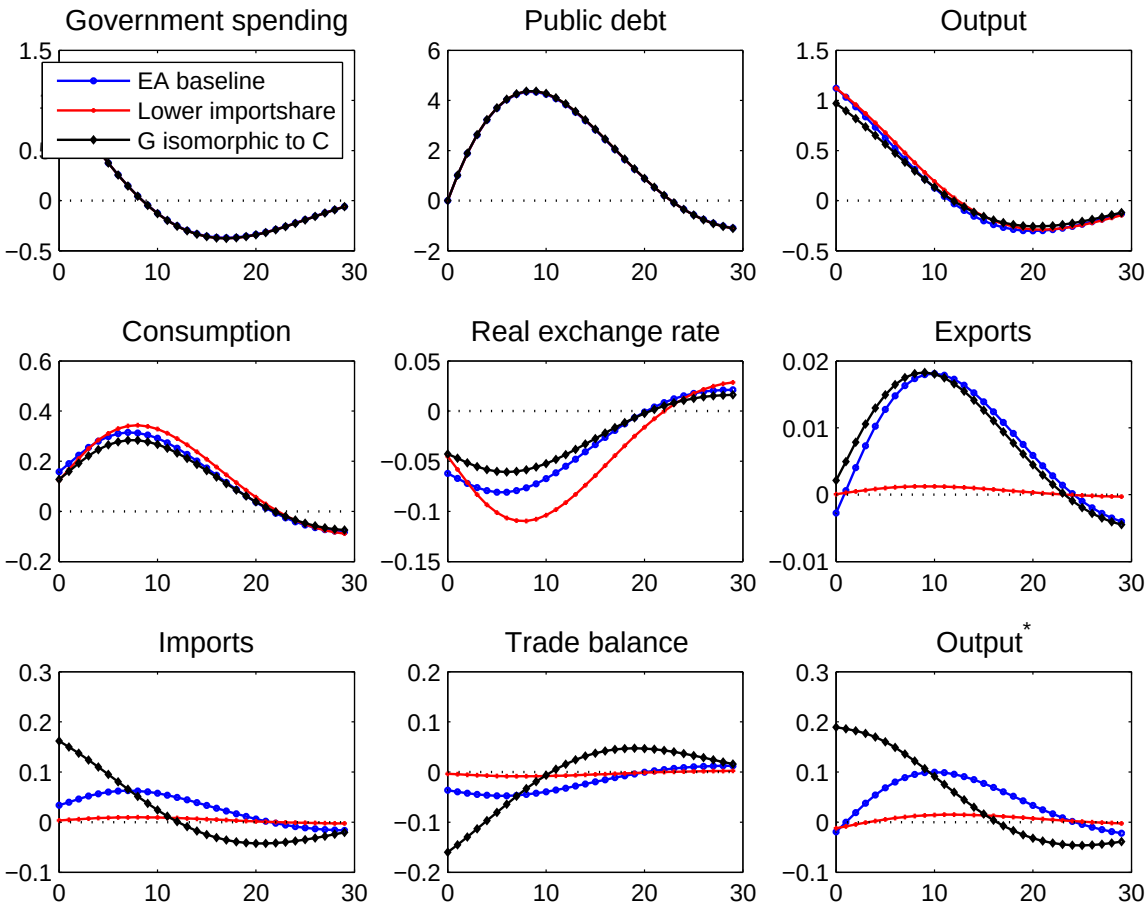

Figure 4: Effects of government spending shock in Home: baseline scenario for trade with EA (blue lines with circles) vs scenario where government spending falls on domestic and foreign goods (black lines with diamonds) and scenario where imports in Home account for 2 percent of GDP (red lines with crosses). Notes: see figure 3.

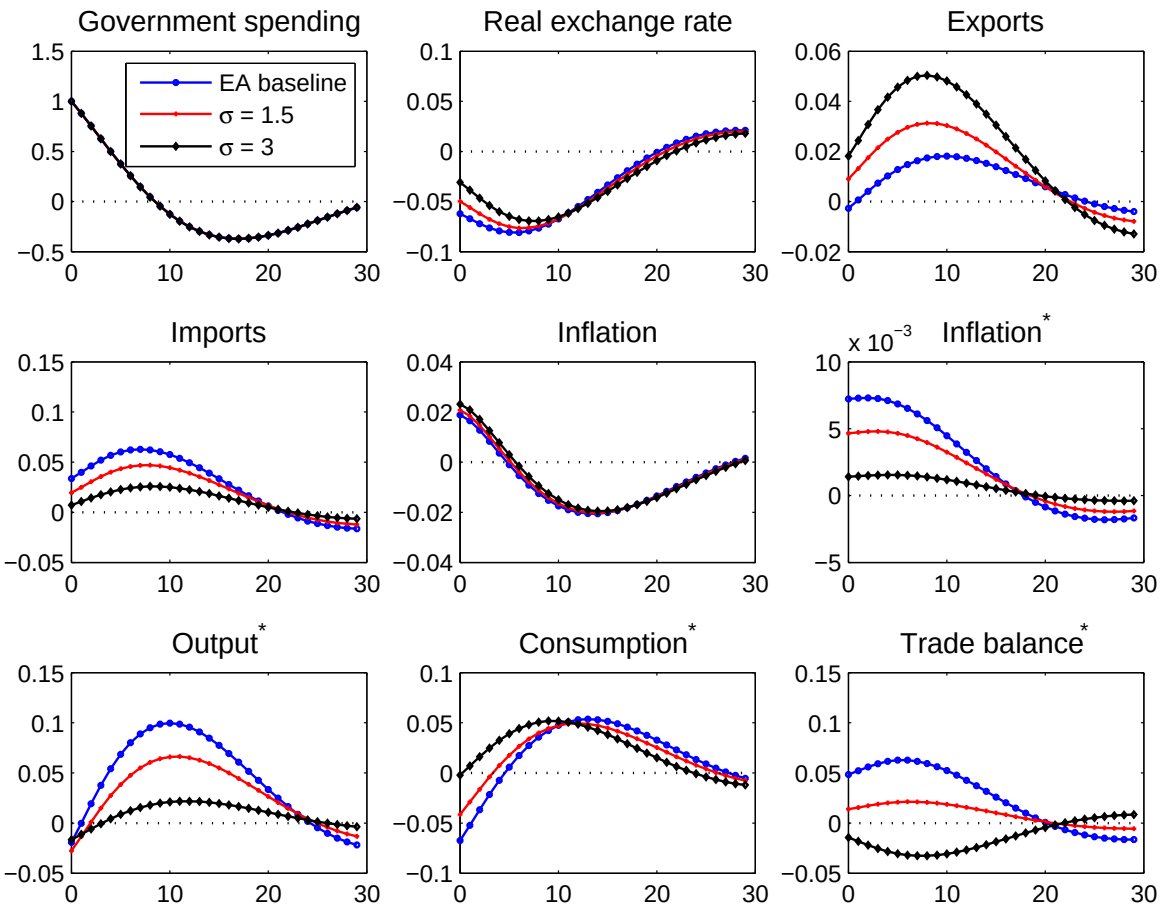

Figure 5: Effects of government spending shock in Home: baseline scenario for trade with EA (blue lines with circles) vs scenario with $\sigma = 1.5$ (red lines with crosses) and $\sigma = 5$ (black lines with diamonds). Notes: see figure 3.

$\sigma = \{1.5, 5\}$, displayed by the red lines with crosses and the black lines with diamonds, respectively. We find that these alternative assumptions alter the model's prediction as far as spill-over effects are concerned. As the real exchange depreciates, demand shifts, all else equal, towards goods produced in Home. This is reflected by rising Home exports. This effect is stronger, the stronger the trade price elasticity. For high values of this elasticity, the increase in Home exports dominates the increase in Home imports (which is due to an increased level of Home activity), such that the Foreign trade balance moves into a deficit. As a result, spill-overs from the Home fiscal expansion on Foreign output are weaker relative to the baseline scenario.

At the same time, these experiments make clear that spill-over effects do not operate merely through the trade balance. Instead, as expressions (17) and (18) also illustrate, the level private expenditures is tightly linked to the long-term real interest rate, which reflects the entire path of future short-term real rates. These, in turn, are related to the dynamics of domestic (producer price) inflation in Home *and* Foreign and the resulting adjustment in policy rates through the central bank. As a result of spending reversals, private agents expect a decline in domestic inflation in Home and—provided a monetary stance prescribed by the interest rate feedback rule—a fall in short term real rates (see Corsetti et al. 2011 for a detailed discussion) . This, all else equal, lowers the long-term real interest rate and the more so, the closer in time the expected reversal is phased-in.

Taking the perspective of Foreign, the dynamics of Home inflation and Home monetary policy have a direct bearing on the long-term real interest rate. In fact, the strength with which the expected decline in both—due to the reversal of Home government spending—makes itself felt in Foreign depends on the openness of Foreign, i.e. the weight of goods produced abroad within Foreign's consumption basket. It is through this *financial channel*, that fiscal policy generates sizeable international spill-over effects: as the long-term rate falls gradually over time, in line with the approaching reversal, the dynamic adjustment of private expenditure in Foreign follows an inversely shaped pattern. Clearly, openness also magnifies the strength of the *trade channel*. In our baseline scenario, the trade channel initially produces positive spill-over effects. This, in turn, raises inflation and the policy rate in Foreign. As a result, consumption falls initially. It recovers and increases relative to steady state as positive spill-over effects through the financial channel gradually gain weight.

3.5 The policy framework

So far, we have discussed simulation results against the background of the VAR evidence, which captures the average effect of government spending innovations over the entire sample period. We have shown that the model predictions align well with the evidence along various dimensions and identified dimensions in which the model fails quantitatively. In doing so, we have also identified channels through which domestic fiscal policy measures are likely to spill over onto other countries.

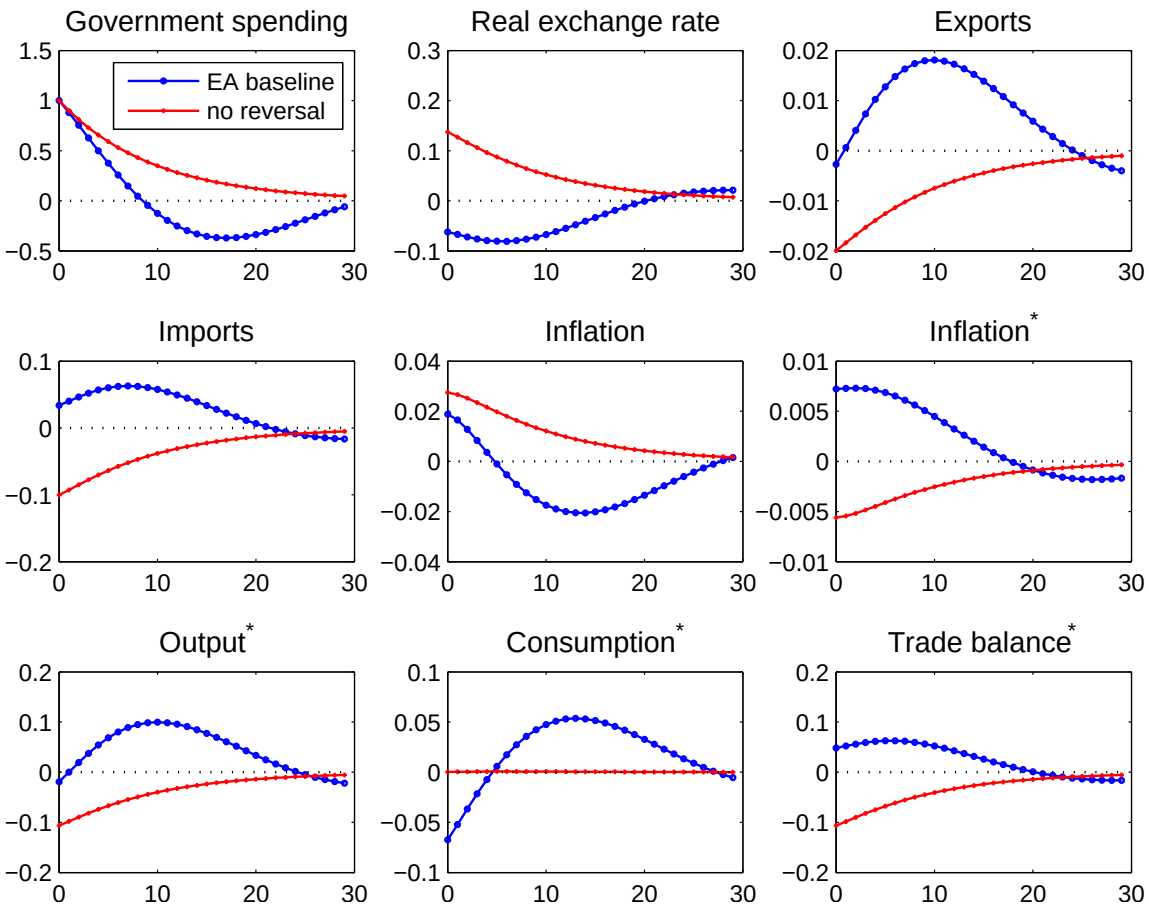

Figure 6: Effects of government spending shock in Home: baseline scenario for trade with EA (blue lines with circles) vs scenario without spending reversal (red lines with crosses). Notes: see figure 3.

Specifically, for our baseline calibration the financial channel turns out to be responsible for an hump-shaped increase of Foreign output in response to a Home fiscal expansion, reflecting the dynamics of long-term real interest rates. These dynamics, i.e. the fact that long-term real interest decline in response to a fiscal innovation is a result of our assumption of a policy framework which gives rise to spending reversals (see Corsetti et al. 2011). In the following, we highlight the role of the policy framework by displaying, in figure 6, the dynamic adjustment to a Home fiscal expansion under the assumption that government spending follows an exogenous AR(1) process, as is commonly done in the literature ($\psi_G = 0$).

The difference in the dynamic adjustment across the two specifications is quite pronounced. For once, in the absence of a spending reversal the real exchange rate appreciates (see Corsetti et al. 2011). Moreover, Home consumption (not shown) declines, because long-term real rates in Home increase (not shown). This leads to a fall in Home imports, but as Home exports also fall in response to the appreciation, the Home trade balance (not shown) improves. Conversely, the trade balance in Foreign declines which accounts for the fall in inflation and, hence, the policy rate in Foreign (not shown). Yet, as the Home interest rate increases throughout, there is no stimulating effect on Foreign consumption through the financial channel in the absence of reversal. For our parameterization, Foreign consumption is virtually flat. Overall, the spill-over on Foreign output is thus negative in the absence of a Home spending reversal.

It is important to stress that the spending reversal exerts a stimulating effect on global private expenditure only to the extent that it is accommodated by Home monetary policy. Only because the anticipated reversal induces, all else equal, a deflationary effect, which—under the Taylor rule assumed here—map into expectations of lower future real rates, does the long-term real interest rate fail to increase strongly in response to the Home fiscal expansion. In a sense, our baseline scenario—under which the model's prediction align quite well with the VAR evidence—is thus a simple illustration of the more general insight that the interaction of monetary and fiscal policy, both at short and medium term horizon are shaping the global economy's response to the fiscal intervention.

Another instance where this point manifests itself is the zero lower bond (ZLB) on policy rates, which has gained renewed attention in the context of the global financial crisis 2007–09. Christiano et al. (2009) and Woodford (2010), among others, have illustrated that the government spending multiplier is likely to be considerably larger in an economic environment where monetary policy is unable to maintain its interest target due to a binding constraint on policy rates which prevents it from lowering rates below zero. In this case, monetary policy will typically not raise policy rates in order to counteract the inflationary impulse of a fiscal expansion such that the latter effectively lowers real interest rates and crowds in private expenditure.[14] Bodenstein et al. (2010) consider the ZLB in the

[14] As we have seen, such a crowding-in may also been observed as a result of spending reversals. In the absences of these, standard models predict a crowding-out, however.

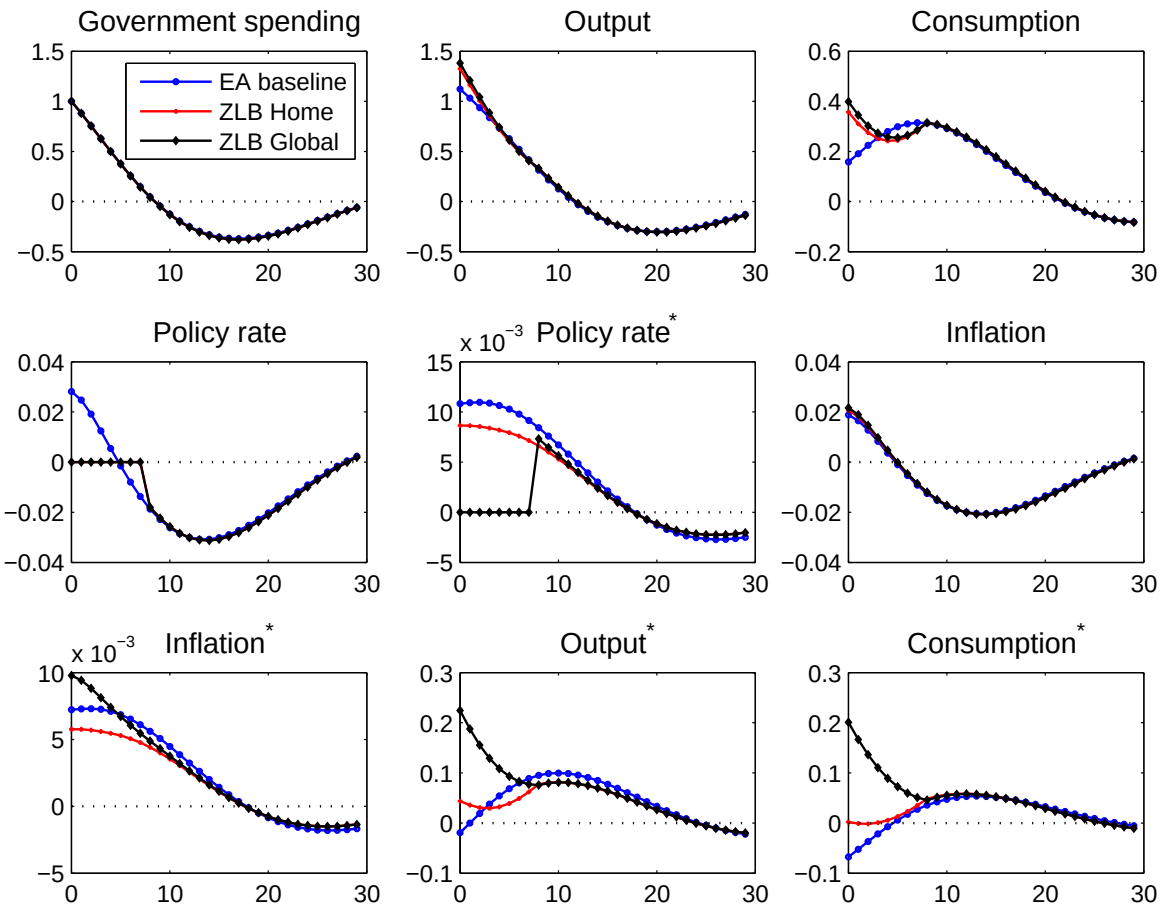

Figure 7: Effects of government spending shock in Home: baseline EA trade scenario (blue lines with circles) vs a scenario where ZLB binds for 8 quarters in Home (red line with crosses) and a scenario where ZLB binds in Home and Foreign for 8 quarters (black lines with diamonds). Notes: see figure 3.

context of a two country model. Specifically, they show that foreign demand shocks (among these shocks to foreign government spending) tend to have considerably larger effects on domestic output if the central bank is constrained in adjusting domestic policy rates by the ZLB.

We also consider this possibility in the context of our model. Figure 7 shows the results for two alternative scenarios relative to the baseline case without the ZLB binding (blue lines with circles). First, we consider a scenario where the ZLB in Home binds for 8 quarters (red lines with crosses). Second, we consider a global liquidity trap with the ZLB binding for 8 quarters in both countries (black lines with diamonds). For the first case we observe a moderate increase in the output effect at home and only a small increase in international spill-overs.[15] In case the ZLB binds also with respect

[15]The effects of the ZLB constraint on the Home output response are limited here, because the reversal induces already quite a sizeable output effect on impact. Importantly, in the reversal scenario Home policy rates fall relative to steady state already before the ZLB ceases to bind the the ZLB scenario. In the absence of reversals $\psi_G = 0$, we find that the Home output response more than doubles in case the ZLB binds for 8 quarters on Home policy rates.

to Foreign policy rates, we find, however a sizeable increase in spill-overs (see also Bodenstein et al. 2010). The effect of the ZLB constraint on Foreign policy rates is stronger in the present scenario, because inflation dynamics would imply an extended period of increased Foreign policy rates in the absence of the ZLB constraint. As a result, Foreign real interest rates decline, stimulating private expenditure and hence Foreign output. International spill-overs on Foreign output resulting from a Home fiscal expansion are thus considerably larger if the ZLB binds in Foreign.

4 Conclusion

TBC

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