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FISCAL POLICY, THE REAL EXCHANGE RATE AND TRADED GOODS*

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We estimate the effects of government spending shocks on the CPI real exchange rate, the trade balance and their co-movements with GDP and private consumption. We decompose the variations of the CPI real exchange rate into variations of the traded goods real exchange rate and the relative price of traded to non-traded goods. We reach three main conclusions: a rise in government spending induces a *depreciation* of the CPI real exchange rate and a trade balance deficit; private consumption rises in response to a government spending shock and therefore co-moves positively with the real exchange rate; both components of the CPI real exchange depreciate.

We employ Vector Auto Regression (VAR) techniques to estimate the effects of fiscal policy and, in particular, government spending on the CPI real exchange rate and the trade balance in the US and three other OECD countries. Our empirical analysis delivers two key results. First, a rise in government spending tends to induce a real exchange rate *depreciation* and a trade balance deficit, although, especially in the US, the latter effect tends to be small. Second, in all countries private consumption rises in response to a government spending shock and, therefore, co-moves positively with the real exchange rate.

Two important implications follow from these results. Our evidence provides support for a traditional 'twin deficit' hypothesis, in stark contrast with a recent study by Kim and Roubini (2008). A second implication concerns the consistency of facts and theory. Both the response of the real exchange rate and its co-movement with private consumption and the trade balance are at odds with a benchmark general equilibrium open economy model featuring complete financial markets. In fact, while the model is successful in replicating the negative response of the trade balance to a government spending shock that we observe in the data and also in linking the magnitude of that response to the degree of openness, it has counterfactual predictions on the response of the real exchange rate and of private consumption. We argue that the key failure of the model lies in the equilibrium behaviour of private consumption: in the model, as a result of a typical wealth effect on labour supply, private consumption falls in response to a rise in government spending, whereas the opposite is true in the data. This in turn explains the behaviour of the real exchange rate in the reference model: with complete asset markets, a risk-sharing arbitrage condition ties the ratio of the marginal utilities of consumption across countries to the real exchange rate. Via this condition and provided that deviations from purchasing power parity are feasible, the fall in consumption is accompanied by an equilibrium appreciation of the real exchange rate.

We proceed by investigating further the sources of the CPI real exchange rate movements in the data. A traditional approach decomposes the real exchange rate into two terms:

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(*i*) the cross-country (log) difference in traded goods prices (*traded* goods real exchange rate);

(*ii*) the cross-country (log) difference in the relative price of traded to non-traded goods (relative price of *non-traded* goods).

Cyclical movements in the former are typically attributed to two sources: deviations from the law of one price in traded goods and home bias in consumption. Engel (1999) argues that a large share of the variability of CPI real exchange rates can indeed be attributed to the cross-country relative price of traded goods, thereby de-emphasising the role of non-traded goods as a source of real exchange rate variations substantially. Recent literature (Burstein *et al.*, 2005; Betts and Kehoe, 2006) has pointed out that part of this conclusion can be driven by the standard practice of measuring traded goods prices in terms of retail prices. The latter, in fact, are highly contaminated by non-traded input components, such as distribution costs and wholesaling. By employing alternative methods to control for the non-traded component of traded goods, this literature has placed a larger emphasis on the role of non-traded goods for cyclical real exchange rate movements.

We resort to two alternative methodologies to measure *traded* goods prices. The first, as in Betts and Kehoe (2006), consists in measuring traded goods prices with producer price indexes (PPI). The second methodology, as in Burstein *et al.* (2005), consists in measuring traded goods prices as a weighted average of export and import prices. The motivation for the latter approach is that PPI indexes often do not include prices of genuinely traded goods. Our interest is to decompose the *conditional* response of the CPI real exchange rate into the conditional response of the traded goods real exchange rate and of the relative price of non-traded goods. We draw two main conclusions from this analysis: first, in most cases *both* components of the CPI real exchange rate tend to depreciate in response to a rise in government spending (hence both relative prices contribute to the depreciation of the overall CPI real exchange rate); second, although it varies across countries and across methodologies, the contribution of the relative price of *non-traded* goods to the cyclical variations of the real exchange rate (conditional to government spending shocks) is not negligible and is particularly strong in the case in which traded goods prices are measured in terms of export and import prices.

The implications of these results are twofold. First, the simultaneous depreciation of both relative prices adds another wrinkle to the already puzzling behaviour of the CPI real exchange rate. In fact, we argue below that a general feature of a standard two-sector business cycle model is that both the traded goods real exchange rate and the relative price of non-traded goods *appreciate* in response to a rise in government spending. Second, our results show that modelling the cyclical variations of *non-traded* goods prices is important not only to describe the unconditional movements of the CPI real exchange rate (as suggested by a recent literature) but also to characterise the *conditional* response of the real exchange rate to selected structural shocks.

Ours is not the first paper to use VAR techniques to study the effects of fiscal policy on the trade balance. Kim and Roubini (2008) show that in the US a budget deficit shock causes an improvement in the trade balance. We argue below that this finding is the result of a methodology to identify fiscal shocks that we believe has several undesirable and counterfactual features. In addition to the Kim and Roubini study, Corsetti and Müller (2006) also apply a methodology close to ours – essentially an extension of Blanchard and Perotti (2002) to include the real exchange rate and the trade balance. Their focus is mainly on explaining differences across countries in the response of the trade balance, while ours is mostly on the joint response of trade balance, consumption and real exchange rate, and their implications for models with complete asset markets. In Sections 3 and 4 we expand on a comparison of our methodology and results with those of Kim and Roubini and Corsetti and Müller.

The outline of the article is as follows. Section 1 discusses the key real exchange rate concepts and decompositions we use in the article. Section 2 describes the methodology we use to identify fiscal shocks. Section 3 presents the main empirical results. Section 4 discusses a comparison with Kim and Roubini (2008) and shows how the differences in the results can be ascribed to crucial differences in the specification. Section 5 presents an analysis of government spending shocks in a baseline model with complete asset markets. Section 6 identifies the main inconsistencies between facts and theory. Section 7 discusses a series of theoretical challenges for the literature and possible solutions. Section 8 concludes.

1. The Real Exchange Rate, the Terms of Trade, and the Relative Price of Traded Goods

Let $P_t \equiv \left[(1-\omega)(P_{N,t})^{1-\rho} + \omega(P_{T,t})^{1-\rho}\right]^{\frac{1}{1-\rho}}$ denote the CPI index in the economy, with ω being the share of traded goods in the final consumption basket and ρ being the elasticity of substitution between traded and non-traded goods. In turn, let $P_{T,t} \equiv \left[(1-\alpha)(P_{h,t})^{1-\eta} + \alpha(P_{f,t})^{1-\eta}\right]^{\frac{1}{1-\eta}}$ be the price of the final traded good, where $P_{f,t}$ and $P_{h,t}$ denote the price of imported and domestically produced goods (all expressed in units of domestic currency), α is the share of imported goods in the consumption basket, and η is the elasticity of substitution between domestic and imported goods.

We define the *terms of trade* as the relative price of imported goods $S_t \equiv P_{f,t}/P_{h,t}$. Notice that:

$$\frac{P_{T,t}}{P_{h,t}} = [(1-\alpha) + \alpha S_t^{1-\eta}]^{\frac{1}{1-\eta}} \equiv g(S_t) \tag{1}$$

with $g'(S_t) > 0$.

The relative price of traded goods is defined as

$$\begin{aligned} Q_t &\equiv \frac{P_{T,t}}{P_{N,t}} \\ &= g(S_t)Q_{h,t} \end{aligned} \tag{2}$$

where $Q_{h,t} \equiv P_{h,t}/P_{N,t}$ is the *sectoral* relative price of domestic goods (a measure of the domestic traded relative to non-traded goods).

We also define

$$\frac{P_t}{P_{N,t}} = [(1-\omega) + \omega Q_t^{1-\rho}]^{\frac{1}{1-\rho}} \equiv h(Q_t) \tag{3}$$

with $h'(Q_t)>0$. Similarly, $h^*(Q_t^*) \equiv [(1-\omega)+\omega(Q_t^*)^{1-\rho}]^{\frac{1}{1-\rho}}$, with $Q_t^* \equiv P_{T,t}^*/P_{N,t}^*$, where an asterisk denotes the foreign economy (or rest of the world) and where we have assumed $\omega = \omega^*$.

The CPI real exchange rate is the relative price of the consumption basket in the two economies:

$$\mathcal{E}_t \equiv \frac{E_t P_t^*}{P_t}$$

where E_t is the nominal exchange rate (the price of one unit of foreign currency expressed in units of domestic currency).

Using (3), a typical decomposition of the real exchange reads as follows:

$$\begin{aligned}\mathcal{E}_t &= \left(\frac{E_t P_{T,t}^*}{P_{T,t}}\right) \times \left(\frac{P_{T,t}/P_t}{P_{T,t}^*/P_t^*}\right) \\ &= \mathcal{E}_{T,t} \times \mathcal{E}_{N,t}\end{aligned} \tag{4}$$

where $\mathcal{E}_{T,t} \equiv E_t P_{T,t}^*/P_{T,t}$ is the bilateral real exchange rate in traded goods, and $\mathcal{E}_{N,t} \equiv [Q_t/h(Q_t)]/[Q_t^*/h^*(Q_t^*)]$ is the cross-country ratio of the relative price of traded (to non-traded) goods. We label the latter index as the *relative price of non-traded goods.*

Notice that in the particular case of the *law of one price* holding continuously, and implying (in a symmetric equilibrium) $P_{H,t} = E_t P_{H,t}^*$ and $P_{F,t} = E_t P_{F,t}^*$, one can write $\mathcal{E}_{T,t}$ as:

$$\mathcal{E}_{T,t} = \left[\frac{S_t}{g(S_t)}\right] \tag{5}$$

In other words, with the law of one price holding, movements in the traded goods real exchange rate $\mathcal{E}_{T,t}$ are simply proportional to the terms of trade. Variations in $\mathcal{E}_{T,t}$ are however still feasible due to the possible presence of home bias in consumption. In the extreme cases of absence of home bias and absence of a non-traded good sector, the consumption real exchange is constant. In general, both movements in the terms of trade S_t and in the relative price of non-traded goods Q_t contribute to the variations in the CPI real exchange rate.

1.1. *The Decomposition in the Data*

We wish to study the response of the CPI real exchange rate and its components to an innovation in government spending. In order to do that, we need to measure the following real exchange rate decomposition for each country i in our sample:

$$\varepsilon_t^i = \varepsilon_{T,t}^i + \varepsilon_{N,t}^i, \tag{6}$$

where all variables are expressed in logs. Throughout we measure the real exchange rate as the consumption-based relative CPI:

$$\varepsilon_t^i = e_t^i + cpi_t^* - cpi_t^i,$$

where e_t^i is the nominal exchange rate between country i's currency and a trade-weighted basket of currencies, cpi_t^i is the CPI in country i and cpi_t^* is a trade-weighted measure of the CPI in a sample of trade partners of country i (all measured in logs). Formally, we construct cpi_t^* as:

$$cpi_t^* = \sum_{j \neq i} \gamma_{i,j}\, cpi_t^j, \tag{7}$$

where j is an index of the trade partners of country i, and $\gamma_{i,j}$ measures the trade share of country i from country j.[1]

A key issue concerns measuring the *traded* goods real exchange rate $\varepsilon_{T,t}^i$. A first approach consists in simply approximating $\varepsilon_{T,t}^i$ with the (log) terms of trade (see the discussion above). This approach, however, is misleading for it ignores the pervasive evidence of deviations from the law of one price at the level of individual goods.[2]

Engel (1999) and Betts and Kehoe (2006) propose to measure the price of traded goods by means of the *producer price index* (PPI).[3] Hence a second approach consists in measuring $\varepsilon_{N,t}^i$ directly as

$$\varepsilon_{N,t}^i = (ppi_t^i - cpi_t) - (ppi_t^* - cpi_t^*)$$

with ppi_t^* being a trade-weighted index of the PPI indexes in a sample of trade partners of country i computed as:

$$ppi_t^* = \sum_{j \neq i} \gamma_{i,j} \text{ and } ppi_t^j,$$

where cpi_t^* is measured as in (7). Thus, note that our measures of ε_t^i and $\varepsilon_{N,t}^i$ are consistent in the sense that for each country i they use the same sample of trading partners and the same weights. After deriving $\varepsilon_{N,t}^i$, one can then compute $\varepsilon_{T,t}^i$ residually from (6): of course, this is numerically identical to constructing $\varepsilon_{T,t}^i$ directly using the weights $\gamma_{i,j}$.

Burnstein *et al.* (2005) criticise the approach of measuring traded goods prices with the PPI on the grounds that PPI indexes do not include import prices and, for several OECD countries, also exclude export prices. In other words, PPI indexes often do not include prices of genuinely traded goods. They hence propose to measure the index of traded goods prices as a log-linear combination of the *import* and *export* price indexes. Following Burnstein *et al.* (2005) we compute the index of traded goods prices as the arithmetic average of the import and export price index in country i:

$$p_{T,t}^i = \frac{1}{2}\left(p_{m,t}^i + p_{x,t}^i\right)$$

where $p_{m,t}^i$ and $p_{x,t}^i$ denote the import and export price indexes in country i (all in logs).

[1] As in Burstein *et al.* (2005) $\gamma_{i,j}$ is measured as

$$\gamma_{i,j} = \frac{1}{2}\left[\left(\frac{EXP_{i,j}}{EXP_i}\right) + \left(\frac{IMP_{i,j}}{IMP_i}\right)\right]$$

where $EXP_{i,j}$ is exports of country i to country j, EXP_i it total exports of country i, $IMP_{i,j}$ is imports of country i from country j, and IMP_i is total imports of country i.

[2] See Goldberg and Knetter (1997) for an extensive theoretical survey. The work by Engel (1999) strongly documents deviations from the law of one price for consumer prices also at a high level of disaggregation.

[3] Our approach differs from Betts and Kehoe (2006) in that we compute *effective* rather than bilateral real exchange rates.

Table 1

Bilateral and Total Trade Shares

(average important and export share between 1980 and 2001)

	Australia	Canada	UK	US
Australia		0.005	0.011	
Canada	0.018		0.018	0.197
Denmark			0.016	
Finland			0.012	
Germany	0.042	0.017	0.128	0.048
Greece				
Italy	0.024	0.009	0.047	0.021
Japan	0.207	0.049	0.035	0.133
Korea	0.041	0.010		0.032
Mexico		0.012		0.079
Netherlands	0.012	0.006	0.074	0.021
Spain			0.028	0.009
Sweden	0.010	0.004	0.027	
Switzerland		0.004	0.026	0.011
United Kingdom	0.053	0.024		0.047
Venezuela		0.005		0.014
United States	0.161	0.715	0.126	
Total trade share	0.568	0.862	0.557	0.643

Source. Burstein *et al.* (2005).
Note. All our data on import, export prices, CPIs and PPIs are from IFS. Table 1 shows the composition of the trade basket and the respective bilateral trade weights for our four reference countries Australia, Canada, UK and US). The Table reports the weights $\gamma_{i,j}$ used to compute cpi_t^*, ppi_t^*, and $p_{T,t}^*$ (see main text). BER refer to the Burstein *et al.* decomposition (based on computing traded goods prices with export and import prices); BK refers to the Betts and Kehoe decomposition (based on measuring traded goods prices with the PPI).

We then compute a measure for $p_{T,t}^*$:

$$p_{T,t}^* = \sum_{j \neq i} \gamma_{i,j} p_{T,t}^j.$$

In this case, after deriving $\varepsilon_{T,t}^i$, one can then compute $\varepsilon_{N,t}^i$ using (6) and the measure of ε_t^i that we construct consistently with $\varepsilon_{T,t}^i$.

For all our price index measures we draw data from the IFS. In Table 1 we report the values of the weights $\gamma_{i,j}$ and the composition of the trading basket for each country *i*.

Figure 1 displays the time series for ε_t^i and $\varepsilon_{T,t}^i$ when the latter is constructed measuring traded goods prices in terms of export and import prices, whereas Figure 2 displays the same time series when traded goods prices are measured with the PPI.[4] The evidence refers to four countries: Australia, Canada, UK and US (below we explain why we focus our analysis on these four countries), although the range of trade partners is larger and varies for each country. The sample is 1971:1 to 2006:4. In all cases, when traded goods prices are measured in terms of PPI, the traded goods real exchange rate co-moves closely with the CPI real exchange rate. When traded goods prices are measured in terms of export and import prices, however, ε_t^i and $\varepsilon_{T,t}^i$ can diverge

[4] In both cases, for each country *i*, the CPI real exchange ε_t^i is obtained as the sum of the two components $\varepsilon_{T,t}^i$ and $\varepsilon_{N,t}^i$. Hence $\varepsilon_{N,t}^i$ is simply the difference between the series reported in each Figure.

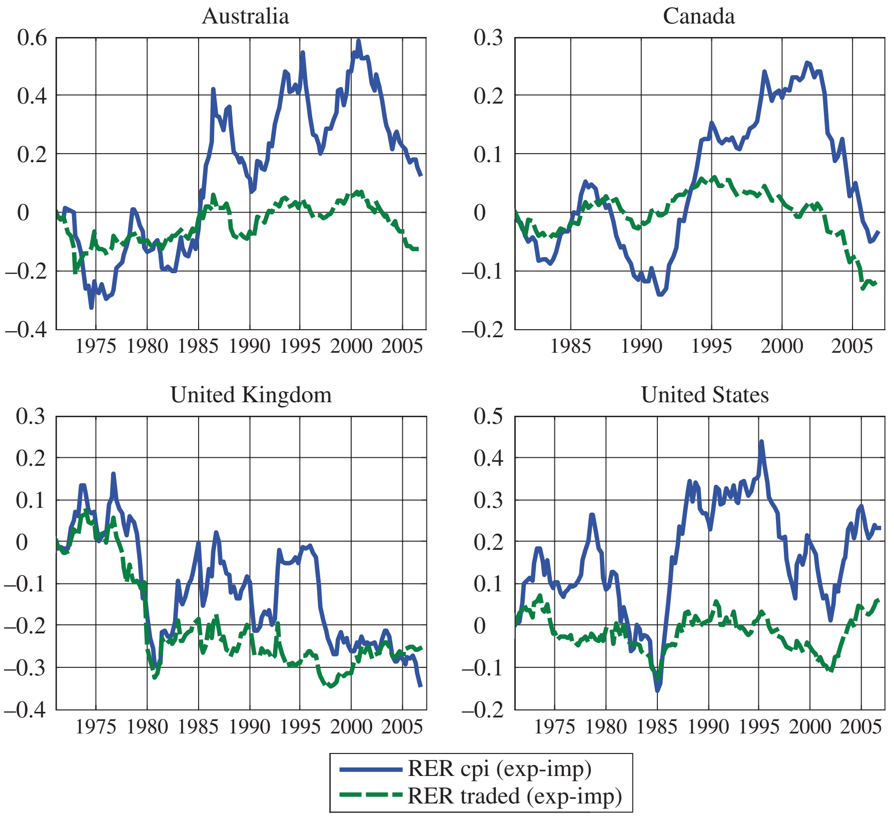

Fig. 1. *CPI vs. Traded-goods Real Exchange*
(computing traded goods prices using export and import prices as in BER)

substantially. Overall, the above results are in line with those in Burstein *et al.* (2005), who emphasise that measuring traded goods prices in terms of PPI may be misleading because the PPI often does not include the prices of genuinely traded goods. In turn, this may lead to an underestimation of the contribution of the relative price of non-traded goods to the variability of the CPI real exchange rate.

Table 2 displays the *unconditional* variance of all relative prices: ε^i_t, $\varepsilon^i_{T,t}$ and $\varepsilon^i_{N,t}$. The data show that the contribution of the two components to the variance of the CPI real exchange rate depends crucially on the methodology applied to measure traded goods prices. In a nutshell, measuring traded goods prices in terms of export and import prices magnifies the variance of the relative price of non-traded goods, whereas the reverse is true when traded goods prices are measured in terms of PPI.

2. Empirical Methodology

Our method for identifying fiscal shocks is an extension of Blanchard and Perotti (2002) and Perotti (2004, 2007). Corsetti and Müller (2006) also apply the same

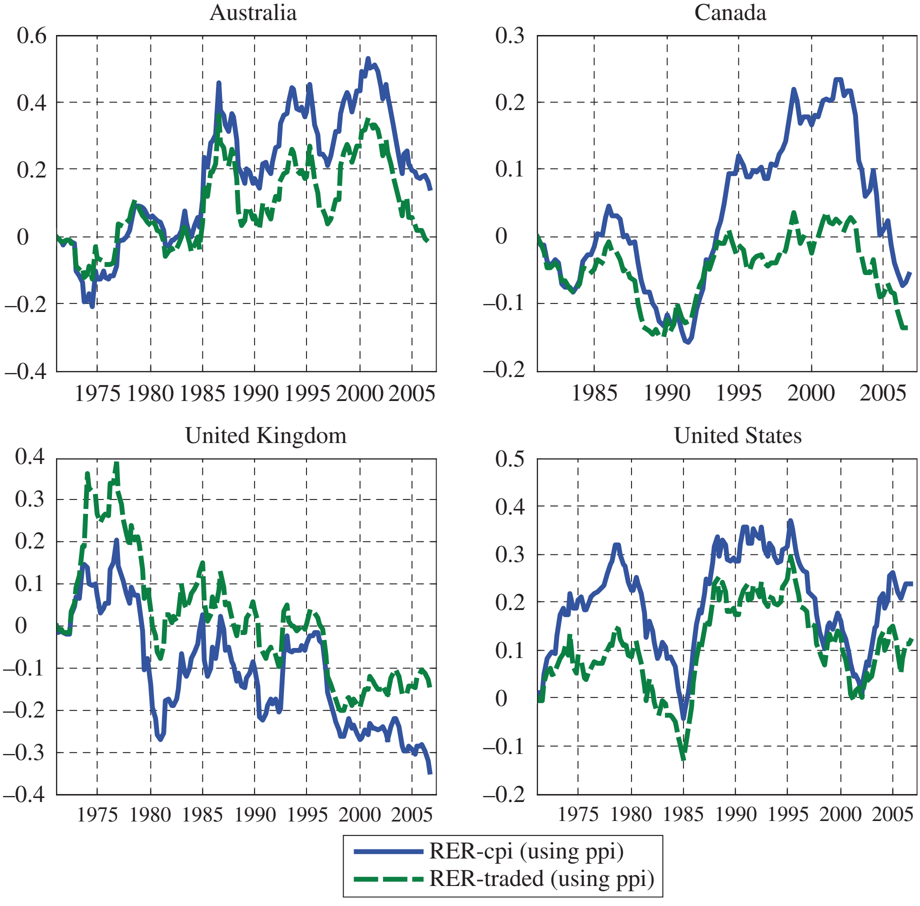

Fig. 2. *CPI vs. Traded-goods Real Exchange*
(computing traded goods prices using PPIs, as in BK)

method to study the effects of fiscal policy on the trade balance: however, their interest is different from the study of the joint responses of private consumption, the trade balance and the real exchange rate, on which we focus.[5]

We illustrate the methodology using a bivariate example. Consider the vector $\mathbf{X}_t \equiv [g_t \quad y_t]'$, where g_t and y_t are the log of real government spending on goods and services ('government spending' for short), and the log of real GDP, respectively, both in per capita terms. Consider the reduced form VAR

$$\mathbf{X}_t = \mathbf{A}(L)\mathbf{X}_{t-1} + \mathbf{U}_t, \tag{8}$$

where $\mathbf{A}(L)$ is a polynomial of order 4 and $\mathbf{U}_t \equiv [u_t^g \quad u_t^y]'$ is the vector of reduced form residuals.

[5] See also Ravn *et al.* (2007), who employ pooled SVAR techniques and study specifically the response of the real exchange rate to government spending shocks and Enders *et al.* (2008), who resort to sign restrictions to achieve identification.

Table 2

Decomposition of the Variance of the CPI Real Exchange Rate (in %)

	$\text{var}(\varepsilon_t)$	$\text{var}(\varepsilon_{T,t})$		$\text{var}(\varepsilon_{N,t})$	
	CPI based	BER	BK	BER	BK
Australia	0.218	0.044	0.139	0.148	0.014
Canada	0.045	0.011	0.024	0.026	0.011
United Kingdom	0.109	0.063	0.119	0.048	0.033
United States	0.112	0.028	0.061	0.065	0.010

The reduced form residual u_t^g is a combination of three effects. First, the *automatic response* of tax revenues and government spending to output innovations; second, the *systematic discretionary response* of policymakers to output innovations; third, the true *structural shocks* to government spending.

Formally, one can write:

$$u_t^g = \alpha_g u_t^y + e_t^g \tag{9}$$

$$u_t^y = \alpha_y u_t^g + e_t^y \tag{10}$$

where the coefficient α_g in (9) captures the first two components described above and e_t^g is the structural government spending shock. Clearly, e_t^g is correlated with the reduced form residuals, hence it cannot be obtained by an OLS estimation of (9).

However, because it takes longer than a quarter for discretionary fiscal policy to respond to shocks, the *systematic discretionary response* is absent in quarterly data. Thus, α_g captures only the third component, the *automatic response*: one can then use available external information on the elasticity of government spending to GDP to compute the appropriate value of the coefficient α_g; see Blanchard and Perotti (2002) for a detailed description. With α_g at hand, one can then construct the cyclically adjusted shock:

$$u_t^{g,CA} \equiv u_t^g - \alpha_g u_t^y = e_t^g. \tag{11}$$

The shock e_t^g thus estimated is orthogonal to the other structural shock e_t^y, hence it can be used as an instrument for u_t^g in (10). Once the structural shocks are thus identified, one can then proceed to estimate the impulse responses.

It is worth mentioning that the methodology for identifying fiscal shocks is controversial. A common criticism is that the fiscal shocks estimated by the econometrician may in reality be anticipated by the private sector, thus possibly leading to incorrect impulse responses: see Ramey (2008) and Perotti (2007) for a discussion. Mertens and Ravn (2009) and Fisher and Peters (in this issue), however, provide support to the view that this is not a serious problem in practice.

3. Evidence

In this Section we describe the sample choice, the specification of the empirical model and illustrate the baseline results.

3.1. *Data and Specification*

Our sample comprises four countries: US, UK, Canada and Australia.[6] We begin by discussing the US in detail and then extend the evidence to other countries.

Our benchmark VAR specification includes the following variables:

(*i*) the log of real government spending,
(*ii*) the log of real net taxes (tax revenues less transfers),
(*iii*) the log of real GDP,
(*iv*) the log of real private consumption,
(*v*) net exports of goods and services as a share of GDP,
(*vi*) the log of the CPI-based real effective exchange rate ε_t (an increase is a depreciation) and
(*vii*) the log of the traded goods real exchange rate $\varepsilon_{T,t}$.

The first four variables are expressed in per capita terms and deflated using the GDP deflator. The benchmark specification also includes quarterly dummies, a linear trend and a quadratic trend.[7]

All data, except the real exchange rate variables, are from the National Income Accounts, and are seasonally adjusted by the original sources. Government spending is defined as current spending on goods and services, i.e., government consumption; in the US, these also include defence investment, whose items in the other countries are already included under government consumption. All government budget variables refer to the general government. Perotti (2007) provides the full details on the construction of the government budget variables.[8] Our sample runs from 1980:1 to 2006:4. The results do not change significantly if we start in 1972:1 or 1975:1.[9]

We assume that, in quarterly data, the contemporaneous elasticity of government purchases to output, α_{gy}, is 0. The elasticity of net taxes to GDP is constructed from the elasticities of the individual components (personal and business income taxes, social security taxes, indirect taxes, unemployment benefits) which in turn are computed from data provided by the OECD, using the methodology illustrated in Perotti (2007).

[6] Since the method of identification described above relies crucially on the existence of data of high enough frequency, the choice of the countries is dictated by the availability of non-interpolated quarterly budget data for the general government.

[7] This specification of the reduced form is similar to that of Corsetti and Müller (2006), with a few differences: their list of variables includes both government spending and the budget deficit as a share of GDP but not net taxes; they include the inflation rate; most importantly, they have the terms of trade instead of the real exchange rate. Implicitly, we will discuss some of these differences in the next Sections.

[8] Hence the 'official' EUROSTAT measure of the CPI real effective exchange rate differs from our measure ε_t constructed above (and obtained as the sum of $\varepsilon_{T,t}$ and $\varepsilon_{N,t}$). The difference is that the range of trade partners we use to build ε_t may not be representative of the total trade exposure of each country. We verified, however, that our constructed measure of the CPI real exchange rate co-moves closely with the official Eurostat measure.

[9] At least until the Smithsonian agreement of December 1971 it is not entirely clear how to characterise the international monetary system after the breakdown of Bretton Woods; moreover the years around 1975 were turbulent years hit by many shocks.

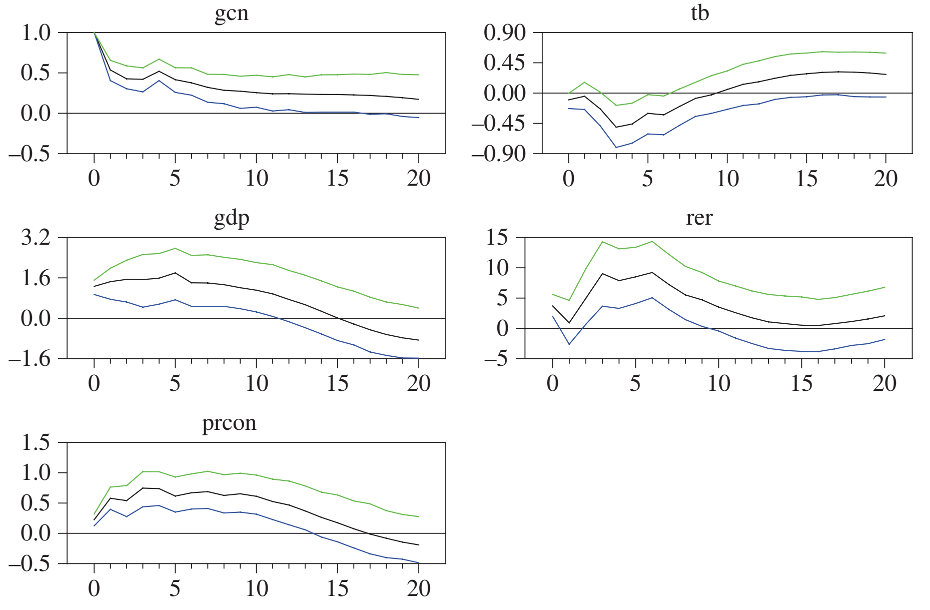

Fig. 3. *Benchmark VAR*

3.2. *Results: the US*

Figure 3 displays the responses of the key variables of the benchmark specification to a government spending shock equal to 1% of GDP. This specification includes the CPI real exchange rate ε_t and the traded goods real exchange rate $\varepsilon_{T,t}$ based on the Burstein-Eichenbaum-Rebelo (BER) decomposition described earlier.

The responses of government spending and private consumption are expressed as shares of GDP, by multiplying the response from the VAR (which is expressed in logs) by the sample average share of that variable in GDP (the trade balance is already expressed as a share of GDP). For each variable, the Figure displays the impulse response and the 68% confidence bands, corresponding to the 16th and 84th percentiles of the responses based on 500 Monte Carlo simulations.

Government spending falls by about 0.5 percentage points of GDP after 2 quarters, and then reverts slowly to trend. The GDP response is positive, by about 1.6 percentage points at the peak. The response of private consumption is also positive, with a peak slightly above 0.5 percentage points of GDP. The trade balance falls initially and significantly to about −0.45 percentage points of GDP, and then goes back to trend (with a small and insignificant overshooting after about three years). Thus, in contrast to Kim and Roubini (2008), in the US we do not find evidence of crowding-in of net exports by the budget deficit;[10] in fact, we find some evidence to the contrary. Finally, there is clear and significant evidence of a depreciation of the CPI real exchange rate, by about 5% at the end of the first year.

[10] The implied response of the budget deficit, not shown here, always has the same sign as the government spending response.

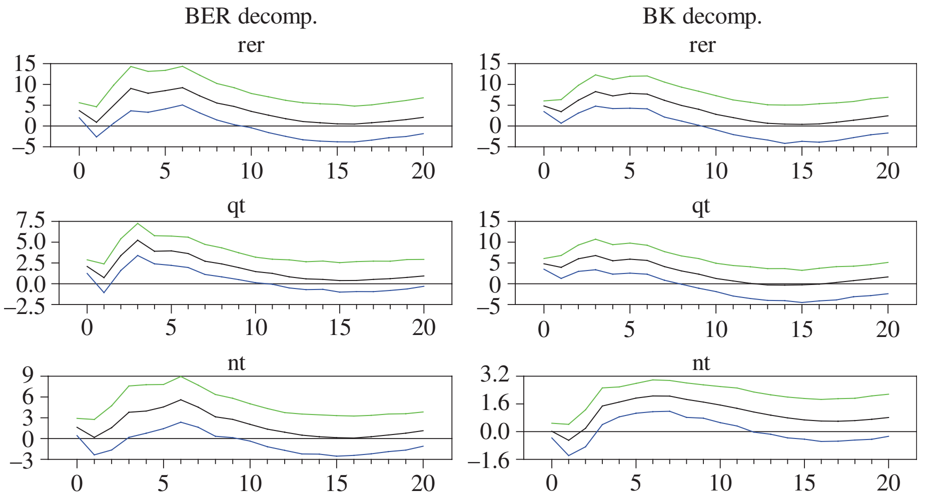

Fig. 4. *Decomposition of CPI Real Exchange Rate*

Figure 4 displays impulse responses of the components of the CPI real exchange rate, the traded goods real exchange rate $\varepsilon_{T,t}$ and the relative price of non-traded goods $\varepsilon_{N,t}$, for both the BER decomposition (column 1) and the BK decomposition (column 2). The sum of the two components is precisely the response of the CPI real exchange rate ε_t. We see clearly that *both* components of the real exchange rate depreciate, with the size of the depreciation being very similar across decompositions.

Row 2, column 1 of Figure 5 shows the response of the *terms of trade* (measured as the relative price of imports to exports) to the same rise in government spending. For a comparison, in row 1, column 1 it also displays the response of the traded goods real exchange rate from the BER decomposition (as displayed in column 1 of the previous Figure). The terms of trade are sometimes incorrectly used as an alternative measure of the traded goods real exchange rate. Notice that the terms of trade initially *appreciate,*

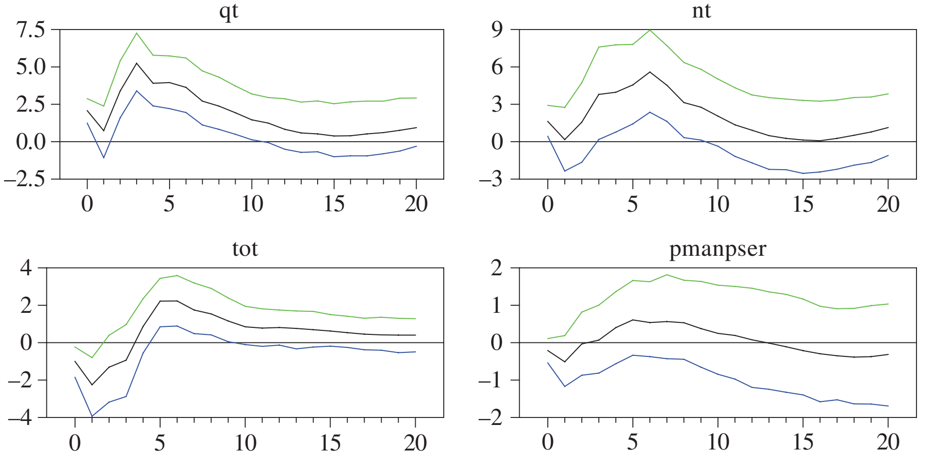

Fig. 5. *Terms of Trade and Relative Price of Manufacturing to Services*

suggesting that correctly accounting for deviations from the law of one price and for the role of non-traded goods is crucial to obtain a depreciation of the CPI real exchange rate (see our discussion above).

The same Figure (row 2, column 2) also displays the response of the price of manufacturing relative to services. The latter may be considered as an alternative measure of the relative price of traded (manufacturing) to non-traded (services) goods. Again as a comparison, the Figure also displays the response of the relative price of non-traded goods $\varepsilon_{N,t}$ (row 1, column 2). Our results show that it is important to account for the fact that $\varepsilon_{N,t}$ is a 'relative-relative' price (see (4)). In fact the response of the relative price of manufacturing is small and statistically insignificant, whereas our measure of $\varepsilon_{N,t}$ shows a significant depreciation.

3.3. *Results from Other Countries*

Figure 6 displays impulses responses for the other three countries, Australia, Canada and the UK. The VAR specification is the same as for the US, with linear and quadratic trends. The last row shows the response of $\varepsilon_{N,t}$, from a specification that includes $\varepsilon_{T,t}$ and $\varepsilon_{N,t}$ as the two relative price variables. We display results from the BER decomposition only, since very similar results hold under the BK decomposition. With the partial exception of Canada, we observe the same pattern that we highlighted in the US. Namely, in response to a government spending shock both GDP and private consumption increase, although now less than in the US. The trade balance worsens in the short run and all the real exchange rate measures depreciate, although once again

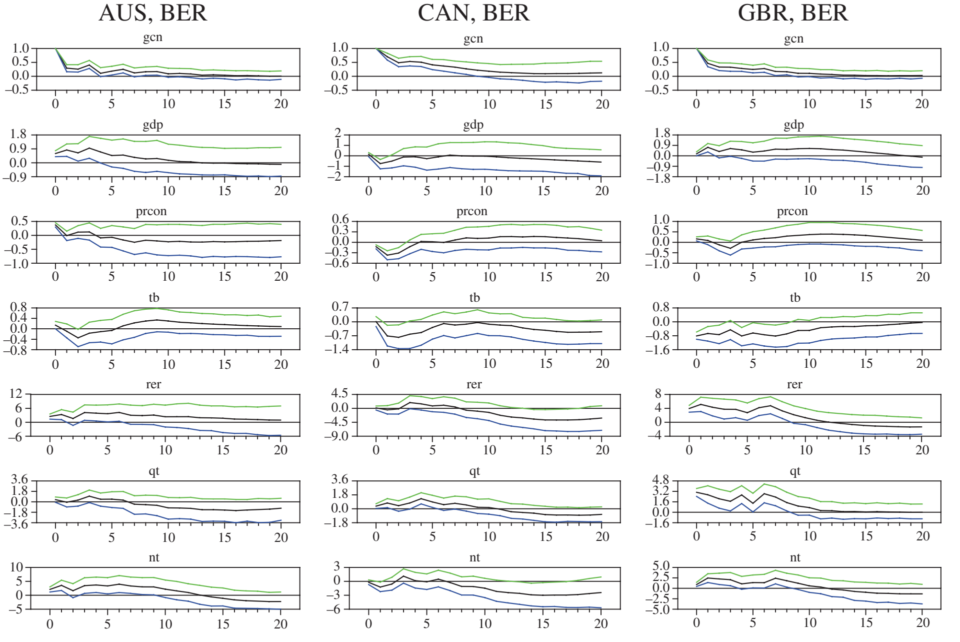

Fig. 6. *Other Countries*

less so than in the US. As mentioned, Canada is a partial exception, in that GDP and consumption decline slightly.

4. Comparison with Kim and Roubini (2008)

Using a different specification and identification, Kim and Roubini (2008) (KR henceforth) and Corsetti and Müller (2006) find that in the US a shock to the budget deficit/GDP ratio typically causes a significant and (in the case of Kim and Roubini) large improvement in the current account/GDP ratio. As we have shown above, we do not find much support for this 'twin divergence' result. These differences can largely be traced to the differences in the specification and identification methods.

KR estimate a VAR in five variables: the log of real GDP, the primary budget deficit/GDP ratio, the trade balance/GDP ratio, the three-months ex-ante real interest rate, and the log of the real exchange rate. The shocks are identified via a simple Choleski orthogonalisation, with the variables in the order listed above. Note that this identification scheme has one important consequence: when there is a positive shock to the budget deficit, real GDP on impact is not allowed to change.

KR estimate the responses to a budget deficit shock normalised to 1% of GDP. They consistently find a negative initial effect of a deficit shock on GDP, and a non-negligible *positive* effect on the trade balance, even in the short run. When we estimate the same specification as KR, we too find the same results (not shown).

Thus, the key difference in KR with the results based on our specification is that a positive budget deficit shock tends to generate a negative response of GDP, and a positive response of the trade balance. It is easy to see that there are two reasons for this: KR specify the budget deficit as a share of GDP; in addition, in identifying the budget deficit shock they ignore the automatic effect of GDP on the budget deficit itself. For both reasons, the identification method generates a confusion between a negative GDP shock and a positive deficit shock.

To see this, suppose the true model is a version of (9) and (10), where for comparability with KR we have replaced the log of real government spending with the budget deficit as a share of GDP:

$$u_d = \beta u_y + \varepsilon_d \tag{12}$$

$$u_y = \gamma u_d + \varepsilon_y \tag{13}$$

where d is the budget deficit/GDPratio and u_d and u_y are the reduced form deficit and GDP innovations. $\beta < 0$ because of the automatic effects of GDP on tax revenues and of the positive effect on the denominator, and $\gamma > 0$ as implied by most models (provided at least that taxes are not too distortionary). KR orthogonalise the reduced form innovations via a Choleski ordering in which GDP comes first:

$$u_y = \tilde{\varepsilon}_y \tag{14}$$

$$u_d = \tilde{\beta} u_y + \tilde{\varepsilon}_d \tag{15}$$

where a tilde denotes a coefficient, or a variable, as estimated with the KR identification approach.

The parameter $\tilde{\beta}$ is estimated by OLS; however, note that in the data the true deficit shock ε_d is correlated positively with u_y. In fact, from (12) and (13) we have:

$$u_y = \frac{\gamma}{1-\beta\gamma}\varepsilon_d + \frac{1}{1-\beta\gamma}\varepsilon_y. \tag{16}$$

Hence, forcing $\tilde{\varepsilon}_d$ in (15) to be uncorrelated with u_y implies that $\tilde{\varepsilon}_d$ must be correlated negatively with the true GDP shock ε_y. If the trade balance is also correlated negatively with the true GDP shock, this also builds in a positive spurious correlation between the budget deficit and the trade balance. This explains both the negative response of GDP and the positive response of the trade balance to the estimated deficit shock.[11]

Intuitively, suppose there is a negative realisation of the true GDP shock. The deficit/GDP ratio will increase for two reasons: because the denominator falls and because in the numerator tax revenues fall. This creates a spurious negative correlation between the deficit and the GDP innovations. Furthermore, as GDP falls, the trade balance improves, thus also creating a spurious positive correlation between the deficit and the trade balance innovations.

Note that, if d represented the log of government spending instead of the deficit/GDP ratio as the fiscal variable, by our discussion in Section 2, with quarterly data $\beta = 0$; yet, a Choleski ordering in which output comes first, as in (14) and (15), would still impose a negative correlation between $\tilde{\varepsilon}_d$ and ε_y as long as $\gamma > 0$. This type of Choleski ordering also implies that a shock to government spending has no impact effect on total output, hence it must crowd out private output *exactly* one for one on impact.

These observations call for a different specification and identification strategy. First, a Choleski ordering in which GDP come first is not suitable to identify the structural fiscal shocks, and can lead to profoundly misleading results. Second, the current GDP is an endogenous variable and should not appear at the denominator of the fiscal variables whose shocks we are studying.

5. An Analysis of Government Spending Shocks in the Open Economy

In this Section we lay out a theoretical discussion of the channels through which shocks to government spending affect the dynamics of the real exchange rate. We build a small open economy complete-market model that shares many features of the recent open economy New Keynesian literature.[12] In addition to the most standard features, we introduce home bias in consumption and a distinction between a traded and a non-traded good sector.[13] Since most of the details of the model are well known, we defer its presentation and numerical calibration to the Appendix (available from the authors on request).

[11] More formally, note that, because of the positive correlation between u_y and ε_d, the OLS estimate of $\tilde{\beta}$ exceeds the true β. Also, from (12) and (14), $\tilde{\varepsilon}_d = \varepsilon_d - (\tilde{\beta} - \beta)u_y$ and, from (16), $\mathrm{cov}(\tilde{\varepsilon}_d, \varepsilon_y) = -(\tilde{\beta} - \beta)\sigma^2_{\varepsilon_y}/(1-\beta\gamma)^2 < 0$.

[12] See, among many others, Corsetti and Pesenti (2001), Devereux and Engel (2003), Galí and Monacelli (2005). We emphasise that our results do not hinge crucially on the assumption of a small open economy nor on the assumed structure of financial markets. Results obtained under a two-country structure with incomplete markets are only slightly different quantitatively, and are available upon request from the authors.

[13] For the sake of simplicity the equilibrium representation should be considered equivalent to the one emerging from a world structure with either a continuum of small countries, as in Gali and Monacelli (2005), or with two countries of relative population size n and $1-n$, with the size n of the small economy shrinking to zero.

Here we simply recall that, under complete international markets for state contingent assets, consumption risk-sharing typically implies the condition:

$$\kappa \frac{U^*_{c,t}}{U_{c,t}} = \mathcal{E}_t \tag{17}$$

where κ is a positive constant and $U_{c,t}$ and $U^*_{c,t}$ denote the marginal utility of consumption in the domestic economy and in the rest of the world respectively. This condition establishes a tight link between the behaviour of relative consumption and of the CPI real exchange rate.[14]

We also notice that the firm's efficiency conditions imply an equilibrium relationship between sectoral real marginal costs which in log-linear terms reads:

$$mc_{h,t} - mc_{N,t} = \alpha s_t - q_t, \tag{18}$$

where a subscript h denote the domestic traded sector and α is the share of imported goods in traded goods consumption (a measure of openness). Thus, sectoral differences in the real marginal cost are driven (if $\alpha > 0$) by the gap between the terms of trade and the relative price of traded goods. Under flexible prices in both sectors, implying $mc_{h,t} = mc_{N,t} = 0$, variations in the relative price of traded goods result from variations in the terms of trade as a mere implications of openness.

Figure 7 displays theoretical impulse responses to a rise in government spending of 1% above its steady-state value. We report the response of selected variables under three scenarios: flexible prices in both sectors, sticky prices only in the non-traded sector and prices equally sticky in both sectors.

The key for an intuitive understanding of the working of our model is the negative wealth effect caused by government spending.[15] The rise in government consumption, by implying a rise in future taxes, raises the shadow value of wealth and, therefore, induces a fall in private consumption. In turn, for any given level of world consumption (which coincides with output in our model, given that the rest of the world is approximately a closed economy), international risk-sharing, via (17), requires an appreciation of the CPI real exchange. Thus, the model predicts that the responses of private consumption and the real exchange rate have the same sign.

Notice, however, that *both* components of the real exchange rate, $\varepsilon_{T,t}$ and $\varepsilon_{N,t}$, tend to *appreciate*, although the contribution of the traded goods real exchange rate is quantitatively more important. To understand the dynamics of the components of the real exchange rate, it is useful to recall that, log-linearising (2), (3), and (5), one can write

$$\varepsilon_{T,t} = (1-\alpha)s_t \tag{19}$$

and

$$\begin{aligned} \varepsilon_{N,t} &= (1-\omega)q_t \\ &= (1-\omega)\big(\alpha s_t + q_{h,t}\big) \end{aligned} \tag{20}$$

where small case letters denote percentage deviations from respective steady state values (and where we have assumed that Q^*_t is constant for simplicity). Hence

[14] In our model we assume separable preferences in consumption and leisure and absence of taste/preference shocks.
[15] To make sure, by wealth effect here we mean the Hicksian wealth effect on labour supply.

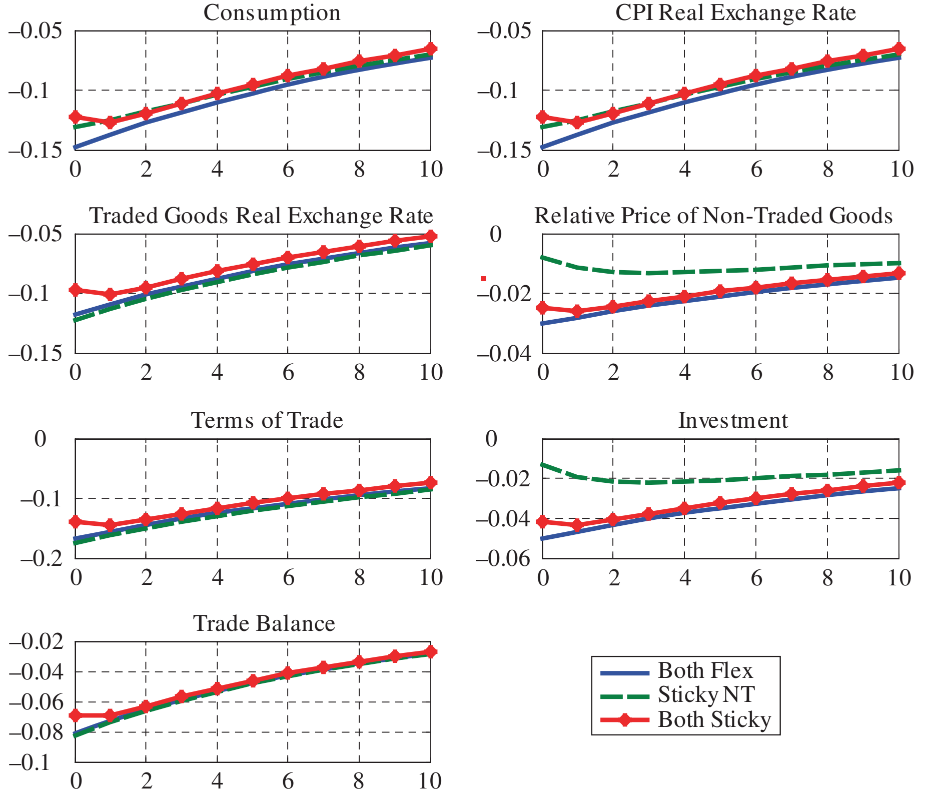

Fig. 7. *Theoretical Impulse Responses to a 1% Rise in Aggregate Government Spending*

movements in $\varepsilon_{T,t}$ are proportional to the terms of trade, whereas movements in $\varepsilon_{N,t}$ depend on the relative price of traded to non-traded goods q_t (whose movements in turn depend on the terms of trade and on the sectoral relative price of traded to non-traded goods $q_{h,t}$).

Consider the effect on $\varepsilon_{T,t}$ first. Due to home bias in consumption, the rise in government spending produces a rise in the price of domestic vs. imported tradable goods and, therefore, an appreciation of the terms of trade and a fall in $\varepsilon_{T,t}$. Under flexible prices (i.e. constant real marginal cost in both sectors), (18) implies that also the relative price of traded to non-traded goods q_t will fall. This is consistent with the fact that, being government spending more intensive in non-traded goods, the price of the latter rises, inducing an appreciation of the relative price of traded goods.

Notice that the degree of nominal price rigidity is not qualitatively crucial for the results. The main reason for controlling for alternative degrees of price stickiness is that in principle, with flexible traded and sticky non-traded, the sectoral relative price $q_{h,t}$ could rise, possibly inducing a depreciation of $\varepsilon_{N,t}$. In fact, this particular case (represented with a dashed line in the figure) is the one in which $\varepsilon_{N,t}$ falls the least. However, the main implication of assuming that prices are relatively more sticky in the non-traded sector is that the relative price of traded goods falls more smoothly, but qualitatively the effects are similar: namely, $\varepsilon_{N,t}$ always tends to appreciate.

The rise in government spending also produces a fall in investment. This is the result of a fall in the shadow value of investment (Tobin's *q*) which, in equilibrium, depends on current and expected future movements in the rental cost and the real interest rate (see the Appendix available from the authors on request). The real interest rate, both current and future, rises to support a lower level of consumption, thus depressing the Tobin's *q*. On the other hand, the rental cost rises initially, exerting an upward pressure on the Tobin's *q*, but then reverts quickly to the steady state. The net effect is a fall in the shadow value, which drives investment down.[16] Overall, the fall in investment, coupled with the fall in consumption, is not sufficient to turn the trade balance deficit into a surplus: the trade balance always deteriorates regardless of the degree of price stickiness, as a result of the increased government spending coupled with the real exchange rate appreciation.

6. Comparing Facts and Theory: Some New Puzzles

While our empirical evidence suggests (differently from some related literature) that the 'twin deficits' hypothesis is broadly consistent with the data, a series of important anomalies still emerge in other respects. We identify at least *three* main potential puzzles from our comparison of facts and theory. All of them stem from a basic discrepancy between the model and the data: in the model, the key force driving all results is the negative wealth effect of government spending that depresses private consumption; but in the data, private consumption rises.[17]

6.1. *The Real Exchange Rate Puzzle*

While in the data we observe a real exchange rate *depreciation* following a positive government spending shock, a real *appreciation* is a robust feature of the theoretical framework, regardless of the presence of investment and/or of the assumed degree of price stickiness.

The reason is straightforward: the wealth effect drives private consumption down and the international risk-sharing condition implies that the real exchange rate *must* appreciate. This result holds in virtually any model displaying complete asset markets and some ingredient-generating deviations from PPP (like home bias and/or the presence of non-traded goods). It also holds in models with different frictions like local currency pricing, pricing-to-market and trade costs (Engel, 2002) and in models with

[16] Notice also that the fall in investment is dampened in the case in which prices are sticky only in the non-traded sector. This is because the shadow value of investment is inversely related to the relative price of traded goods, with this holding also in the absence of adjustment costs on capital (see the Appendix for more details, available from the authors on request).

[17] The response of private consumption to a government spending shock is a key issue in the recent empirical literature on the macroeconomic effects of government spending: on one hand, in the SVARs of Blanchard and Perotti (2002), Galí *et al.* (2007) and Perotti (2007), the response is positive; on the other hand, in the VARs based on the 'narrative approach' of Edelberg *et al.* (1999), Burnside *et al.* (2004) and Ramey (2008) it is negative.

traded and non-traded goods. A strong positive correlation between (relative) consumption and the real exchange rate continues to hold even in bond-only economies, as in Chari *et al.* (2002).

In addition, the real depreciation in response to a rise in government spending observed in the data lies in stark contrast with a traditional Mundell-Fleming model. In that model, represented by an open economy extension of the traditional IS-LM apparatus, a rise in government purchases, by boosting domestic aggregate demand, entails a rise in the domestic interest rate. This causes a nominal (and real) appreciation and in turn a deterioration of the trade balance.

Interestingly, a 'modern variant' of the Mundell-Fleming model, namely the model by Obstfeld and Rogoff (1995), predicts exactly the opposite. In that framework, where PPP holds throughout, the behaviour of the nominal exchange rate tracks that of the price level closely. The key effect (shared with a benchmark neoclassical model) is that, under the assumption that the fiscal authority follows a balanced budget rule, a rise in government consumption generates a fall in private consumption via a typical wealth effect on employment. This induces a fall in the demand for money which, for a given supply of money, requires a rise in the price level to restore the equilibrium in the money market. Because of PPP, a relative rise in the domestic price level entails, unlike the Mundell-Fleming model, a one-to-one nominal depreciation. Hence the Obstfeld-Rogoff model predicts the observed nominal depreciation and the rise in the price level. Yet this happens for the 'wrong' reason, since in the model the main channel operates through a *fall* in private consumption, in stark contrast with the estimated response of the latter emerging from our empirical analysis.

6.2. *The Consumption–Real Exchange Rate Co-movement Puzzle*

The same mechanism explains the second, related puzzle. Because the very reason for the real exchange rate appreciation is the decline in private consumption, in all the models with complete asset markets reviewed above the real exchange rate and private consumption responses have negative signs. In the data, we do find that the signs of the private consumption and real exchange rate responses are the same but they are both *positive*.

Models with complete asset markets also predict a positive correlation between the real exchange rate and private consumption conditional on a government spending shock. We find that the conditional correlation between the two variables is positive in three countries and zero in Canada; even in the former case this is not supporting evidence for the model, because it happens for the 'wrong' reasons: in the data, both private consumption and the real exchange rate increase after a government spending shock.[18]

[18] Any statement on the correlation between *relative* consumption and the real exchange rate is well defined in the case of the small open economies belonging to our sample. In fact, if, in response to an innovation in government spending, domestic consumption rises and the real *effective* exchange rate depreciates, *relative* consumption rises as well, since rest-of-the world consumption is exogenous to domestic government spending innovations. However, in the case of the US, we need to assume implicitly (and realistically) that consumption in the rest of the world rises by less than US consumption in response to a US increase in government spending. We devote to future research the analysis of the international transmission of fiscal shocks.

6.3. *The Real Exchange Rate Decomposition Puzzle*

In the model, both components of the real exchange rate tend to appreciate, while we have seen that the opposite is true in the data.

7. Theoretical Challenges

As long as we maintain the assumption of international risk-sharing, we cannot hope to resolve the puzzles above unless we can generate a positive response of private consumption to a government spending shock. Generating that positive response requires counteracting the negative wealth effect of government spending on private consumption. Broadly speaking, this can be done in three different classes of models, that we categorise as follows:

(*i*) Incomplete asset markets;
(*ii*) Non-separable utility;
(*iii*) Equilibrium variable markups.

7.1. *Incomplete Asset Markets*

Galí *et al.* (2007) introduce rule-of-thumb (ROT henceforth) consumers in an otherwise standard New Keynesian model with monopolistic competition and nominal price rigidity (with the latter feature generating counter-cyclical movements in the markup). ROT consumers are myopic agents that are completely ruled out from financial markets, and therefore consume only out of their current real (labour) income. The mechanism works as follows. A rise in government spending leads to a rise in employment, as in any standard dynamic equilibrium model, as well as to a rise in the real wage, consistent with the fall in the markup. With real labour income rising, consumption by ROT agents increases too. With enough of these individuals, the model can generate a positive response of total private consumption to a government spending shock.

Extensions of the ROT-consumers channel to the open economy have however been scant. Erceg *et al.* (2005) analyse the effects of fiscal shocks on the trade balance and the real exchange rate in a last-generation New Open Macro model with several frictions. In a version of their model, Erceg *et al.* also include a role for ROT consumers. However, while successful on the front of generating a positive response of consumption, the simulations reported in Erceg *et al.* continue to generate a real appreciation in response to a government consumption shock. The intuition is straightforward. In the models of Galí *et al.* (2007) and Erceg *et al.* (2005), the positive response of aggregate consumption is due to the ROT agents; however the consumption of the forward-looking agents still declines because of the negative wealth effect on labour supply. But it is only these agents who have access to complete international financial markets, hence it is their consumption behaviour that determines the movement of the real exchange rate via the international risk-sharing condition. Thus, the real exchange rate must appreciate even in the Erceg *et al.* (2005) model.

7.2. Non-separable Preferences

A second approach to counteracting the wealth effect of government spending shocks preserves the assumption of complete asset markets but allows for non-separability in preferences between consumption and leisure. The latter feature can in turn be introduced in two alternative ways: first, as in the closed economy models of Basu and Kimball (2002) and Linnemann (2005); second, as in the preference specification of Greenwood *et al.* (1988) (GHH henceforth), where wealth effects of labour supply movements are ruled out by assumption.

Suppose momentary utility is specified as $U(C_t, L_t) = (1-\sigma)^{-1} C_t^{1-\sigma} \; V(L_t)$, with $\sigma > 1$, where $L_t = 1 - N_t$ is leisure. King *et al.* (1998) show that $V(L_t)$ must be decreasing and convex to guarantee a balanced-growth path (i.e., steady-state consumption growth at constant leisure). Note that this specification implies $U_{CL} < 0$, i.e., that consumption and employment are complements. Linnemann (2005) shows that, if the complementarity is strong enough, preferences of this form can deliver a positive effect of a government spending shock on private consumption within a standard neoclassical model. If we specify $V(L_t)$ to take the form $(1-L_t)^{1+\varphi}$, with $\varphi > 0$, the marginal utility of wealth λ_t reads

$$\lambda_t = \frac{N_t^{1+\varphi}}{C_t^{\sigma}} \qquad (21)$$

The risk-sharing condition linking the real exchange rate to the international ratio of the marginal utilities of consumption now becomes (expressed in log-linearised form, and assuming constant world output for simplicity):

$$\varepsilon_t = \sigma c_t - (1+\varphi) n_t. \qquad (22)$$

As a result, the equilibrium effect on the real exchange rate will depend crucially on the relative strength of the consumption and employment responses, which in turn depend on the values of the elasticities σ and φ. It is easy to show that, for reasonable calibrations of σ and φ, one can obtain a positive co-movement between consumption and the real exchange rate in response to a rise in government spending.[19] Recently, however, Bilbiie (2009) has called into question the plausibility of this channel. He shows that the conditions on preferences required to obtain a rise in private consumption, and therefore (in our context) also a real exchange rate depreciation, have the undesirable implication that either private consumption or leisure be inferior goods.

Suppose, alternatively, that preferences take the non-separable form as in GHH. In particular:

$$U(C_t, N_t) = \frac{\left(C_t - \psi N_t^{\zeta}\right)^{1-\sigma}}{1-\sigma}, \qquad (23)$$

where, in this notation, $1/(\zeta - 1)$ is the elasticity of labour supply. Notice that under this preference specification the marginal rate of substitution between consumption and leisure is independent of the level of consumption. In fact:

[19] These results are available upon request from the authors.

$$MRS_{c,n} \equiv \frac{-U_{n,t}}{U_{c,t}} = \zeta\psi N_t^{\zeta-1}. \quad (24)$$

From (24), the labour supply schedule takes the form

$$\frac{W_t}{P_t} = \zeta\psi N_t^{\zeta-1}. \quad (25)$$

Variations in consumption do not affect the labour supply schedule: put differently, there is no wealth effect of government spending on labour supply. If goods markets are perfectly competitive and prices fully flexible, variations in government spending are also immaterial for the position of the labour demand schedule. As a result, both consumption and employment are unresponsive to government spending shocks. Introducing nominal price rigidity (and therefore variable markups) restores a labour demand channel. Monacelli and Perotti (2008) show that, coupled with price stickiness, a standard model with GHH preferences can deliver 'Keynesian' effects of fiscal policy: employment, the real wage and consumption all rise in response to an expansion in government spending. What about the real exchange rate? Under GHH preferences, the log-linearised international risk-sharing condition reads (assuming constant world output for simplicity):

$$\varepsilon_t = \Phi c_t - \Psi n_t,$$

where $\Phi \equiv \sigma N$, $\Psi \equiv \sigma\zeta\psi N^{\zeta}$ and N is the steady-state level of employment. As hinted above, under flexible prices, $c_t = n_t = 0$ in equilibrium and, hence, also $\varepsilon_t = 0$ for all t. Under sticky prices, the response of the real exchange rate will depend on the strength of the response of consumption relative to the one of employment. For any given σ, it turns out that the model requires extremely low (and arguably unrealistic) values of the elasticity of labour supply (i.e., high values of ζ) in order for the consumption effect to counterbalance the employment effect.[20]

7.3. *Variable Markups*

As already argued above, with separable preferences in consumption and leisure, the presence of variable markups is generally a necessary condition to obtain a positive response of consumption to a government spending shock. A counter-cyclical markup is equivalent to a rightward shift in labour demand in response to a rise in government spending: if the shift is strong enough, the real wage can increase despite the downward shift in labour supply. In turn, the increase in the real wage can generate a rise in consumption via a substitution effect from leisure. In the New Keynesian literature, the typical way of generating variable markups is the assumption of nominal price stickiness. As we have seen above, however, this feature by itself is usually not sufficient to generate movements in the markup sizeable enough to induce a rise in consumption, both in closed and open economy environments.

Alternative models that generate equilibrium variable markups regardless of the assumption of price stickiness appear promising. In Ravn *et al.* (2007) markups are

[20] The results are not displayed here and are available upon request from the authors.

endogenous due to the presence of 'deep habits', i.e., habits in the consumption of individual differentiated varieties. A key assumption is that deep habits apply both to private households as well as to the government. A rise in government spending is associated with a higher share of the price elastic component in total spending, hence with a decline in the markup. Thus, in their model, which maintains the assumption of complete international asset markets, fluctuations in the markup are sufficiently sizeable so as to generate not only a positive response of consumption but also, under certain conditions, a depreciation of the real exchange rate, via the usual risk-sharing condition.

An alternative channel that leads to counter-cyclical markups relies on preferences with non-constant elasticity of substitution in varieties, as in Kimball (1995). This feature makes the price elasticity of demand a function of the quantity produced, thereby leading to a kinked demand function for any individual variety. In this environment, a change in demand for output endogenously affects the price elasticity of demand and hence markups. In general, this channel generates complementarity in price setting. In an international context, if foreign competitors lower their price, thereby inducing a terms of trade appreciation for any given level of the domestic price, this will lower the desired markup by domestic firms and will induce them – ceteris paribus – to restrain price increases. Hence, in principle, a positive equilibrium relationship between the markup and the terms of trade should exist. The model of Gust *et al.* (2006) has exactly this insight, which is applied to an otherwise standard two-country model with the goal of generating incomplete pass-through of nominal exchange variations on prices. As regards the effects of government spending shocks on the real exchange rate, though, the problem persists. In fact, in order for the model to generate a counter-cyclical movement in the markup, one needs a real exchange rate appreciation, once again in contrast with our empirical results.

8. Conclusions

We have shown that, in the data, a variation in government spending produces surprising implications for the CPI real exchange rate. In sharp contrast to a standard open-economy business cycle model with complete asset markets, the real exchange rate depreciates in response to a rise in government spending. The key to this result is the behaviour of private consumption, which rises in the data whereas it falls in the model as a result of a negative wealth effect.

We have also shown that both components of the CPI real exchange rate (the traded goods real exchange rate and the relative price of non-traded goods) depreciate in response to a rise in government spending. This result is also puzzling, on two grounds. First, in a standard model, if the law of one price holds, a rise in government spending produces an appreciation of the terms of trade, which in turn (if home bias holds) should lead to an appreciation of the traded goods real exchange rate, in contrast with our evidence. Second, a long tradition in international macroeconomics (Frankel and Razin, 1992) has argued that, because government spending is intensive in services (i.e., non-traded goods), a shock to government spending on goods and services should increase the relative price of non-traded goods. In a standard model, this mechanism also leads to an appreciation of the relative price of traded to non-traded goods but we have shown that this result is contradicted in the data.

In the baseline model we have illustrated above, variations in the traded goods real exchange rate are due only to home bias in consumption. One may suggest that features that generate deviations from the law of one price, such as distribution services along the lines of Burstein *et al.* (2005) and Corsetti and Dedola (2005), may be helpful in generating the correct cyclical movements of the components of the CPI real exchange rate. With distribution services, the retail price of traded goods would depend on the producer price and on the price of non-traded distribution services. A rise in government spending (intensive in non-traded goods) may then help in boosting the relative price of traded to non-traded goods upward, thereby possibly helping the model to match the observed depreciation of the $\mathcal{E}_{N,t}$ component of the real exchange rate. However, this feature would not necessarily help in simultaneously generating also the observed depreciation of the traded goods real exchange rate.[21]

We have illustrated a series of promising theoretical extensions that revolve around one basic principle: generating a positive response of consumption to a rise in government spending. Models with non-separable preferences and with equilibrium variable markups seem promising in this dimension but score differently on the issue of the consumption-real exchange rate co-movement puzzle. Enriching equilibrium models with these features, as well as with features generating deviations from the law of one price in traded goods, should be the scope of future research on this subject.

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