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# Fiscal shocks and the exchange rate

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# Fiscal shocks and the exchange rate*

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**Abstract**

This paper studies how the interaction between the monetary policy regime and the degree of home bias in public consumption affects the exchange-rate response to fiscal shocks in dynamic open-economy models. Our analysis compares the classic Redux model of Obstfeld and Rogoff (1995) and a modern New Keynesian DSGE two-country model, and highlights the substantially different transmission mechanism between the two.

*JEL classification*: E52, E62, F41, F42.

*Keywords*: *Redux* Model, Exchange Rate, Fiscal Shocks, Endogenous Monetary and Fiscal Policy.

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# 1 Introduction

The financial crisis that led the world economy into recession in 2009 stimulated a revived interest in the role of fiscal policy as a stabilization tool. Relevant discretionary fiscal interventions have been undertaken in the US and in many other industrialized countries, often coupled with expansionary monetary policies. Interestingly, however, although the effects of fiscal shocks and their international transmission have long been investigated in the literature, not much consensus was achieved.

In this paper, we study the role that public-spending composition and the monetary policy regime play in shaping the exchange-rate response to fiscal shocks. We find that the appreciation implied by modern open-economy Dynamic Stochastic General Equilibrium (DSGE) new Keynesian models critically hinges on two specific features of the latter: endogenous monetary policy and home bias in public consumption.[1]

The theoretical implications about the effects of fiscal shocks on the exchange rate are mixed. The seminal Obstfeld and Rogoff (1995) *Redux* model shows that a balanced-budget fiscal expansion – where government spending is symmetrically distributed on domestic and foreign goods – depreciates the exchange rate. This finding contradicts the well known implications of the static open-economy version of the IS-LM model developed by Mundell and Fleming. The alternative assumption of complete home bias in government consumption leads to a null effect on the exchange rate (Ganelli, 2005a). DSGE open-economy new Keynesian models such as Corsetti and Pesenti (2001) and Devereux and Engel (2003) find that after a balanced-budget fiscal expansion, private consumption decreases and, through international risk sharing, the exchange rate appreciates. Exchange rate depreciation occurs if we introduce incomplete financial markets (Kollmann, 2010), productive government spending (Basu and Kollmann, 2013) or spending reversals (Corsetti et al, 2012).

Also the recent empirical evidence is mixed, with results that depend on the period and on the countries studied. Kim and Roubini (2008) and Monacelli and Perotti (2010) provide time-series evidence that the real exchange rate depreciates in response to a positive primary government deficit shock. Beetsma et al. (2008) and Bénétrix and Lane (2013), using a panel-VAR analysis for the period 1971-2008, find that a positive shock to government spending appreciates the real exchange rate in the EMU countries. This result holds for different measures of government spending and it is more pronounced when government consumption is chosen as dependent variable.[2]

The analysis of fiscal policy, in general, has been somehow delayed with respect to studies

[1] These models are also often referred to as New Open-Economy Macroeconomics (NOEM) models.

[2] A similar result is found in Canova and Pappa (2007), who show that in the US and in the EMU government spending shocks raise the state's price level relative to the union, implying real appreciation.

investigating the role of monetary policy in the NOEM framework. This is largely due to the fact that Ricardian equivalence holds in the benchmark *Redux* model. A natural implication is that only balanced-budget policies can be studied, while debt policies have no relevance. Only recently, the standard two-country framework based on the Representative Agent (RA) model has been extended to account for agents' heterogeneity, turnover in financial markets and some form of market imperfection or incompleteness that allow to depart from Ricardian equivalence and investigate fiscal policies more in detail (see Ganelli, 2005b, Cavallo and Ghironi, 2002, Di Giorgio and Nisticò, 2007, 2013). These advances allow a comparison between the outcomes of fiscal shocks in the static Mundell–Fleming model and the intertemporal approach used in the modern literature (see Ganelli, 2005b) and a better understanding of the role played by different factors in affecting the exchange-rate response.

In this paper we study the effects of fiscal expansions on the exchange rate in two popular theoretical models, and show that the different implications between the two can be explained by the interaction between the monetary policy regime and the degree of home bias in public consumption. Specifically, we compare the *Redux* model of Obstfeld and Rogoff (1995), which implies an exchange-rate depreciation, and the modern two-country DSGE model, implying instead an appreciation. The latter one is extended with a "perpetual youth" structure of the demand side, along the lines of Di Giorgio and Nisticò (2007, 2013), in order to break Ricardian equivalence and allow the analysis also of debt-financed fiscal policy. We show that, once we extend the *Redux* model to account for endogenous monetary policy and home-bias in public consumption – two distinctive features of modern two-country models – the exchange rate appreciates in response to fiscal shocks, just like in modern models. The transmission mechanism, however, is substantially different: in the former case it works through money demand and in the latter one through firms' marginal costs. Moreover, we show that this different transmission mechanism also implies that the exchange-rate appreciation occurs regardless of the financing of the fiscal expansion (tax versus debt), in contrast to Ganelli (2005b)'s result of ambiguous responses derived in a *Redux*-type model.

The paper is organized as follows. In Section 2, we generalize the *Redux* model to study the role that home bias in government consumption and endogenous monetary policy play in determining the effects of balanced-budget fiscal shocks on the exchange rate. In Section 3 we use a fully specified non-Ricardian two-country DSGE model of the business cycle and investigate the effects also of non-balanced-budget fiscal shocks on key macroeconomic variables. Section 4 concludes.

## 2 A simple framework: generalizing the *Redux* model.

In this section we extend the simple *Redux* model of Obstfeld and Rogoff (1995) to study the interplay between the degree of home bias in public spending and the monetary policy regime in transmitting fiscal shocks to the exchange rate.[3]

The Home country consists of a continuum of "Yeoman Farmer" households on the interval $[0, n]$, indexed by $h$, while Foreign agents are on the interval $(n, 1]$, indexed by $f$. Domestic households choose consumption $C$, real money balances $\frac{M}{P}$ and work effort in the production of output $y$, in order to maximize[4]

$$\sum_{k=0}^{\infty} \beta^k \left[ \log C_{t+k} + \chi \log \left( \frac{M_{t+k}}{P_{t+k}} \right) - \frac{\kappa}{2} y_{t+k}(h)^2 \right]$$

subject to the flow budget constraint

$$P_t B_t + M_t = P_t (1 + r_{t-1}) B_{t-1} + M_{t-1} + P_t(h) y_t(h) - P_t C_t - P_t T_t \tag{1}$$

where $B_{t-1}$ and $r_{t-1}$ denote, respectively, the stock of bonds carried over by home residents from period $t-1$, and the real interest rate earned on bonds between $t-1$ and $t$, while $T_t$ are real taxes. The private consumption index $C$ ($C^*$ in the Foreign country) is a Dixit-Stiglitz aggregator of all the brands produced worldwide, where domestic and foreign goods are treated symmetrically:[5]

$$C = \left[ \int_0^1 c(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}} \tag{2}$$

in which $\theta > 1$ is the elasticity of substitution between any two brands of goods, either

[3] Since the model builds on Obstfeld and Rogoff (1995) and Ganelli (2005a), in the paper we focus on the distintive elements of our setup, and refer the reader to the aforementioned papers for details about the other ingredients.

[4] Foreign households face a symmetric problem.

[5] For comparison with the model of the next Section (and the recent NOEM literature) notice that this is equivalent to assuming the domestic consumption bundle as the following Dixit-Stiglitz aggregator of domestic and imported goods

$$C = \left[ n^{1/\theta} C_H^{\frac{\theta-1}{\theta}} + (1-n)^{1/\theta} C_F^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$$

where, in turn, the latter are bundled together through

$$C_H = \left[ \left( \frac{1}{n} \right)^{1/\epsilon} \int_0^n c(h)^{\frac{\epsilon-1}{\epsilon}} dh \right]^{\frac{\epsilon}{\epsilon-1}} \qquad C_F = \left[ \left( \frac{1}{1-n} \right)^{1/\epsilon} \int_n^1 c(f)^{\frac{\epsilon-1}{\epsilon}} df \right]^{\frac{\epsilon}{\epsilon-1}}.$$

The specification of this section, along the lines of Obstfeld and Rofoff (1995) and Ganelli (2005a), implies that the elasticity of substitution between any two domestic brands is equal to the elasticity of substitution between domestic and foreign goods: $\epsilon = \theta$. In this sense, domestic and foreign goods are treated symmetrically in (2).

domestic of foreign, and $z \in [0,1]$. The optimal intra-temporal allocation, then, implies the following brand-specific private demand

$$c(z) = \left(\frac{p(z)}{P}\right)^{-\theta} C^W,$$

where $C^W \equiv nC + (1-n)C^*$ is world private consumption and $P = \left(\int_0^1 p(z)^{1-\theta} dh\right)^{\frac{1}{1-\theta}}$ is the domestic consumer-price index.

## 2.1 Fiscal policy and home-bias in public consumption.

Fiscal policy is conducted by setting the amount of public consumption $G$, which the government finances through lump-sum taxes $T$.[6] In particular, we assume that the government of each country consumes composite bundles of both domestic and foreign goods:

$$G = \left[v^{1/\theta} G_H^{\frac{\theta-1}{\theta}} + (1-v)^{1/\theta} G_F^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \tag{3}$$

$$G^* = \left[v^{*1/\theta} G_H^{*\frac{\theta-1}{\theta}} + (1-v^*)^{1/\theta} G_F^{*\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \tag{4}$$

where the weights are, respectively, $1-v = (1-n)\lambda$ and $v^* = n\lambda$, with $\lambda \in [0,1]$. Moreover:[7]

$$G_H = \left[\left(\frac{1}{n}\right)^{1/\theta} \int_0^n g(h)^{\frac{\theta-1}{\theta}} dh\right]^{\frac{\theta}{\theta-1}} \qquad G_F = \left[\left(\frac{1}{1-n}\right)^{1/\theta} \int_n^1 g(f)^{\frac{\theta-1}{\theta}} df\right]^{\frac{\theta}{\theta-1}}.$$

This specification generalizes the *Redux* model analyzed in Obstfeld and Rogoff (1995), as it allows to account for an arbitrary degree of home bias in public consumption, measured by $(1-\lambda)$. Indeed, in the *Redux* model – which is nested in our framework under the calibration $\lambda = 1$ – there is no home bias, as government spending is defined identically to private consumption, and it is therefore uniformly distributed across domestic and foreign goods, as in (2). We will show that this is one of the two key features behind the *Redux* model's implications for the exchange-rate response to fiscal shocks. A second polar case that our

[6] The specification of the household's problem studied in this simple model implies Ricardian Equivalence and does not allow to analyze meaningfully non-Balanced-Budget fiscal policies. We will later relax this assumption.

[7] Analogous equations hold for the foreign country, with appropriate asterisks:

$$G_H^* = \left[\left(\frac{1}{n}\right)^{1/\theta} \int_0^n g^*(h)^{\frac{\theta-1}{\theta}} dh\right]^{\frac{\theta}{\theta-1}} \qquad G_F^* = \left[\left(\frac{1}{1-n}\right)^{1/\theta} \int_n^1 g^*(f)^{\frac{\theta-1}{\theta}} df\right]^{\frac{\theta}{\theta-1}}.$$

framework nests – when $\lambda = 0$ – is the one studied by Ganelli (2005a), in which public consumption is fully home biased and each government therefore consumes only domestic goods, so that $G = G_H$ and $G^* = G^*_F$.[8]

Using the definition of $v$ and $v^*$, equation (3) implies the following public demand for brand $h$:

$$g(h) = \left(\frac{p(h)}{P_G}\right)^{-\theta} \left[vG + (1-v)Q^{\theta}G^*\right], \tag{5}$$

where

$$P_G = \left[vP_H^{1-\theta} + (1-v)\,P_F^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{6}$$

is the public consumption-based price index,

$$P_H = \left(\frac{1}{n}\int_0^n p(h)^{1-\theta}dh\right)^{\frac{1}{1-\theta}} \qquad\qquad P_F = \left(\frac{1}{1-n}\int_n^1 p(f)^{1-\theta}dh\right)^{\frac{1}{1-\theta}} \tag{7}$$

are the home-currency producer-price indexes of domestic and foreign brands, respectively,[9] and $Q$ is the real exchange rate for public consumption, given by

$$Q \equiv \frac{\mathcal{E}P_G^*}{P_G} = \frac{\left[v^* + (1-v^*)\left(\frac{P_F}{P_H}\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}}{\left[v + (1-v)\left(\frac{P_F}{P_H}\right)^{(1-\theta)}\right]^{\frac{1}{1-\theta}}},$$

in which $\mathcal{E}$ is the nominal exchange rate, defined as the nominal home-currency price of foreign currency. Moreover, we assume that the law of one price holds ($p(z) = \mathcal{E}p^*(z)$, for all $z \in [0,1]$): given unbiased private consumption bundles, purchasing power parity for the latter holds as well, i.e. $P = \mathcal{E}P^*$. While PPP holds for private consumers, however, it does not for public ones, as the composition of public spending treats asymmetrically domestic and imported goods: $P_G \neq \mathcal{E}P_G^*$ and $Q$ may deviate from 1.

Therefore, the producer of good $h$ faces at time $t$ the following demand curve:

$$y_t^d(h) = \left(\frac{p_t(h)}{P_t}\right)^{-\theta} C_t^W + \left(\frac{p_t(h)}{P_{G,t}}\right)^{-\theta} \left[vG_t + (1-v)Q_t^{\theta}G_t^*\right]. \tag{8}$$

[8] This specification is in line with the empirical evidence for OECD countries, which reports a strong degree of home bias in public consumption (see, for example Brulhart and Trionfetti, 2004 and Trionfetti, 2000). This is also the benchmark specification of public spending in most of the recent NOEM literature relying on DSGE models (see, among many others, Corsetti and Pesenti, 2001, Benigno, 2004, and Beetsma and Jensen, 2005) and will therefore be our benchmark case in Section 3.

[9] For the foreign country, a set of equations analogous to (5)–(7) holds, with appropriate asterisks.

Aggregating (8) across domestic brands delivers the aggregate demand for domestic goods:

$$Y_t = \left(\frac{P_{H,t}}{P_t}\right)^{-\theta} C_t^W + \left(\frac{P_{H,t}}{P_{G,t}}\right)^{-\theta} \left[vG_t + (1-v)Q_t^{\theta} G_t^*\right], \tag{9}$$

while the optimal choice of production effort implies the aggregate supply of domestic goods

$$Y_t^{(\theta+1)/\theta} = \left(\frac{\theta-1}{\theta\kappa}\right)\frac{1}{C_t}\left[C_t^W + \left(\frac{P_{G,t}}{P_t}\right)^{\theta}\left(vG_t + (1-v)Q_t^{\theta}G_t^*\right)\right]^{1/\theta}. \tag{10}$$

We analyze the equilibrium of the model when producer prices are set one period in advance: they are predetermined at time $t$, but then they fully adjust after one period.[10] We take a log-linear approximation around an initial symmetric steady state where $\overline{C}_0 = \overline{C}_0^*$, $\overline{Q}_0^* = 1$ and $\overline{G}_0 = \overline{G}_0^* = \overline{B}_0 = \overline{B}_0^* = 0$. We denote with $\widehat{x}$ and $\widehat{\widehat{x}}$ respectively the short-run and long-run log-linear deviation of variable $X$ from such steady state.[11] In this approximation, since producer prices are preset, consumer prices at time $t$ are proportional to the nominal exchange rate $\widehat{e}$, and equilibrium domestic and foreign output are determined by the aggregate demand schedules:

$$\widehat{y} = \widehat{c}^W + v\widehat{g} + (1-v)\widehat{g}^* + \theta(1-n)\widehat{e} \tag{11}$$

$$\widehat{y}^* = \widehat{c}^W + v^*\widehat{g} + (1-v^*)\,\widehat{g}^* - \theta n\widehat{e} \tag{12}$$

which, in relative terms, imply (using again the definition of $v$ and $v^*$)

$$\widehat{y} - \widehat{y}^* = (1-\lambda)\left(\widehat{g} - \widehat{g}^*\right) + \theta\widehat{e}. \tag{13}$$

Were prices fully flexible, instead, output would be determined by aggregate supply:

$$(\theta+1)\widehat{y} = -\theta\widehat{c} + \widehat{c}^W + v\widehat{g} + (1-v)\widehat{g}^* \tag{14}$$

$$(\theta+1)\widehat{y}^* = -\theta\widehat{c}^* + \widehat{c}^W + v^*\widehat{g} + (1-v^*)\widehat{g}^*, \tag{15}$$

[10] This effectively breaks the dynamics of the model in only two periods: the short-run, in which prices do not adjust and output is demand determined, and the long-run, when prices fully adjust and output is therefore supply determined.

[11] Exceptions are variables whose steady state level is zero, like public spending – defined as $\widehat{g} \equiv \frac{dG}{\overline{C}_0^W}$ and $\widehat{g}^* \equiv \frac{dG^*}{\overline{C}_0^W}$ – and net foreign assets – defined as $\widehat{\widehat{b}} \equiv \frac{dB}{\overline{C}_0^W}$ and $\widehat{\widehat{b}}^* \equiv \frac{dB^*}{\overline{C}_0^W}$. Notice that the latter only change in the long-run.

implying, in relative terms

$$(\theta+1)\left(\widehat{y}-\widehat{y}^{*}\right)=-\theta\left(\widehat{c}-\widehat{c}^{*}\right)+(1-\lambda)\left(\widehat{g}-\widehat{g}^{*}\right). \tag{16}$$

Using the balanced-budget restriction in the domestic and foreign budget constraints, we can derive the long-run net foreign asset position of the two countries

$$\begin{aligned}\widehat{\overline{b}} &= \widehat{y}-\widehat{c}-\widehat{g}-(1-n)\,\widehat{e}\\ \widehat{\overline{b}}^{*} &= \widehat{y}^{*}-\widehat{c}^{*}-\widehat{g}^{*}+n\widehat{e},\end{aligned}$$

which, together with the market clearing condition $n\widehat{\overline{b}}+(1-n)\widehat{\overline{b}}^{*}=0$ and (13), imply

$$\frac{\widehat{\overline{b}}}{1-n}=(\theta-1)\widehat{e}-\left(\widehat{c}-\widehat{c}^{*}\right)-\lambda\left(\widehat{g}-\widehat{g}^{*}\right). \tag{17}$$

Notice that, regardless of the actual degree of home bias in public spending, the relationship linking long-run changes in consumption and net foreign assets is the same as in the *Redux* model:

$$\widehat{c}-\widehat{c}^{*}=\frac{\overline{r}\widehat{\overline{b}}(1+\theta)}{(1-n)2\theta}, \tag{18}$$

where $\overline{r}\equiv\frac{1-\beta}{\beta}$ and $\widehat{\overline{c}}-\widehat{\overline{c}}^{*}=\widehat{c}-\widehat{c}^{*}$, as implied by the cross-country difference of the consumption Euler equations.

Combining (18) with (17) allows to derive an equation describing the equilibrium in the goods market, and the role played by fiscal policy:

$$\widehat{e}=\frac{\theta(1+\beta)+1-\beta}{(1-\beta)\left(\theta^{2}-1\right)}\left(\widehat{c}-\widehat{c}^{*}\right)+\frac{\lambda}{\theta-1}\left(\widehat{g}-\widehat{g}^{*}\right). \tag{19}$$

This schedule, which we label **GG** in analogy to Obstfeld and Rogoff (1995), is upward-sloping in the plane $(\widehat{c}-\widehat{c}^{*},\,\widehat{e})$ because relative domestic consumption can rise, *ceteris paribus*, only if the exchange rate depreciates in the short run, thereby allowing domestic output to increase. Notice that the degree of home bias in public spending determines the extent to which short-run fiscal shocks affect the equilibrium in the goods market and thereby the nominal exchange rate. In the *Redux* case ($\lambda=1$) a domestic fiscal expansion shifts the **GG** schedule upwards to the maximum extent, thereby inducing depreciation pressures on the nominal exchange rate. In the opposite polar case of complete home bias ($\lambda=0$), instead, a fiscal expansion does not affect the goods market – as in Ganelli (2005a) – given that the higher fiscal spending and higher taxation affect only domestic agents.

## 2.2 Money demand and endogenous monetary policy.

We assume that money supply is controlled – both at home and abroad – through feedback rules of the kind

$$\widehat{m} = \mu - \phi \widehat{y} \tag{20}$$

$$\widehat{m}^{*} = \mu^{*} - \phi \widehat{y}^{*}, \tag{21}$$

in which a systematic, endogenous component allows short-run money supply to respond counter-cyclically to domestic output.[12] In the feedback rules above, $\mu$ and $\mu^{*}$ are exogenous, permanent monetary policy shocks, and $\phi > 0$ is the response coefficient.[13]

Notice that, again, this framework generalizes the *Redux* model, where monetary policy is entirely exogenous, and which is therefore nested under the calibration $\phi = 0$.[14] We will show that this is the second key element behind the *Redux* model's implications for the exchange rate response to fiscal shocks.

The money-supply differential, therefore, reads:

$$\widehat{m} - \widehat{m}^{*} = (\mu - \mu^{*}) - \phi(1-\lambda)\left(\widehat{g} - \widehat{g}^{*}\right) - \theta\phi\widehat{e}, \tag{22}$$

where we used equation (13) to substitute out relative output.

Moreover, consider the cross-country difference in money demands:

$$\widehat{m} - \widehat{m}^{*} - \widehat{e} = \widehat{c} - \widehat{c}^{*} - \frac{\beta}{1-\beta}\left(\widehat{\overline{e}} - \widehat{e}\right), \tag{23}$$

and use the long-run versions of (22) and (23) to derive the equilibrium long-run exchange rate:

$$\widehat{\overline{e}} = \frac{\mu - \mu^{*} - \left(\widehat{c} - \widehat{c}^{*}\right)}{1+\theta\phi}. \tag{24}$$

Equations (22), (23) and (24) determine the equilibrium in the money market, which is synthetically described by the following **MM** schedule:

$$\widehat{e} = \frac{(\mu - \mu^{*}) - \left(\widehat{c} - \widehat{c}^{*}\right)}{1+\theta\phi} - \frac{\phi(1-\lambda)(1-\beta)}{\beta + (1-\beta)(1+\theta\phi)}\left(\widehat{g} - \widehat{g}^{*}\right). \tag{25}$$

As in Obstfeld and Rogoff (1995) and Ganelli (2005a), the **MM** schedule is downward-sloping in the plane $(\widehat{c} - \widehat{c}^{*}, \widehat{e})$ because an increase in relative domestic consumption raises

[12] We consider a feedback rule responding to output only, as domestic prices are rigid in the short run.

[13] For analytical convenience, we assume symmetric response coefficients across countries.

[14] This is also the case in Ganelli (2005a, 2005b).

domestic money demand relatively more than abroad, implying – *ceteris paribus* – a relative excess demand for domestic currency and thereby an appreciation of the nominal exchange rate. The required appreciation, however, is smaller under endogenous monetary policy, as the ensuing reduction in relative output triggers an increase in relative money supply, restoring the money-market equilibrium more rapidly: the **MM** is therefore flatter. A permanent increase in relative money supply (increase in $\mu - \mu^*$), on the other hand, by inducing a relative excess supply of domestic currency, shifts the **MM** schedule upwards and implies depreciation pressures.

Differently from Obstfeld and Rogoff (1995) and Ganelli (2005a), however, the feedback component of the monetary policy rules implies that the **MM** schedule shifts also in response to temporary fiscal shocks, as they induce short-run fluctuations in output and thereby trigger an endogenous response of money supply. Notice that the extent to which the **MM** shifts depends also on the degree of home bias in public spending, $(1 - \lambda)$. If the latter is uniformly distributed across domestic and foreign goods ($\lambda = 1$, as in the *Redux* model), indeed, the output effects of a short-run fiscal expansion are identical at home and abroad: monetary policy responds symmetrically in the two countries and relative money supply does not change, leaving also the **MM** unchanged.[15] For any nonzero degree of home bias in public consumption, however, the endogenous monetary policy response will be asymmetric across countries, and the ensuing change in relative money supply will shift the **MM** downwards and produce appreciation pressures on the nominal exchange rate, the more so the stronger the home bias.

## 2.3 Fiscal shocks and the exchange rate.

The simple framework outlined above allows to analyze the effects on the nominal exchange rate of a temporary fiscal expansion, under alternative scenarios, and to study the implications of the two features that we added to the *Redux* model: home-bias in fiscal spending and endogenous monetary policy.

The first scenario is one in which public consumption is uniformly distributed between domestic and foreign goods – i.e. $\lambda = 1$, like in the *Redux* model. In this scenario, whether monetary policy is exogenous as in Obstfeld and Rogoff (1995) – i.e. $\phi = 0$ in (20)–(21) – or endogenous – i.e. $\phi > 0$ – is irrelevant for the exchange-rate response to fiscal shocks.

[15] The **MM** schedule would move also in this case if the response coefficients in the monetary policy rules were different across countries.

As shown by Obstfeld and Rogoff (1995), indeed, the **GG** schedule in this case reads as

$$\widehat{e} = \frac{\theta(1+\beta)+1-\beta}{(1-\beta)\left(\theta^2-1\right)}\left(\widehat{c}-\widehat{c^*}\right) + \frac{1}{\theta-1}\left(\widehat{g}-\widehat{g^*}\right). \tag{26}$$

On the other hand, equation (25) in this case implies $\widehat{y} - \widehat{y}^* = \theta\widehat{e}$, and the monetary policy rules (in difference terms) therefore read

$$\widehat{m} - \widehat{m}^* = (\mu - \mu^*) - \theta\phi\widehat{e}, \tag{27}$$

which shows that, regardless of the magnitude of the response coefficient $\phi$, the relative money supply does not endogenously respond to fiscal shocks, implying that the **MM** schedule becomes simply

$$\widehat{e} = \frac{(\mu-\mu^*) - (\widehat{c}-\widehat{c}^*)}{1+\theta\phi}. \tag{28}$$

Therefore, a balanced-budget government spending shock at Home shifts the **GG** upwards, as in the *Redux* model, while it does not move the **MM** schedule, even if monetary policy is endogenous. This result is graphically shown in Figure 1: a temporary fiscal shock depreciates the exchange rate in equilibrium. Indeed, when public consumption is uniformly distributed among domestic and foreign brands, a government spending shock, regardless of the country of origin, acts as a global shock. As a consequence, output in both countries responds symmetrically and relative money supply therefore does not change.[16] Private consumption, on the other hand, falls more at home than abroad, as the tax burden is only borne by domestic consumers. The ensuing reduction in relative money demand implies an excess supply of domestic currency and, thereby, a nominal depreciation of the exchange rate. This is the familiar implication of the *Redux* model. Allowing for an endogenous component in monetary policy is not enough to qualitatively affect the result derived by Obstfeld and Rogoff (1995).

The second scenario is the one analyzed by Ganelli (2005a), in which public consumption is fully home biased ($\lambda = 0$). In this scenario, the specific assumption about monetary policy is key to understand the exchange-rate response to fiscal shocks. If monetary policy is exogenous – i.e. $\phi = 0$, as in Ganelli (2005a) – it is straightforward to see that neither the **GG**

$$\widehat{e} = \frac{\theta(1+\beta)+1-\beta}{(1-\beta)\left(\theta^2-1\right)}\left(\widehat{c}-\widehat{c^*}\right) \tag{29}$$

[16] This depends on the assumption that monetary policy at home and abroad use identical response coefficients $\phi$. In the case of asymmetric response coefficients, the specific assumption about whether monetary policy is endogenous or not does, indeed, affect the results.

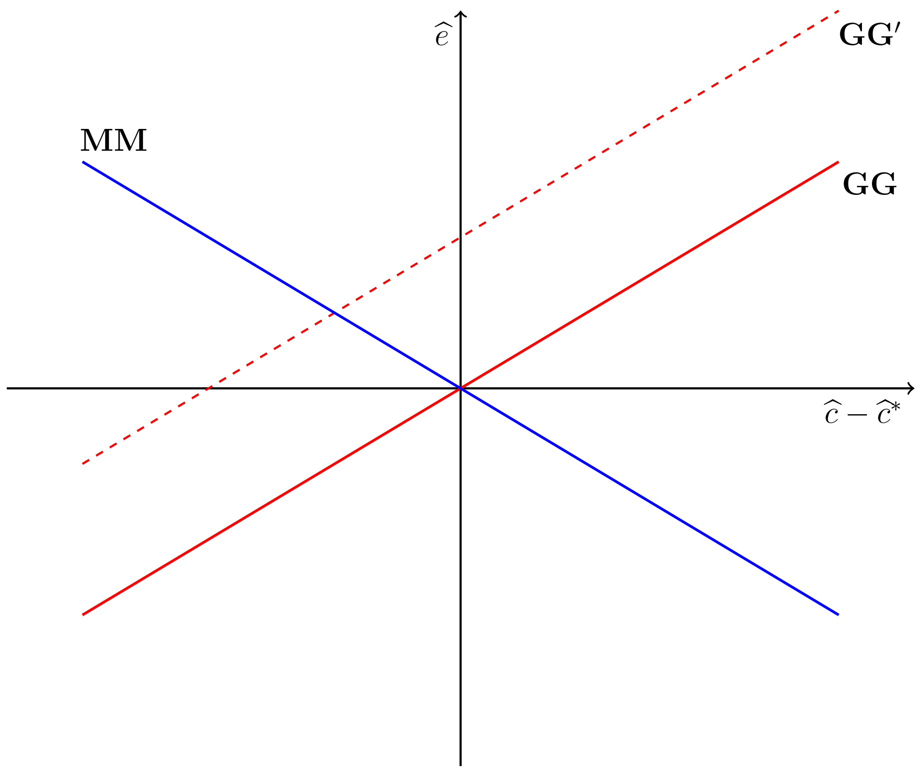


**Figure 1:** A temporary expansion in domestic government spending, with zero home bias ($\lambda = 1$) and endogenous monetary policy ($\phi > 0$).

nor the **MM**

$$\widehat{e} = (\mu - \mu^*) - (\widehat{c} - \widehat{c}^*) \tag{30}$$

respond to fiscal shocks. As a consequence, a temporary expansion in domestic public consumption does not have any effect on the nominal exchange rate. This is the quasi-neutrality result derived in Ganelli (2005a): with full home bias in public consumption and exogenous monetary policy, the expansion in public spending falls entirely on domestic goods, and the implied tax burden is borne entirely by domestic consumers. As a consequence, domestic and foreign consumption do not react, and the exchange rate neither depreciates nor appreciates. The only variable on which the fiscal shock is not neutral is domestic output, which increases with a unitary multiplier, with no spillover to the current account or foreign output.

If instead monetary policy is endogenous ($\phi > 0$) the implication is radically different. Indeed, while the **GG** schedule is still (29), equilibrium in the money market is now described by the following **MM**:

$$\widehat{e} = \frac{(\mu - \mu^*) - (\widehat{c} - \widehat{c}^*)}{1 + \theta\phi} - \frac{\phi(1-\beta)}{\beta + (1-\beta)(1+\theta\phi)} (\widehat{g} - \widehat{g}^*) \,. \tag{31}$$

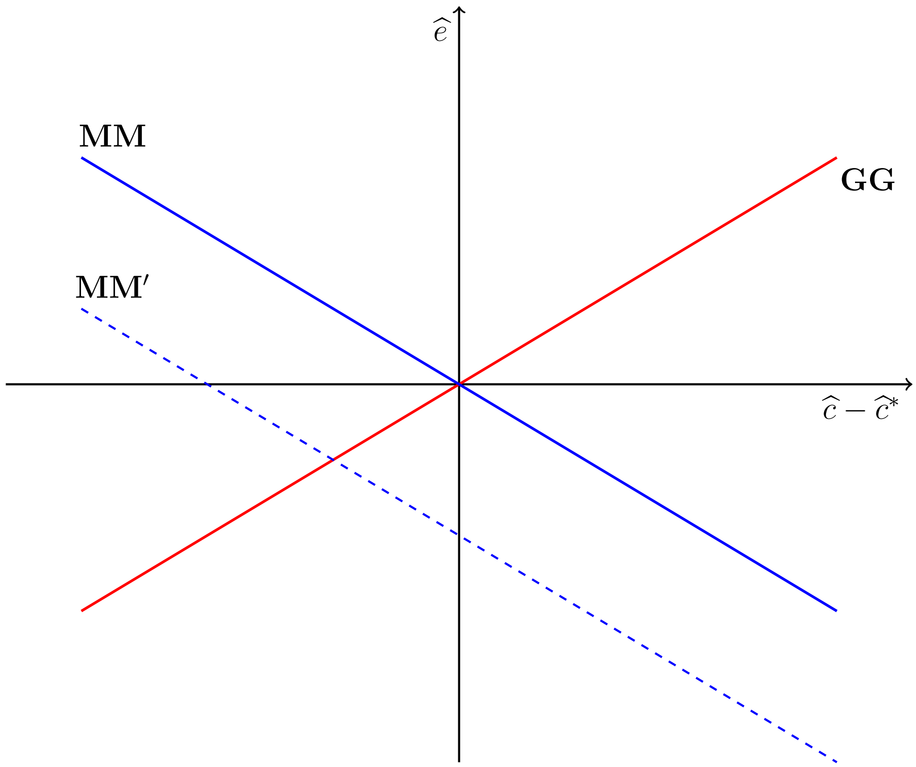


**Figure 2:** A temporary expansion in domestic government spending, with full home bias ($\lambda = 0$) and endogenous monetary policy ($\phi > 0$).

The asymmetric response of real output, indeed, triggers an asymmetric endogenous response of monetary policy as well, which reduces relative money supply, thereby implying a nominal exchange-rate appreciation. This is captured, in Figure 2, by a downward shift in the **MM** schedule.

A scenario in which public spending is fully home biased and monetary policy has an endogenous feedback component, therefore, reverses the result of the *Redux* model and restores the basic implication of the Mundell-Fleming model, that an increase in public spending determines an exchange-rate appreciation.[17]

In the general case of incomplete home bias in public consumption and endogenous monetary policy, described by equations (19) and (25), both transmission mechanisms discussed so far are simultaneously at work, as displayed by Figure 3. The **GG** schedule shifts upwards, the more so the less home-biased public consumption (the higher $\lambda$), and the **MM** downwards, the more so the more endogenous monetary policy (the higher $\phi$). Whether the equilibrium response of the exchange rate implies a depreciation or an appreciation depends therefore on the relative importance of the two additional features that we added to the

[17] It is important to notice, however, that the transmission channel here is different than Mundell-Fleming's.

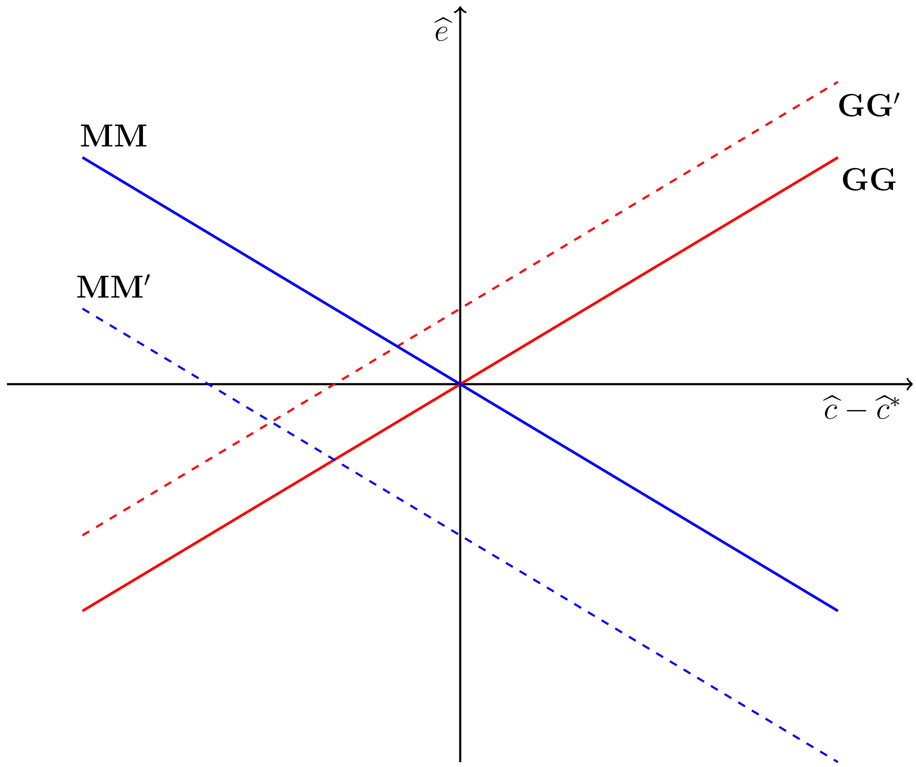


**Figure 3:** A temporary expansion in domestic government spending, with incomplete home bias ($0 < \lambda < 1$) and endogenous monetary policy ($\phi > 0$).

*Redux* model.

To explore the implications of our *generalized Redux* model, Figure 4 plots the equilibrium change in the nominal exchange rate for a calibrated economy, for different values of the two key parameters: $\lambda$ and $\phi$.[18] The figure displays the result already implied by the graphical analysis: the more home-biased public spending and the more endogenous monetary policy, the more a temporary fiscal expansion implies an appreciation of the nominal exchange rate. Interestingly, however, looking at the contour lines at the base of the plot (in particular the orange line starting from the origin) reveals that most of the surface is below the zero plane, suggesting that moderate degrees of home bias in public consumption and endogenous response of monetary policy to the cycle, are enough to reverse the implication of the *Redux* model, and restore the Mundell-Fleming result that a temporary fiscal expansion appreciates the nominal exchange rate.

[18]The calibration of $\beta$ is consistent with an annualized steady state interest rate of 4%, while the price-elasticity of brand-specific demands is taken from Rotemberg and Woodford(1997): $\theta = 7.66$. The qualitative implication of Figure 4 is robust to alternative calibrations of $\beta$ and $\theta$.

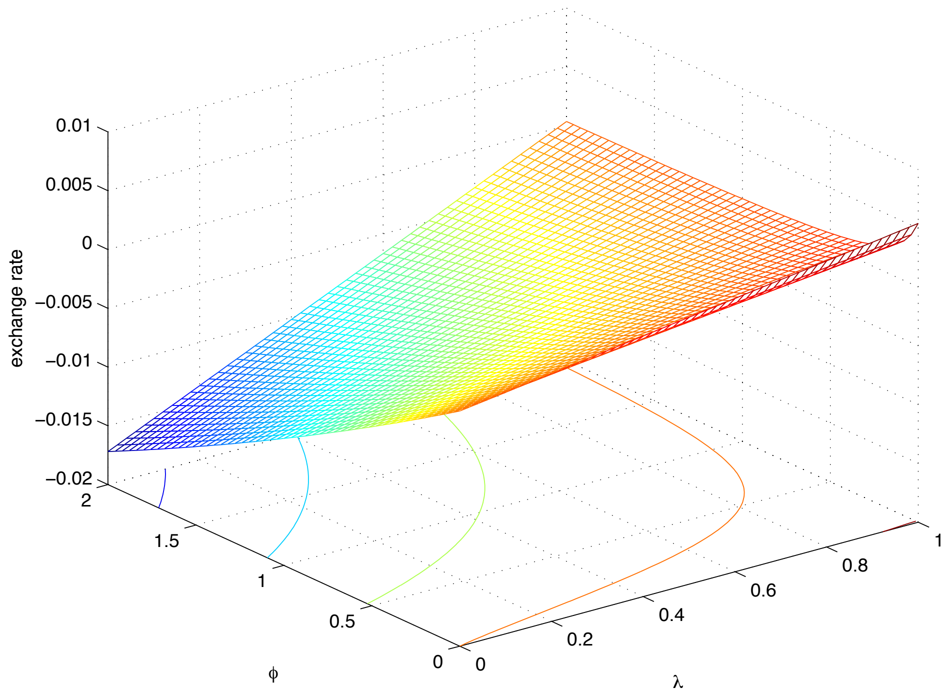


**Figure 4:** Exchange-rate short-run response to a temporary expansion in domestic government spending: the role of the degree of home-bias ($\lambda$) and endogenous monetary policy ($\phi$).

# 3 A DSGE Two-Country Model

In this section we analyze a standard two-country DSGE model, which, in the modern NOEM and DNK tradition, features nominal rigidities in the form of a Calvo (1983) price-setting mechanism and where monetary policy is specified as the control of a short-term interest rate through a Taylor-type feedback rule.[19] In order to be able to analyze a broader range of fiscal shocks and compare our results with existing literature, moreover, we extend the standard framework to also break Ricardian equivalence through a perpetual-youth structure of the demand side of the economy. The general model is therefore a two-country OLG economy, along the lines of Di Giorgio and Nisticò (2007, 2008).[20]

The world economy consists of a continuum of households and firms in the interval [0, 1], divided in two countries $H$ and $F$, of dimension $n$ and $(1-n)$ respectively. The two countries are structurally symmetric. Each domestic household belonging to cohort $j$ supplies labor

[19]See, among others, Benigno (2004) and Galí and Monacelli (2005).

[20]We refer to Di Giorgio and Nisticò (2007, 2008) for details about the OLG open-economy framework.

inputs ($N$) to firms and demands consumption goods in order to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t (1-\gamma)^t \Big[\log C_t(j) + \delta \log(1 - N_t(j))\Big]$$

where $C_t(j)$ is an unbiased bundle of both domestic and imported goods:[21]

$$C_t(j) = \left[ n^{\frac{1}{\theta}} C_{H,t}(j)^{\frac{\theta-1}{\theta}} + (1-n)^{\frac{1}{\theta}} C_{F,t}(j)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}. \tag{32}$$

The productive sector produces a continuum of perishable goods, which are differentiated across countries (with elasticity of substitution $\theta > 0$) and with respect to one another (with elasticity of substitution $\epsilon > 1$). Both domestic and foreign firms face, each period, an exogenous probability of optimally changing the price of their good (see Calvo, 1983), and are subject to the law of one price. The joint assumption of unbiased consumption bundles and the law of one price implies purchasing power parity:

$$P_t = \mathcal{E}_t P_t^*, \tag{33}$$

where $\mathcal{E}$ denotes the nominal exchange rate defined as the domestic price of foreign currency.

The demand-side of the economy is a discrete-time stochastic version of the perpetual youth model introduced by Blanchard (1985) and Yaari (1965). Each period, in each country, a constant share $\gamma$ of traders in the financial markets are randomly replaced by newcomers with zero-financial wealth; from that period onward, these newcomers start trading in the financial markets and face a constant probability $\gamma$ of being replaced as the next period begins.[22] Consumers have log-utility preferences over consumption and leisure, supply labor services in a domestic competitive labor market and demand consumption goods. Moreover, they allocate savings among a full set of domestic state-contingent private securities and two internationally traded riskless financial assets issued in the two currencies by the governments to finance their budget deficits. Each consumer in each country is endowed with an equal amount of non-tradable shares of the domestic firms.

The solution of the optimization problem of domestic and foreign households delivers a set of cohort-specific equilibrium conditions which, once aggregated across cohorts, describe the aggregate labor supply[23]

$$\delta P_t C_t = W_t (1 - N_t), \tag{34}$$

[21] Symmetric relations hold for the foreign country, with appropriate asterisks.

[22] For a thorough discussion of this mechanism, see Castelnuovo and Nisticò (2008), and Nisticò (2011).

[23] For details on the features of the model and the derivation of individual and aggregate equilibrium conditions, see Di Giorgio and Nisticò (2008, 2013).

where $W$ denotes the nominal wage, and the dynamic path of aggregate consumption

$$C_t = \sigma E_t \left\{ \mathcal{F}_{t,t+1} \frac{P_{t+1}}{P_t} \right\} \Omega_t + \frac{1}{\beta} E_t \left\{ \mathcal{F}_{t,t+1} \frac{P_{t+1}}{P_t} C_{t+1} \right\} \tag{35}$$

in which $\mathcal{F}_{t,t+1}$ denotes the stochastic discount factor, $\Omega_t$ the financial wealth in real terms, and the first term captures the financial wealth effect on consumption, which is increasing in the turnover rate $\gamma$:

$$\sigma \equiv \gamma \frac{1-\beta(1-\gamma)}{\beta(1-\gamma)}.$$

This additional term with respect to the RA set up is a direct implication of the random replacement of a fraction of traders in the financial market with newcomers holding zero-wealth. Indeed, the interaction between long-time traders with accumulated wealth and newcomers holding zero financial wealth drives a wedge between the equilibrium stochastic discount factor and the *average* marginal rate of intertemporal substitution in consumption. In fact, while the cohort-specific Euler equation is the same as in the Representative Agent setup, because of the insurance mechanism *à la* Blanchard, their aggregation is not straightforward (as it is in the RA setup) because the composition of traders in the financial markets tomorrow will include newcomers entering with zero-wealth to replace a share of long-time traders. These newcomers will consume on average less than long-time traders because they will not have any accumulated wealth. Aggregation will therefore account for this difference by means of a wedge between the stochastic discount factor and the average marginal rate of substitution in consumption. Such wedge is proportional to the stock of financial wealth and creates a link between average consumption growth and the dynamics of financial wealth.

Notice that what drives the financial wealth effect is not the finiteness of individual agents' planning horizon, because the effect of this feature is sterilized by the insurance mechanism à la Blanchard. The financial wealth effect only appears in aggregate terms, and is truly implied by the presence of agents with zero-wealth and their interaction with long-time traders. This argument is crucial for the interpretation of the nature of parameter $\gamma$, and its possible quantitative calibration. As the rate of replacement ($\gamma$) approaches zero the wealth effect fades away and the model converges to the RA set up.

Our baseline assumption with respect to fiscal policy is the standard feature of NOEM DSGE models: the government of each country consumes an exogenously given amount of domestic goods only[24]

$$G = \left[ \left( \frac{1}{n} \right)^{1/\epsilon} \int_0^n g(h)^{\frac{\epsilon-1}{\epsilon}} dh \right]^{\frac{\epsilon}{\epsilon-1}} \qquad G^* = \left[ \left( \frac{1}{1-n} \right)^{1/\epsilon} \int_n^1 g^*(f)^{\frac{\epsilon-1}{\epsilon}} df \right]^{\frac{\epsilon}{\epsilon-1}}.$$

As a consequence, public demand for brands $h$ and $f$ is equal to:

$$g(h) = \left( \frac{p(h)}{P_H} \right)^{-\epsilon} G \qquad g^*(f) = \left( \frac{p^*(f)}{P_F^*} \right)^{-\epsilon} G^*.$$

The government of domestic country can finance its own consumption $G_t$ by levying lump-sum taxes $T_t$ to domestic households and by issuing nominal debt denominated in local currency $B_{i,t}^n$, for $i = H, F$. This implies the following budget constraint for the domestic fiscal authority, in real per-capita terms (let $B \equiv B^n/P$):

$$B_{H,t} = (1 + r_{t-1}) \frac{P_{t-1}}{P_t} B_{H,t-1} + Z_t, \tag{36}$$

where $Z_t$ denotes the domestic real primary deficit, defined as

$$Z_t \equiv \frac{P_{H,t}}{P_t} G_t - T_t. \tag{37}$$

The supply side of the economy is standard in the New-Keynesian tradition. Firms have access to a stochastic linear technology, with country-specific productivity shock denoted by $A_t$. Firms choose labor demand in a competitive labor market by minimizing their total real costs subject to the technological constraint.

In equilibrium, the real marginal cost for the two countries will be

$$MC_t = \frac{\delta C_t}{A_t - Y_t \Xi_t} \left[ n + (1-n) \mathcal{S}_t^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{38}$$

$$MC_t^* = \frac{\delta C_t^*}{A_t^* - Y_t^* \Xi_t^*} \left[ n \mathcal{S}_t^{\theta-1} + (1-n) \right]^{\frac{1}{1-\theta}}, \tag{39}$$

in which $\mathcal{S}$ denotes the terms of trade and $\Xi$ and $\Xi^*$ capture (second-order) relative price dispersion among firms of country $H$ and $F$, respectively. Such firms set output prices according to Calvo's (1983) staggering mechanism – with $1 - \vartheta$ $(1 - \vartheta^*)$ being the probability for each firm in country $H$ $(F)$ to optimally adjust its price. In equilibrium, this assumption

[24] We will later compare the implications of such specification with those of the case in which, as in Obstfeld and Rogoff (1995) and Ganelli (2005b), public consumption is instead uniformly distributed across domestic and imported goods.

implies a set of familiar New Keynesian Phillips Curves.

## 3.1 The Linear Model.

We analyze a first-order approximation of the model's equilibrium conditions around a zero-inflation/zero-deficit steady state. Let $x_t \equiv \log X_t - \log X$ denote the log-deviation of variable $X$ from its steady state.[25] Moreover, let $x^W \equiv nx^H + (1-n)x^F$ denote world aggregates and $x^R \equiv x^H - x^F$ denote $H$ relative aggregates. We also set $s_c \equiv Y/C$.

Our model economy can be summarized by the following linear equations. An aggregate labor supply relates each country's hours worked to domestic consumption and the real wage:

$$c_t + \varphi n_t = w_t - p_t, \tag{40}$$

where $\varphi$ is the inverse Frisch-elasticity of labor supply. Nominal interest rates are linked through a standard Uncovered Interest-rate Parity (UIP) condition

$$E_t \Delta e_{t+1} = r_t - r_t^*, \tag{41}$$

which, coupled with the Law of One Price and unbiased consumption bundles, implies

$$r_t - E_t \pi_{t+1} = r_t^* - E_t \pi_{t+1}^*, \tag{42}$$

in which $\pi_t \equiv \log(P_t/P_{t-1})$ and $\pi_t^* \equiv \log(P_t^*/P_{t-1}^*)$ are the CPI-based inflation rate for country $H$ and $F$, respectively.

Net foreign assets $\alpha$, expressed in terms of country $H$'s position, evolve as a function of consumption differential and the terms of trade:

$$\alpha_t = \frac{1}{\beta}\alpha_{t-1} + (\theta - 1)(1-n)s_t - (1-n)c_t^R. \tag{43}$$

The dynamics of net foreign assets with respect to the terms of trade are the result of two competing effects. On the one side, a depreciation of $s_t$ deteriorates the current account because it reduces the real value of domestic production, relative to absorption (negative absorption effect: $-(1-n)s_t$). On the other side, a deterioration of the terms of trade makes domestic goods more competitive in the international markets, and imply a switch towards home goods and a consequent improvement in net foreign asset holdings (positive switching effect: $\theta(1-n)s_t$). As long as Home and Foreign goods are substitute in the utility

[25] Exceptions are $g_t \equiv \frac{G}{Y}\log(G_t/G)$, $\tau_t \equiv \frac{T}{Y}\log(T_t/T)$, and $z_t$, $\omega_t$, and $b_{i,t}$ which, given the assumption of zero-primary deficit in steady state, we define as $z_t \equiv Z_t/C$, $\omega_t^i \equiv \Omega_t^i/C$ and $b_{i,t} \equiv B_{i,t}/C$.

of consumers ($\theta > 1$) the positive switching effect dominates and a deterioration of the terms of trade implies a current account surplus.

Let $\pi_{i,t} \equiv \log(P_{i,t}/P_{i,t-1})$ denote the PPI-based inflation rate for country $i$. The terms of trade, then, evolve according to:

$$s_t = s_{t-1} + \Delta e_t + \pi_{F,t} - \pi_{H,t}. \tag{44}$$

Public debt, in country $H$, follows the linearized law of motion:

$$b_{H,t} = \frac{1}{\beta} b_{H,t-1} + z_t, \tag{45}$$

where the real primary deficit equals:

$$z_t = s_c(g_t - \tau_t) - (s_c - 1)(1-n)s_t \tag{46}$$

The state equations for domestic, world and relative consumption read:

$$c_t = E_t c_{t+1} - (r_t - E_t \pi_{t+1} - \varrho) + \sigma\beta\omega_t \tag{47}$$

$$c_t^W = E_t c_{t+1}^W - (r_t^W - E_t \pi_{t+1}^W - \varrho) + \sigma b_t^W \tag{48}$$

$$c_t^R = E_t c_{t+1}^R + \sigma b_t^R + \frac{\sigma}{1-n}\alpha_t \tag{49}$$

in which $\varrho$ is the steady-state real interest rate, and relative public debt evolves according to $b_t^R = \frac{1}{\beta} b_{t-1}^R + z_t^R$.

On the supply side, Calvo price-setting implies two NKPC of the usual kind:

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \zeta mc_t, \tag{50}$$

$$\pi_{F,t} = \beta E_t \pi_{F,t+1} + \zeta^* mc_t^*, \tag{51}$$

in which $\zeta \equiv \frac{(1-\vartheta)(1-\beta\vartheta)}{\vartheta}$, $\zeta^* \equiv \frac{(1-\vartheta^*)(1-\beta\vartheta^*)}{\vartheta^*}$, and the real marginal costs, expressed in terms of aggregate and relative variables, follow:

$$mc_t = \frac{s_c + \varphi}{s_c} c_t^W + (1-n)c_t^R + (1-n)\frac{s_c + \varphi\theta}{s_c} s_t + \varphi g_t - (1+\varphi)a_t \tag{52}$$

$$mc_t^* = \frac{s_c + \varphi}{s_c} c_t^W - n c_t^R - n\frac{s_c + \varphi\theta}{s_c} s_t + \varphi g_t^* - (1+\varphi)a_t^*. \tag{53}$$

### 3.2 Parameterization

We parameterize the model on a quarterly frequency, following previous studies and convention, and consistently with Di Giorgio and Nisticò (2013). Specifically, the steady-state net quarterly interest rate $\varrho$ was set at 0.01, implying a long-run real annualized interest rate of 4%.[26] The rate of replacement $\gamma$ was set equal to 0.1, consistently with the evidence for the U.S. recently provided, in a related framework, by Castelnuovo and Nisticò (2010). In order to meet the steady-state restrictions, the intertemporal discount factor $\beta$ was set at 0.99. The degree of monopolistic competition is taken from Rotemberg and Woodford (1997), $\epsilon$ =7.66, which implies an average markup of 15%. In line with estimates provided for the U.S. by Smets and Wouters (2007), we set the Calvo parameter at 0.75, implying that prices are revised on average once a year. Parameter $s_c$ was set equal to 1.25, implying a ratio of public consumption to output of about 20%. As to the steady-state Frisch elasticity of labor supply, $1/\varphi$, there is wide controversy about the value that should be assigned to this parameter. The empirical microeconomic literature suggests values for $\varphi$ ranging from .1 to .5 (see Card, 1994, for a survey), while business cycle literature mostly uses values greater than 1 (see e.g. Cooley and Prescott, 1995). We choose a baseline value of $\varphi$ =0.5, consistently with the microevidence. The elasticity of substitution between Home and Foreign goods was set equal to $\theta = 1.5$, which implies that home and foreign goods are substitute in the utility function of consumers. Finally, we parameterize the dimension of the Home country $n$ to 0.6, roughly consistent with the ratio of the U.S. GDP to the one of the Euro-10.

**Table 1:** Stochastic properties of the productivity shocks.

| **Shock** | $P_a$ | | $\sigma_a$ | $corr(u_a, u_a^*)$ |
|---|---|---|---|---|
| $a$ | **0.723** | **-0.067** | **0.0062** | **0.0910** |
| | (11.142) | (-0.765) | | |
| $a^*$ | **0.214** | **0.608** | **0.0041** | |
| | (4.976) | (10.544) | | |

As to the stochastic shocks, we allow for international propagation of productivity shocks and therefore assume that they evolve as a stationary VAR(1) process: $\mathbf{a}_t = \mathbf{P}_a \mathbf{a}_{t-1} + \mathbf{u}_{at}$, where $\mathbf{a} \equiv [a \quad a^*]'$. To calibrate persistence and volatilities, we estimate the VAR using quarterly HP-filtered data on labor productivity in the U.S. and the Euro Area for the period

[26]Since we focus on a symmetric steady state the values reported in the text are meant to refer to both countries as well as to the world economy.

**Table 2:** Stochastic properties of the fiscal shocks.

| **Shock** | $\rho_g$ | $\sigma_g$ | $Adj.R^2$ | **Shock** | $\rho_\tau$ | $\sigma_\tau$ | $Adj.R^2$ |
|---|---|---|---|---|---|---|---|
| $g$ | **0.692** | **0.0066** | **0.4674** | $\tau$ | **0.768** | **0.0192** | **0.5802** |
| | (11.164) | | | | (14.008) | | |
| $g^*$ | **0.638** | **0.0041** | **0.4159** | $\tau^*$ | **0.905** | **0.0105** | **0.8181** |
| | (10.056) | | | | (25.269) | | |

spanning from 1970:1 to 2005:4.[27] The values obtained are reported in Table 1 ($t$-statistics in parenthesis).

As the table shows, we find significant evidence of an international stochastic relation between productivity in the U.S. and the Euro Area, and a small positive correlation between the innovations.

Analogously, to calibrate persistence and volatility of the fiscal shocks ($g_t = \rho_g g_{t-1} + u_{g,t}$ and $\tau_t = \rho_\tau \tau_{t-1} + u_{\tau,t}$), we estimate an independent AR(1) process for each shock, using quarterly HP-filtered data on government consumption and real personal taxes in the U.S. and the Euro Area for the available sample (1970:1 to 2005:4). The values obtained are reported in Table 2.

Given the structural symmetry of our framework, we follow Backus, Kehoe and Kydland (1992), among the others, and use for the benchmark simulation a symmetrized version of our estimates. We therefore calibrate matrix $P_a$ to

$$P_a = \begin{bmatrix} 0.665 & 0.074 \\ 0.074 & 0.665 \end{bmatrix}, \tag{54}$$

the standard deviations of productivity shocks at $\sigma_a = \sigma_a^* = 0.0056$ and the correlation at the estimated value (0.0910). As to the fiscal shocks, we calibrate $\rho_g = \rho_g^* = 0.665$, $\sigma_g = \sigma_g^* = 0.0054$, $\rho_\tau = \rho_\tau^* = 0.836$ and $\sigma_\tau = \sigma_\tau^* = 0.0148$.

[27]See Di Giorgio and Nisticò (2013) for a discussion. Data for the Euro Area are taken from the Area-Wide Model Database, Labour Productivity, series ID: LPROD. Data for the U.S. are constructed, for consistency with the corresponding series for the Euro Area, as real GDP over employment, using data from the Federal Reserve Economic Data, FRB of St Louis, series ID: GDPC96 (for real GDP) and CE16OV (for employment). The Area-Wide Model Database is available to EABCN members at http://www.eabcn.org/data/awm/index.htm. For a description of this database, see Fagan et al. (2005).

## 3.3 Fiscal Shocks, Endogenous Policy and the Exchange Rate

In this section we study the dynamic response of the economy to fiscal shocks, and focus particularly on the role of endogenous monetary and fiscal policy in shaping the short-run and long-run response of the exchange rate.

As to economic policy, we assume in each country the presence of two policy makers: a Central Bank and a fiscal authority. The former sets the domestic nominal interest rate and the latter either public consumption or the level of domestic taxes.[28]

Monetary policy follows a simple instrument rule of the kind introduced by Taylor (1993), where the nominal interest rate responds to deviations of the GDP deflator $\pi_{H,t}$ and the domestic output gap from the zero targets:

$$r_t = \varrho + \phi_\pi \pi_{H,t} + \phi_x x_t + u_{m,t}, \tag{55}$$

in which $u_{m,t}$ are white noises capturing pure monetary policy shocks. In the simulation analysis below, we study different parameterizations for the response coefficients, to assess the role of endogenous policy on the exchange-rate response to fiscal shocks. As baseline calibration for the response coefficients and the volatility of monetary policy shocks, we use the following (symmetrized) values, consistent with the estimates provided for the U.S. and the Euro Area by Smets and Wouters (2003, 2007): $\phi_\pi = \phi_\pi^* = 2$, $\phi_x = \phi_x^* = 0.1$, $\sigma_m = \sigma_m^* = 0.0016$.

As to fiscal policy, we consider several alternative specifications, focusing only on "passive" (in the sense of Leeper, JME 1991) or implementable (in the sense of Schmitt-Grohe and Uribe, 2006) fiscal rules. The first specification considers the case in which the government targets a balanced budget in every period:

$$z_t = 0. \tag{56}$$

In this case, an increase in public consumption is, financed through an equivalent increase in domestic taxes.

Given the non-Ricardian structure of our model, we can also analyze alternative fiscal regimes which do not imply a balanced budget in every period. In particular, one alternative regime has real taxes follow an exogenous, stationary autoregressive process:

$$\tau_t = \rho_\tau \tau_{t-1} + (1 - \rho_\tau)\xi_b b_{t-1} + u_{z,t}, \tag{57}$$

where a drift adjusting to the stock of outstanding debt insures equilibrium determinacy

[28] In the following, we assume that the foreign authorities behave symmetrically.

$(\xi_b = (\varrho/s_c))$ and fiscal solvency. In this regime, therefore, an increase in public consumption is financed through new debt.

The third specification considers the case in which governments set their primary deficit following a counter-cyclical feedback rule of the kind:

$$z_t = -\mu_b b_{t-1} - \mu_x x_t + u_{z,t}. \tag{58}$$

This specification was analyzed by recent empirical and theoretical literature (see Galí and Perotti, 2003 and Di Giorgio and Nisticò, 2013), and encompasses different fiscal regimes, depending on the specific values for the response coefficients.

If the response coefficients on the output gap are zero and those on the stock of debt as low as needed to ensure determinacy, this fiscal rule corresponds to a passive fiscal regime like (57), and, therefore, an increase in public consumption is simply and entirely financed through new debt.

Non-zero response coefficients, on the other hand, imply that the fiscal regime actively reacts to the business cycle and the dynamics of the public debt, potentially affecting the transmission mechanism of any kind of shock. In this scenario, we calibrate the response coefficients with the following (symmetrized) values, consistent with the estimates provided by Galí and Perotti (EP, 2003) for the U.S. and the group of EMU10: $\mu_x = \mu_x^* = 0.7$, $\mu_b = \mu_b^* = 0.1$.

### 3.3.1 The Dynamic Response to Fiscal Shocks

Here we evaluate the dynamic effects of a wide range of fiscal policy shocks, and compare the implications for the exchange rate with those discussed in the related literature.

First, in Figures 5 and 6 we examine the effects of a balanced-budget expansion in public consumption. When government spending is home biased, an increase in $g$ tends to raise marginal costs at home relatively more than abroad (equations (52)–(53)), thereby triggering an increase in relative interest rates to offset the inflationary pressures. This results in a short-run appreciation of the nominal exchange rate, which worsens the external position. As a consequence, relative consumption falls (equation (49)). In our setting, therefore, the final short-run effect on relative consumption and net foreign assets are the same as in Ganelli (2005b) and Obstfeld–Rogoff (1995), while the effects on the exchange rate are reversed. This effects are shown by the solid lines in Figure 5.

This difference in results, as shown analytically in a simplified version of this model in Section 2, is due to the joint presence of home-biased public consumption and endogenous monetary policy. To isolate the effects of these two additional assumptions, relative

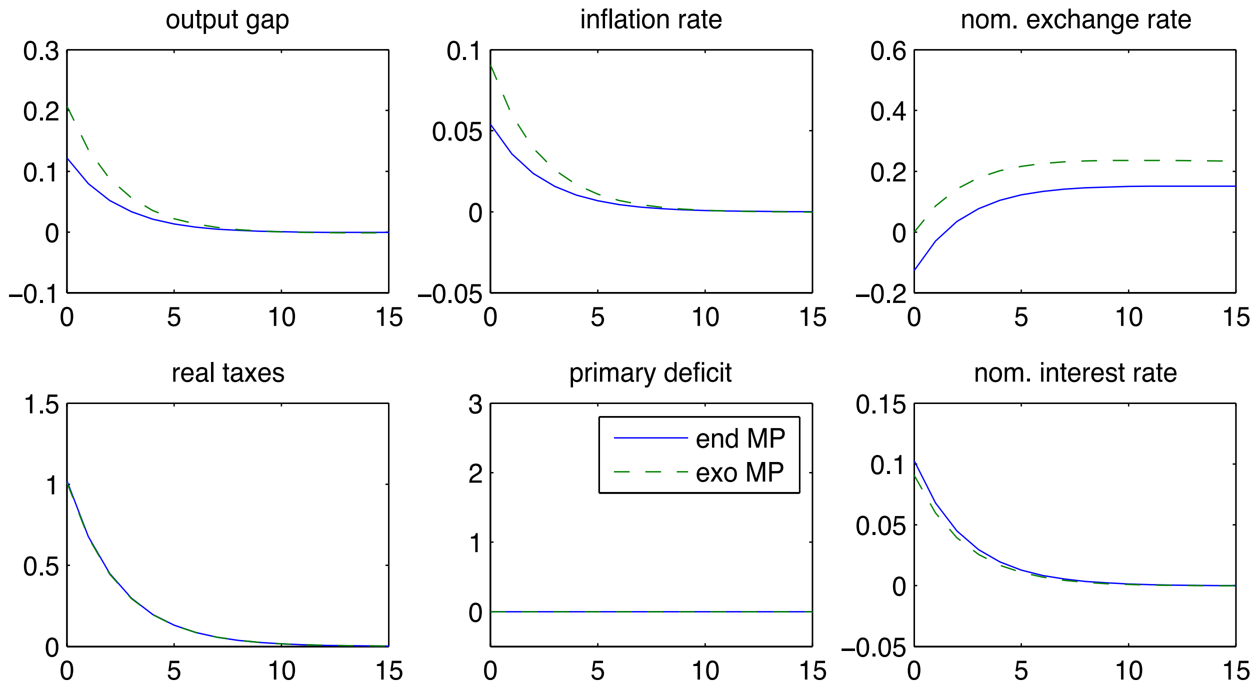


**Figure 5:** Response of selected variables to a 1%, balanced-budget increase in public consumption. Solid line: endogenous monetary policy. Dashed line: exogenous monetary policy.

to Obstfeld–Rogoff (1995), the dashed line in Figure 5 displays the dynamic response of our economy when monetary policy is exogenous in real terms, meaning that the real interest rate does not respond to either inflation, nor the output gap.[29]

The dashed line in Figure 5, indeed, confirms the results derived in the simple model of Section 2: when monetary policy is exogenous and government spending is fully biased towards domestic products, the nominal exchange rate does not move at all in the short-run, in response to a balanced-budget fiscal shock. This is also the quasi-neutrality result discussed in Ganelli (2005a), where however, the key role of exogenous monetary policy was not identified.

Notice that the higher inflationary pressures induced in the home country sets the domestic price level on a higher path relative to foreign one. In the long-run, accordingly, when both inflation rates are back to zero, this difference in the price levels remains and is responsible for the permanent depreciation of the nominal exchange rate.

Figure 6 shows the role played by the composition of public consumption. The solid line shows the response to a balanced-budget increase in government spending, when the latter is

[29]This corresponds to calibrating $\phi_\pi = 1$ and $\phi_x = 0$, in equation (55). In order for the rational expectation equilibrium to be determinate, we cannot impose a fully exogenous monetary policy, i.e. a *nominal* interest-rate peg. Notice, however, that a *nominal* interest-rate peg is not necessary to characterize exogenous monetary policy in this framework, as both inflation and real activity respond to the *real* interest rate.

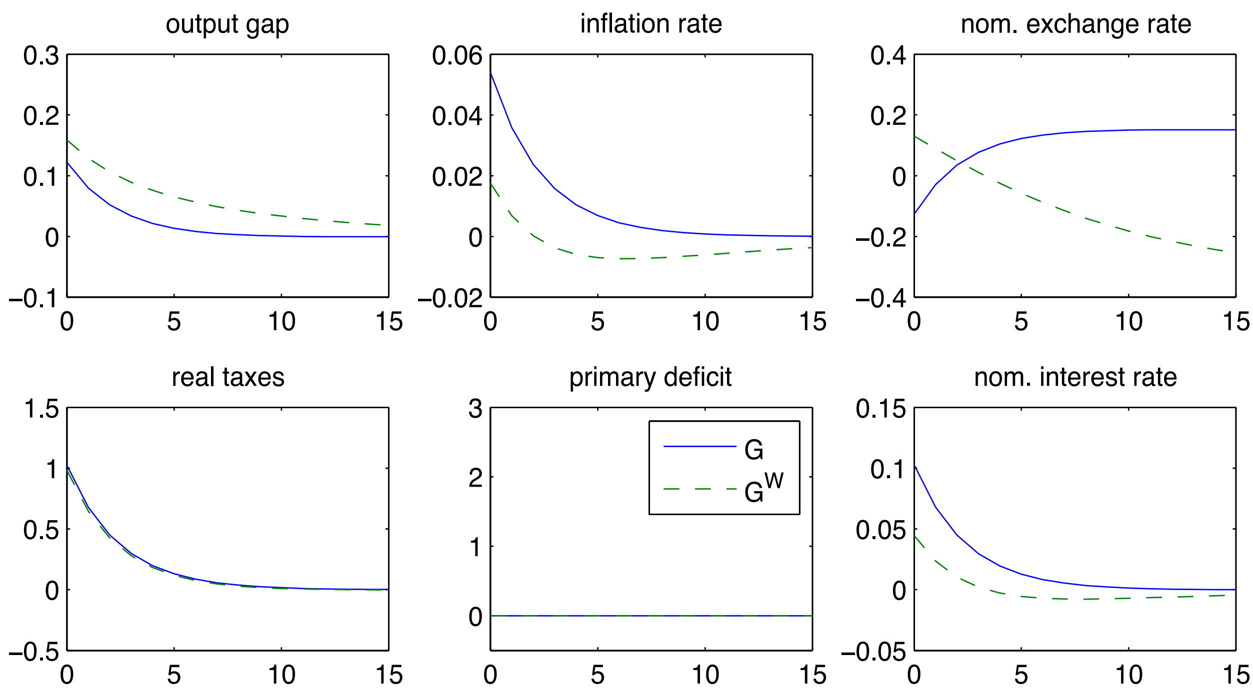


**Figure 6:** Response of selected variables to a 1%, balanced-budget increase in public consumption. Solid line: home-biased public consumption. Dashed line: uniformly-distributed public spending.

fully biased towards domestically-produced goods, as in Ganelli (2005a), while the dashed line corresponds to the case discussed in Obstfeld–Rogoff (1995) and Ganelli (2005b), in which public consumption is uniformly distributed across all goods produced in the international economy. The top-right panel of Figure 6 displays the result: if government spending is uniformly distributed across domestic and foreign goods, the exchange rate depreciates in the short run, while it appreciates in the long-run.

Although this is the same result as in the *Redux* model, the transmission mechanism is radically different. In Obstfeld–Rogoff (JPE, 1995) an increase in public consumption crowds out consumption both at home and abroad; however, since monetary policy is exogenous and the fiscal expansion is financed by an increase of domestic taxes only, domestic consumption falls more than foreign one, and the ensuing excess supply of money is higher at home than abroad. The exchange rate therefore depreciates. In our DNK model, instead, the transmission mechanism works through marginal costs. An increase in public spending that is directed towards both home and foreign goods has positive effects on the marginal costs of both countries. However, since the fiscal expansion is financed by an increase in domestic taxes only, domestic consumption falls more than foreign one and relative consumption therefore falls. Equations (52)–(53) then imply that foreign marginal costs increase more than domestic ones, triggering a relatively stronger response by foreign monetary policy. Contrary to the case of home-biased public spending, therefore, the relative interest rate falls, thereby

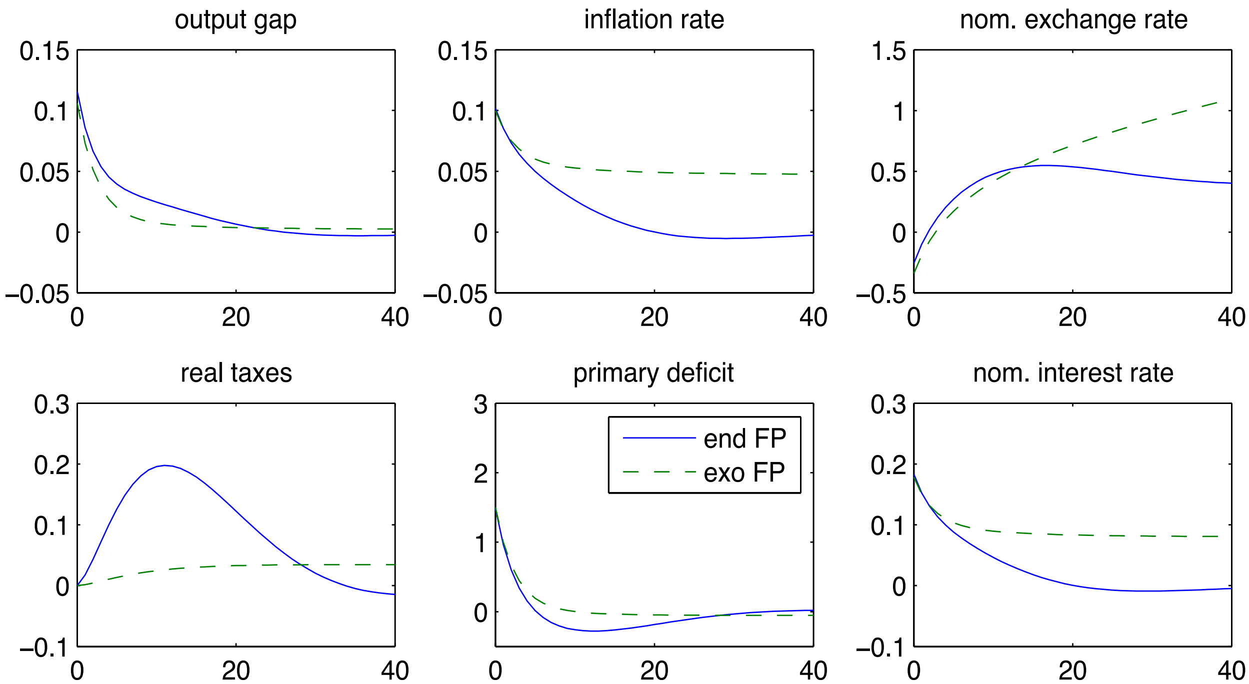


**Figure 7:** Response of selected variables to a 1%, debt-financed increase in public consumption. Solid line: endogenous fiscal policy. Dashed line: exogenous fiscal policy.

depreciating the exchange rate.[30] This result, as shown in the simple model of Section 2, is independent, from a qualitative perspective, on the assumption on whether monetary policy is endogenous or not.

The long-run effects on the nominal exchange rate also depend on the degree of home bias in government consumption. If public spending is completely home-biased, the on-impact increase in relative marginal costs sets domestic prices on a higher path, which in the long-run translates into a permanently depreciated exchange rate. On the contrary, if public spending is uniformly distributed across domestic and foreign goods, the relative marginal costs actually fall, as discussed above. The domestic price level therefore jumps on a lower path, which in the long-run translates into a permanently appreciated exchange rate.

All the effects discussed so far are clearly independent of the overlapping-generation structure of our DNK model, since the balanced-budget specification of the fiscal expansions considered does not have any effect on the accumulation of public debt and therefore does not trigger wealth effects any different from the representative-agent case. Our overlapping-generation structure, however, allows us to use our framework to simulate also other kinds of fiscal shocks, and study in particular the response of the exchange rate.

[30] As shown by the other panels in Figure 6, relative to the case of home-biased public spending, the weaker inflationary pressures that arise in the home country translate into a lower actual inflation rate, a milder increase in the domestic interest rate and, thereby, a higher output gap.

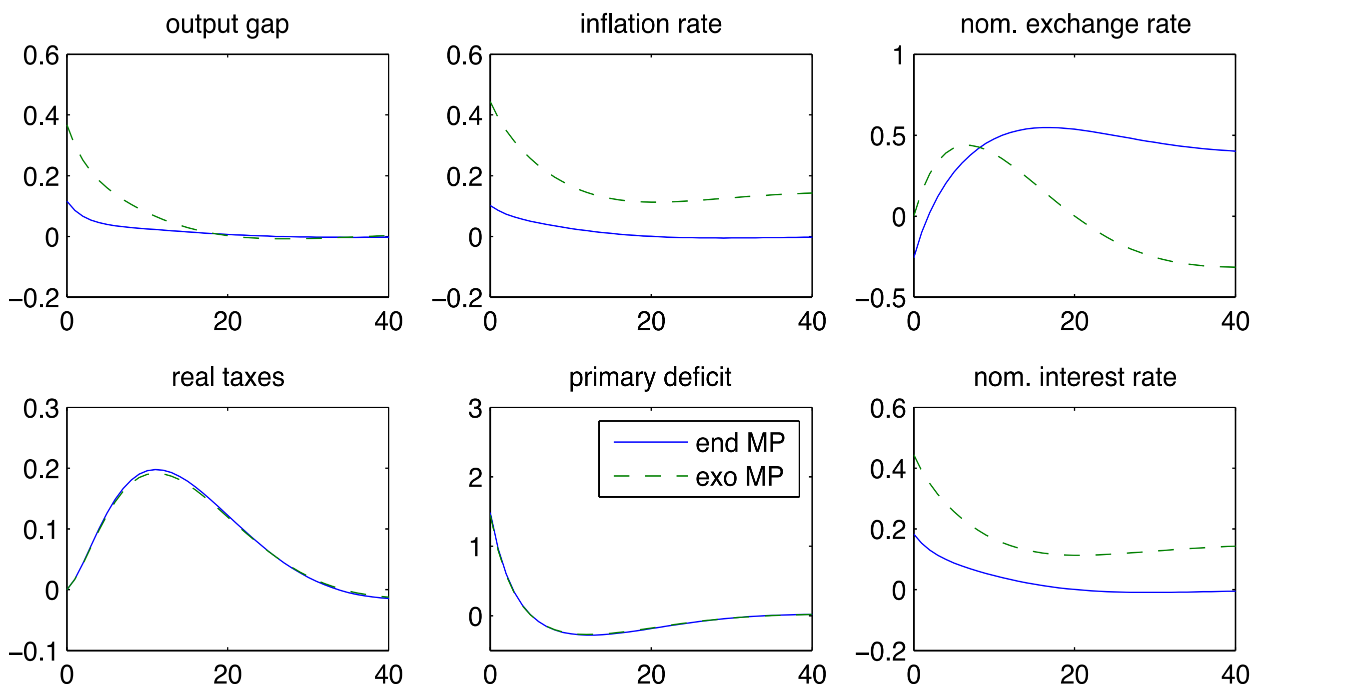


**Figure 8:** Response of selected variables to a 1% increase in public spending. Solid line: endogenous monetary policy. Dashed line: exogenous monetary policy.

Using a perpetual-youth version of the *Redux* model, Ganelli (2005b) argues that the effects on the exchange rate of an increase in public spending depend on how the expansion is financed: a balanced-budget (tax-financed) expansion would imply an on-impact depreciation through a reduction in relative consumption and an increase in domestic prices, while the effects of a debt-financed expansion would be ambiguous because a tax-cut tends to appreciate the exchange rate on impact. This result follows directly from the assumption that public expenditure is uniformly distributed over domestic and foreign goods, so that an increase in public expenditure acts as a global demand shock.

In our framework with complete home bias, a debt-financed expansion in public consumption unambiguously induces an appreciation of the nominal exchange rate on impact and a depreciation in the transition, as shown by Figure 7.

This result is independent of the specification of fiscal policy, whether it is completely exogenous and real taxes follow (57) – dashed line in the figure – or it cares about the business cycle and the stock of debt, by adjusting the primary deficit according to (58) – solid line.[31]

Notice that, again, endogenous monetary policy plays an important role in shaping the response of the exchange rate to fiscal shocks. This is shown by Figure 8, where fiscal policy follows the feedback rule of equation (58). When monetary policy is exogenous, indeed,

[31] In the case of exogenous fiscal policy, moreover, the long-run response of the exchange rate is a stronger depreciation, as it also reflects the accumulation of net foreign liabilities implied by the lack of fiscal discipline.

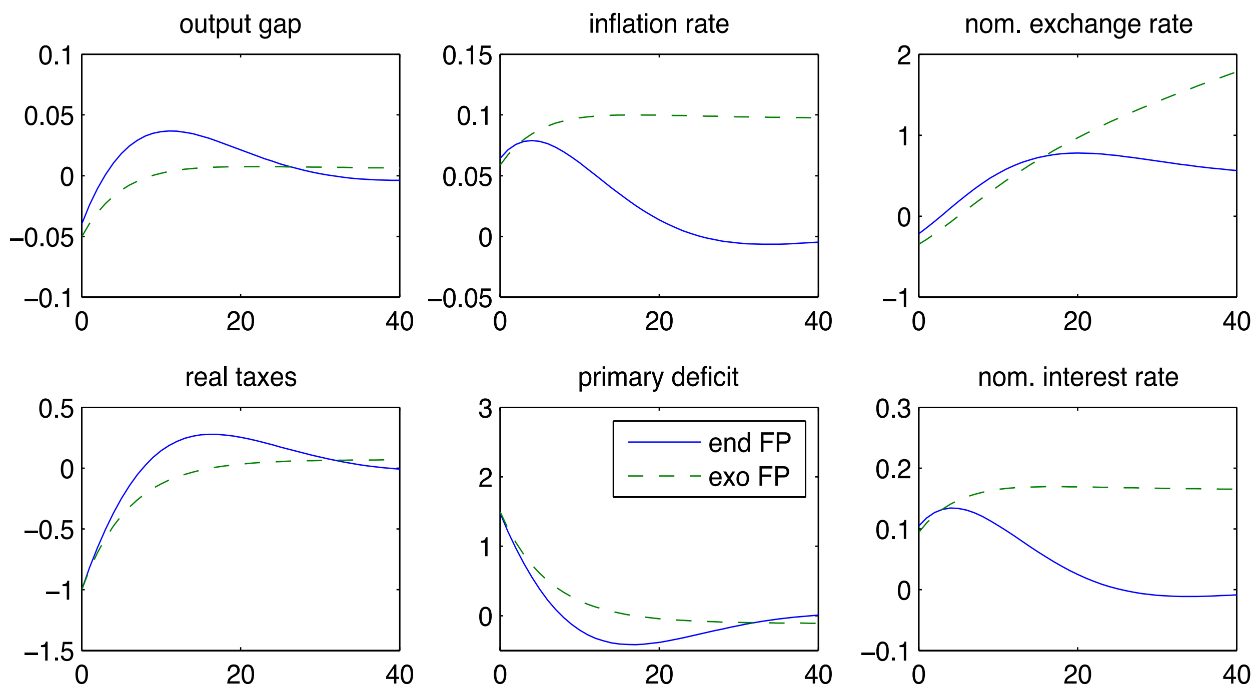


**Figure 9:** Response of selected variables to a 1% tax cut. Solid line: endogenous fiscal policy. Dashed line: exogenous fiscal policy.

the quasi-neutrality result holds and there is no short-run response of the exchange rate to a tax cut. Under endogenous monetary policy, however, the exchange rate appreciates unambiguously.[32]

A debt-financed increase in government spending is equivalent to the combination of a balanced-budget fiscal expansion (Figures 5 and 6) and a tax cut. The latter is analyzed in Figure 9 under different fiscal regimes. The dashed line shows the dynamic response when fiscal policy is completely exogenous, and real taxes follow (57), while the solid line shows the case in which fiscal policy adjusts the primary deficit according to the feedback rule of equation (58). In both scenarios, a tax cut induces a fiscal deficit and the issuance of new debt to finance it. On impact, the world and relative stocks of outstanding debt increase, as well as world and relative consumption, through wealth effects. The increase in relative consumption then induces upward pressures on relative marginal costs, which require an increase in relative nominal interest rates and the ensuing appreciation in the nominal exchange rate.

It is now straightforward why a debt-financed expansion in public spending unambiguously appreciates the exchange rate: both a balanced-budget expansion in public consump-

[32]Notice that in this case, the specification of monetary policy also affects the long-run response of the exchange rate: under endogenous monetary policy the long-run exchange rate depreciates, as before, while it appreciates when monetary policy is exogenous.

tion and a tax cut induce an appreciation. Under the commonly used assumption of home biased government consumption and endogenous monetary policy, therefore, it is possible to perfectly reconcile the NOEM implications with the traditional Mundell-Fleming result: a fiscal expansion leads to an appreciation of the exchange rate on impact regardless of how this expansion is financed.

# 4 Concluding Remarks

This paper analyzes the determinants of the exchange-rate response to fiscal shocks in two different and widely used theoretical settings, and contributes to the literature by highlighting the role played by the monetary policy regime and public spending composition.

We first show that in a generalized version of the *Redux* model, the effects of balanced-budget fiscal shocks on the exchange rate critically depend on the degree of home bias in public spending and on the monetary policy regime. When government consumption is uniformly distributed across domestic and foreign goods – as in the original Obstfeld and Rogoff (1995) paper – an increase in domestic public spending leads to an exchange-rate depreciation, regardless of the monetary policy regime. On the other hand, when government consumption is home-biased, the exchange rate appreciates if monetary policy is countercyclical: the increase in relative domestic output implied by the fiscal expansion induces a reduction in relative money supply and, therefore, a nominal exchange-rate appreciation.

The same exchange-rate response is implied by the modern two-country DSGE model, in which monetary policy follows standard Taylor rules. The transmission mechanism at work, however, is substantially different and works through relative marginal costs: a domestic fiscal shock implies higher relative marginal costs, which trigger an increase in relative interest rates to offset the inflationary pressures, leading to a short-run appreciation of the nominal exchange rate. Finally, using a "perpetual youth" extension of the modern two-country DSGE model – where Ricardian equivalence does not hold – we show that these results hold regardless of how the fiscal expansion is financed.

# References

Backus, D.K., P.J. Kehoe and F.E. Kydland. (1992) "International Business Cycles." *Journal of Political Economy*, 100, 4, pp. 745-775

Basu, Parantap and Robert Kollmann (2013) ""Productive Government Purchases and the Real Exchange Rate." *The Manchester School*, vol. 81(4), pp. 461–469

Beetsma, Roel M. W. J. and Henrik Jensen. (2005) "Monetary and Fiscal Policy Interactions in a Micro-founded Model of a Monetary Union." *Journal of International Economics* 67, pp. 320–352

Beetsma, Roel M. W. J., Frank Klasssen and Massimo Giuliodori (2008) ""The Effects of Public Spending Shocks on Trade Balances and Budget Deficits in the European Union." *Journal of European Economic Association* vol. 6, pp. 414–423

Bénétrix, Agústin and Philip R. Lane (2013) ""Fiscal Shocks and the Real Exchange Rate." *International Journal of Central Banking* vol. 9(3), pp. 1–32

Benigno, Pierpaolo. (2004) "Optimal Monetary Policy in a Currency Area." *Journal of International Economics*, Vol. 63, Issue 2, pp. 293–320

Blanchard, Olivier J. (1985) "Debt, Deficits, and Finite Horizons." *Journal of Political Economy*, 93

Brulhart, M. and F. Trionfetti. (2004) "Public expenditure, international specialisation and agglomeration." *European Economic Review* 48, pp. 851–881.

Calvo, Guillermo. (1983) "Staggered Prices in a Utility Maximizing Framework." *Journal of Monetary Policy*, 12

Canova, Fabio and Evi Pappa (2007) ""Price Differentials in Monetary Unions: the Role of Fiscal Shocks." *Economic Journal*, vol. 117(520), pp. 713–737

Card, D. (1994), "Intertemporal Labor Supply: An Assessment," in C. Sims, ed., *Advances in Econometrics, Sixth World Congress*, New York: Cambridge University Press.

Castelnuovo, Efrem and Salvatore Nisticò. (2008) "Stock Market Conditions and Monetary Policy in a DSGE Model for the U.S." CeMASM Working Paper n. 11.

Cavallo, Michele and Fabio Ghironi. (2002) "Net Foreign Assets and the Exchange Rate: Redux Revived." *Journal of Monetary Economics*, vol. 49(5), pp. 1057-1097

Cooley, T. and E. Prescott (1995) "Economic Growth and Business Cycles", in T. Cooley, ed., *Frontiers of Business Cycle Research*, Princeton, Princeton University Press.

Corsetti, Giancarlo and Paolo Pesenti (2001) "Welfare And Macroeconomic Interdependence." *The Quarterly Journal of Economics*, vol. 116(2), pp. 421–445

Corsetti, Giancarlo, André Meier and Gernot J. Müller (2012) ""Twin Deficit or Twin

Divergence? Fiscal Policy, Current Account, and Real Exchange Rate in the US." *The Review of Economics and Statistics* vol. 94(4), pp. 878–895

Devereux, Michael and Charles Engel (2003) "Monetary Policy in the Open Economy Revisited: Price Setting and Exchange-Rate Flexibility." *Review of Economic Studies*, vol. 70, pp. 765–783

Di Giorgio, G. and S. Nisticò (2007). "Monetary Policy and Stock Prices in an Open Economy." *Journal of Money Credit and Banking*, 39, 8, pp. 1947–1985

Di Giorgio, G. and S. Nisticò (2008). "Fiscal Deficits, Current Account Dynamics and Monetary Policy." Italian Ministry of Economics and Finance. Working Paper n. 8.

Di Giorgio, G. and S. Nisticò (2013). "Productivity shocks, stabilization policies and the dynamics of net foreign assets" *Journal of Economic Dynamics and Control*, 37, 1, pp. 210–230

Fagan, Gabriel, Jrme Henry, and Ricardo Mestre. (2001) "An Area-wide Model (AWM) for the Euro Area." ECB Working Paper No. 42.

Favero, Carlo and Tommaso Monacelli. (2005) "Fiscal Policy Rules and Regime (In)Stability: Evidence from the U.S." mimeo

Galí, Jordi and Tommaso Monacelli. (2005) "Monetary Policy and Exchange Rate Volatility in a Small Open Economy." *Review of Economic Studies*, 72, pp. 707-734.

Galí, Jordi and Roberto Perotti. (2003) "Fiscal Policy and Monetary Integration in Europe." *Economic Policy*, 37, pp. 533-572

Ganelli, Giovanni. (2005a) "Home Bias in Government Spending and Quasi Neutrality of Fiscal Shocks." *Macroeconomic Dynamics*, 9, pp. 288–294

Ganelli, Giovanni. (2005b) "The New Open Economy Macroeconomics of Government Debt." *Journal of International Economics*, 65, pp. 167-184

Kim, Soyoung and Nouriel Roubini (2008) ""Twin Deficit or Twin Divergence? Fiscal Policy, Current Account, and Real Exchange Rate in the US." *Journal of International Economics* vol. 4, pp. 362–383

Kollmann, Robert (2010) ""Government Purchases and the Real Exchange Rate." *Open Economies Review*, vol. 21, pp. 49–64

Leeper, E. M. (1991) "Equilibria Under 'Active' and 'Passive' Monetary and Fiscal Policies." *Journal of Monetary Economics* 27, pp. 129-47.

Lubik, T. and Schorfheide, F. (2006) "A Bayesian Look at New Open Economy Macroeconomics." in M. Gertler and K. Rogoff (eds), *NBER Macroeconomics Annual 2005*, Cambridge, MA: MIT Press.

Monacelli, Tommaso and Roberto Perotti (2010) ""Fiscal Policy, the Real Exchange Rate and Traded Goods." *The Economic Journal* vol. 120, pp. 437–461

Nisticò, Salvatore. (2011) "Optimal Monetary Policy and Stock-Price Dynamics in a non-Ricardian DSGE Model", CASMEF Working Paper n.7

Nisticò, Salvatore. (2012) "Monetary Policy and Stock-Price Dynamics in a DSGE Framework." *Journal of Macroeconomics*, vol. 34 (1), pp. 126–146

Obstfeld, Maurice and Kenneth S. Rogoff. (1995) "Exchange Rate Dynamics Redux." *Journal of Political Economy*, 103, 624-60

Rotemberg, Julio and Micheal Woodford. (1997) "An optimization-based econometric framework for the evaluation of monetary policy." In: Bernanke, B., Rotemberg, J. (Eds.), *NBER Macroeconomics Annual 1997*, MIT Press, Cambridge.

Smets, Frank and Raf Wouters. (2002) "Openness, Imperfect Exchange Rate Pass-through and Monetary Policy." *Journal of Monetary Economics*, vol. 49(5), pp. 947-981

Smets, Frank and Raf Wouters. (2003) "An estimated dynamic stochastic general equilibrium model of the Euro area." *Journal of the European Economic Association*, vol. 1, pp. 1123–1175

Smets, Frank and Raf Wouters. (2007) "Shocks and frictions in US business cycles: a Bayesian DSGE approach." *American Economic Review*, vol 97, pp. 586–606

Schmitt-Grohe, Stephanie and Martin Uribe. (2006) "Optimal Simple and Implementable Monetary and Fiscal Rules." forthcoming *Journal of Monetary Economics*

Taylor, John B. (1993) "Discretion versus Policy Rules in Practice." *Carnegie-Rochester Conference Series on Public Policy*, 39

Trionfetti, F. (2000) *Discriminatory Public Procurement and International Trade.* Blackwell Publishers.

Yaari, Menahem E. (1965) "Uncertain Lifetime, Life Insurance, and the Theory of the Consumer." *Review of Economic Studies*, 32.