Fiscal shocks and the exchange rate in a generalized *Redux* model*

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May 25, 2015

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 a generalized version of the *Redux* model of Obstfeld and Rogoff (1995). We show that the joint presence of home bias in public consumption and endogenous monetary policy overturns the result of the *Redux* model, implying an exchange-rate appreciation in response to an expansionary fiscal shock.

JEL classification: E52, E62, F41, F42.

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

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*We would like to thank seminar participants at "Sapienza" University and conference participants at the "XXII International Conference on Money, Banking and Finance - Rome, December 2013" and at the "55^{th} Annual SIE Conference - Trento, October 2014" . We acknowledge financial support from the Italian Ministry of University and Research (PRIN 2011 "Asymmetric information, adjustment costs and efficiency: microeconomic foundations and macroeconomic implications".). Usual disclaimers apply.

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1 Introduction

The effects of fiscal shocks and their international transmission have long been investigated in the literature. Not much consensus was achieved about the exchange rate response to fiscal shocks. The starting point of the theoretical literature is Obstfeld and Rogoff (1995) *Redux* model, where it is shown that a balanced-budget fiscal expansion – where government spending is symmetrically distributed on domestic and foreign goods – depreciates the exchange rate. The intuition behind this result is simple: the increase in the tax burden affects only the country that rises public consumption, while the expansionary effect of the increase in demand is shared with the foreign country. The alternative assumption of complete home bias in government consumption leads to a null effect on the exchange rate (Ganelli, 2005): public spending is used to purchase only domestic goods and the cost of this policy is thus perfectly offset by the gains in terms of higher domestic demand.

This result of the *Redux* model contradicts the well known implication of the static open-economy version of the IS-LM model developed by Mundell and Fleming. Also DSGE open-economy new Keynesian models, such as Corsetti and Pesenti (2001) and Devereux and Engel (2003), find that a balanced-budget fiscal expansion induces and increase in private consumption and, through international risk sharing, an exchange-rate appreciation. In general, moreover, the baseline specification of the New Open-Economy Macroeconomics (NOEM) models also implies an exchange-rate appreciation, following a balanced-budget fiscal expansion. A depreciation may instead occur if we introduce incomplete financial markets (Kollmann, 2010), productive government spending (Basu and Kollmann, 2013) or spending reversals (Corsetti et al, 2012).

The recent empirical evidence on the subject 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.[1]

This note generalizes the *Redux* model along two dimensions that prove to be critical in shaping the exchange-rate response to fiscal shocks: the composition of public spending and the monetary policy regime. We clarify that the appreciation implied by modern NOEM models critically hinges on two specific features: endogenous monetary policy and home bias

[1]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.

in public consumption.[2] Once these two features are introduced in the *Redux* model, the results of the two frameworks are reconciled, and the exchange rate appreciates in response to fiscal shocks. In particular, we show that the composition of public spending is not the only relevant variable to take into account when evaluating the international spillovers of fiscal shocks, as claimed by Ganelli (2005), but that the monetary policy regime is also key. Indeed, an increase in home-biased public spending is more expansionary at home than abroad; if monetary policy is endogenous and countercyclical, this triggers a relatively stronger monetary restriction at home, which appreciates the exchange rate. Our analysis nests the two polar cases of Obstfeld and Rogoff (1995) and (Ganelli, 2005).

The paper is organized as follows. In Section 2, we generalize the *Redux* model introducing home bias in government consumption and endogenous monetary policy. Section 3 shows to what extent the effects of balanced-budget fiscal shocks on the exchange rate depend on the degree of home bias and the response coefficient in the monetary policy rule. 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. Since the model builds on Obstfeld and Rogoff (1995) and Ganelli (2005), 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.

2.1 Households, technology, private and public consumption.

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[3]

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

[2]The empirical evidence for OECD countries supports the assumption of home-biased public spending. See, for example Trionfetti (2000), Brulhart and Trionfetti (2004) and Nakamura and Steinsson (2011).

[3]Foreign households face a symmetric problem.

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:

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

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

Differently from private consumption, public consumption is home biased. 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:[4]

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

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

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

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

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,

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

are the home-currency producer-price indexes of domestic and foreign brands, respectively,[5] 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.

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

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

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

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

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

2.2 Equilibrium, fiscal policy and monetary policy.

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.[6] 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 $\widehat{\overline{x}}$ respectively the short-run and long-run log-linear deviation of variable X from such steady state.[7] 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^*)

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

[6] 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.

[7] 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 $\widehat{\overline{b}} \equiv \frac{dB}{\overline{C}_0^W}$ and $\widehat{\overline{b}}^* \equiv \frac{dB^*}{\overline{C}_0^W}$. Notice that the latter only change in the long-run.

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

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

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

implying, in relative terms

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

The government sets the amount of public consumption G and finances it through lump-sum taxes T. 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

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

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 $\left(\widehat{c}-\widehat{c^*},\ \widehat{e}\right)$ 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.

The early NOEM literature has modeled monetary policy in terms of the central bank's control of the money supply. We assume that money supply is controlled – both at home and abroad – through feedback rules of the kind

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

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

The money supply rules (20)-(21) can be seen as a monetarist variant of the Taylor rule, in which a systematic, endogenous component allows short-run money supply to respond counter-cyclically to domestic and foreign output respectively.[8] In the feedback rules above, μ and μ^* are exogenous, permanent monetary policy shocks, and $\phi > 0$ is the response coefficient.[9]

Notice that, again, this framework generalizes the *Redux* model, where monetary policy is entirely exogenous, and which is therefore nested under the calibration $\phi = 0$.[10] 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:

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

[8]We consider a feedback rule responding to output only, as domestic prices are rigid in the short run.
[9]For analytical convenience, we assume symmetric response coefficients across countries.
[10]This is also the case in Ganelli (2005).

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

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

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 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.[11] 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.

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

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

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.

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 ϕ, 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.[12] 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

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

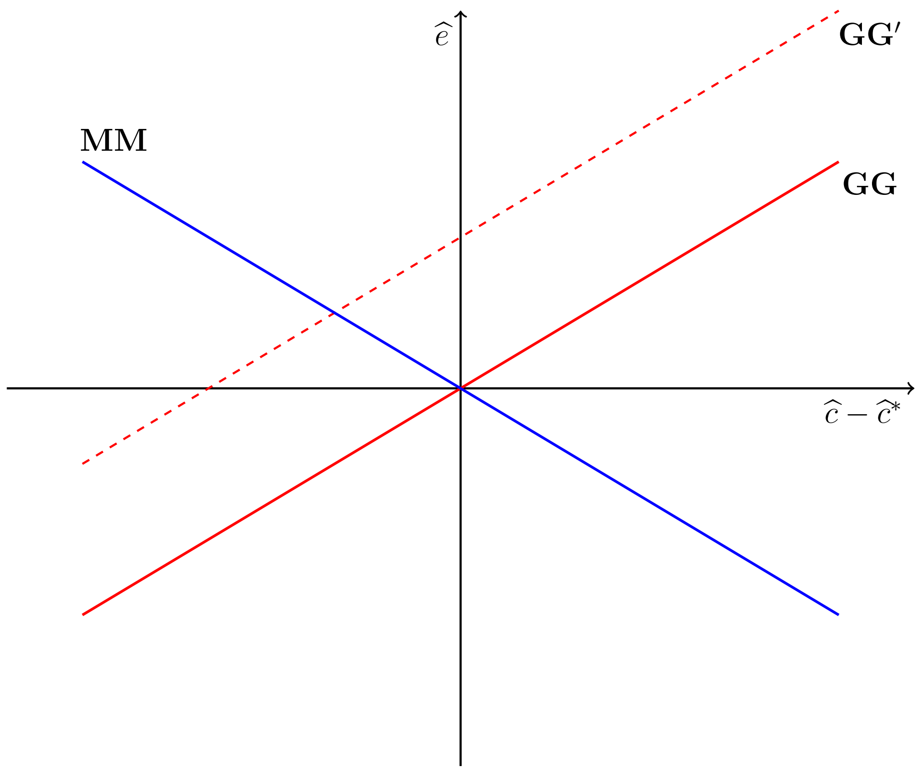

Figure 1: A temporary expansion in domestic government spending, with zero home bias ($\lambda = 1$) and endogenous monetary policy ($\phi > 0$).

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**

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

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.

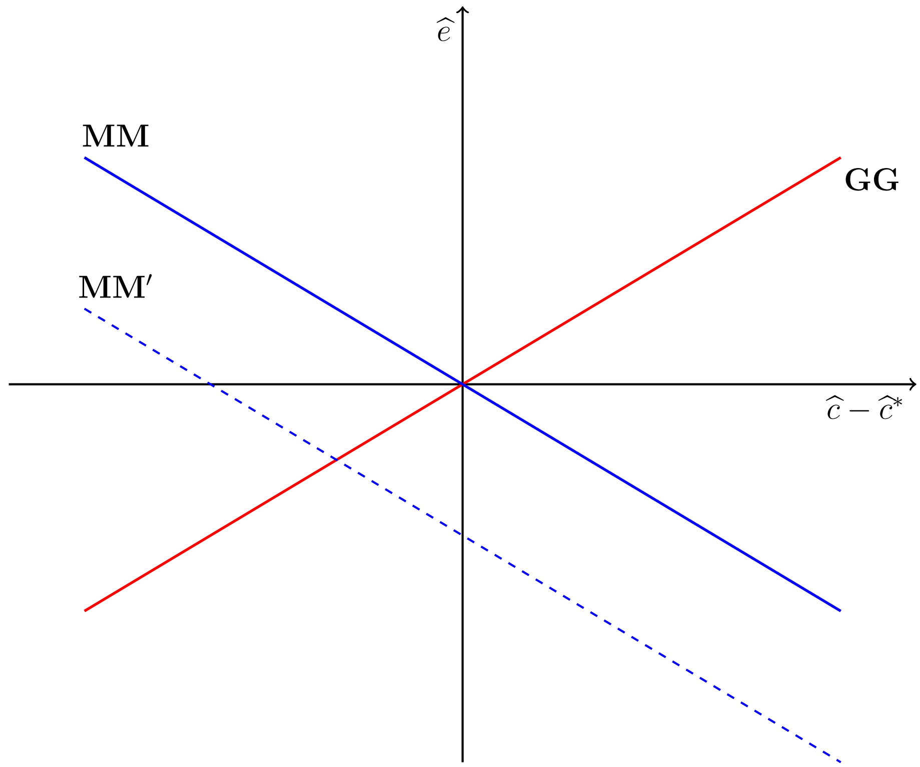

Figure 2: A temporary expansion in domestic government spending, with full home bias ($\lambda = 0$) and endogenous monetary policy ($\phi > 0$).

Indeed, while the **GG** schedule is still (29), equilibrium in the money market is now described by the following **MM**:

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

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.[13]

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

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

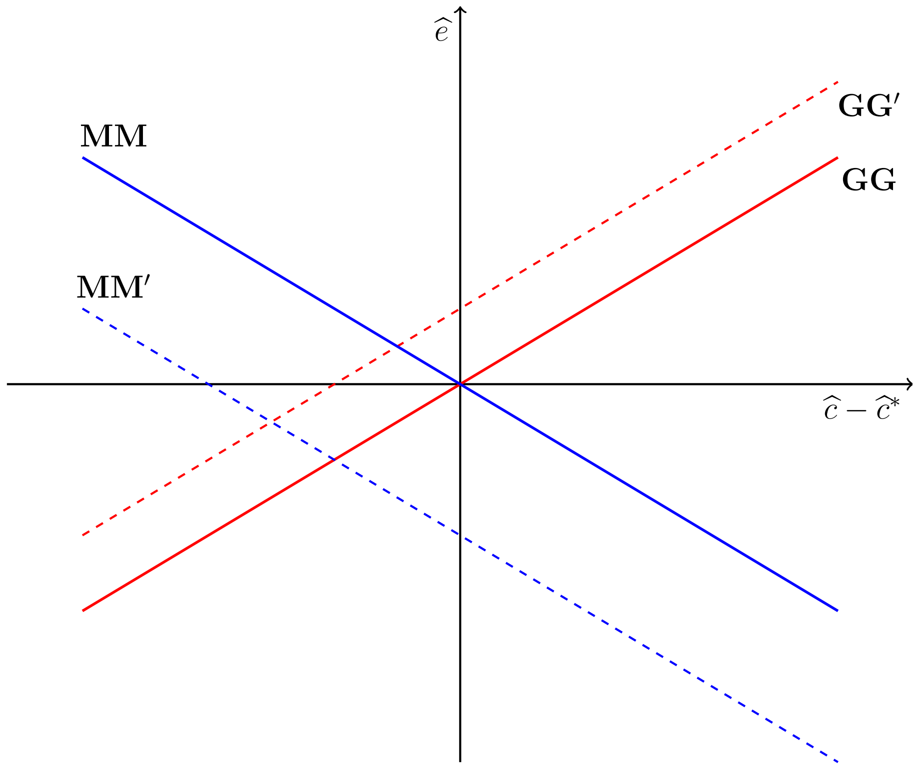

Figure 3: A temporary expansion in domestic government spending, with incomplete home bias ($0 < \lambda < 1$) and endogenous monetary policy ($\phi > 0$).

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 λ), and the **MM** downwards, the more so the more endogenous monetary policy (the higher ϕ). 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 *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: λ and ϕ.[14] 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

[14]The calibration of β 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 β and θ.

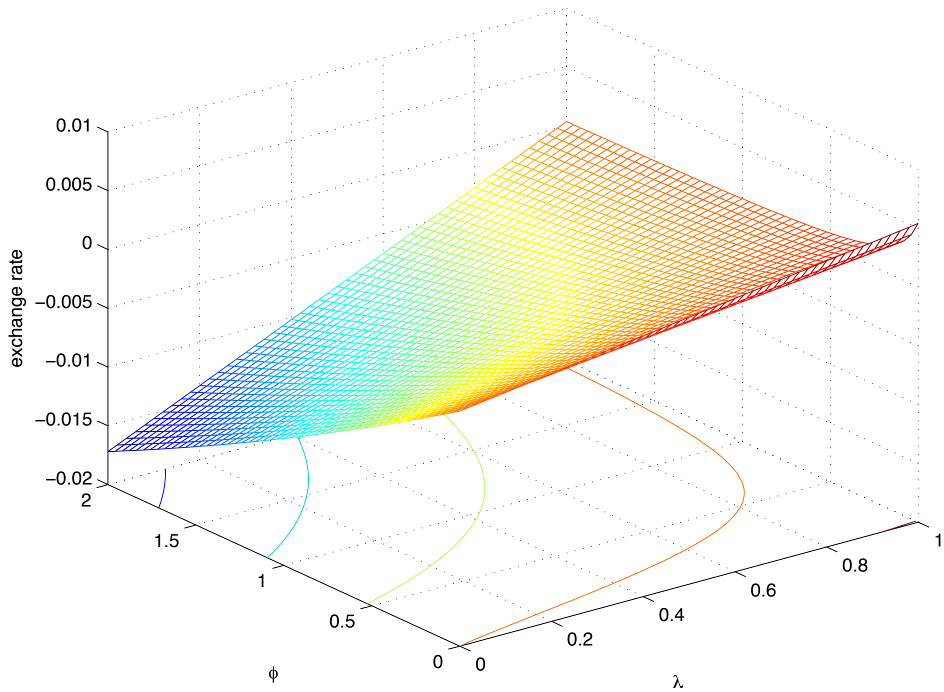

Figure 4: Exchange-rate short-run response to a temporary expansion in domestic government spending: the role of the degree of home-bias (λ) and endogenous monetary policy (ϕ).

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.

4 Concluding Remarks

This paper analyzes the determinants of the exchange-rate response to fiscal shocks in a generalized version of the *Redux* model, by highlighting the role played by the monetary policy regime and public spending composition.

We show that 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 an increase in domestic public spending acts as a global shock. Domestic and foreign output respond symmetrically, while domestic private consumption falls more than abroad. With relative money supply unchanged, the ensuing reduction in money demand leads to an exchange-rate depreciation. On the other hand, when government consumption is home-biased (partially or fully), 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.

By assuming realistic features such as endogenous monetary policy and even a moderate degree of home bias in public consumption, our generalized *Redux* model exhibits the same qualitative results of both the static Mundell-Fleming framework and the prototypical NOEM-DSGE model, such as Corsetti and Pesenti (2001) or Devereux and Engel (2003). Finally, Di Giorgio et al. (2014) show that a similar interplay between the degree of home bias in public spending and the monetary policy regime is crucial to shape the exchange-rate response to fiscal shocks in a perpetual-youth DSGE model, where the implied departure from Ricardian equivalence allows for a thorough analysis of different financing schemes for fiscal expansions.

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