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Fiscal Shocks and Helicopter Money in Open Economy*

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Abstract

We study the effects of expansionary fiscal shocks in a two-country DSGE model with perpetual youth. We consider two alternative financing regimes, monetary financing and debt financing, and find that a money-financed fiscal stimulus is more expansionary on output and inflation. We investigate how the transmission mechanism is related to the open-economy dimension and how structural parameters affect macroeconomic dynamics.

JEL classification: E32, E52, F41, F42.

Keywords: Exchange Rate, Fiscal Shocks, Helicopter Drop.

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1 Introduction

One of the relevant consequences of the recent economic and financial crises regarded the severe challenges imposed to the modus operandi of monetary policy. Throughout the world, central banks have first reduced interest rates to very low levels and then experienced many new tools of intervention. Such changes occurred notwithstanding the wide consensus reached both in the literature and in monetary policy practice at the start of the new millennium as to best conduct central banking. The Federal Reserve reacted to the subprime mortgage crisis by creating innovative facilities to provide liquidity to financial markets and institutions, before starting a long series of quantitative easing programs that quintupled its balance sheet with respect to the 2007 level. The European Central Bank moved first by simply modifying the technical features of some of its instruments (mainly the maturity of open market operations and collateral requirements) before undertaking a true cultural revolution in 2015 with the adoption of a quantitative easing policy. More in general, most central banks have used "unconventional" policy tools (including negative interest rates) to face the extraordinary challenges induced by the financial turmoils.

During the Great Recession many governments also relied on fiscal policies in order to sustain aggregate demand. Such interventions increased structural deficits and, in turn, public debts. At the end of 2014, according to the BIS, issuances of government debt were eighty percent higher at a global level with respect to 2007. Such macroeconomic policies, however, were not always successful in helping a rapid recovery in aggregate demand. In particular, output, employment and inflation have not reached their target level for a long time on both sides of the Atlantic. This is also probably due to the scarce or absent coordination between monetary and fiscal policies. This scenario has revived the interest in additional policy measures that may stimulate the economy without using the nominal interest rates and without inducing further increases in government debt. Recently, Lord Turner revived the idea of a "helicopter drop", i.e. an injection of outside money into the economy. Such expansion in the central bank balance sheet could take on different forms, going from the original paradigm of Milton Friedman (1948, 1969), implemented with a direct transfer to bank, fiscal or pension accounts, to a money-financed fiscal stimulus, as a more effective response to cope with stagnating economy and inflation below target. Buiter (2014), Giavazzi and Tabellini (2014), Reichlin, Turner and Woodford (2013) and Galí (2017) consider the effectiveness of a fiscal stimulus financed through money creation, requiring neither an increase in the stock of government debt nor higher taxes, current or future. In particular, Galì (2017) uses a baseline closed-economy DSGE model that does not offer a realistic quantitative analysis of the effects of a money-financed fiscal stimulus, but assesses its qualitative implications in comparison to other financing schemes. He shows that a money-financed fiscal stimulus induces larger output levels than a debt-financed one. In a model with heterogenous agents, Punzo and Rossi (2016) compare the redistributive effects of the two financing schemes when government increases public spending.

In this paper we study a money-financed fiscal stimulus in a two country DSGE model. We investigate the effects of an increase in government spending and of a tax cut and compare the macroeconomic dynamics with the ones following a standard debt-financing scheme. Our analysis contributes to the literature in two dimensions. First, following Di Giorgio and Nisticò (2007, 2013), we consider a perpetual youth structure of the demand side of the economy to break Ricardian equivalence. In such an environment fiscal policy can produce relevant wealth effects because of the coexistence into the economy of heterogenous agents. This framework also allows for a richer investigation of different fiscal policies and financing schemes with respect to representative agent models which imply fiscal policy neutrality. Second, our analysis is conducted in a fully specified two-country DSGE model to explore the international transmission of fiscal shocks. In this framework, the real exchange rate and the terms of trade affect primary deficits and the supply-side through their effect on marginal costs. This is in addition to the standard demand effect on consumption. Moreover, in our model net foreign assets are an important determinant of private consumption because of the perpetual-youth structure. Such dynamics are critically affected by the mechanism used to finance fiscal expansion.

Our paper is linked to the large theoretical literature on the effects of fiscal policy in open economy that started with the Redux model of Obstfeld and Rogoff (1995). This strand of literature highlights that the international transmission of fiscal shocks is deeply affected by the degree of home bias in government consumption and the way in which monetary policy is conducted (see Ganelli, 2005 and Di Giorgio, Nisticò, and Traficante, 2015). Corsetti and Pesenti (2001) and Devereux and Engel (2003) develop standard DSGE open-economy models where balanced-budget fiscal expansions lead to an appreciation of the exchange rate. Most of the recent empirical evidence shows, however, that the exchange rate depreciates after a positive fiscal shock (see for example Bénétrix and Lane, 2013). Di Giorgio, Nisticò and Traficante (2017) discuss how it is possible to reconcile such evidence with the theoretical literature and provide a model coherent with the former by assuming a positive spillover effect of government consumption on private sector productivity.

With respect to the recent literature on the fiscal role of monetary policy, in this paper we find that a money-financed fiscal stimulus is generally more expansionary. It is, however, less powerful with respect to a closed economy setting because of the counteracting effect induced, in an open economy, by the appreciation in the real exchange rate that limits the initial expansion of the primary deficit. We analyze the qualitative implications of the model highlighting the international transmission of the different adopted policies and the role played by the most relevant structural features and parameters.

The rest of the paper is organized in the following way. Section 2 presents the two-country non-Ricardian DSGE model. In Section 3 we provide a numerical simulation of the effects of fiscal expansions on key macroeconomic variables, for different degrees of coordination and financing schemes. Section 4 concludes.

2 The Model

The world economy consists of two structurally symmetric countries, H and F, of equal size. Households, in each country, supply labor inputs to firms and demand a bundle of consumption goods consisting of both home and foreign goods. The productive sector produces a continuum of perishable goods, in the interval [0, 1], which are differentiated across countries and with respect to one another. There are nominal rigidities in the form of a Calvo (1983) price-setting mechanism and we break Ricardian equivalence through a perpetual-youth structure of the demand side of the economy, along the lines of Di Giorgio and Nisticò (2007, 2013).

In country H we consider two coordination schemes between fiscal and monetary policy. If fiscal policy is financed by debt or taxes, the central bank sets the short-term interest rate through a Taylor-type feedback rule, while, in the case of monetary financing, the interest rate adjusts accordingly to guarantee equilibrium in the money market. Country F controls the short-term interest rate through a Taylor-type feedback rule and has a balanced budget.

2.1 The Demand Side

We adopt 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 γ of traders in the financial markets is 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 γ of being replaced as the next period begins. Consumers have log-utility preferences over consumption C_t, real money balances M_t/P_t and leisure $1 - L_t$, supply labor services in a domestic competitive labor market and demand consumption goods. Consequently, each domestic household belonging to cohort j maximizes the following utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t (1-\gamma)^t \left[\log C_t(j) + \delta \log(1 - L_t(j)) + \chi \log \left(\frac{M_t(j)}{P_t} \right) \right]$$

subject to the flow budget constraint

$$\begin{aligned} P_t C_t(j) + E_t\{\mathcal{F}^H_{t,t+1} Q_{H,t}(j)\} + B_{H,t}(j) + \mathcal{E}_t B_{F,t}(j) + M_t(j) \leq \\ \leq \frac{1}{1-\gamma} \left[(1+i_{t-1}) B_{H,t-1}(j) + \mathcal{E}_t (1+i^*_{t-1}) B_{F,t-1}(j) + Q_{H,t-1}(j) + M_{t-1}(j) \right] + \\ + W_t L_t(j) + P_t D_t(j) - P_t T_t(j) \end{aligned} \quad (1)$$

where β represents the discount factor, $B_{i,t}$ $(i = H, F)$ denotes two internationally traded riskless zero-coupon nominal bonds issued in the two currencies by the governments to finance their budget deficits, $Q_{H,t}(j)$ denotes cohort j's holdings of the portfolio of state-contingent assets, denominated in domestic currency, for which the relevant discount factor pricing one-period claims is $\mathcal{F}^H_{t,t+1}$.[1] Moreover, $D_t(j) \equiv \int_0^1 D_t(h, j)\, \mathrm{d}h$ denotes j's claims on real profits from domestic firms and $T_t(j)$ are real lump-sum taxes levied by the domestic fiscal authority on household j.

The consumption index for a household belonging to cohort j is a CES bundle of domestic and imported goods:

$$C(j) = \left[\kappa^{\frac{1}{\theta}} C_H(j)^{\frac{\theta-1}{\theta}} + (1-\kappa)^{\frac{1}{\theta}} C_F(j)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \quad (2)$$

$$C^*(j) = \left[(1-\kappa)^{\frac{1}{\theta}} C^*_H(j)^{\frac{\theta-1}{\theta}} + \kappa^{\frac{1}{\theta}} C^*_F(j)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \quad (3)$$

where $\theta > 0$ measures the elasticity of substitution between Home and Foreign goods and there is home bias in consumption ($\kappa > 0.5$). The consumption sub-indexes $C_i(j)$ and

[1] Given the assumption of complete domestic markets, the stochastic discount factor is unique.

$C_i^*(j)$ result from Dixit-Stiglitz aggregation of the goods produced in the two countries, with elasticity of substitution $\epsilon > 1$:

$$C_i(j) = \left[\int_0^1 C_i(k,j)^{\frac{\epsilon-1}{\epsilon}} dk\right]^{\frac{\epsilon}{\epsilon-1}} \qquad C_i^*(j) = \left[\int_0^1 C_i^*(k,j)^{\frac{\epsilon-1}{\epsilon}} dk\right]^{\frac{\epsilon}{\epsilon-1}}, \tag{4}$$

for each $i = H,\ F$ indexing the two countries and each $k = h,\ f$ indexing the continuum of differentiated goods, with $h, f \in [0, 1]$.

Total expenditure minimization yields the consumption-based price indexes for the goods produced in the two countries

$$P_i = \left[\int_0^1 P_i(k)^{1-\epsilon} dk\right]^{\frac{1}{1-\epsilon}} \qquad P_i^* = \left[\int_0^1 P_i^*(k)^{1-\epsilon} dk\right]^{\frac{1}{1-\epsilon}} \tag{5}$$

for each $i = H,\ F$ and each $k = h,\ f$, and the respective consumer-price indexes (CPI)

$$P = \left[\kappa P_H^{1-\theta} + (1-\kappa) P_F^{1-\theta}\right]^{\frac{1}{1-\theta}} \qquad P^* = \left[(1-\kappa) {P_H^*}^{1-\theta} + \kappa {P_F^*}^{1-\theta}\right]^{\frac{1}{1-\theta}}. \tag{6}$$

In the equations above, $P_i(k)$ and $P_i^*(k)$ are the prices of the generic brand k – produced by the country i – denominated in the currency of country Home and Foreign, respectively. We assume that prices of the differentiated goods are set in the producer's currency (Producer Currency Pricing, PCP), and that the Law of One Price (LOP) holds:

$$P_i(k) = \mathcal{E} P_i^*(k) \qquad\qquad P_i = \mathcal{E} P_i^*,$$

for each $k = h, f$ and $i = H, F$, where $\mathcal{E}$ is the nominal exchange rate defined as the domestic price of foreign currency. Therefore, equations (5) imply that $P_H = \mathcal{E} P_H^*$ and $P_F = \mathcal{E} P_F^*$. However, equations (6) show that, since Home and Foreign agents' preferences are not necessarily identical, there can be deviations from purchasing power parity (PPP) unless $\kappa = 0.5$ that is, $P \neq \mathcal{E} P^*$. We measure the deviations from PPP through the real exchange rate, defined as $Q \equiv \mathcal{E} P^*/P$. Moreover, we define the Terms of Trade (ToT) as the relative price of foreign goods in terms of home goods ($\mathcal{S} \equiv P_F/P_H = P_F^*/P_H^*$).

Accordingly, under the assumption that each country government consumes an exogenously given amount of national goods, the brand-specific demand for good h, produced in country H is

$$\begin{aligned} Y_H(h) &\equiv C_H(h) + C_H^*(h) + G_H(h) = \\ &= \left(\frac{P_H(h)}{P_H}\right)^{-\epsilon} \left[\kappa \left(\frac{P_H}{P}\right)^{-\theta} C + (1-\kappa)\left(\frac{P_H^*}{P^*}\right)^{-\theta} C^* + G\right], \end{aligned} \tag{7}$$

while that for good f produced in country F is

$$\begin{aligned} Y_F^*(f) &\equiv C_F(f) + C_F^*(f) + G_F^*(f) = \\ &= \left(\frac{P_F^*(f)}{P_F^*}\right)^{-\epsilon} \left[(1-\kappa) \left(\frac{P_F}{P}\right)^{-\theta} C + \kappa\left(\frac{P_F^*}{P^*}\right)^{-\theta} C^* + G^*\right], \end{aligned} \tag{8}$$

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 (where W_t denotes the nominal wage), money demand and consumption as a function of financial and non financial wealth in real terms Ω_{t-1} and $\mathcal{H}_t$ respectively.[2]

$$\delta P_t C_t = W_t(1 - L_t), \tag{9}$$

$$\frac{M_t}{P_t} = \frac{\chi(1 + i_t)}{i_t} C_t \tag{10}$$

$$P_t C_t = \frac{1 - \beta(1 - \gamma)}{(1 - \gamma)(1 + \chi)} \Omega_{t-1} + \frac{1 - \beta(1 - \gamma)}{1 + \chi} \mathcal{H}_t \tag{11}$$

The latter expression, together with the budget constraint, yields the dynamic path of aggregate consumption:

$$C_t = \sigma E_t \left\{ \mathcal{F}_{t,t+1} \frac{P_{t+1}}{P_t} \Omega_{t+1} \right\} + \frac{1}{\beta} E_t \left\{ \mathcal{F}_{t,t+1} \frac{P_{t+1}}{P_t} C_{t+1} \right\}, \tag{12}$$

where first term captures the financial-wealth effect on consumption, which is increasing in the turnover rate γ:

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

This additional term with respect to the representative-agent (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: as the rate of replacement (γ) approaches zero the wealth effect fades away and the model converges to the RA set up. While the cohort-specific Euler equation is the same as in the RA setup, given 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 old traders.[3]

Given the definition of the terms of trade, the equilibrium relative prices follow:

$$\frac{P_H}{P} = \left[\kappa + (1 - \kappa)\mathcal{S}^{1-\theta} \right]^{\frac{1}{\theta - 1}} \qquad \frac{P_F^*}{P^*} = \left[\kappa + (1 - \kappa)\mathcal{S}^{\theta-1} \right]^{\frac{1}{\theta - 1}},$$

[2] Ω_t denotes the financial wealth in real terms:

$$\Omega_t(j) \equiv \frac{1}{1 - \gamma} \frac{1}{P_t} \left[(1 + r_{t-1}) B_{H,t-1}(j) + \mathcal{E}_t (1 + r_{t-1}^F) B_{F,t-1}(j) + Q_{H,t-1}(j) + M_{t-1}(j) \right]$$

and $\mathcal{H}_t$ is the expected discounted stream of income:

$$\mathcal{H}_t = E_t \sum_{k=0}^{\infty} \mathcal{F}_{t,t+k} (1 - \gamma) (W_{t+k} L_{t+k} + Z_{t+k} - T_{t+k})$$

[3] For a thorough explanation of this point, see Di Giorgio and Nisticò (2013) and Nisticò (2016).

which affect the equilibrium aggregate demands implied by market clearing in country H

$$Y_H = \kappa \left(\frac{P_H}{P}\right)^{-\theta} C + (1-\kappa)\left(\frac{P_H^*}{P^*}\right)^{-\theta} C^* + G \tag{13}$$

and country F

$$Y_F^* = (1-\kappa)\left(\frac{P_F}{P}\right)^{-\theta} C + \kappa\left(\frac{P_F^*}{P^*}\right)^{-\theta} C^* + G^*. \tag{14}$$

The Real Exchange Rate, finally, is determined by:

$$Q \equiv \frac{\mathcal{E}P^*}{P} = \left[\frac{\kappa\mathcal{S}^{1-\theta} + (1-\kappa)}{\kappa + (1-\kappa)\mathcal{S}^{1-\theta}}\right]^{\frac{1}{1-\theta}}. \tag{15}$$

2.2 The Government

We assume that public consumption is fully home-biased: the government consumes an exogenously given amount of domestic goods only

$$G = \left[\int_0^1 g(h)^{\frac{\epsilon-1}{\epsilon}} dh\right]^{\frac{\epsilon}{\epsilon-1}} \qquad G^* = \left[\int_0^1 g^*(f)^{\frac{\epsilon-1}{\epsilon}} df\right]^{\frac{\epsilon}{\epsilon-1}}. \tag{16}$$

Given Dixit-Stiglitz aggregation of the domestic public-consumption goods, public demand for brand h and f is equal to:

$$g(h) = \left(\frac{p(h)}{P_H}\right)^{-\epsilon} G \qquad g^*(f) = \left(\frac{p^*(f)}{P_F^*}\right)^{-\epsilon} G^*. \tag{17}$$

Government consumption can be financed by levying lump-sum taxes T_t to domestic households, by seigniorage and by issuing riskless one period nominal debt denominated in local currency B_t. This implies the following flow budget constraint for the fiscal authority of country H, in nominal terms:

$$B_t + M_t - M_{t-1} = (1+i_{t-1})B_{t-1} + P_t Z_t, \tag{18}$$

where Z_t denotes the domestic real primary deficit, defined as

$$Z_t \equiv \frac{P_{H,t}}{P_t} G_t - T_t. \tag{19}$$

Equivalently, we can express (18) in real terms:

$$\tilde{B}_t + \frac{\Delta M_t}{P_t} = \mathcal{R}_{t-1}\tilde{B}_{t-1} + Z_t, \tag{20}$$

where $\tilde{B}_t \equiv \frac{B_t}{P_t}$ denotes respectively real debt, $\mathcal{R}_t \equiv (1+i_t)(P_t/P_{t+1})$ the (ex-post) gross real interest rate and $\Delta M_t/P_t$ seignorage in period t.

Our analysis will focus on equilibria around a steady state with zero inflation, zero deficit (and consequently zero debt) and constant real balances. This allows us to express the level of seignorage, expressed as a fraction of steady state output, as in Galí (2017):

$$\frac{\Delta M_t}{P_t Y} = \frac{\Delta M_t}{M_{t-1}} \frac{P_{t-1}}{P_t} \frac{M_{t-1}}{P_{t-1} Y} = \frac{1}{V} \Delta m_t \tag{21}$$

where $m_t \equiv \log M_t$, and $V = PY/M$ is the steady state income velocity of money. This implies that, up to a first order approximation, the level of seignorage is proportional to nominal money growth.

2.3 The Supply Side

Each firm producing brand h and f has access to a linear technology:

$$Y_{H,t}(h) = L_t(h), \qquad\qquad Y^*_{F,t}(f) = L^*_t(f).$$

Labor market is competitive. In equilibrium, the real marginal costs for the two countries are, respectively:

$$MC_t = \frac{P_t W_t}{P_{H,t}} \qquad\qquad MC^*_t = \frac{P^*_t W^*_t}{P^*_{F,t}}.$$

Using the brand-specific demand functions (7)–(8) and aggregating across domestic brands, we get the domestic aggregate production functions for the two countries:

$$Y_{H,t}\Xi_t = L_t \quad L_t \qquad\qquad Y^*_{F,t}\Xi^*_t = L^*_t,$$

in which Ξ_t and Ξ^*_t capture (second-order) relative price dispersion among domestic firms in the two countries, while L_t and L^*_t are the domestic and foreign aggregate per-capita amount of hours worked.

Equilibrium in the labor market then implies that real marginal costs equal

$$MC_t = \frac{\delta C_t}{1 - Y_{H,t}\Xi_t} \frac{P_t}{P_{H,t}} \qquad\qquad MC^*_t = \frac{\delta C^*_t}{1 - Y^*_{F,t}\Xi^*_t} \frac{P^*_t}{P^*_{F,t}} \tag{22}$$

for the domestic and foreign economy, respectively.

Finally, we assume price rigidity à la Calvo with a constant probability $1 - \vartheta$ of price revision each period.

2.4 The Linear Model.

Let lower-case variables denote percentage deviations from steady state $x_t \equiv \frac{X_t - X}{X}$.[4] Linearization of the model around a zero inflation/zero deficit/zero seignorage equilibrium yields a set of equations.

[4]Except: $c_t \equiv \frac{C_t - C}{Y_H}$, $c^*_t \equiv \frac{C^*_t - C^*}{Y^*_F}$, $g_t \equiv \frac{G_t - G}{Y_H}$, $g^*_t \equiv \frac{G^*_t - G^*}{Y^*_F}$, $\tau_t \equiv \frac{T_t - T}{Y_H}$, $\tau^*_t \equiv \frac{T^*_t - T^*}{Y^*_F}$, $\mathrm{nfa}_t \equiv \frac{\mathrm{NFA}_t}{Y_H}$, $z_t \equiv \frac{Z_t}{Y_H}$, $z^*_t \equiv \frac{Z^*_t}{Y^*_F}$, $\mathrm{nfa}_t \equiv \frac{\mathrm{NFA}_t}{Y_H}$, $b_t \equiv \frac{B_t}{Y_H}$, $b^*_t \equiv \frac{B^*_t}{Y^*_F}$, $\mathrm{nx}_t \equiv \frac{\mathrm{NX}_t}{Y_H}$, $\omega_t \equiv \frac{\Omega_t}{Y_H}$.

The Uncovered Interest-rate Parity (UIP) shows the relationship between interest rates:

$$i_t - E_t \pi_{t+1} = i_t^* - E_t \pi_{t+1}^* + E_t \Delta q_{t+1} \tag{23}$$

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:

$$\pi_t = \pi_{H,t} + (1 - \kappa) \Delta s_t \tag{24}$$

$$\pi_t^* = \pi_{F,t}^* - (1 - \kappa) \Delta s_t, \tag{25}$$

and the real exchange rate and terms of trade are related through

$$q_t = (2\kappa - 1) s_t. \tag{26}$$

Money demand at Home and abroad are respectively:

$$m_t - p_t = c_t - \beta r_t \tag{27}$$

$$m_t^* - p_t^* = c_t^* - \beta r_t^*, \tag{28}$$

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

$$\mathrm{nfa}_t = \frac{1}{\beta} \mathrm{nfa}_{t-1} + \frac{1}{2} (y_t^R - g_t^R - c_t^R) - \alpha (1 - \kappa) s_t \tag{29}$$

The equilibrium dynamics of aggregate consumption at Home and abroad follow

$$c_t = E_t c_{t+1} - \alpha (r_t - E_t \pi_{t+1} - \varrho) + \sigma \mathrm{nfa}_t + \sigma b_t + \sigma m_t \tag{30}$$

$$c_t^* = E_t c_{t+1}^* - \alpha (r_t^* - E_t \pi_{t+1}^* - \varrho) - \sigma \mathrm{nfa}_t + \sigma b_t^* + \sigma m_t^* \tag{31}$$

Public debt in real terms evolves according to

$$b_t + m_t - m_{t-1} = \beta^{-1} b_{t-1} + z_t \tag{32}$$

$$b_t^* + m_t^* - m_{t-1}^* = \beta^{-1} b_{t-1}^* + z_t^*, \tag{33}$$

where primary deficits are defined by

$$z_t = g_t - \tau_t - (1 - \alpha)(1 - \kappa) s_t \tag{34}$$

$$z_t^* = g_t^* - \tau_t^* + (1 - \alpha)(1 - \kappa) s_t. \tag{35}$$

On the supply side, Calvo price-setting implies two New Keyenesian Phillips Curves of the usual kind:

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \lambda mc_{H,t} \tag{36}$$

$$\pi_{F,t}^* = \beta E_t \pi_{F,t+1}^* + \lambda mc_{F,t}^* \tag{37}$$

where $\lambda \equiv \frac{(1-\vartheta)(1-\beta\vartheta)}{\vartheta}$ and the real equilibrium marginal costs follow:

$$mc_t = \frac{1}{\alpha}c_t + \varphi y_{H,t} + (1-\kappa)s_t \tag{38}$$

$$mc_t^* = \frac{1}{\alpha}c_t^* + \varphi y_{F,t}^* - (1-\kappa)s_t \tag{39}$$

with φ indicating the inverse of the steady-state Frisch elasticity of labor supply.

The total demand for domestic goods reads

$$y_{H,t} = 2\alpha\theta\kappa(1-\kappa)s_t + \kappa c_t + (1-\kappa)c_t^* + g_t \tag{40}$$

$$y_{F,t}^* = -2\alpha\theta\kappa(1-\kappa)s_t + \kappa c_t^* + (1-\kappa)c_t + g_t^* \tag{41}$$

Finally, relative quantities are defined as

$$c_t^R = c_t - c_t^* \tag{42}$$

$$y_t^R = y_{H,t} - y_{F,t}^* \tag{43}$$

$$g_t^R = g_t - g_t^* \tag{44}$$

2.5 Monetary and fiscal policies

In order to close the model we need to specify how monetary and fiscal policy is conducted in each country. We first describe which kind of policies we consider in country H. A domestic fiscal stimulus can be defined either as a positive deviation of government spending from its steady-state value ($g_t \equiv \frac{G_t - G}{Y_H} > 0$) or as a negative deviation of lump-sum taxes from their steady-state value ($\tau_t \equiv \frac{T_t - T}{Y_H} < 0$).[5] In both cases we assume an exogenous autoregressive process with the same coefficient of persistence:

$$g_t = \rho_g g_{t-1} + u_{g,t} \quad \rho_g \in [0,1] \tag{45}$$

$$\tau_t = \rho_g \tau_{t-1} + \xi_b b_{t-1} + u_{g,t} \tag{46}$$

where the coefficient ξ_b measures the response of taxes to the outstanding debt and it insures fiscal solvency over time. A fiscal stimulus increases primary deficit (34) directly and indirectly, through its effect on the terms of trade (see discussion in the next section). Such fiscal stimulus can be financed either with debt or by issuing money. In the latter case, the monetary base increases to keep the public deficit constant. This requires that the real seigniorage equates the primary deficit:

$$\Delta\frac{M_t}{P_t} = Z_t \quad \text{or} \quad \Delta m_t = V z_t \tag{47}$$

In this regime, the growth rate of nominal money supply is proportional to the primary deficit and the interest rate adjusts to guarantee equilibrium in the money market.

[5] A fiscal contraction will of course be given by $g_t < 0$ or $\tau_t > 0$.

In the case of a debt-financed scheme, monetary policy is characterized by a standard Taylor rule given by

$$i_t = \varrho + \phi_\pi \pi_{H,t} + \phi_x x_t, \tag{48}$$

where the nominal interest rate responds to deviations of the domestic inflation $\pi_{H,t}$ and output gap x_t from zero targets. Differently from the regime with money-financing, money supply is not determined by z_t, but it adjusts endogenously in order to satisfy money demand at the interest rate set by central bank.

As regards the foreign country, we assume a conventional policy mix in which fiscal policy sticks to balanced budget and monetary policy follows a standard Taylor rule such as equation (48).

2.6 Parameterization

We parameterize the structural model on a quarterly frequency, following previous studies and convention. Given an intertemporal discount factor $\beta = 0.99$, the steady-state net quarterly interest rate ϱ is set at 0.01.[6] We calibrate $\alpha = 0.8$ as in Galí (2017), while the rate of replacement γ is set equal to 0.1, consistently with the evidence for the U.S. recently provided by Castelnuovo and Nisticò (2010).

We follow Rotemberg and Woodford (1997) with respect to the degree of monopolistic competition (ϵ =7.66) and the elasticity of real wages to aggregate hours ($\varphi = 0.5$) , while we set the degree of price stickiness $\vartheta = 0.75$, in line with estimates provided for the U.S. by Smets and Wouters (2007). With respect to the parameters that refer to the open-economy dimension of our model, we set the elasticity of substitution between Home and Foreign goods equal to $\theta = 1.5$, which implies that home and foreign goods are substitute in the utility function of consumers, and, finally, the degree of home bias in private consumption $\kappa = 0.6$.

As to monetary policy, in the case of debt-financed fiscal policy, (48) is calibrated consistently 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 regards fiscal policy in country H, we follow Galí (2017) for the case of money financing and we set $V = 3$ as the steady state income velocity of money.[7] Moreover we set ξ_b equal to the steady state real interest rate ρ in (46).[8] Finally, to calibrate persistence and volatility of the fiscal shocks, we follow Di Giorgio and Nisticò (2013), who estimate the persistence of government consumption in the U.S. and the Euro Area for the available sample (1970:1 to 2005:4). Under the assumption of structural symmetry between domestic and foreign country, the calibrated values are $\rho_g = \rho_g^* = 0.665$, $\sigma_g = \sigma_g^* = 0.0054$.

[6] The values reported in the text refer to both countries, given the assumption of symmetric steady state

[7] This value corresponds approximatively to the average income velocity in the U.S. and the Euro Area over the period 1960–2015, taking values referred to the monetary base $M0$. The weight attached to real balances in the utility function χ is derived considering the steady-state version of (10), expressed as a fraction of Y: the resulting value is $\chi = 0.0042$

[8] The response to lagged real debt ξ_b guarantees fiscal solvency. We also simulated the model under a countercyclical rule in terms of primary deficit, but the qualitative results are similar to those under a tax rule. Graphs are available upon request.

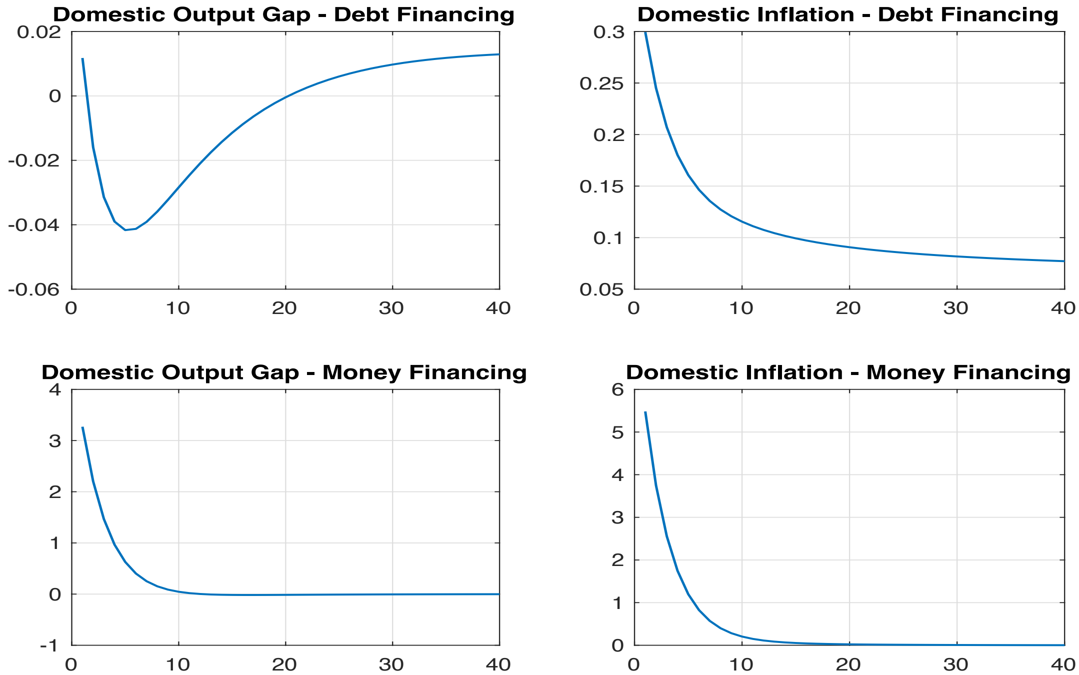

Figure 1: Response of domestic output gap and inflation to a 1% increase in public spending. Upper panel: debt financing. Lower panel: money financing. All variables are expressed in percentage points, inflation is expressed in annual terms.

3 The Effects of a Fiscal Stimulus

In this section we evaluate the macroeconomic effects of different fiscal shocks under alternative financing schemes. We start by analyzing the response to an increase in government spending. Figure 1 compares the induced dynamics of inflation and the output gap. We use two separate panels for each financing scheme given the sizable difference in the magnitude of the responses. The shock is considerably more expansionary under money financing, due to the different reaction of the real exchange rate. The latter is shown in figure 2, where other relevant dynamic responses are compared. In particular, the impact reaction on the output gap is 0.01 under debt financing, and about 3.3 under money financing. Inflation reaction is about fifteen times higher on impact under money financing.

Notice that, under debt financing, the fiscal shock is expansionary on impact, but the implied appreciation of the real exchange rate (common to baseline DSGE models) induces a hump-shaped decline in the output gap (only at the end of the time horizon, when the domestic currency depreciates, the output gap is positively affected). Under monetary financing, on the other hand, we obtain a strong and persistent expansion in the domestic output gap and in inflation. When the domestic government uses debt (solid blue line), the real exchange rate appreciates and limits the expansionary effect of the fiscal shock on output.[9] The low response to the stock of public debt in (46) does not guarantee real debt stabilization even forty quarters after the issuance of new public debt necessary to finance

[9]This is quite standard in DSGE open economy models notwithstanding mixed empirical evidence. See the discussion in Di Giorgio, Nisticò and Traficante (2017).

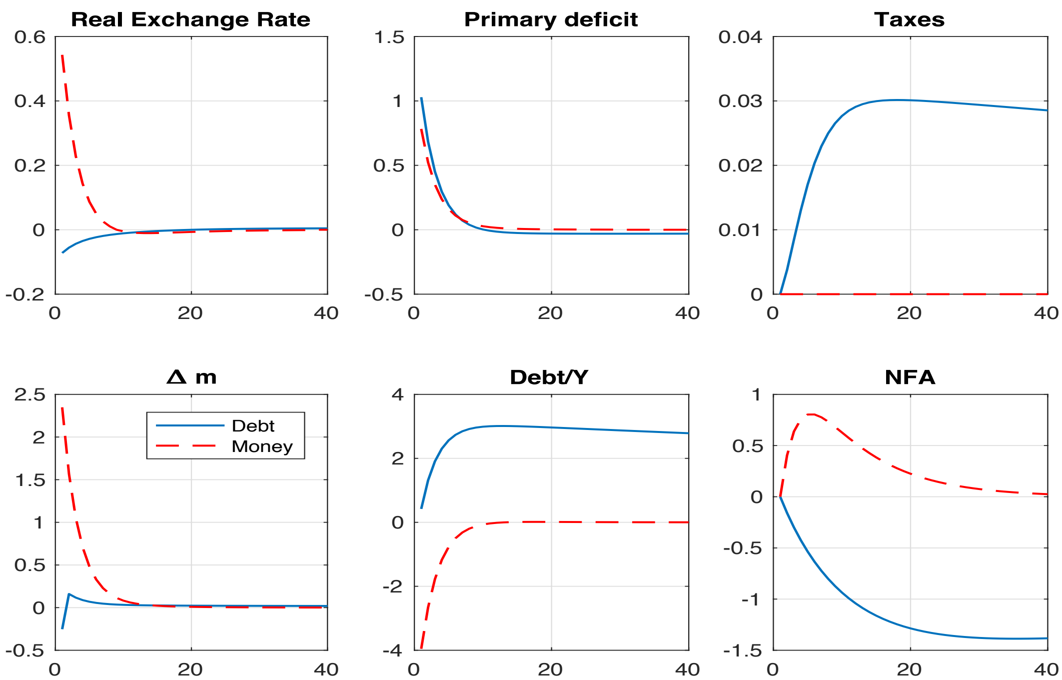

Figure 2: Response of selected variables to a 1% increase in public spending. Solid line: debt-financing; dashed line: money financing. All variables are expressed in percentage points.

the fiscal stimulus. More in detail, the one percent increase in public spending brings about an increase in real public debt three times higher, both in levels and as a fraction of output. Under monetary financing (dashed red line), on the other hand, we observe a sizable and persistent expansion in domestic output gap and inflation. The expansion in inflation induced by the monetary accommodation of the fiscal stimulus induces a decline in the real interest rate and, in turn, an expansion in private consumption. Differently from the case in which the government uses public debt, the pressure towards the real appreciation is more than offset by the increase in money supply and the exchange rate depreciates in nominal and real terms. Monetary financing guarantees that real debt remains constant and that the government does not increase taxes. As a consequence, the debt-to-GDP ratio decreases for about ten quarters, driven by growth in real activity.

A key difference between the two financing regimes is related to the international transmission of the fiscal shock. Under debt financing, we observe a persistent decline in the NFA position, due to a worsening in the trade balance and to the weak response to the stock of public debt. The low degree of fiscal discipline also implies that the evolution of primary deficit is mainly driven by the real exchange rate and relative output gap: country H runs a small primary surplus when the real exchange rate and the output gap are close to reverse their dynamics (after about 3 years in our simulation). The low primary surplus reached, however, cannot modify the negative NFA position. On the other hand, a fully accommodative money-financed fiscal stimulus implies an increase in relative consumption and output. Given a stable debt level, reached through monetary accommodation, country H experiences a surplus in the trade balance and an improvement in the NFA position.[10]

[10]Notice that the way fiscal policy is designed may affect the international transmission of fiscal shocks.

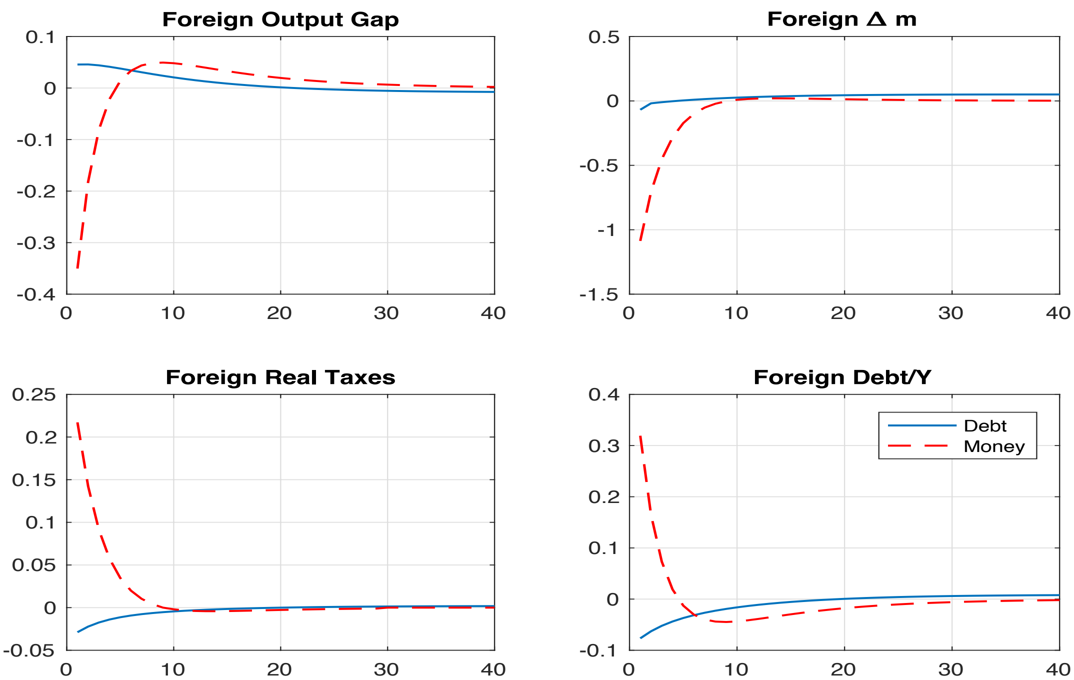

Figure 3: Response of selected foreign variables to a 1% increase in public spending. Solid line: debt-financing; dashed line: money financing. All variables are expressed in percentage points.

In figure 3 we show how the fiscal stimulus in country H transmits in country F where we assumed the policy authorities follow balanced budget and a Taylor rule. Under a debt-financed fiscal stimulus in country H (solid line), the real appreciation improves foreign competitiveness: as a consequence, country F experiences an expansion in output and a pressure towards a primary surplus. Money supply and real taxes reduce mildly in order to guarantee balanced budget, while the expansion in output drives the reduction in debt-to-GDP ratio. Interestingly, the dynamics change dramatically when country H uses money to finance its fiscal stimulus (dashed red line). The real depreciation implied by the money financing spills over country F inducing a negative output gap. Since country F has balanced budget, the debt-to-GDP ratio mirrors (in the opposite direction) the hump-shaped path in output. Moreover, the need to keep public debt unchanged implies a restrictive fiscal policy (higher taxes). Quantitatively, the restriction in foreign money is much stronger with respect to the case of a debt-financed expansion in country H due to equilibrium in the money market.

The results shown in the previous figures suggest that a money-financed fiscal stimulus is substantially more expansionary in terms of output. However, in welfare terms, the effects of these policies are not clear ex ante. At first glance, the relative higher increase in output is accompanied by a higher jump in inflation, so that there should be a trade-off in following this

In particular, if the fiscal authority follows a countercyclical fiscal rule, which also reacts to the stock of outstanding debt, instead of the exogenous rule (46), a debt-financed fiscal stimulus would call for a fiscal response able to reduce the output gap. As a consequence, the negative NFA position would be lower and would last less quarters. Di Giorgio and Nisticò (2013) show the relevance of the degree in fiscal discipline in the international transmission of productivity shocks.

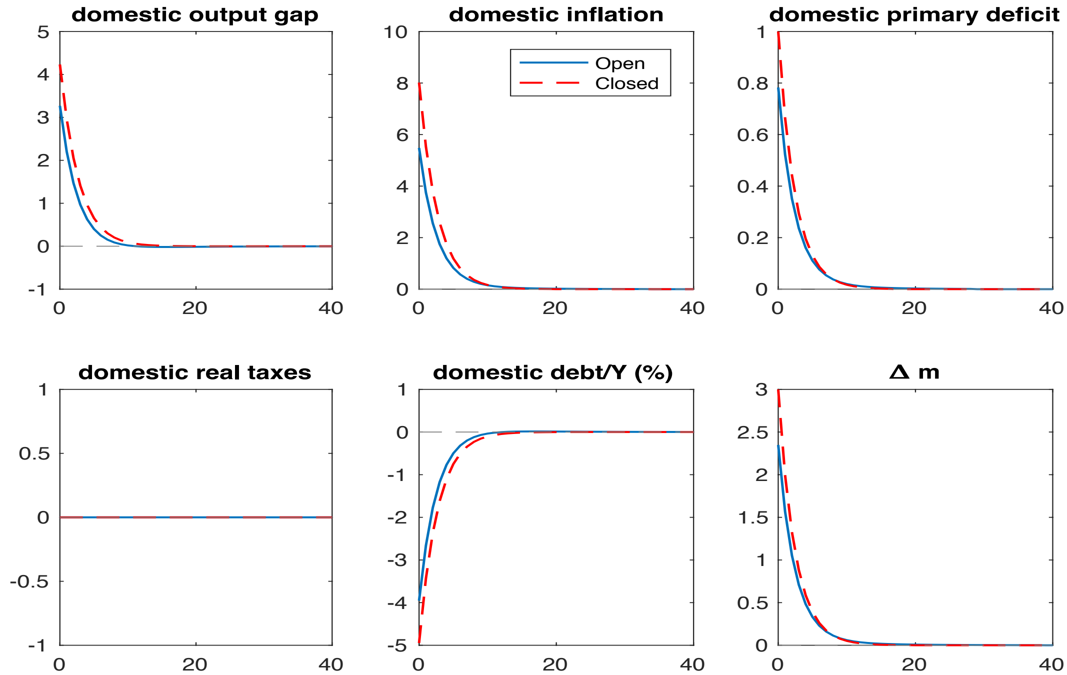

Figure 4: Response of selected variables to a 1% money-financed increase in public spending. Solid line: open economy; dashed line: closed economy. All variables are expressed in percentage points, inflation is expressed in annual terms.

kind of unconventional policies. In countries that are in deflation or low inflation, the cost of having such a surge in inflation could be negligible, while in "normal times", conventional monetary and fiscal policies are likely to be preferred.[11]

In order to evaluate how the open economy dimension affects the dynamics after a money-financed increase in public spending, we simulate the model also in closed economy[12], showing the differences with respect to the open-economy case in figure 4. The relative expansion of the output gap and inflation in country H is larger on impact in a closed economy (dashed line). In particular, money creation accommodates fiscal policy more in a closed economy because the appreciation in the terms of trade makes primary deficit lower in an open economy (solid line). Due to the higher expansionary effect on output, in a closed-economy, country H can also reduce more its debt-to-GDP ratio. Notice that this result holds also in the debt-financing regime (not shown here): in open economy, when the central bank does not accommodate the fiscal stimulus, the real appreciation crowds out fiscal policy and, after the low expansion on impact, country H enters a persistent recession.

We now move to analyze how the most relevant structural features and parameters of our economy affect the dynamic transmission following an increase in domestic government spending.

[11] A formal welfare analysis would clarify this issue. Galí (2017), in a baseline closed-economy DSGE model, evaluates welfare as a first order approximation to household utility. Comparing the effects of a debt-financed increase in public spending with those of a money-financed increase, he finds that the loss in utility is lower in the case of a monetary financing, because of the higher consumption enjoyed by households in this case.

[12] More exactly, we are considering the case of $\kappa = 0.99999$, which is almost the closed-economy version of our model.

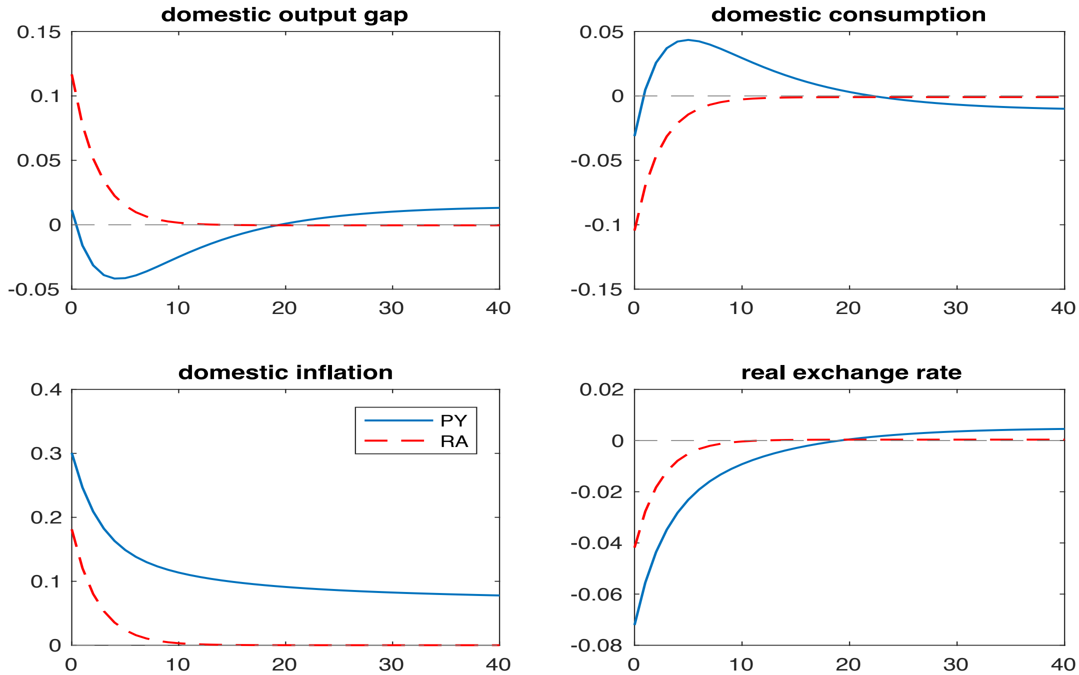

Figure 5: Response of selected variables to a 1% debt-financed increase in public spending. Solid line: perpetual youth model; dashed line: representative agent model. All variables are expressed in percentage points, inflation is expressed in annual terms.

Given the relevance of agents' heterogeneity for the demand side of the model, in figure 5 we compare the macroeconomic dynamics under debt financing with those that could be obtained in a representative agent version of the economy. In the picture the case of perpetual youth is drawn with a solid line, while a dashed line is used for the case of representative agent. The graph highlights that the qualitative response of the economy after the shock is not influenced by the demand structure. We can observe, however, that with perpetual youth the higher debt induced by the fiscal shock implies a smaller contraction in consumption on impact and then a persistent hump-shaped increase. Consistently with that, domestic inflation and the real exchange rate appreciation are substantially higher with perpetual youth. As underlined above, the higher (and more persistent) real exchange rate appreciation is a relevant variable to explain the contraction in the output gap. If we repeat the analysis in the monetary financing regime, the quantitative differences between a model with a representative agent and a model with perpetual youth would be almost negligible. In this regime, in fact, the huge monetary accommodation induces a substantial real depreciation under both demand structures. As shown above, this real depreciation is the key variable in shaping the very expansionary path followed by domestic output gap and inflation.[13]

We now investigate in figure 6 how nominal rigidity, i.e. the degree of price stickiness, shapes the dynamics in the case of a money-financed fiscal stimulus. When prices are flexible (dashed line), the increase in money supply is just able to counteract the push towards real appreciation induced by the increase in public spending, leaving mostly unaffected all real variables. As expected, domestic inflation (and also CPI, not shown here) jumps on impact,

[13]The graphs about this exercise are available on request.

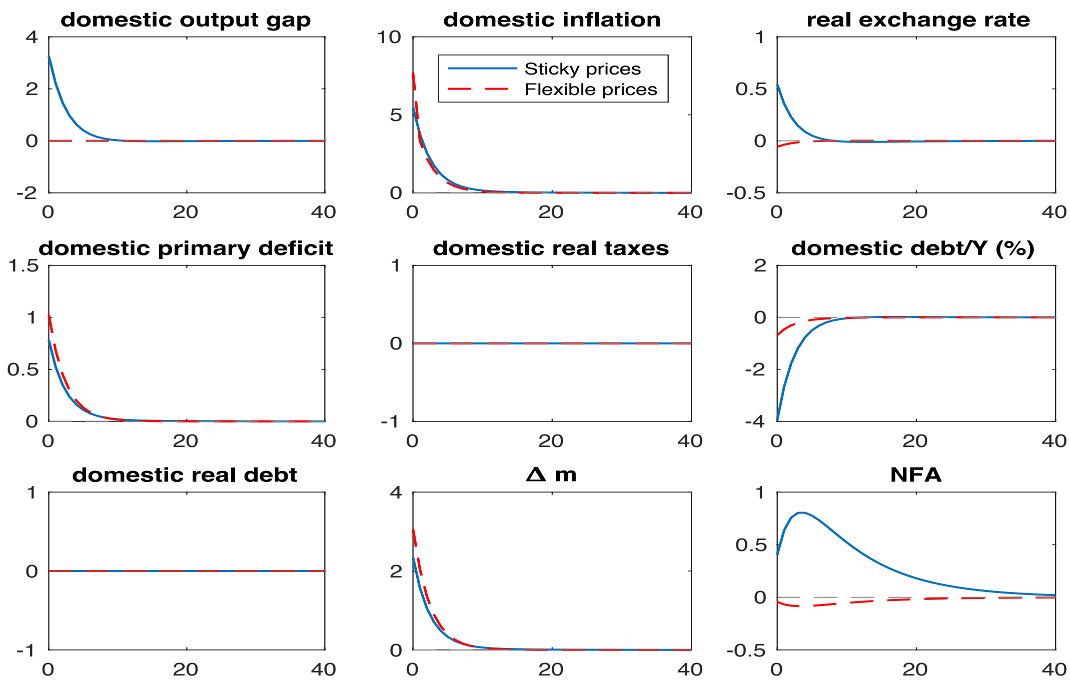

Figure 6: Response of selected variables to a 1% money-financed increase in public spending. Solid line: sticky prices ($\vartheta = 0.75$); dashed line: flexible prices ($\vartheta = 0.001$). All variables are expressed in percentage points, inflation is expressed in annual terms.

inducing a higher increase in the domestic primary deficit with respect to the case of sticky prices.

In order to check robustness of our results and allow for a more comprehensive comparison with the closed economy analysis in Galí (2017), in figures 7–8 we plot the dynamic responses to a tax cut, under both debt and money financing. Comparison of figure 7 with figure 1 shows that the response of output and inflation to a fiscal stimulus is independent of the kind of shock considered (government spending versus taxes) under money financing. Under debt financing, on the contrary, the response of output is negative on impact after a tax cut due to the strong appreciation in the real exchange rate. Moreover, domestic inflation is also less impacted following a debt-financed tax cut with respect to a debt-financed increase in government expenditure. Variables in figure 8 show a dynamics closely matching those in figure 2.

With respect to the analysis of Galí (2017), the main difference is the non-zero response of output and inflation that follow a tax cut, even when it is financed with debt. This is due to the absence of Ricardian equivalence and the international transmission of shocks via the terms of trade.

4 Concluding comments

In this paper we consider a two-country DSGE model with perpetual youth which allows financial wealth to directly affect the consumption dynamics. We compare the effects of both an increase in government spending and a tax cut under debt and monetary financing.

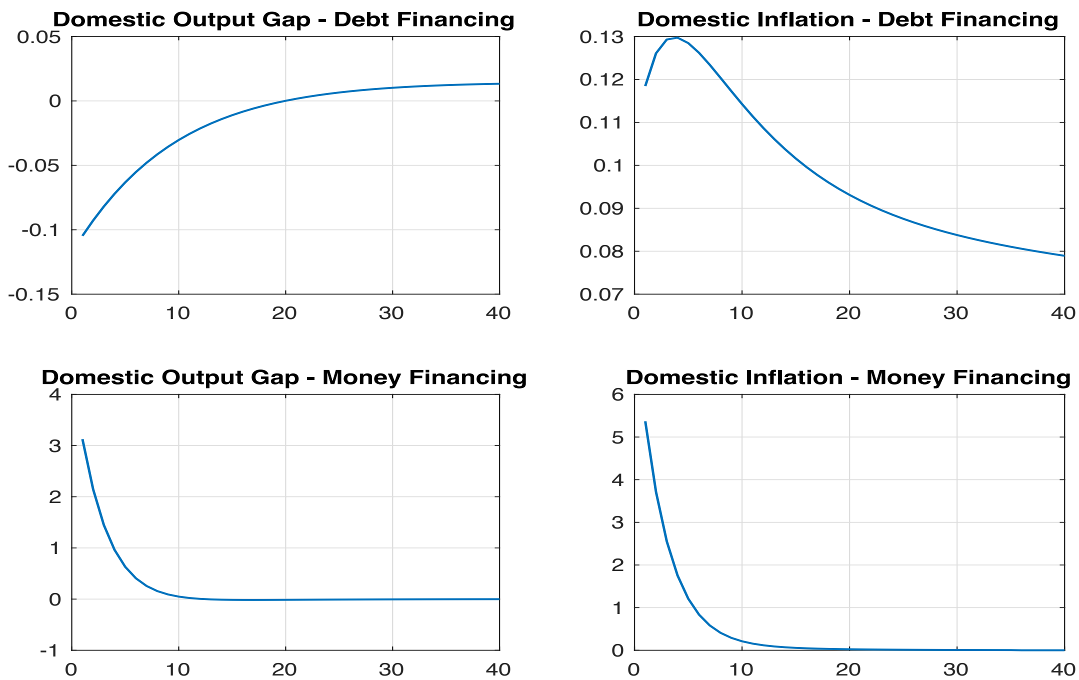

Figure 7: Response of domestic output gap and inflation to a 1% tax cut. Upper panel: debt financing. Lower panel: money financing. All variables are expressed in percentage points, inflation is expressed in annual terms.

Our main finding is that the fiscal stimulus is considerably more expansionary, on both output and inflation, under monetary financing. This is due to the real depreciation implied by the monetary expansion. Compared to the debt-financed fiscal stimulus, the increase in money supply more than offsets the appreciation in the terms of trade induced by the fiscal shock. For the foreign country, on the other hand, we observe an output expansion in the case of debt-financed fiscal stimulus at Home and a recession in the case of monetary financing. Another contribution of our paper is that we compare our model with the standard closed-economy DSGE model used by Galí (2017). We show that a money-financed fiscal stimulus is less expansionary in open economy because of the real appreciation of the currency. Moreover, we obtain similar macroeconomic outcomes following a tax cut, even when debt-financed.

Future research could include welfare analysis and an investigation on optimal monetary and fiscal policy. This would require to explicitly derive a reasonable welfare criterion and to properly model strategic interactions between the two countries.

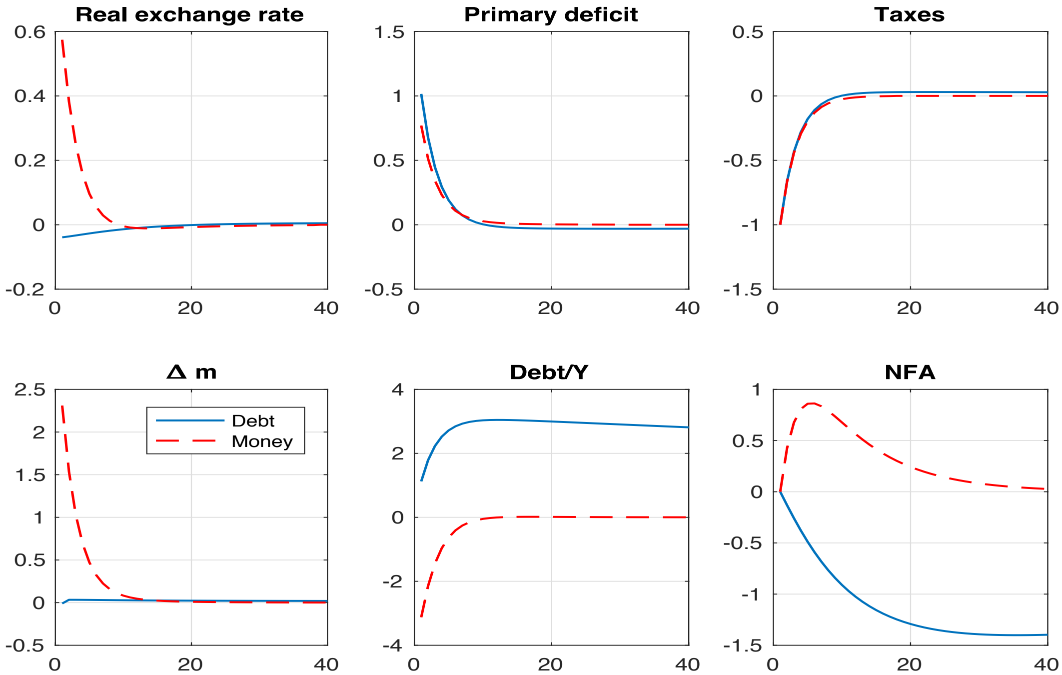

Figure 8: Response of selected variables to a 1% tax cut. Solid line: debt-financing; dashed line: money financing. All variables are expressed in percentage points.

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