Floats, pegs and the transmission of fiscal policy

Giancarlo Corsetti, Keith Kuester, and Gernot J. Müller*

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Abstract

According to conventional wisdom, fiscal policy is more effective as a stabilization tool under a fixed than under a flexible exchange rate regime. In this paper we reconsider the transmission of shocks to government spending across these regimes, within a standard new-Keynesian model of a small open economy. Because of the stronger emphasis on intertemporal optimization, the new-Keynesian framework requires a precise specification of fiscal and monetary policies, and their interaction, at both short and long horizons. We derive an analytical characterization of the transmission mechanism of expansionary spending policies under a peg, showing that long-term real rates necessarily rise with impact inflation, driving down private demand even though short-term real rates fall. As this need not be the case under floating exchange rates, the conventional wisdom needs to be qualified. In fact, under plausible strategies of budget consolidation, fiscal stimulus is not necessarily less expansionary under floating exchange rates.

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1 Introduction

One of the most popular pieces of wisdom in economic policy is the idea that fiscal policy is more effective in a fixed exchange rate regime or a currency union, relative to a regime of flexible exchange rates. In light of the experience of many countries pursuing a currency peg, the popularity of this economic tenet is somewhat surprising. In the practice of policymaking, it is well understood that, under a peg, news about a relaxation of the fiscal stance is often destabilizing in the foreign exchange markets. That is, such news tends to generate pressure on the peg. To the extent that monetary policy needs to move to defend the peg, a fiscal expansion ends up creating the need for a monetary contraction, with negative effects on economic activity.

Admittedly, the popularity of the above mentioned tenet is not universal among the fathers and mothers of modern international macroeconomics. An instance of an early, insightful discussion of fiscal policy using the Mundell-Fleming (henceforth MF) model is provided by Dornbusch (1980). According to Dornbusch, the prediction that a fiscal expansion tends to strengthen the exchange rate is an unappealing feature of conventional theoretical models. To bring the model closer to reality, he encompasses medium-term monetary developments in the model, focusing on the case in which government expansions in the short run foreshadow deficit monetization over the medium run. In this case, the effects of fiscal policy are compounded with (and magnified by) expectations of monetary expansion in the future, and can thus be quite large, relative to the corresponding multiplier under a credible fixed exchange rate (a regime which rules out monetization).

In this paper, we revisit the theoretical foundations of the conventional wisdom on the relative effectiveness of fiscal policy under alternative exchange rate regimes, using a standard new-Keynesian model of a small open economy. Following Dornbusch, we recognize the inherent link between the macroeconomic effects of short-run stimulus and private expectations about medium-run policy developments. Different from Dornbusch, we do not focus on prospective deficit monetization, but consider alternative and arguably more plausible fiscal policy regimes in the medium run. In particular, building on Corsetti, Meier, and Müller (2009), henceforth CMM, our specific contribution consists of contrasting the implications of alternative debt-stabilization regimes involving adjustment of either tax rates or spending, or both.

Using this approach, we show that taking the textbook analysis at face value may be misleading: an important result of the paper is that fiscal policy is not necessarily less effective under flexible exchange rates. A plausible regime of medium-run fiscal consolidation in which, after the initial stimulus, both spending and taxes are adjusted so as to stabilize debt, can easily undermine the ranking according to the conventional wisdom.

The key driver of our results is the tight connection between private demand and the long-term interest rate in real terms which characterizes the new-Keynesian model, see Woodford (2003). In this model, the real long-term rate is a core indicator of the overall stance in stabilization policy: for private demand to increase in response to a shock, this rate must fall. But, under the expectation hypothesis, long-term rates reflect the entire path of (current and future anticipated) monetary and fiscal decisions, via the effects of the latter on short-term rates over time, a transmission mechanism analyzed in detail by CMM. By focusing on the same mechanism, in this paper we are able to derive sharp predictions on the macroeconomic dynamics following any given fiscal expansion, as a function of the regimes governing the evolution of fiscal and monetary/exchange rate policy after the initial fiscal shock has occurred.

By way of example, everything else equal, the long-term rate tends to fall with an anticipated contraction in government spending in the near future. As this is expected to cause a slowdown of inflation, under floating rate, private agents also expect the central bank to cut policy rates. At the same time, with nominal rigidities, anticipation of falling inflation in the near future affects price setting much in advance, translating into lower inflation (and thus lower policy rates) already today. These considerations suggest that, at the time when the stimulus is implemented, it may well be possible that long-term rates actually fall, instead of increasing, driving up private demand.

This is not possible under a peg. Indeed, a specific contribution of this paper consists of a simple analytical characterization of the impact effect of temporary shocks (including fiscal ones) on the long-term rate in a regime of limited exchange rate flexibility. Namely, assuming complete financial markets and separable additive utility, up to a first-order approximation the long-term rate moves exactly with the initial (unexpected) change in the CPI. In other words, an initial bout of inflation in response to a fiscal expansion approximates well the rise in long-term real rates on impact. In turn, such a rise drives a proportional fall in consumption demand.[1]

A corollary of this result is that, under a peg, short-term and long-term real rates commove negatively in response to a fiscal shock: the latter necessarily rise on impact, even if the former fall one-to-one with the rate of inflation. This result exposes the theoretical weaknesses of arguments, such as the so-called Walter's critique, which rule out this possibility. According to the Walter's critique, under a fixed exchange rate, exogenous cyclical shocks (including fiscal shocks) are amplified by endogenous pro-cyclical movements in the real interest rate. A fixed exchange rate regime, therefore, is inherently destabilizing. It is apparent that this argument relies on the maintained (but incorrect) assumption that real rates move necessarily in the same direction over the whole maturity structure.

We derive additional results by enriching the baseline new-Keynesian framework with features capturing financial imperfections and frictions. After establishing that our main conclusions go through

[1] The constant of proportionality depends on the curvature of the utility function. While this condition does not hold exactly if markets are incomplete, or preferences are not additive separable, the main insight of a positive relation between initial unexpected inflation and the movement in the long-term rate provides a useful insights into the fiscal transmission mechanism in more general model specifications.

under incomplete financial markets, we study the case of economies with limited asset market participation—a fraction of households are excluded from financial markets, possibly because of (non-modeled) costs of access to them. Fiscal stabilization is typically motivated by pointing out that a significant fraction of households may face financial constraints, making monetary policy less potent. We show that our main results carry over in this environment as well, where fiscal policy becomes overall more effective.

This paper is organized as follows. Section 2 reviews the conventional wisdom based on the traditional Mundell-Fleming model. Section 3 presents our new-Keynesian (NK) model. Section 4 reconsiders the conventional wisdom in the NK framework, focusing on the special case of an exogenous autoregressive fiscal disturbance. Section 5 derives analytical results regarding the fiscal transmission mechanism. Section 6 carries out experiments for a general specification of fiscal policy with endogenous correction of both taxes and spending. Section 7 explores the robustness of our results in the presence of financial frictions. Section 8 concludes.

2 The conventional view and its (early) critics

The conventional wisdom is typically stated referring to the textbook version of the Mundell-Fleming model, illustrated graphically by Figure 1. Aggregate demand is on the X axis, the nominal interest rate on the Y axis. The downward sloping line is the IS curve, derived from the equilibrium condition investment=saving, and expressing output as a declining function of the interest rate. The position of the IS curve depends on the level of the exchange rate: with preset prices, a nominal (=real) depreciation moves the IS to the right, through a positive competitiveness effect on real export. In the background of this curve, the exchange rate is determined by the uncovered interest parity condition—so that a fixed exchange rate requires equality between the domestic and the foreign interest rate in nominal terms. Under a floating rate, one needs to make an assumption about agents expectations of future exchange rates. Without loss of generality, for our purpose it is analytically convenient to assume that the exchange rate follows a random walk.[2] Money demand is a positive function of output, negative function of the nominal interest rate.

This model leads to a simple yet powerful delivery of our results of interest. In a small open economy (foreign interest rate and prices are given), a spending expansion has a large multiplier effect on output under fixed exchange rates, while it just crowds out net exports one-to-one under flexible exchange rates. The reason for these differential results is a different degree of monetary accommodation across the two regimes.

Under fixed exchange rates, the domestic interest rate is constrained to be identical to the foreign

[2] Many textbook models assume stationary expectations instead: the exchange rate in the future is expected to revert to some given value.

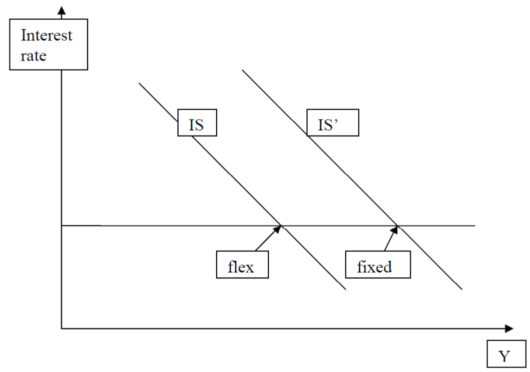

Figure 1: Expansion of government spending in Mundell-Fleming model (textbook version).

one. Hence there must be full monetary accommodation of any change in money demand. So, if government interventions drive up employment and income, households and firms raise their demand for cash, and the central bank cannot but raise its supply by the same amount. If it did not, the interest rate would rise, and a higher interest rate would tend to appreciate the currency (via the uncovered interest parity condition), contradicting its commitment to maintain the currency peg.

Under a flexible rate regime, instead, the central bank is not committed to any particular exchange rate parity. If a spending expansion were successful to raise employment, incomes and therefore the demand for money, there would be an upward pressure on interest rates which would in turn tend to appreciate the currency. But a stronger currency reduces aggregate demand and income, by crowding out net exports, and therefore counteracts the effects of the initial stimulus on interest rates. Since, in equilibrium, there cannot be any upward pressure on the interest rate, the exchange rate must therefore appreciate enough, on impact, to rule out any change in the level of aggregate demand, output and money demand. So, a government expansion results exclusively in nominal and real appreciation, and a different composition of final demand, with more public demand, less exports. [3]

Such sharp results are of course sensitive to the parameterization of expectations. Assuming a stationary exchange rate, for instance, the impact appreciation of the exchange rate under a floating

[3] Note that in this simple exercise monetary accommodation works through changes in the money supply: the interest rate actually remains constant in both regimes. The analysis of the flexible exchange rate regime is indeed typically carried out under the assumption of a constant money supply. It is worth emphasizing, nonetheless, that such an assumption is not as restrictive as it may sound. To appreciate this point, reconsider the analysis assuming that, under a flexible rate regime, the central bank follows a Taylor-type rule. Without loss of generality, assume that the central bank sets current rates responding also to expected inflation. With a Taylor rule in place, in response to a demand expansion producing inflationary pressure, the monetary stance would become contractionary. But because of the uncovered interest parity, an increase in the interest rate above the international level (under our random walk assumption) would result in capital inflows, which would keep appreciating the currency. In equilibrium, the exchange rate must adjust on impact, ruling out excess demand and therefore inflationary pressure.

regime would create expectations of depreciation in the future. In equilibrium, the domestic interest rate would rise above the foreign one, with crowding out effects on domestic investment. The substance of the analysis above would not be affected, but there would be some response in equilibrium policy rates, and the composition of final demand, whereas a larger government spending would correspond to both lower net exports and lower investment. A further observation is that, encompassing price dynamics in the model, the inflationary consequences of a spending expansion should be more pronounced under a fixed exchange rate.

The presumption that the degree of monetary accommodation is necessarily higher under a peg is nonetheless controversial, even in the traditional literature. Implicit in the analysis by Dornbusch (1980), for instance, is the notion that, in practice, monetary accommodation tends to be quite pronounced under a floating regime—a position motivated by the empirical observation that the nominal exchange rate tends to depreciate with fiscal expansions.[4].

3 A small open economy model

In the following we outline a new Keynesian small open economy similar to Galí and Monacelli (2005). Our exposition follows Corsetti et al. (2009), except that, for clarity of exposition, in our baseline scenario we assume complete international financial markets. In a later section, we consider alternative assumptions regarding the set of internationally traded assets and the fraction of households which participate in domestic asset markets. Our exposition focuses on the domestic economy and its interaction with the rest of the world, ROW, for short.[5]

3.1 Final Good Firms

The final consumption good, C_t, is a composite of intermediate goods produced by a continuum of monopolistically competitive firms both at home and abroad. We use $j \in [0, 1]$ to index intermediate good firms as well as their products and prices. Final good firms operate under perfect competition and purchase domestically produced intermediate goods, $Y_{H,t}(j)$, as well as imported intermediate goods, $Y_{F,t}(j)$. Final good firms minimize expenditures subject to the following aggregation technology

$$C_t = \left[(1-\omega)^{\frac{1}{\sigma}} \left(\left[\int_0^1 Y_{H,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \right)^{\frac{\sigma-1}{\sigma}} + \omega^{\frac{1}{\sigma}} \left(\left[\int_0^1 Y_{F,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \quad (1)$$

where σ measures the trade price elasticity, i.e., the extent of substitution between domestically produced goods and imports for a given change in the terms of trade. The parameter $\epsilon > 1$ measures the

[4]Recent empirical evidence is provided by Ilzetzki, Mendoza, and Vegh 2010 and Corsetti, Meier, and Müller 2010

[5]Our small open economy can be interpreted as the limiting case within a two-country world of an economy that has a relative size of zero, see De Paoli (2009).

price elasticity across intermediate goods produced within the same country, while ω measures the weight of imports in the production of final consumption goods.

Expenditure minimization implies the following price indices for domestically produced intermediate goods and imported intermediate goods, respectively,

$$P_{H,t} = \left(\int_0^1 P_{H,t}(j)^{1-\epsilon} di\right)^{\frac{1}{1-\epsilon}}, \qquad P_{F,t} = \left(\int_0^1 P_{F,t}(j)^{1-\epsilon} di\right)^{\frac{1}{1-\epsilon}}. \tag{2}$$

By the same token, the consumption price index is

$$P_t = \left((1-\omega)P_{H,t}^{1-\sigma} + \omega P_{F,t}^{1-\sigma}\right)^{\frac{1}{1-\sigma}}. \tag{3}$$

Regarding the ROW, we assume an isomorphic aggregation technology. Further, the law of one price is assumed to hold at the level of intermediate goods such that

$$P_{F,t}\mathcal{E}_t = P_t^*, \tag{4}$$

where $\mathcal{E}_t$ is the nominal exchange rate (the price of domestic currency in terms of foreign currency) and P_t^* denotes the price index of imports measured in foreign currency. It corresponds to the foreign price level, as imports account for a negligible fraction of ROW consumption. For future reference we define the terms of trade as

$$S_t = \frac{P_{H,t}}{P_{F,t}}. \tag{5}$$

3.2 Intermediate Good Firms

Intermediate goods are produced on the basis of the following production function: $Y_t(j) = H_t(j)$, where $H_t(j)$ measures the amount of labor employed by firm j.

Intermediate good firms operate under imperfect competition. We assume that price setting is constrained exogenously by a discrete time version of the mechanism suggested by Calvo (1983). Each firm has the opportunity to change its price with a given probability $1-\xi$. Given this possibility, a generic firm j will set $P_{H,t}(j)$ in order to solve

$$\max E_t \sum_{k=0}^{\infty} \xi^k \rho_{t,t+k} \left[Y_{t,t+k}(j)P_{H,t}(j) - W_{t+k}H_{t+k}(j)\right], \tag{6}$$

where $\rho_{t,t+k}$ denotes the stochastic discount factor and $Y_{t,t+k}(j)$ denotes demand in period $t+k$, given that prices have been set optimally in period t. E_t denotes the expectations operator.

3.3 Households

For our baseline scenario we assume that there is a representative household which ranks sequences of consumption and labor effort, $H_t = \int_0^1 H_t(j)$ according to the following criterion

$$E_t \sum_{k=0}^{\infty} \beta^k \left(\frac{C_{t+k}^{1-\gamma}}{1-\gamma} - \frac{H_{t+k}^{1+\varphi}}{1+\varphi}\right). \tag{7}$$

We assume that the household trades a complete set of state-contingent securities with the rest of the world. Letting $\Xi_{t+1}(h)$ denote the payoff in units of domestic currency in period $t+1$ of the portfolio held by household h at the end of period t and $\rho_{t,t+1}$ the stochastic discount factor, the budget constraint of the household is given by

$$W_t H_t + \Upsilon_t - T_t - P_t C_t = E_t \{\rho_{t,t+1} \Xi_{t+1}\} - \Xi_t, \tag{8}$$

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

3.4 Monetary and fiscal policy

The specification of monetary policy is obviously dependent on the exchange rate regimes. Under flexible exchange rates, we assume that the central bank sets the nominal short-term rate following a Taylor-type rule:

$$\log(R_t) = \phi_\pi (\Pi_{H,t} - \Pi_H), \tag{9}$$

where $\Pi_{H,t} = P_{H,t}/P_{H,t-1}$ measures domestic inflation. Here and in the following, variables without time subscript refer to the steady-state value of a variable. In this case, the nominal exchange rate is free to adjust in accordance with the equilibrium conditions implied by the model.

Under an exchange rate peg, instead, the monetary authorities adjust the policy rate so that the exchange rate remains constant at its steady state level:

$$\mathcal{E}_t = \mathcal{E}. \tag{10}$$

As regards fiscal and budget policy, we assume that government spending falls on an aggregate of domestic intermediate goods only:

$$G_t = \left(\int_0^1 Y_{H,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}. \tag{11}$$

We also posit that intermediate goods are assembled so as to minimize costs. Thus the price index for government spending is given by $P_{H,t}$. Government spending is financed either through taxes, T_t, or through issuance of nominal one-period debt, D_t. The period budget constraint of the government reads as follows

$$R_t^{-1} D_{t+1} = D_t + P_{H,t} G_t - T_t. \tag{12}$$

Unless otherwise specified, taxes are assumed to be lump-sum. Define $D_{Rt} = D_t/P_{t-1}$ as a measure for real, beginning-of-period, debt, and $T_{Rt} = T_t/P_t$ as taxes in real terms. Recalling that variables without time subscript refer to steady state values, we posit that fiscal policy is described by the following feedback rule from debt accumulation to the level of spending and taxes

$$G_t = (1-\rho)G + \rho G_{t-1} - \psi_G D_{Rt} + \varepsilon_t, \;\; T_{Rt} = \psi_T D_{Rt}, \tag{13}$$

where ε_t measures an exogenous iid shock to government spending. The ψ-parameters capture the responsiveness of spending and taxes to government spending and debt. In this respect, we should emphasize that in the literature the transmission of government spending is often analyzed under the assumption $\psi_G = 0$. In our setup, Ricardian equivalence obtains in this case, as the path of government spending is exogenously given, and the time path of debt and lump-sum taxes becomes irrelevant for the real allocation. Compared to this benchmark, allowing for $\psi_G > 0$ fundamentally alters the fiscal transmission mechanism—see Corsetti et al. (2009). For once, strictly speaking, ricardian equivalence fails. A debt financed cut in taxes dynamically leads to adjustment in real spending, affecting the real allocation. Moreover, the time profile of adjustment crucially affects the intertemporal price of consumption, with sharp implications for macro dynamics. Below we analyze the fiscal transmission mechanism in light of these considerations, contrasting a floating exchange rate regime with a pegged exchange rate regime.

3.5 Equilibrium

Equilibrium requires that firms and households behave optimally for given initial conditions, exogenously given developments in the ROW, and government policies. Moreover, market clearing conditions need to be satisfied. At the level of each intermediate good, supply must equal total demand stemming from final good firms, the ROW, and the government:

$$Y_t(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\epsilon} \left((1-\omega)\left(\frac{P_{H,t}}{P_t}\right)^{-\sigma} C_t + \omega \left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\sigma} C^*_t + G_t\right), \tag{14}$$

where $P^*_{H,t}$ and C^*_t denote the price index of domestic goods expressed in foreign currency and ROW consumption, respectively. It is convenient to define an index for aggregate domestic output: $Y_t = \left(\int_0^1 Y_t^{\frac{\epsilon-1}{\epsilon}}(j)dj\right)^{\frac{\epsilon}{\epsilon-1}}$. Substituting for $Y_t(j)$ using (14) gives the aggregate relationship

$$Y_t = (1-\omega)\left(\frac{P_{H,t}}{P_t}\right)^{-\sigma} C_t + \omega \left(\frac{P^*_{H,t}}{P^*_t}\right)^{-\sigma} C^*_t + G_t. \tag{15}$$

We also define the trade balance in terms of steady-state output

$$TB_t = \frac{1}{Y}\left(Y_t - \frac{P_t}{P_{H,t}} C_t - G_t\right). \tag{16}$$

In what follows, we will consider a first-order approximation of the equilibrium conditions of the model around a deterministic steady state with balanced trade, zero debt, zero inflation, and purchasing power parity. For simplicity, throughout we also assume that there are only shocks in the domestic economy. In the appendix we provide a detailed overview of the linearized equilibrium conditions. Small-case letters indicate deviations from steady state.

3.6 A canonical representation of the model

In the tradition of the new-Keynesian literature (see e.g. Galí and Monacelli (2005), we write the equilibrium conditions of the model in terms of a IS equation, a Phillips curve, and a description of the policy rules.[6] The dynamic IS equation is:

$$y_t = E_t y_{t+1} - \frac{(1-\chi)\varpi}{\gamma}(r_t - E_t \pi_{H,t+1}) - E_t \Delta \hat{g}_{t+1}, \tag{17}$$

where $\pi_{H,t}$ denotes domestic (producer price) inflation and $\hat{g}_t$ denotes the deviation of government spending from steady state measured in percent of steady state output. χ measures the government spending-to-output ratio in steady state and $\varpi = 1 + \omega(2-\omega)(\sigma\gamma - 1)$.

The open-economy new Keynesian Phillips curve is given by

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \kappa \left(\varphi + \frac{\gamma}{(1-\chi)\varpi}\right) y_t - \kappa \frac{\gamma}{(1-\chi)\varpi} \hat{g}_t, \tag{18}$$

where $\kappa = (1-\beta\xi)(1-\xi)/\xi$.

Either monetary policy is characterized by an interest rate feedback rule (in which case the nominal exchange rate is free to adjust) or monetary authorities adjust the policy rate so as to peg the exchange rate to its steady state level. Formally, we have:

$$r_t = \phi_\pi \pi_{H,t}, \quad \text{or} \quad e_t = 0, \tag{19}$$

i.e. regarding the peg we merely specify a targeting rule; for an analysis of the implementation via an interest rate rule see Benigno, Benigno, and Ghironi (2007).

4 The effects of fiscal policy across exchange rate regimes: revisiting the conventional wisdom

In theoretical studies of the macroeconomic effects of fiscal policy, government spending is typically assumed to follow an exogenously given AR(1) process. In our framework, this assumption corresponds to the case of no feedback from debt accumulation to spending, $\psi_G = 0$, which, as already mentioned, implies Ricardian equivalence. This provides a useful starting point for our inquiry.

The main question in this section concerns how and why the exchange rate regime may alter the transmission of an autoregressive spending shock matched by higher lump-sum taxes. Using model simulations, we will show that this basic exercise supports a particular aspect of the conventional

[6] Details on the derivation are provided in the appendix. As Galí and Monacelli (2005) abstract from government spending, our representation differs from theirs. Importantly, we represent the canonical form using output, rather than the output gap, because changes in government spending also alter the natural output level. Galí and Monacelli (2008) consider a very similar setup, but focus on the special case where the intertemporal elasticity of substitution and the trade price elasticity are equal to one.

wisdom, namely, that fiscal policy is more effective under fixed than under floating exchange rates (in which the central bank follows a Taylor rule).

In our numerical experiments, we adopt the following parameter values: a period in the model corresponds to one quarter. The discount factor β is set to 0.99. We assume that the coefficient of relative risk aversion, γ, and the inverse of the Frisch elasticity of labor supply, φ, take the value of one. The trade price elasticity σ is set equal to unity as well. As price rigidities are bound to play an important role in the transmission of government spending shocks, we assume a fairly flat Phillips curve. We do so by setting $\xi = 0.9$, a value that implies an average price duration of 10 quarters. Note that such a parameterization *prima facie* is in conflict with evidence from microstudies such as Nakamura and Steinsson (2008). Nonetheless, the choice of a relatively high degree of price rigidities seems appropriate in the context of our framework, as we abstract from several model features which would imply a flatter Philips curve for any given value of ξ, e.g., non-constant returns to scale in the variable factor of production or non-constant elasticities of demand.[7] We also abstract from wage rigidities. In specifying monetary policy, we set $\phi_\pi = 1.5$. Finally, the average share of government spending in GDP is set to 20 percent.

Figure 2 displays the impulse response to an exogenous increase in government spending by one percent of GDP, for two economies that are identical in all respects but for the exchange rate (and thus the monetary) regime. The responses of output and government spending are measured in percent of steady state output. The responses of the other variables are measured in percentage deviations from steady state. The horizontal axes indicate quarters. The solid line refers to the exchange rate peg, while a dashed line marks the floating regime. The AR(1) process of government spending, identical across exchange rate regimes, is shown in the upper left panel.

A first notable result is that, in both regimes, the response of output (upper right panel) is positive, but smaller than unity throughout. This is quite different from the predictions of the Mundell-Fleming model for a small open economy with perfect capital mobility. As already discussed above, according to this model, government spending multipliers on output should be larger than one under a peg, zero under a float.

Nonetheless, our results do agree with the conventional theory in relative terms: in response to a positive (autoregressive) fiscal shock, GDP under the peg exceeds that under the float by approximately 25 percent on impact and the response of GDP remains stronger under the peg for the first couple of quarter after the initial impulse. As we compare the transmission mechanism under different exchange rate regimes using the same exogenous fiscal experiment, larger output effects under a peg reflect a more accommodative monetary policy.

[7] See Galí, Gertler, and López-Salido (2001) or Eichenbaum and Fisher (2007) for further discussion of how real rigidities interact with nominal price rigidities in the context of the new Keynesian model. Note that the latter study also considers a non-constant price elasticity of demand, which further increases the degree of real rigidities.

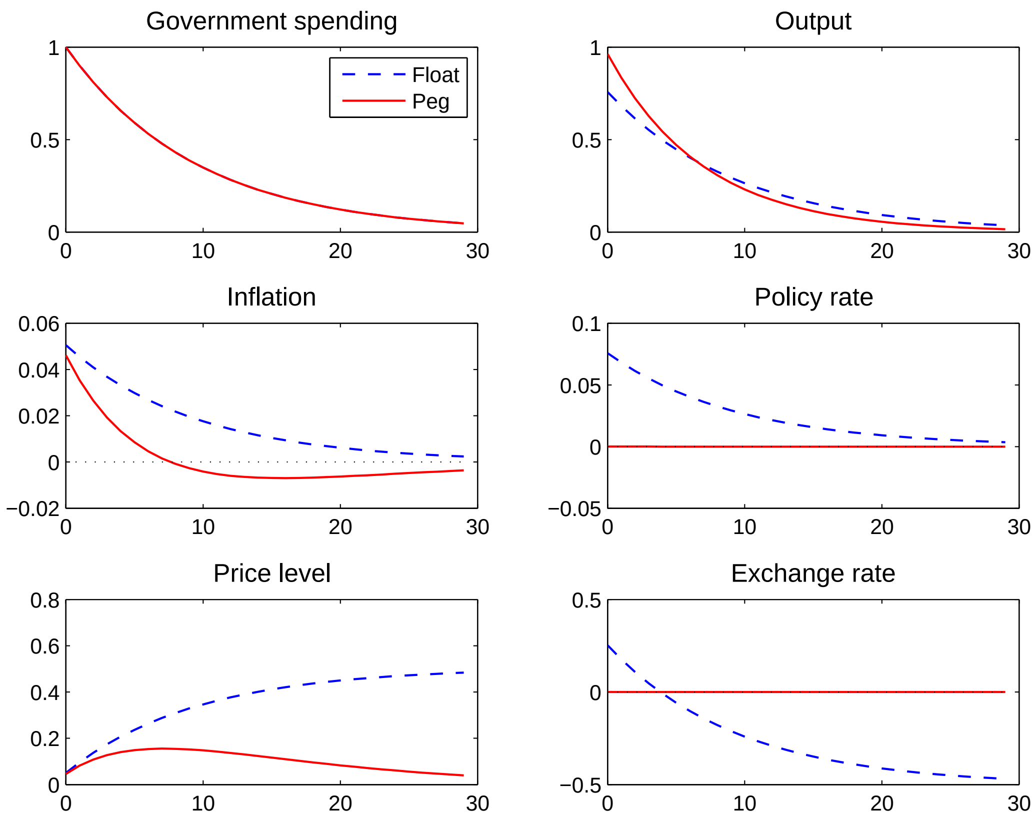

Figure 2: Effect of government spending shock under peg and float. Notes: dashed lines display responses under floating exchange rates; solid lines display responses under pegged exchange rates. Output and government spending are measured in percent of steady state output. Other variables are measured in percentage deviations from steady state (quarterly frequency). Horizontal axes indicate quarters. Inflation and price level pertain to the price of domestically produced goods.

Further notable results shown in Figure 2 concern the response of inflation and the price level. On impact, the response of domestic inflation (middle left panel) is positive irrespective of the exchange rate regime. Yet, over time, inflation follows divergent paths. Under a peg, inflation falls below its steady state value after about 2 years. Under a float, it remains positive throughout. This has direct implications for the policy rate. Under a float, the Taylor rule implies that the policy rate rises sharply on impact, and only gradually reverts back to its steady state level. In nominal terms, the policy rate under a float thus remains above the constant nominal rate, dictated by the need to maintain the peg. Moreover, as the Taylor principle is satisfied under a float,, real short-term interest rates rise above steady-state levels throughout the expansionary fiscal stance such that the long-term real interest rate rises as well.

The differential behavior of inflation also maps into an apparent long-run divergence in the price level for domestically produced goods ($p_{H,t}$), and thus in the nominal exchange rate. With the central bank following a Taylor rule under a float, monetary authorities adjust the policy rate in response to the rate of growth in prices, and nominal prices drift to a permanently higher level. Since purchasing power parity (henceforth PPP) must be satisfied in the long-run, the nominal exchange rate depreciates proportionally over time. So, under a float, both the level of domestic prices and the nominal exchange rate display a unit root behavior.

When the exchange rate remains (credibly) pegged to its initial level, instead, long-run PPP requires domestic prices to revert back to their initial steady state level. After an initial positive bout, inflation must therefore fall below its steady state rate. Intuitively, in the short run firms respond to the additional demand from the government by raising prices, which make them less competitive in the world market. As government spending progressively reverts back to its initial level, domestic firms need to re-gain competitiveness: when re-optimizing prices, they do so by setting lower prices along with a falling government demand.

5 The transmission mechanism: useful analytical results (and a critique of the Walters critique)

Before turning to further experiments with our model, it is useful to present a close-up analysis of how temporary fiscal shocks are transmitted to the real economy, depending on the interaction of fiscal and monetary policy over different time horizons. An important lesson from the new-Keynesian model is indeed that fiscal policy cannot be modeled without specifying a medium and long-term policy framework. Relative to the Mundell-Fleming, new-Keynesian analysis assigns a much greater role to optimal intertemporal allocation by households in response to changes in relative prices, notably the path of real interest rates.

In the baseline NK model, the optimal path of consumption is characterized by the Euler equation.

Using a linearized version of the model (see appendix) and solving forward this equation yields

$$c_t = -\frac{1}{\gamma} E_t \underbrace{\sum_{s=0}^{\infty} (r_{t+s} - \pi_{t+1+s})}_{\equiv z_t}, \tag{20}$$

where we have used the fact that the economy is stationary, and thus always reverts back to steady state (i.e. $\lim_{s\to\infty} c_{t+s} = 0$). Equation (20) shows that, in terms of deviations from steady state, current consumption is determined by expectations over the entire path of future ex-ante real interest rates. Since the expectation hypothesis holds in the model, the latter can be interpreted as a measure for the real return on a bond of infinite duration, i.e., as a measure for the long-term real interest rate.[8]
It is easy to see how the long-term real rate synthesizes fiscal and monetary interactions across all time horizons, in response to fiscal (as well as to any other types of) shocks (see Corsetti et al. (2009)). As already mentioned, under a float, monetary policy is not constrained by the need to bring the price level back to its initial steady state level in the long run. With a Taylor rule in place, the monetary stance in response to a fiscal expansion is contractionary in both the short and the long run, to a degree that depends on the parameterization of the coefficient ϕ_π. Since the increase in spending cause inflation to remain persistently positive, short-term rates are expected to remain above or at their steady state value over time, implying a rise in long rates on impact.[9]
Under a currency peg, monetary policy appears to be more accommodative in the short run, since in real terms short-term interest rates fall one-to-one with inflation. By the same token, however, short real rates rise in the medium and the long-run, when, for an unchanged nominal exchange rate, purchasing power parity drives inflation into negative territory (in deviations from steady state). In our first exercise above, for instance, real short-term rates initially fall below steady state, but become positive after about 8 quarters.
This observation raises the issue of determining in which direction the long-term rate moves on impact. Under our simplifying assumptions (a small open economy, constant foreign variables), it is possible to provide a simple analytical insight on this question. Recall that under complete financial markets, the economy is stationary and always reverts back to steady state after a temporary increase

[8]The long-term real interest rate is also—via the risk sharing condition—tightly linked to the real exchange rate: $-\gamma c_t = q_t = z_t$ (see appendix). Hence, movements in the long-term interest rate may simultaneously rationalize changes in consumption and the real exchange rate. Specifically, Corsetti et al. (2009) discuss how the expected path of future government spending alters the behavior of long-term real interest rates and thus the short-run adjustment to an exogenous innovation in government spending.

[9]Because our Taylor rule is specified in terms of domestic good inflation, but the real rate is obtained using the CPI inflation, the long-term rate can be written as the sum of domestic good inflation (multiplied by one minus the Taylor coefficient on inflation) and the terms of trade, both in deviations from their steady state value. Substituting out the terms of trade, we can further write:

$$z_t = \phi_\pi \pi_{H,0} + E_0 \sum_{s=1}^{\infty} \left[\left(\phi_\pi - 1 + \frac{\omega}{1-\omega} \right) \pi_{t+s} + \frac{\omega}{1-\omega} e_{t+s} \right] \tag{21}$$

.

in domestic government spending. As PPP holds in the long run, $\lim t \to \infty P_t = P^*$ under an exchange rate peg. Put differently, in the long run, the domestic price level is pinned down by the foreign price level. It follows that $\sum_{t=0}^{\infty} \pi_t = 0$ so that, with the domestic interest rate pegged to the foreign one, constant by assumption:

$$z_0 = \underbrace{\left(\sum_{t=0}^{\infty} -\pi_{t+1} \right) - \pi_0}_{=0} + \pi_0 = \pi_0.$$

On impact, the response of the real long-term interest rate is equal to the initial, unanticipated, change in CPI inflation. As the initial effect of an increase in government spending on inflation is positive, the long-term rate increases, and consumption cannot but decline. Moreover, a positive differential between domestic and foreign long-term real rates causes the exchange rate to appreciate in real terms.

It is worth stressing that the above result holds in general, not only for fiscal shocks, with a number of interesting implications. A point in case concerns a fallacious argument regarding macroeconomic adjustment (or lack thereof) under a fixed exchange rate regime, known as the Walters critique. Such argument moves from the observation that, holding the nominal interest rate constant, the inflationary effects of a positive demand shock translate into a fall in the short-term real interest rate. This endogenous movement in the real interest rate, the argument goes, is expansionary: it boosts demand further, rather than stabilizing it. In its extreme form, the Walters critique states that, a small open economy pursuing a currency peg or participating in a currency union, becomes unstable, since shocks are amplified by procyclical movements in the monetary stance.

In the past, this critique has been counteracted by pointing out that rising prices would crowd out exports, naturally stabilizing demand through the real exchange rate channel. The modern paradigm clarifies a deeper problem at the root of the fallacy. As shown above, under a peg, the long-run real rates, which drive private demand, actually rise one-to-one with the initial bout of inflation. While the short-run inflationary consequences of a positive demand shock simultaneously reduce short-term rates in real terms, these are not directly relevant for private spending decisions.

Note that a reference to the effects of rising prices on competitiveness is still appropriate in our argument: competitiveness is the economic force behind PPP. What the new-Keynesian model emphasizes is that one cannot contrast the real exchange rate channel to the interest rate channel, treating them as independent of each other. In equilibrium, they both shape the intertemporal price relevant for private consumption/saving decisions.

6 The conventional wisdom on its head: the role of interactions between the exchange rate regime and the medium-term fiscal framework

The role of intertemporal prices in the transmission of fiscal policy, emphasized by the baseline new-Keynesian model, calls attention on the importance of broadening the analysis as to encompass general specifications of the medium-term framework— beyond the case $\psi_G = 0$. Specifically, in what follows we will set $\psi_T = 0.02$ and contrast results for $\psi_G = 0$ and $\psi_G = 0.02$. Note that in the latter case, an expansion leads to an endogenous dynamic adjustment of spending over time. From a quantitative point of view, our assumptions imply that government spending is cut, and taxes are increases, by 0.02 basis points for every increase of government debt by one percent (all measured in units of steady-state output).

For economies with floating rates, the relevance of debt stabilization for the effectiveness of fiscal stimulus cannot be overstated. CMM analyzes in detail the implications of endogenous dynamic cuts in spending, dubbed "spending reversals." Here we are specifically interested in the extent to which adjustment via spending reversals alter fiscal policy transmission under a pegged exchange rate.

As a benchmark reference, Figure 3 shows impulse responses for the float, essentially revisiting CMM for the limiting case of a small open economy: solid lines display results assuming $\psi_G = 0$, while dashed lines display results assuming $\psi_G = 0.02$. As stressed by CMM, in anticipation of a spending reversal, the consumption multiplier becomes positive on impact: consumption demand is actually crowded in. The macroeconomic response on output is therefore larger.

The transmission mechanism is analogous to the one discussed under the peg in the previous section. The key to understanding it is the response of inflation. The rate of inflation, positive in the short run, turns negative over time (relative to steady state), before spending cuts are actually implemented. With sticky prices, in fact, forward-looking firms optimally adjust prices downward ahead of the fall in demand.

Note that, relative to the case of $\psi_G = 0$, inflation is lower for approximately 30 quarters from the shock, with the exception of the very short term, when prices are driven higher by a stronger aggregate demand. As policy rates follow the same pattern, the long-term real rate falls on impact, rather than rising, boosting private consumption.

Relative to the case of $\psi_G = 0$, then, the expansion in spending in the short run raises demand and output by more on impact, and is accompanied by a fall (not a rise) in the long-term interest rate. Notably, this implies that the exchange rate depreciates, instead of appreciating, consistent with recent body for economies adopting floating rates (see the discussion in Corsetti et al. 2010).

The case of a currency peg (the main focus of our contribution) is shown in Figure 8: solid lines display impulse responses assuming $\psi_G = 0$, while dashed lines refers to spending reversals. The notable result from these experiments is that, under a peg, the medium-term fiscal framework does

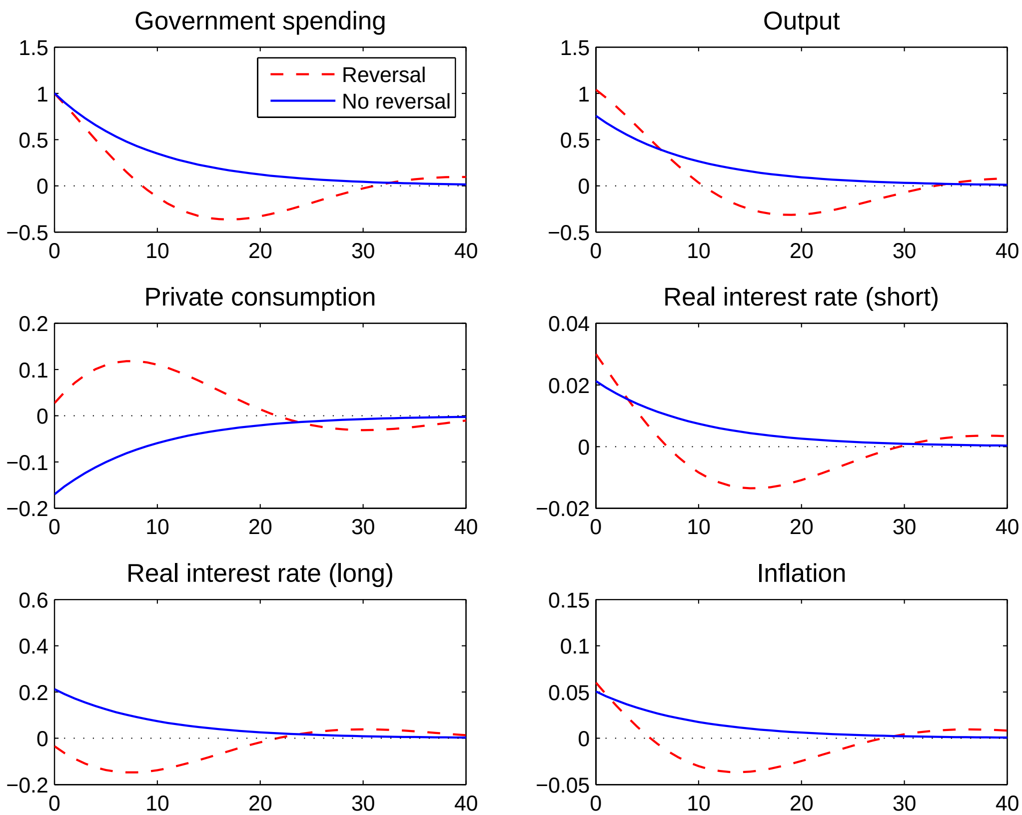

Figure 3: Effect of government spending shock under floating exchange rates. Notes: solid (dashed) lines display responses without (with) spending reversals; output, consumption and government spending are measured in percent of steady state output. Other variables are measured in percentage deviations from steady state. Horizontal axes indicate quarters. Inflation and price level pertain to the price of domestically produced goods.

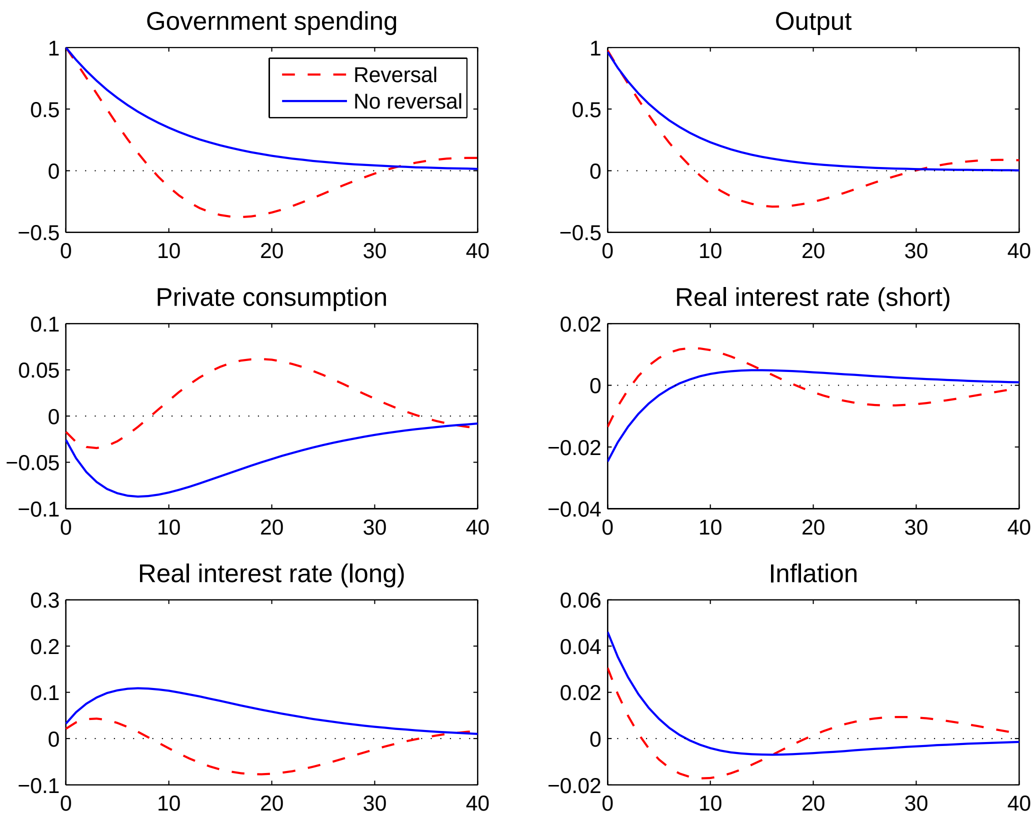

Figure 4: Effect of government spending shock under pegged exchange rate. Notes: see Figure 8.

not seem to make a difference for the short-run impact of fiscal policy. The response of output and consumption in the first period is essentially the same whether or not stimulus today is followed by spending cuts over time.

To understand this intriguing outcome, compare inflation across the two experiments: relative to $\psi_G = 0$, inflation under reversals is lower for 15 quarters, higher afterwards. Since the interest rate is fixed in nominal terms, by lowering inflation for 15 quarters, spending cuts exert a relatively contractionary effect on economic activity. However, because of PPP, the level of prices must converge in the long run to the initial value: hence, reversals imply a higher inflation rate in the medium- to the long-run, which translates into lower short-term real rates over that horizon. In our experiment, these contrasting movements in short term rates over different horizons balance each other out, in determining the response of the long rate. On impact, this turns out to move very similarly across the two fiscal regimes.

These results have notable consequences for assessing the conventional wisdom. To synthesize our main conclusion, in Figure 5 we again report the transmission of spending shocks across exchange rate regimes, but now allow for a regime of debt consolidation through adjustment in spending. As is apparent from the figure, fiscal policy is not less effective under floating exchange rates. Prospective spending cuts do not impact on the short-run transmission of fiscal stimulus under a peg. However, they do considerably affect the transmission in the case of floating rates.

To come full circle, we would like to emphasize that this conclusion is in line with the analysis and results by Dornbusch (1980), although the model is quite different. The current paper's contribution consists in generalizing the concern in the earlier literature for policy regimes in the medium run. In this and related papers, all we are saying is that debt consolidation strategies do matter for determining the sign and strength of the short run transmission of fiscal stimulus.

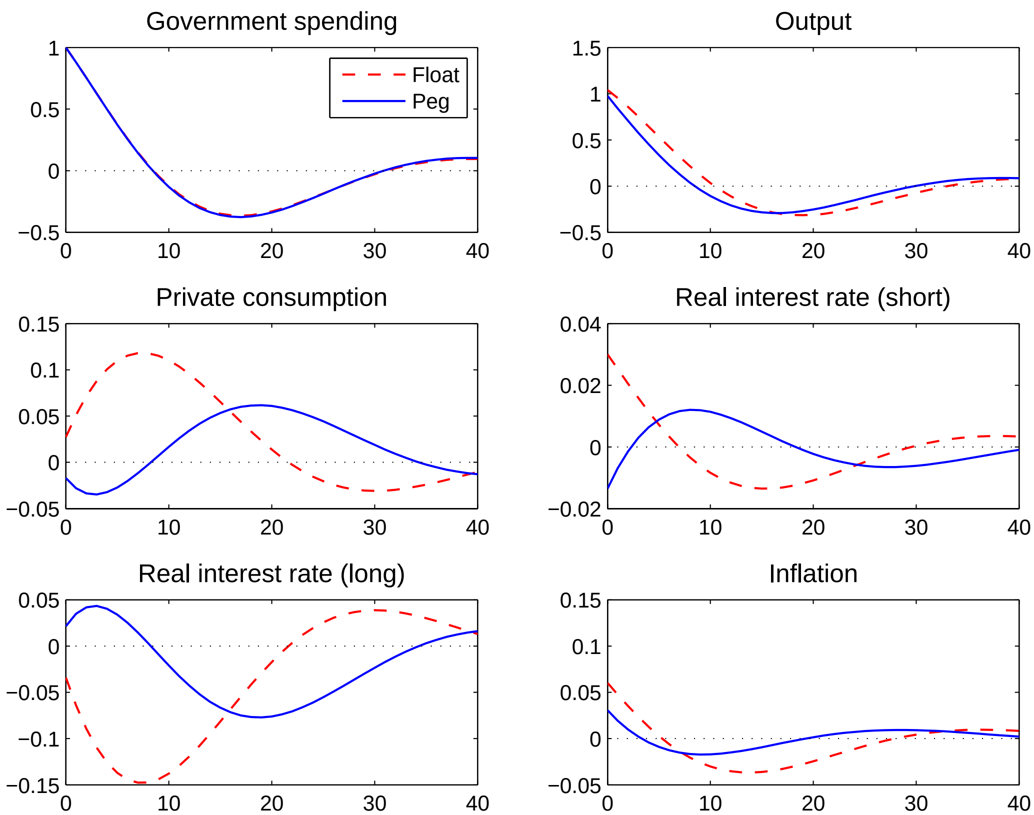

Figure 5: Effect of government spending shock with reversals: peg vs float. Notes: see Figure 8.

7 Financial markets

So far, we have developed our analysis under the assumption of complete markets. A relevant question concerns the extent to which our results are sensitive to financial frictions. In this section, we explore this issue under two to alternative assumptions on the structure of financial markets. First, we relax the assumption that financial markets are complete at the international level and allow for trade in nominally non-contingent bonds only. Second, we assume that, in addition, access to domestic financial markets is restricted. Specifically, we assume that the only a subset of the population has access to asset markets. Households without access consume their disposable income in each period. Our setup is similar to the closed-economy variants of Galí, López-Salido, and Vallés (2007) and Bilbiie, Meier, and Müller (2008).

7.1 Model setup

Our model is amended by positing that, out of a continuum of households in $[0, 1]$ residing in our small open economy, a fraction $1-\lambda$ are asset holders, indexed with a subscript 'A'. These households own firms, and may trade one-period bonds both domestically and internationally. The remaining households (a fraction λ of the total) do not participate at all in the asset market, i.e., they are 'non-asset holders', and indexed with a subscript 'N'. As in Bilbiie et al. (2008), differences between households are assumed to arise from their respective capacity to participate in asset markets, rather than from preferences.

A representative asset-holding household chooses consumption, $C_{A,t}$, and supplies labor, $H_{A,t}$, to intermediate good firms in order to maximize

$$E_t \sum_{k=0}^{\infty} \beta^k \left(\frac{C_{A,t+k}^{1-\gamma}}{1-\gamma} - \frac{H_{A,t+k}^{1+\varphi}}{1+\varphi} \right) \tag{22}$$

subject to the period budget constraint

$$R_t^{-1} A_{t+1} + R_{F,t}^{-1} B_{t+1}/\mathcal{E}_t + P_t C_{A,t} = A_t + B_t/\mathcal{E}_t + W_t H_{A,t} - T_t + \Upsilon_t. \tag{23}$$

where A_t and B_t are one-period bonds denominated in domestic and foreign currency, respectively. R_t and $R_{F,t}$ denote the gross nominal interest rates on both bonds. Ponzi schemes are ruled out by assumption.

We assume that the interest rate paid or earned on foreign bonds by domestic households is determined by the exogenous world interest rate, R_t^*, plus a 'spread' which decreases in the real value of bond holdings scaled by output, that is:

$$R_{F,t} = R_t^* - \chi \frac{B_{t+1}}{Y_t P_t}, \tag{24}$$

This assumption ensures the stationarity of bond holdings (even for very small values of χ) and thus allows us to study the behavior of the economy in the neighborhood of a deterministic steady state.[10]
A representative non-asset holding household chooses consumption, $C_{N,t}$, and supplies labor, $H_{N,t}$, to intermediate good firms in order to maximize its utility flow on a period-by-period basis

$$\frac{C_{N,t}^{1-\gamma}}{1-\gamma} - \frac{H_{N,t}^{1+\varphi}}{1+\varphi} \tag{25}$$

subject to the constraint that consumption expenditure equals net income

$$P_t C_{N,t} = W_t H_{N,t} - T_t. \tag{26}$$

For non-asset holders, consumption equals disposable income in each period; hence they are also referred to as 'hand-to-mouth consumers'.
Aggregate consumption and labor supply are given by

$$C_t = \lambda C_{N,t} + (1-\lambda) C_{A,t} \tag{27}$$

$$H_t = \lambda H_{N,t} + (1-\lambda) H_{A,t}, \tag{28}$$

where $H_t = \int_0^1 H_t(j)dj$ is aggregate labor employed by domestic intermediate good firms.
Regarding asset markets, we assume that foreigners do not hold domestic bonds. Market clearing for domestic currency bonds therefore requires

$$(1-\lambda)A_t - D_t = 0. \tag{29}$$

The market for foreign currency bonds clears by Walras' law.

7.2 Fiscal transmission with imperfect risk sharing

This section presents model simulations under either incomplete markets, or incomplete markets and limited market participation, as specified above. Regarding the models parameters, we maintain the same values as in the section above, except for the trade price elasticity σ. As is well known, with a value of one for such elasticity, relative price would move as to insure complete risk sharing even under incomplete international asset markets, see Cole and Obstfeld (1991). Since we are interested in the sensitivity of our results to environments with imperfect risk sharing, we set $\sigma = 2/3$. For the sake of space, we only focus on the case of exogenous autoregressive spending shocks with $\psi_G = 0$.
Figure 6 contrasts the results for the baseline scenario (complete financial markets) with those obtained under the assumption that international financial markets are incomplete. As before, we posit

[10] Our particular specification draws on Kollmann (2002), who studies a model similar to ours. Schmitt-Grohé and Uribe (2003) consider a real model of a small open economy and suggest the above mechanism of a debt-elastic interest rate as one among several ways of 'closing small open economy models' (that is, inducing stationarity) with incomplete markets.

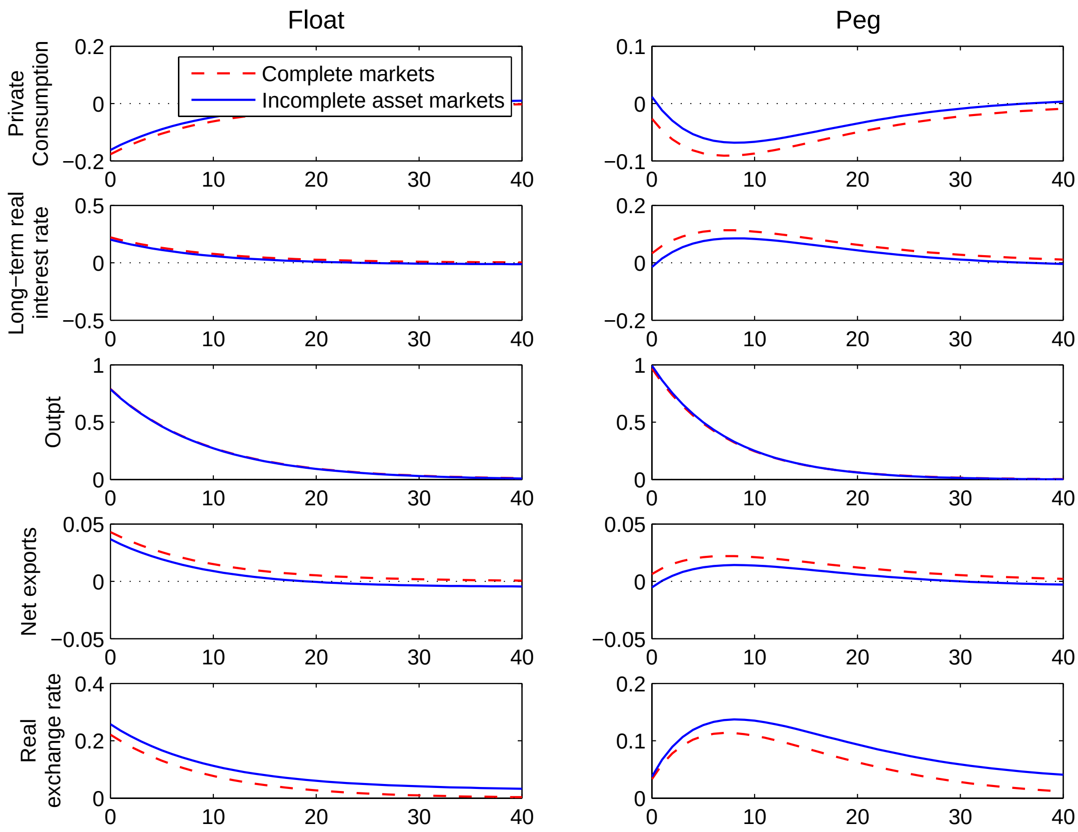

Figure 6: Effect of government spending shock under complete and incomplete international financial markets. Notes: solid (dashed) lines display responses assuming incomplete (complete) financial markets; output and consumption are measured in percent of steady state output, long term interest rates are measured in percentage deviations from steady state. Horizontal axes indicate quarters.

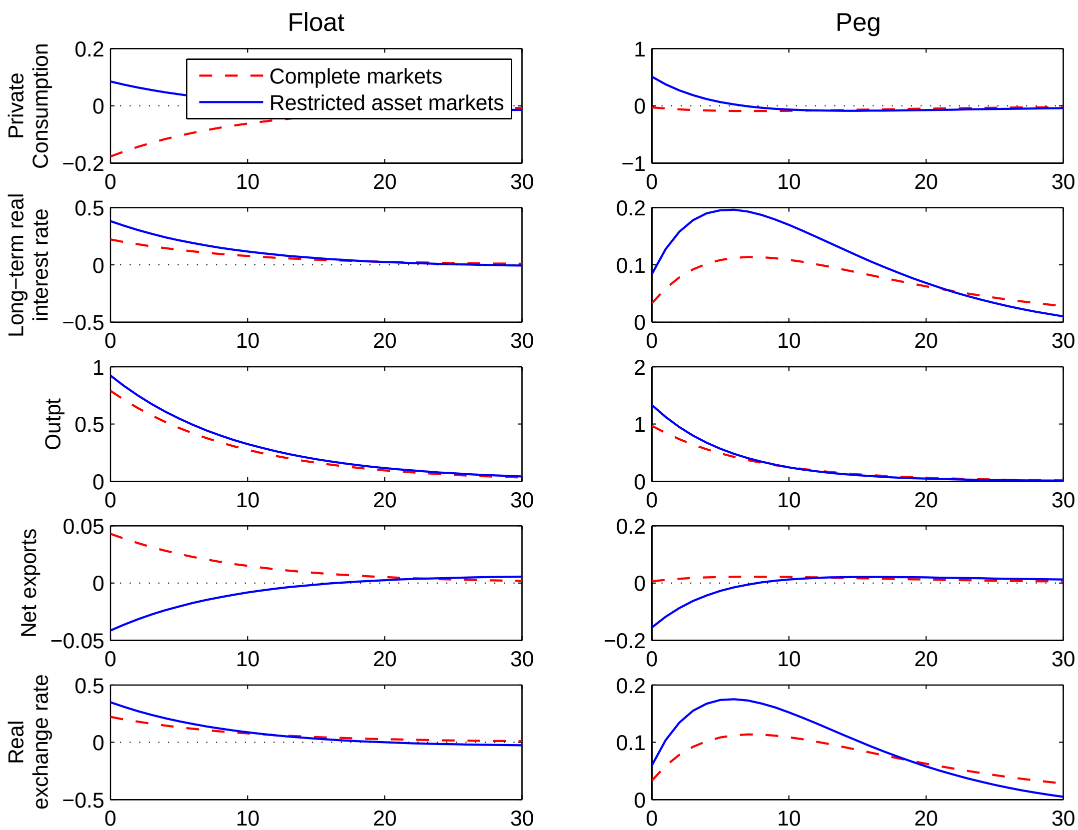

Figure 7: Effect of government spending shock under unrestricted and restricted financial markets. Notes: solid and dashed lines display responses assuming restricted (only bonds traded at international level and $\lambda = 1/3$) and unrestricted (complete financial markets), respectively; output and consumption are measured in percent of steady state output, long term interest rates are measured in percentage deviations from steady state. Horizontal axes indicate quarters.

an exogenous increase in government spending by one percent of steady state output (not shown). The left column shows the results for the float, while the right column shows the results for the peg. The solid lines display the results obtained under the assumption that there is only trade in nominally non-contingent bonds at the international level. The dashed line display responses obtained under the baseline scenario of complete financial markets. Observe that the response of consumption (top row) is somewhat higher with incomplete markets, in both exchange rate regimes, corresponding to a different dynamics of long-term real interest rates. However, from a quantitative point of view, differences in the response of consumption and output are modest.[11].

Figure 7 contrasts results for the baseline scenario (complete financial markets) with the case of

[11]This finding is in line with earlier research, which have found that the allocation under incomplete financial markets is quite close to the allocation under complete markets, unless the trade price elasticity is substantially different from one on either side, and, for the case of a high elasticity, shocks are persistent or follow a diffusion, see Corsetti, Dedola, and Leduc (2008)

limited participation. In this case, we assume both that the set of assets traded across countries is restricted to trade in non-contingent bonds, and that—within a country—access to trade in bonds is restricted, so that only a fraction $1 - \lambda$ has access to trade in bonds. Results for this case are displayed by the solid lines (as before dashed lines pertain to the baseline scenario of complete financial markets). We report again the responses of consumption, long-term real interest rates and output to an exogenous increase in government spending by one percent of GDP.

With limited participation, the dynamic adjustment of consumption is quite different compared to our results in Section 4. On impact, consumption now increases, both under the float and under the peg. Interestingly, this is so despite the fact that the response of long-term real rates is actually positive throughout. The reason is straightforward: in our specification, a considerable fraction of households has no access to asset markets. Their consumption is thus a function of current income, and thus not directly linked to changes in long-term interest rates. Because of the strong consumption response, we also find a considerably stronger output effect. With $\psi_G = 0$, however, the model once again lends support to the conventional wisdom: the macroeconomic transmission of fiscal shocks is somewhat stronger under the peg, with an impact multiplier above one.

8 Conclusions

Does a fixed exchange rate or a currency board magnify the power of budget policies in determining economic activity? Can small countries in the euro area expect more from fiscal stabilization than countries outside the area? Decades of practice in economic policy have already qualified the positive answer to be found in textbook treatments of the Mundell-Fleming model. In this paper we have explored theoretical reasons for reframing the conventional wisdom in a richer way.

Building on CMM, our analysis applies a simple yet general lesson from the traditional approach: the effectiveness of today's stimulus depends on the medium-run policy framework, including both monetary and fiscal considerations. The effect of stimulus changes not only with the exchange rate regime and the monetary strategy pursued by the central bank, but also with the debt consolidation strategy pursued by the government. In other words, according to conventional wisdom, one cannot assess fiscal stimulus independently of the exchange rate regimes. In our generalization, the same should be said for debt consolidation strategies.

As a result of fiscal and monetary interactions, the textbook rendition of the conventional wisdom should not be taken at face value. To the extent that budget adjustment translates into spending cuts in addition to tax hikes (the case stressed by CMM), anticipations of future contraction tend to magnify the output effects of fiscal expansions under flexible rates—while have limited or no effects under a peg (as shown in this paper). These results raise a number of analytical, empirical and policy issues, which, properly addressed, should help defining the preconditions for successful fiscal stabilization.

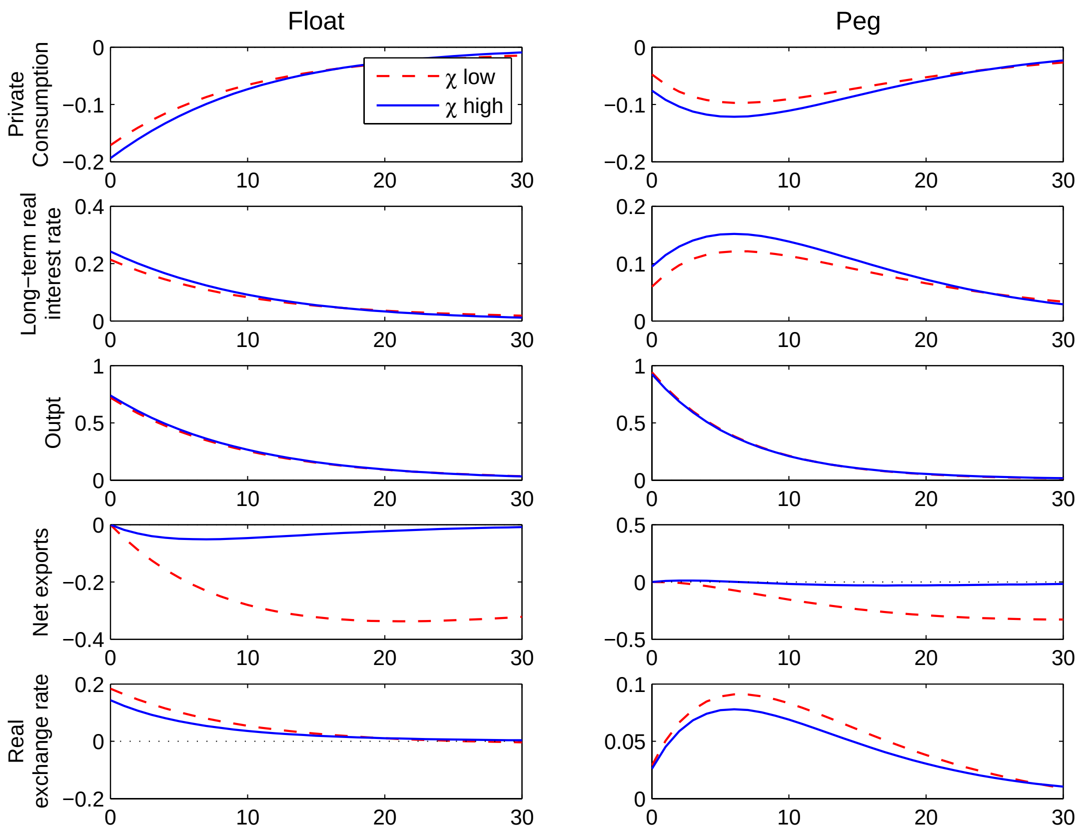

Figure 8: Effect of government spending shock. Notes: incomplete markets, $\sigma = 1.5$, baseline $\chi = .001$ vs $\chi = .1$.

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A Equilibrium conditions of linearized model

In the following we outline the linearization of the model and state the equilibrium conditions used in the simulations discussed in the paper. Small letters denote percentage deviations from steady state values, 'hats' denote deviations from steady state values scaled by steady-state output. Throughout we assume that variables in the rest of the world are constant. We consider the model which allows for a fraction of households without access to asset markets (see section 7.2) which nests the model with full asset market participation for $\lambda = 0$.

A.1 Definitions and derivations

Price indices The law of one price, the terms of trade, the consumption price index, and, hence CPI inflation can be written as

$$\begin{aligned} p_{F,t} &= p_t^* - e_t && \text{(A.1)} \\ s_t &= p_{H,t} - p_{F,t} && \text{(A.2)} \\ p_t &= (1-\omega)p_{H,t} + \omega p_{F,t} = p_{H,t} - \omega s_t && \text{(A.3)} \\ \pi_t &= \pi_{H,t} - \omega \Delta s_t && \text{(A.4)} \\ q_t &= (1-\omega)s_t, && \text{(A.5)} \end{aligned}$$

where q_t measures the real exchange rate.

Intermediate good firms The production function of intermediate goods is given by $Y_t(j) = H_t(j)$. Using (15) in (14) gives the demand function for a generic good j

$$Y_t(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\epsilon} Y_t, \tag{A.6}$$

So that

$$\int Y_t(j)dj = \zeta_t Y_t, \tag{A.7}$$

where $\zeta_t = \int_0^1 \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\epsilon} dj$ measures price dispersion. Aggregating gives

$$\zeta_t Y_t = \int_0^1 H(j)_t dj = H_t. \tag{A.8}$$

A first order approximation is given by $y_t = h_t$.

The first order condition to the price setting problem is given by

$$E_t \sum_{k=0}^{\infty} \xi^k \rho_{t,t+k} \left[Y_{t,t+k}(j) P_t(j) - \frac{\epsilon}{\epsilon - 1} W_t H_{t+k} \right] = 0 \tag{A.9}$$

In steady state, we have a symmetric equilibrium:

$$P = \frac{\epsilon}{\epsilon - 1}\frac{WH}{Y} = \frac{\epsilon}{\epsilon - 1}MC^n, \tag{A.10}$$

where the second equation defines nominal marginal costs.

Linearizing (A.9) and using the definition of price indices, one obtains a variant of the new Keynesian Phillips curve (see, e.g., Galí and Monacelli 2005):

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \kappa mc_t^r, \tag{A.11}$$

where $\kappa = (1-\xi)(1-\beta\xi)/\xi$ and marginal costs are defined in real terms, deflated with the domestic price index

$$mc_t^r = w_t - p_{H,t} = w_t^r - \omega s_t. \tag{A.12}$$

Here $w_t^r = w_t - p_t$ is the real wage (deflated with the CPI).

Profits per capita are defined as follows

$$\Upsilon_t^{pc} = P_{H,t}Y_t - W_t H_t \tag{A.13}$$

Linearized we have (deflate with cpi)

$$\hat{\Upsilon}_t^{r,pc} = \omega s_t + y_t - \frac{\epsilon - 1}{\epsilon}(w_t^r + h_t). \tag{A.14}$$

Households The first order conditions in deviations are familiar:

$$w_t - p_t = \gamma c_{A,t} + \varphi h_{A,t} \tag{A.15}$$

$$c_{A,t} = E_t c_{A,t+1} - \frac{1}{\gamma}(r_t - E_t \pi_{t+1}) \tag{A.16}$$

Or, in terms of output units (defining $\chi \equiv G/Y$):

$$(1-\chi)w_t^r = \gamma \hat{c}_{A,t} + (1-\chi)\varphi h_{A,t} \tag{A.17}$$

$$\hat{c}_{A,t} = E_t \hat{c}_{A,t+1} - \frac{(1-\chi)}{\gamma}(r_t - E_t \pi_{t+1}) \tag{A.18}$$

The first order conditions for non-asset holders are

$$P_t C_{N,t} = W_t H_{N,t} - T_t \tag{A.19}$$

$$C_{N,t} = \frac{W_t}{P_t} H_{N,t} - T_t^R \tag{A.20}$$

First order approx:

$$Y \hat{c}_{N,t} = \frac{WH}{P}(w_t + h_{N,t}) - Y \hat{t}_t \tag{A.21}$$

Or, after rearranging

$$\hat{c}_{N,t} = \frac{\epsilon - 1}{\epsilon}(w_t^r + h_{N,t}) - \hat{t}_t^r, \tag{A.22}$$

The first order condition for labor supply is given by

$$(1-\chi)w_t^r \quad = \quad \gamma \hat{c}_{N,t} + (1-\chi)\varphi h_{N,t}. \tag{A.23}$$

Regarding international financial market, we consider as baseline scenario a complete set of assets. In this case, consumption is tightly linked to the real exchange rate (see, e.g., Galí and Monacelli 2005)

$$\gamma c_{A,t} = -q_t. \tag{A.24}$$

Alternatively, we assume that there is trade in nominally risk-less bonds only. In this case, we have to keep track of the net foreign asset position, using the flow budget constraint of asset holders

$$R_t^{-1}A_{t+1} + R_{F,t}^{-1}B_{t+1}^*/\mathsf{E}_t + P_t C_{A,t} = A_t + B_t^*/\mathsf{E}_t + W_t H_{A,t} - T_t + \Upsilon_t. \tag{A.25}$$

Recall that $D_t = (1-\lambda)A_t$, i.e. government debt is held by domestic asset holders, and that profits to asset holders only: $(1-\lambda)\Psi_t = \Psi_t^{pc}$. Linearization around zero debt steady state gives

$$\beta \hat{d}_{t+1}/(1-\lambda) + \beta b_{t+1} + \hat{c}_{A,t} = \hat{d}_t/(1-\lambda) + \hat{b}_t + \frac{\epsilon-1}{\epsilon}\alpha(w_t + h_{A,t}) - \hat{t}_t^r + \hat{\Upsilon}_t^{r,pc}/(1-\lambda), \tag{A.26}$$

UIP would imply: $r_t - r_{F,t} = -\Delta E_t e_{t+1}$; yet recall that interest rates on foreign currency bonds (assuming constant world interest rates) are given by $r_{F,t} = -\chi \frac{B_{t+1}}{\beta Y P_t}$ such that

$$r_t + \frac{\chi}{\beta}\hat{b}_{t+1} = -\Delta E_t e_{t+1}. \tag{A.27}$$

Government Rewriting the interest rate feedback rule in terms of deviations from steady state (with zero inflation), we have under a float

$$r_t = \phi\beta\pi_{H,t}, \tag{A.28}$$

recall that $r_t = (R_t - R)/R$. Rewriting the fiscal rules gives

$$\begin{aligned} \frac{G_t - G}{Y} &= \rho\frac{G_{t-1} - G}{Y} + \psi_{gd}\frac{D_t}{YP_{t-1}} + \varepsilon_{g,t} \\ T_{r,t} &= \phi_{td}\frac{D_t}{P_{t-1}}, \end{aligned}$$

or

$$\hat{g}_t \quad = \quad \rho\hat{g}_{t-1} + \psi_{gd}\hat{d}_t + \varepsilon_{g,t} \tag{A.29}$$

$$\hat{t}_t \quad = \quad \psi_{td}\hat{d}_t \tag{A.30}$$

Finally, the government budget constraint is given by

$$\beta\hat{d}_{t+1} = \hat{d}_t + g_y\omega s_t + \hat{g}_t - \hat{t}_t. \tag{A.31}$$

Equilibrium and additional definitions Good market clearing (15) in terms of deviations from steady state is given by

$$y_t = -\sigma(1-\omega)\omega(1-\chi)s_t + (1-\omega)\hat{c}_t - \omega\sigma(1-\chi)s_t + \omega\hat{c}_t^* + \hat{g}_t. \tag{A.32}$$

Rearranging under the assumption that ROW constant

$$y_t = -(2-\omega)\sigma\omega(1-\chi)s_t + (1-\omega)\hat{c}_t + \hat{g}_t. \tag{A.33}$$

Define trade balance in percent of steady state output:

$$TB_t = \frac{P_{H,t}Y_t - P_tC_t - P_{H,t}G_t}{P_{H,t}Y} = \frac{Y_t - C_t\frac{P_t}{P_{H,t}} - G_t}{Y} \tag{A.34}$$

approximatively, in around steady state we have:

$$tb_t = y_t - \hat{c}_t + (1-\chi)\omega s_t - \hat{g}_t. \tag{A.35}$$

A.2 Equilibrium conditions used in model simulation

Optimality of household behavior implies

$$\begin{aligned}
\gamma\hat{c}_{A,t} &= \gamma E_t\hat{c}_{A,t+1} - (1-\chi)(r_t - E_t\pi_{t+1}) && \text{(L.1)}\\
\hat{c}_{N,t} &= \frac{(\epsilon-1)}{\epsilon}(w_t^r + h_{N,t}) - \hat{t}_t && \text{(L.2)}\\
\hat{c}_t &= \lambda\hat{c}_{N,t} + (1-\lambda)\hat{c}_{A,t} && \text{(L.3)}\\
(1-g_y)w_t^r &= \gamma\hat{c}_{A,t} + (1-g_y)\varphi h_{A,t} && \text{(L.4)}\\
(1-g_y)w_t^r &= \gamma\hat{c}_{N,t} + (1-g_y)\varphi h_{N,t} && \text{(L.5)}\\
h_t &= \lambda h_{N,t} + (1-\lambda)h_{A,t} && \text{(L.6)}
\end{aligned}$$

Asset market structures may differ. First, incomplete financial markets: we need the budget constraint of asset-holders (A.26) and the UIP condition (A.27)

$$\begin{aligned}
\beta\hat{d}_{t+1}/(1-\lambda) + \beta b_{t+1} + \hat{c}_{A,t} &= \hat{d}_t/(1-\lambda) + \hat{b}_t + \frac{\epsilon-1}{\epsilon}\alpha(w_t^r + h_{A,t}) - \hat{t}_t^r + \frac{\hat{\Psi}_t^{pc}}{1-\lambda} && \text{(L.7)}\\
r_t + \frac{\chi}{\beta}\hat{b}_{t+1} &= -\Delta E_t e_{t+1} && \text{(L.8)}
\end{aligned}$$

We complete markets we have the risk-sharing condition (A.24) and zero foreign bonds holdings

$$\begin{aligned}
\gamma\hat{c}_{A,t} &= -(1-\chi)q_t && \text{(L.7')}\\
\hat{b}_{t+1} &= 0 && \text{(L.8')}
\end{aligned}$$

Intermediate good firms' behavior is governed by marginal costs (A.12), the Philips curve (A.11) and the production function:

$$mc_t^r = w_t^r - \omega s_t + \tag{L.9}$$

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \kappa mc_t^r \tag{L.10}$$

$$y_t = h_t \tag{L.11}$$

Policies (A.28), (A.29), (A.30), government budget constraint (A.31) and market clearing (A.33)

$$r_t = \beta\phi\pi_{H,t} \text{ or } \Delta e_t = 0 \tag{L.12}$$

$$\hat{t}_t = \psi_{td}\hat{d}_t \tag{L.13}$$

$$\hat{g}_t = \rho\hat{g}_{t-1} + \psi_{gd}\hat{d}_t + \varepsilon_t \tag{L.14}$$

$$\beta\hat{d}_{t+1} = \hat{d}_t + g_y\omega s_t + \hat{g}_t - \hat{t}_t \tag{L.15}$$

$$y_t = -(1-\chi)(2-\omega)\sigma\omega s_t + (1-\omega)\hat{c}_t + \hat{g}_t \tag{L.16}$$

Definitions for the trade balance, relative prices, inflation and profits

$$tb_t = y_t - \hat{c}_t + (1-\chi)\omega s_t - \hat{g}_t \tag{L.17}$$

$$\pi_t = \pi_{H,t} - \omega\Delta s_t \tag{L.18}$$

$$\Delta e_t = (1-\omega)\Delta s_t - \pi_t \tag{L.19}$$

$$q_t = (1-\omega)s_t \tag{L.20}$$

$$\hat{\Psi}_t^{pc} = \omega s_t + y_t - \frac{\epsilon - 1}{\epsilon}\alpha(w_t^r + h_t). \tag{L.21}$$

B Canonical representation

In the following we reduce the number of equations which characterize the equilibrium in order to obtain the canonical representation which is used in section 3. We only consider the case $\lambda = 0$.

B.1 Dynamic IS

Combining good market clearing and risk sharing condition $\gamma c_t = -(1-\omega)s_t$ gives

$$y_t = -\frac{1-\chi}{\gamma}\underbrace{(1+\omega(2-\omega)(\sigma\gamma-1))}_{\equiv\varpi}s_t + \hat{g}_t$$

Hence, we have

$$s_t = -\frac{\gamma}{(1-\chi)\varpi}(y_t - \hat{g}_t),$$

which is equation (A.24) in the main text.
Alternatively, we substitute for the terms of trade in order to obtain:

$$c_t = \frac{1-\omega}{\varpi(1-\chi)}(y_t - \hat{g}_t).$$

This is helpful in rewriting the Euler equation

$$\begin{aligned} c_t &= E_t c_{t+1} - \frac{1}{\gamma}(r_t - E_t(\pi_{H,t+1} - \omega\Delta s_{t+1})) \\ &= E_t c_{t+1} - \frac{1}{\gamma}(r_t - E_t\pi_{H,t+1} - \frac{\omega\gamma}{(1-\chi)\varpi}(\Delta y_{t+1} - \Delta\hat{g}_{t+1}), \end{aligned}$$

where we use $\pi_t = \pi_{H,t} - \omega\Delta s_t$ in the first equation.
Substituting for consumption gives

$$y_t = E_t y_{t+1} - E_t\Delta\hat{g}_{t+1} - \frac{(1-g_y)\varpi}{\gamma}(r_t - E_t\pi_{H,t+1}),$$

which is (17) in the main text.

B.2 Phillips curve

Consider once more marginal costs

$$\begin{aligned} mc_t^r &= w_t^r - \omega s_t = -s_t + \varphi y_t \\ &= \frac{\gamma}{(1-\chi)\varpi}(y_t - \hat{g}_t) + \varphi y_t \end{aligned}$$

Substituting in (A.11) gives (18) in the main text.