

## ADEMU WORKING PAPER SERIES

# The Case for Flexible Exchange Rates in a Great Recession

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June 2016

WP 2016/024

[www.ademu-project.eu/publications/working-papers](http://www.ademu-project.eu/publications/working-papers)

### Abstract

We analyze macroeconomic stabilization in a small open economy which faces a large recession in the rest of the world. We show analytically that for the economy to remain isolated from the external shock, the exchange rate must depreciate not only to offset the collapse in external demand, but also to decouple domestic prices from the deflation in the rest of the world. If monetary policy becomes constrained by the zero lower bound, the scope of exchange rate depreciation is limited and the economy is no longer isolated from the shock. Still in this case there is a "benign coincidence": government spending is particularly effective in stabilizing economic activity. Under fixed exchange rates, instead, the impact of external shock is particularly severe and the effectiveness of fiscal policy reduced.

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**Keywords:** External Shock, Great Recession, Flexible Exchange Rates, Zero Lower Bound, Fiscal Multiplier, Fixed Exchange Rates, Benign Coincidence

Jel codes: F41, F42, E32

## Acknowledgments

Corsetti acknowledges the Centre for Macroeconomics, ADEMU and the Keynes Fellowship at Cambridge University for support in developing the background research. Francesco D'Ascanio provided excellent research assistance. This project is related to the research agenda of the ADEMU project, "A Dynamic Economic and Monetary Union". ADEMU is funded by the European Union's Horizon 2020 Program under grant agreement N° 649396 (ADEMU).

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The ADEMU Working Paper Series is being supported by the European Commission Horizon 2020 European Union funding for Research & Innovation, grant agreement No 649396.

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# 1 Introduction

The case for flexible exchange rates rests on the ability of monetary policy to adjust its stance and let the exchange rate depreciate or appreciate in response to shocks. Hence, even economies with floating exchange rates may suffer a great deal as a consequence of large external shocks, if monetary policy becomes constrained by the the zero lower bound (ZLB) on interest rates. Although the nature of ZLB constraint is quite different from that implied by an exchange rate peg or participation in a currency union, the implications for macroeconomic resilience in the face of external socks are potentially severe.

This has been illustrated forcefully during the great recession. Figure 1 shows the evolution of output and exchange rates in the Scandinavian countries during the great recession. Two of these countries have given up exchange rate flexibility: Finland is a member of the euro area; Denmark operates an independent currency, but maintains a narrow peg to the euro. The other two, Sweden and Norway, pursue inflation targeting, but only in Sweden fell policy rates to the ZLB in 2009–10. The left panel shows a sizeable output contraction for Finland and Denmark, but not for Norway. The contraction in Sweden, in turn, is much larger than in Norway and, in fact, as strong as in Denmark and Finland. The right panel shows that the Norwegian Krone and the Swedish Krona both depreciated sharply during the first year of the crisis, but initially the depreciation was even stronger in Norway.

In this paper, we reassess the ability of the exchange rate to act as shock absorber from the vantage point of a small open economy facing a great recession, during which demand and inflation in the rest of the world collapse. We do so by carrying out a comparative analysis of stabilization policy across exchange rate regimes, explicitly accounting for constraints on monetary policy—be it the ZLB or an exchange rate peg—but also for the monetary-fiscal policy mix. Indeed, it is well understood that an effective fiscal policy requires an adequate degree of monetary accommodation (see, e.g, Woodford, 2011), that may or may not be granted in the absence of exchange rate flexibility, or with policy rates at the zero lower bound.

We find that during a global great recession the case for flexible exchange rates in a small open economy is actually stronger than classic arguments suggest. Provided that the central bank is not constrained in pursuing its inflation objective, the role of floating rates as a shock absorber vis-à-vis an adverse shock to global demand is twofold. First, real depreciation counteracts the fall in net exports driven by the contraction of external demand. Second, additional, sustained depreciation decouples domestic prices from the deflationary crawl in the rest of the world.

Moreover, floating rates continue to be beneficial even if the external shock is so large that



Figure 1: Real GDP (left) and end-of-quarter exchange rate (price of euro in local currency) in selected economies. Sample period: 2007Q4–2012Q4. GDP is normalized to 100 Percent in 2007Q4, the exchange rate is expressed in percentage change relative to 2007Q4. Source: OECD Economic Outlook 98 and Bundesbank.

domestic policy rates become constrained by the ZLB. Anticipating a future monetary expansion, the Home exchange rate still depreciates (although less than in the unconstrained case), thereby providing some isolation from the adverse developments in the rest of the world. In addition, floating exchange rates allow fiscal stimulus to become very effective precisely when monetary policy can deliver less stabilization—a “benign coincidence.”

The opposite holds in case of a fixed exchange rate regime. Lack of exchange rate flexibility not only exposes the economy fully to the adverse consequences of the external demand shock. It also amplifies the transmission of a global great recession by anchoring the domestic price level to the foreign deflationary crawl. This, in turn, pushes up domestic real interest rates and induces a collapse of internal demand. Last but not least, an exchange rate peg prevents fiscal policy from having a significant and persistent effects on domestic inflation, as it remains tied to inflation abroad. At odds with the received wisdom, fiscal policy is not necessarily more effective in a fixed exchange rate. The benign coincidence breaks down.

We establish these results analytically in a stylized framework as well as through model simulations. To state our results as clearly as possible, we build on the workhorse monetary model of a small open economy in its standard New Keynesian specification.<sup>1</sup> Throughout our analysis, we posit a large rise in world preferences for current savings. This shock causes a sustained drop in rest-of-the world demand and rest-of-the world deflation, because it can not be offset by appropriate monetary policy measures in the rest of the world. The exchange

<sup>1</sup>In the new Keynesian specification, a small open economy takes the global equilibrium as given but maintains some monopoly power on its terms of trade—see, for instance, Galí and Monacelli (2005) and De Paoli (2009) which, in turn, build the New Open Economy Macroeconomics literature (Obstfeld and Rogoff, 1996).

rate regime, in turn, is essential in determining to what extent the Home economy remains insulated from both the real drag from the rest-of-the world and the deflationary pressure. To verify the robustness of our findings to varying the degree of capital market integration and financial frictions, in the last part of the paper we rely on model extensions that captures financial imperfections. Building on previous work of ours (Corsetti et al., 2013b), we consider economies with limited risk sharing and vulnerable to sovereign risk crises, which may spillover on borrowing costs and conditions faced by the private sector. We find that, per effect of external shock, sovereign risk per se may exacerbate the negative effects of a recessionary external shock only at the margin. Yet, it causes fiscal policy to become much less effective in stabilizing economic activity exactly when monetary policy is constrained, particularly so under a peg.

Our paper relates to a number of studies which started to reassess the costs and benefits of flexible exchange rates in light of recent developments. In line with Schmitt-Grohé and Uribe (2015) we show that macroeconomic adjustment is indeed particularly painful under a currency peg. The mechanisms, though, differ. Whereas we highlight the lack of effectiveness of both monetary and fiscal stabilization policy, they see wage-setting frictions as the central element. Krugman (2014) emphasizes the benefits of flexible exchange rates in the face of sovereign risk. The paper in the literature closest to ours is Cook and Devereux (2014). They show within a two-country model that a flexible exchange rate regime can make an economy more, rather than less, vulnerable to a large shock. The main difference to our work is the focus and main questions in the analysis. Whereas we focus on the transmission of a large adverse external shock to a small open economy, they focus on the domestic stabilization of a large domestic demand shock shock.<sup>2</sup>

Finally, a number of recent studies have emphasized that fiscal policy is particularly effective in stabilizing open economies, once monetary policy becomes constrained by the ZLB (Cook and Devereux, 2011; Erceg and Lindé, 2012). That the effectiveness of fiscal policy is limited, on the other hand, under an exchange rate peg has been highlighted by earlier studies (Corsetti et al., 2013a; Farhi and Werning, 2012).<sup>3</sup> In the present paper we reconsider those findings in circumstances where a need for effective stabilization arises in the first place.

The text is organised as follows. Section 2 outlines the model by focusing on a log-linear approximation of the equilibrium conditions. Section 3 provides a number of closed-form

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<sup>2</sup>Cook and Devereux (2013) study the case for international policy coordination if in one of two countries monetary policy becomes constrained by the zero lower bound. As regards empirical work Berkmen et al. (2012) document evidence that exchange-rate flexibility seems to have mitigated the adverse impact of the Great Recession.

<sup>3</sup>Erceg and Lindé (2012), however, highlight the importance of price rigidities for the relative size of the government spending multiplier at the ZLB and under an exchange rate peg.

results on the transmission and stabilization of a great recession under alternative policy scenarios in the small open economy. Section 4 illustrates the quantitative relevance of these results through model simulations. It also provides results for a modified environment with financial friction and sovereign risk. Section 5 concludes.

## 2 A New Keynesian small open-economy model

We frame our analysis in the standard New Keynesian model, using a version of the two-country model put forward in Corsetti et al. (2012). Both countries produce a variety of country-specific intermediate goods, with the number of intermediate good producers in the world normalized to unity. While international financial markets are complete, goods market integration is incomplete due to home bias. Hence, while we assume that the law of one price holds at the level of intermediate goods, purchasing power parity fails in the short run. The countries have isomorphic structures, but may differ in terms of size, policies and shocks.

We build a scenario in which a small open economy faces a great recession in the rest of the world. For this purpose we make the following assumptions. First, the size of Home in the world economy approaches zero, while the rest of the world is consolidated in Foreign. As a result, Home behaves like a small open economy, while Foreign behaves like a closed economy.<sup>4</sup> Second, the only source of variation at the world-level is a Foreign “saving shock”. This shock effectively alters the time-discount factor. Such preference shocks often-times are used to model an exogenous variation of the intertemporal allocation of private expenditures (for a textbook treatment see Galí, 2015). For the effect of the shock on the Home economy, one needs to know the effect of the shock on Foreign demand and prices. We shall, third, assume that the shock in Foreign occurs when monetary policy in Foreign is unable to contain its effect.

Importantly, while our focus is on Home, we are explicit about the dynamics in Foreign so that the external shock which impacts Home is fully micro-founded. As a result we may account for the cross-equations restrictions of the model along two dimensions. First, the saving shock in Foreign impacts Home not only via goods markets, but also via financial markets.<sup>5</sup> Second, the model restricts the joint dynamics of output and inflation in Foreign during a great recession. As we shall see both of these matter for Home.

The structure of the model that we use is well-known. We give a detailed description in

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<sup>4</sup>In this case Home is identical to the small open economy of Galí and Monacelli (2005), except for the fact that we allow for government consumption and restrict preferences to log-utility.

<sup>5</sup>The global fall in demand (including the demand for the Home output), and the adjustment in the world interest rate and the price of foreign exports are all taken as given by the small open economy. Because of the fluctuation in the relative price of Home to Foreign consumption, however, full insurance via complete markets does not insulate Home consumption from the external shock.

Appendix A. In the following, instead, we provide a compact exposition, based on a log-linear approximation of the equilibrium conditions around a deterministic and symmetric, zero-inflation steady state. Output is normalized to one. In both the appendix and the text, Foreign variables are indexed with a star. Variables carry a time-subscript,  $t$ . Variables without a hat refer to log deviations from the steady state. Variables that carry a hat refer to deviations in levels. We begin with Foreign and discuss the equilibrium conditions in Home afterwards.

In order to simplify the exposition, and derive tractable pencil and paper solutions, we shall make several simplifying assumptions. The assumptions will be eased later, when we resort to numerical simulations, with little effect as to the qualitative conclusions. One such assumption is Assumption 1, which is made merely to simplify the exposition:

**Assumption 1.** *In steady-state, there is no government consumption in Home or Foreign. We allow for positive government consumption shocks in Home, but not in Foreign. If there are such shocks in Home, they follow the same stochastic structure as the savings shock in Foreign. [XXX This is fairly innocent assumption - in light of Giancarlo's comment I'd rather not emphasize it so much XXX]*

## 2.1 Foreign

Under our assumptions, Foreign operates like a closed economy. The equilibrium dynamics of output,  $y_t^*$ , inflation,  $\pi_t^*$ , and nominal interest rates  $r_t^*$  are driven by the dynamics of the saving shock in Foreign,  $\xi_t^*$ . We will specify a law of motion for the shock later. Conditional on the dynamics of the shock, the evolution of the Foreign economy is captured by the following three equations. The first is the dynamic IS-equation:

$$y_t^* = E_t y_{t+1}^* - (r_t^* - E_t \pi_{t+1}^* + E_t \Delta \xi_{t+1}^*). \quad (1)$$

Here  $E_t$  is the expectations operator and  $\Delta$  marks the difference operator. Next, there is the New Keynesian Phillips curve:

$$\pi_t^* = \beta E_t \pi_{t+1}^* + \kappa (\varphi + 1) y_t^*. \quad (2)$$

Here  $\beta$  is the steady-state time-discount factor.  $\kappa := (1 - \alpha)(1 - \beta\alpha)/\alpha$  measures the slope of the Phillips curve, with  $\alpha \in [0, 1)$  measuring the degree of price stickiness.  $\varphi > 0$  is the inverse of the Frisch elasticity of labor supply. The last equation is an instrument rule for the Foreign central bank that describes monetary policy. We assume that

$$r_t^* = \max\{\phi_\pi \pi_t^* - E_t \Delta \xi_{t+1}^*, -(1 - \beta)\}. \quad (3)$$

Here,  $\phi_\pi > 1$  is the response to inflation in normal times. Foreign can become constrained by the zero-lower-bound, however, explaining the max operator. As long as the central bank can pursue rule (3) without being constrained by the ZLB, the time-discount factor shock does not have an effect on Foreign inflation or output. In this case, monetary policy implements the flexible price allocation under which the saving shock is fully absorbed by changes in the real rate of interest. If, instead, policy becomes constrained the flexible-price allocation can no longer be implemented by monetary policy (alone). In this case eqs. (1)–(2) restrict the joint dynamics of output and inflation.

## 2.2 Home

While the dynamics in Foreign are independent of what happens in Home, Foreign does matter for Home. The following set of equations describes the equilibrium dynamics in Home, given the realization of Foreign variables. The dynamic IS-relation in Home is:

$$y_t = E_t y_{t+1} - (1 - \varpi) \Delta y_{t+1}^* - \Delta \hat{g}_{t+1} + [1 - \nu - \varpi] \Delta \xi_{t+1}^* - \varpi (r_t - E_t \pi_{H,t+1}). \quad (4)$$

Here  $\hat{g}_t$  denotes government expenditure (in units of output). Government spending is financed through lump-sum taxes and falls exclusively on domestically produced goods. In deriving the above equation, we have substituted for Home consumer-price inflation rates. Thus, what remains in the IS-equation is Home producer price inflation,  $\pi_{H,t}$ . inflation (based on Home producer prices). Parameter  $\varpi$  is defined as  $\varpi := 1 + \nu(2 - \nu)(\sigma - 1)$ , where  $\nu \in (0, 1)$ , which measures the degree of openness, with a low  $\nu$  implying a strong home bias, and  $\sigma > 0$ , which measures the trade-price elasticity of international demand.

The New-Keynesian Phillips curve links inflation to expected inflation, as well as a number of variables that determine the evolution of marginal costs in our small open economy

$$\pi_{Ht} = \beta E_t \pi_{Ht+1} + \kappa \left\{ (\varphi + \varpi^{-1}) y_t - \tilde{\varpi}^{-1} [(1 - \varpi) \hat{y}_t^* + \hat{g}_t] + \frac{1 - \nu - \varpi}{\varpi} \xi_t^* \right\}. \quad (5)$$

Note that both the dynamic IS-relation and the New Keynesian Phillips curve in Home are a function of foreign output (that is the same as foreign consumption) as well as the Foreign saving shock, which enter the equations as separate arguments. This is because a Foreign saving shock spills over internationally through two channels. The first is a direct demand channel: given prices, a saving shock leads to less Foreign demand for Home goods—this is the key effect of a global recession that we wish to focus on in our analysis. The second channel works through prices: because of home bias in consumption, for given relative prices the fall in Foreign demand falls disproportionately on Foreign-produced goods. In equilibrium, the relative price of Foreign-produced goods must fall, which in turn crowds out demand for Home goods.

In the following, we wish to focus on the demand channel. We do so by making the following assumption:

**Assumption 2.** *The parameters governing openness ( $v$ ) and the trade elasticity ( $\sigma$ ) are related as*

$$1 - \sigma = (2 - v)^{-1}.$$

The above constraint implies  $1 - v - \varpi = 0$ , so that the Foreign savings shock disappears from equations (4) and (5). In the numerical solutions of the model in section Section 4, we will relax this constraint.

The terms of trade in Home,  $s_t$ , are defined as the price of imports relative to the price of exports. Foreign being large the Foreign consumer price level equals the Foreign producer price level. With the law of one price assumed to hold, and producer currency pricing, we have that

$$s_t = e_t + p_t^* - p_{H,t}, \quad (6)$$

where  $e_t$  is the nominal exchange rate, defined as the price of foreign currency in units of domestic currency,  $p_t^*$  is the (consumer and producer) price level in Foreign and  $p_{H,t}$  is the producer price level in Home. Note that  $\pi_{H,t} = p_{H,t} - p_{H,t-1}$  and  $\pi_t^* = p_t^* - p_{t-1}^*$ .

In equilibrium, demand for Home-produced goods satisfies

$$y_t = (1 - v)s_t + \hat{g}_t + y_t^* - (1 - v)\xi_t^*. \quad (7)$$

This is derived from goods market clearing for Home-produced goods using the risk sharing condition under complete international financial markets.<sup>6</sup> All else equal, Home output depends positively on foreign demand, the terms of trade and Home government consumption. The Home economy (and the full model) is closed by specifying the Home monetary policy regime. We will, in the next section, consider three different scenarios: an independent monetary policy in Home that follows the analog of the rule (3), with and without being constrained by the ZLB, as well as the case of a currency peg.

In equilibrium, eqs. (4)–(7) determine a sequence Home variables  $\{y_t, \pi_{H,t}, p_{H,t}, s_t, e_t, r_t, \hat{g}_t\}_{t=0}^{\infty}$ , given a specification of (i) monetary policy in Home, (ii) fiscal policy in Home, (iii)  $\pi_{H,t} = p_{H,t} - p_{H,t-1}$ , (iv) the sequence  $\{y_t^*, \pi_t^*, p_t^*, \xi_t^*\}_{t=0}^{\infty}$ , as well as initial conditions  $(p_{-1}^*, p_{H,-1})$ .

<sup>6</sup>In our setup complete risk sharing does not imply equal consumption in Home and Foreign because of home bias. Moreover, the saving shock will affect consumption-risk sharing, as it impacts the marginal utility in Foreign.

### 3 The impact of a global recession

In this section, we provide analytical insight on the transmission of a large external demand shock to Home—a small open economy specialized in the production of a country-specific varieties. We study, in particular, how the effects of the shock vary with the extent to which monetary instruments in Home are constrained, either by the zero lower bound or by a commitment to an exchange rate peg. Then, we turn to discussing how effectively fiscal instruments can substitute for monetary ones in the respective regimes.

Throughout, we focus on the effect of the external saving shock that directly affects Foreign households only. The effects of this shock on global demand and production, the world interest rate and the prices produced abroad are endogenous to the world economy, but from the vantage point of the (small) Home economy, they are exogenous, and so is the inward shift in the world demand for the Home goods and the price drift in Foreign exports denoted in Foreign currency. To ensure tractability, we assume that the shock follows a Markov structure.

**Assumption 3.** *In the initial period, Foreign households become more patient, so that  $\xi_t^*$  drops to  $\xi_L^*$ . Each period afterward, with probability  $\mu \in (0, 1)$   $\xi_t^*$  will remain at that same low level for another period, or otherwise permanently revert to the level of  $\xi_t^* = 0$ .*

We have particular, great recession, scenario in mind. Namely, one in which the demand shock hits the Foreign economy when Foreign monetary policy does not respond to the shock, for example, because the Foreign economy was at its zero lower bound to start with.

**Assumption 4.** *The Foreign interest rate,  $r_t^*$ , does not react to the demand shock while the shock lasts.*

Again, these restrictions will be relaxed in the next section, where we will resort to numerical simulations. **[XXX Again, in light of Giancarlo’s comment: I suggest we consolidate Assumption 2 and 3 and label it “Great recession scenario”. I am not sure we relax these “restrictions” in the numerical analysis XXX]**

In addition, we make an assumption for both Home and Foreign. Throughout the paper, we shall focus on cases only in which the equilibrium is determinate both in Foreign and in Home:

**Assumption 5.** *Parameters of the model are restricted to satisfy the determinacy conditions in each scenario. [XXX Again: no need to state this as an assumption—this is fairly common after all XXX]*

With these assumptions, we get a unique representation of the dynamics of Foreign output and Foreign prices. Output and inflation in Foreign inherit the Markov property of the savings

shock, that is, they will look the same in any period in which the shock lasts. We use the subscript “L” to indicate the value that endogenous variables take during the shock period. With this in mind, the marginal impact of the shock on output in Foreign is given by

$$y_L^* = \frac{(1 - \beta\mu)(1 - \mu)}{\underbrace{(1 - \beta\mu)(1 - \mu) - \mu\kappa(1 + \varphi)}_{:=1/\chi > 1}} \xi_L^*. \quad (8)$$

It is important to note here that  $\chi < 1$  and decreasing in  $\mu$ . In words, due to the ZLB constraint binding in Foreign, the discount-factor shock has a disproportionate effect on Foreign’s output. This effect tends to be stronger, the more persistent the shock is and the longer Foreign monetary policy remains constrained.

Foreign inflation also falls in response to the shock:

$$\pi_L^* = \frac{\kappa(1 + \varphi)(1 - \mu)}{\underbrace{(1 - \beta\mu)(1 - \mu) - \mu\kappa(1 + \varphi)}_{> 0}} \xi_L^*. \quad (9)$$

Having characterized the evolution of Foreign demand (output) and Foreign inflation, next we take the vantage point of the small open Home economy. We will consider three types of stabilization policies. In turn, we will assume that the Home monetary policy either (i) features floating exchange rates and is unconstrained by the zero lower bound; (ii) is constrained by the zero lower bound for a finite number of periods amid a floating exchange rate; (iii) is constrained by a credible (and permanent) currency peg.

### 3.1 Unconstrained monetary policy under a floating rate regime in Home

We begin by revisiting, analytically, a classical result: under flexible exchange rates a small open economy has the ability to stabilize the output gap and inflation in response to large foreign demand shocks. It can do so through its own monetary policy, as long as this policy remains unconstrained. To show this, we postulate that the Home monetary authorities is able to implement a rule akin to that in Foreign, but unconstrained by the zero lower bound:

$$r_t = \phi\pi_{H,t} + r_t^n, \text{ with } \phi > 1. \quad (10)$$

where  $r_t^n$  is the natural rate of interest in Home. Under our shock scenario,  $r_t^n$  will be zero after the shock has ceased. Otherwise,

$$r_L^n = \frac{(1 - \mu)\varphi}{1 + \varphi\varpi} (vy_L^* + \hat{g}_L).$$

Here  $\hat{g}_L$  is the value that government consumption is assumed to take during the shock episode. Monetary policy targets producer-price inflation and adjusts policy rates to changes

in the natural rate of interest. Combining the interest rate rule specified above with equations (4) and (5), determines the equilibrium outcome for the interest rate, inflation and output in Home. The model, thus, shows the well-established isomorphism between open and closed-economy settings, as is common in New Keynesian models (Clarida et al., 2001). This is not to say that openness is irrelevant for Home. It matters for the Home economy through  $\varpi$  (the openness parameter  $v$ ). In addition, openness matters here as a source of shocks.

Provided that the central bank follows the rule above, our model yields a well-known result in the literature (see, for instance, Gali, 2015, chapter 4): With complete markets and in the absence of markup shocks, rule (10) above supports the flexible-price allocation. In particular, there is no inflation ( $\pi_{H,t} = 0$ ) and output equals:

$$y_L = \underbrace{\frac{1}{1 + \varphi(1 - v)}}_{<1} (vy_L^* + \hat{g}_L). \quad (11)$$

Flexible exchange rates under stable producer prices partly isolate Home from the external shock. The isolation in terms of output is not complete, though. Rather, monetary policy stabilizes output at the natural level. Under the assumptions made above, the natural level of output declines in response to the external shock. Still, the external-demand multiplier is smaller than unity. Intuitively, it increases in the openness parameter  $v$  (which determines the share of imports-to-GDP in steady state). Only under complete openness ( $v \rightarrow 1$ ) will the Foreign shock be passed through completely.

It is instructive to analyze the accompanying movements in the terms of trade and the nominal exchange rate. The following expression for the terms of trade can be derived by combining the solution for output (11) with the market-clearing condition equation (7):

$$s_L = - \underbrace{\left[ 1 - \chi + \frac{v\varphi}{1 + \varphi(1 - v)} \right]}_{<0} y_L^* - \frac{\varphi}{1 + \varphi(1 - v)} \hat{g}_L^*. \quad (12)$$

What is apparent from this is that the Home terms of trade automatically and unambiguously depreciate if Foreign output—and hence external demand—declines. Expansionary government spending in Home, all else equal, appreciates the Home terms of trade.

The following expression for the nominal exchange rate shows precisely how Home monetary authorities can insulate the domestic economy against the fallout of the external demand shock. From (6), the nominal exchange rate,  $e_t$ , is given by

$$e_t = s_t + p_{H,t} - p_t^*, \quad (13)$$

As long as the Home monetary authority can and does pursue price stability in Home, we

have  $p_{H,t} = 0$ . In this case, taking first differences of equation (13) implies

$$\Delta e_t = \Delta s_t - \pi_t^*.$$

Observe two things. First, the movement in the nominal exchange rate perfectly insulates the Home economy from movements in Foreign inflation alone. In our shock scenario, the nominal exchange rate will depreciate one-to-one with the continuing fall in Foreign's price level, at the disinflation rate  $\pi_L^* < 0$ . On top, in the initial period of the shock, and only in that period, the nominal exchange rate will depreciate in excess of the Foreign deflationary crawl, so as to accommodate the initial period's depreciation of the terms of trade.

This clarifies the two dimensions along which, with monetary authorities pursuing a regime of output gap stabilization and price stability, the nominal exchange rate performs its role of shock absorber. First, it fully insulates agents' expectations of domestic inflation from the Foreign deflationary drift. Second, on impact, it depreciates with the fall in Foreign demand, contributing to real depreciation, thus sustaining domestic employment and competitiveness. While the depreciation of the nominal exchange rate for the sake of competitiveness will be reversed once the shock ends (and  $s_t$  reverts back to zero), the same is not true of the adjustments due to Foreign deflationary drift. The monetary rule (10) does not include an exchange rate target, not even in the long run, hence there is no implicit commitment to keep the domestic price level aligned with the Foreign one. Rather, the nominal exchange rate will be depreciated permanently.

### 3.2 The zero lower bound constraint under floating rates in Home

In our second scenario, the exchange rate regime is still a float, but now also the Home monetary policy rate are assumed to be constrained when the adverse shock in Foreign materializes. Specially, we impose that Home policy rates are constant—for example, because Home had been at its zero lower bound already—as long as the Foreign economy is in the shock state. So, at least temporarily, the Home monetary authority is unable to cushion the foreign shock. In this case the solution for Home output is given by:

$$y_L = \underbrace{\left(1 + \frac{\mu\kappa\varphi(1-v)}{(1-\mu)(1-\beta\mu) - \mu\kappa(1+\varphi(1-v))}\right)}_{:=\Xi} (vy_L^* + \hat{g}_L). \quad (14)$$

where one can show that

$$1 < \Xi < \frac{1}{v}.$$

In other words, the external-demand multiplier is unambiguously larger than unity and thus larger than absent ZLB constraint in Home, compare (14) with (11). Exchange rate flexibility alone is not sufficient to insulate the Home economy from the Foreign demand shock.

While the drop in Home output will never exceed the drop in Foreign output, with the ZLB constraint the output loss due to an external demand shock can be large. The reason for why the multiplier is large at the ZLB (and larger than absent the ZLB) has been extensively explored by the literature, notably in the context of fiscal policy (e.g. Woodford, 2011). The fall in Foreign demand drives down inflation and inflation expectations in a significant and sustained way, causing a rise in (long-term) real interest rates (see also Cook and Devereux, 2014). Specifically, the the solution for inflation is given by:

$$\pi_{H,L} = \frac{(1-\mu)\kappa\varphi}{\underbrace{(1-\beta\mu)(1-\mu) - \mu\kappa(1+\varphi(1-v))}_{>0}} (vy_L^* + \hat{g}_L). \quad (15)$$

Next, we turn to the accompanying movements in the terms of trade and the nominal exchange rate. The solution for the terms of trade for the duration of the shock is given by:

$$s_L = -\frac{1}{(1-v)} [1 - (1-v)\chi - \Xi v] y_L^* - \underbrace{\frac{1-\Xi}{(1-v)}}_{>0} \hat{g}_L. \quad (16)$$

It is instructive to compare this to the solution for the terms of trade when monetary policy follows rule (10) in an unconstrained way, that is, by the expression in equation (12) above. A close inspection of the terms multiplying foreign output reveals that the terms of trade depreciate to a lesser extent in response to a drop of external demand when the ZLB binds in Home. In fact, it is difficult to formally establish the sign of the terms of trade response to the external shock. Still, in our numerical experiments we find the terms of trade to depreciate consistently, even as the ZLB binds in Home.

Importantly, given the dampened response of the terms of trade at the zero lower bound, expression (13) makes clear that the nominal exchange depreciates also less at the ZLB relative to the unconstrained case. Not only do the terms of trade depreciate less at the ZLB, Home producer prices decline as well (and the response of Foreign inflation is independent of monetary conditions on Home). This result is merely formalizing the notion that the nominal exchange rate does not fulfill its role as a shock absorber, once monetary policy is constrained by the ZLB. Still, one can show that Home will never fully import Foreign's deflationary crawl.

With monetary policy unable to cushion the shock, the question naturally arises if Home may nonetheless stabilize the economy through fiscal policy. The expressions above directly speak to this question (see expressions (14) and (15) above). In fact, assuming that government spending is raised by  $\hat{g}_L$  for as long as the economy is in the shock state, we observe that fiscal policy is quite effective in raising output. Remarkably, since  $v < 1$ , the fiscal multiplier

is always larger than the external-demand multiplier [XXX I seems we do not define the external demand multiplier; is  $\nu y_L^*$  external demand or  $y_L^*$ ? Above in (11), it seem it is the former?? XXX]. We think of this result as a sort of “benign coincidence:” if the conditions are such that, due to the ZLB, the effect of an external demand shock is strongly amplified, under those very conditions fiscal policy becomes more effective in stabilizing economic activity. In particular, to prevent a fall in current output per effect of a drop in foreign demand by one percent of domestic GDP, the government needs to commit resources for less than one percent of GDP.<sup>7</sup>

The mechanism underlying the power of fiscal policy at the zero lower bound is well understood by now: higher government spending lowers real interest rates to the extent that fiscal spending raises expected inflation and provided that its inflationary impact is not met by higher policy rates (Christiano et al., 2011; Woodford, 2011). Relative to analyses conducted in a close economy setting, our analysis sheds light on the additional contribution to stabilization of the exchange rate as a shock absorber. Indeed, flexible exchange rates are important element of the effectiveness of fiscal policy in the ZLB scenario, as the next section will make clear.

### 3.3 An exchange-rate peg

We turn to our third, and final, scenario for monetary policy in Home. Namely, we assume that monetary policy adjusts interest rates so as to ensure the following exchange rate target:

$$e_t = 0. \tag{17}$$

Here we abstract from issues pertaining to implementation and from possible constraints on monetary policy.<sup>8</sup>

To understand the implications of an exchange rate peg for the macroeconomic stabilization of our small open Home economy, we derive an expression the evolution of the terms of trade. The Home terms of trade are given by the expression in equation (13). With permanently fixed exchange rates, this means

$$s_t - s_{t-1} = \pi_t^* - \pi_{H,t}. \tag{18}$$

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<sup>7</sup>Note, however, that while government spending may be used to effectively isolate Home from the external-demand shock, this also alters the flexible-price allocation. As a result, at the ZLB it is not feasible to restore the allocation which obtains in the unconstrained case through government spending. To see this, note that if Home inflation is fully stabilized, Home output will not be at the natural level, but at the steady state level.

<sup>8</sup>See, for instance, Benigno et al. (2007). In the event of a binding ZLB constraint, one may think of an appropriate commitment to future policy rates as a way to ensure the exchange rate peg. Recall that one scenario we have in mind is the membership of a small open economy within a currency union.

We may then subtract from the Phillips curve in Foreign (2) its Home counterpart (5) to obtain

$$\pi_t^* - \pi_{H,t} = \beta E_t(\pi_{t+1}^* - \pi_{H,t+1}) + \kappa(\chi[1 + \varphi(1 - \nu)]\hat{y}_t^* - \varphi\hat{g}_t - [1 + \varphi(1 - \nu)]s_t). \quad (19)$$

Organizing terms leads to the following second-order difference equation in the terms of trade:

$$s_t = \psi s_{t-1} + \beta\psi E_t s_{t+1} + \kappa\psi[\chi[1 + \varphi(1 - \nu)]y_t^* - \varphi\hat{g}_t], \quad (20)$$

where  $\psi = [1 + \beta + \kappa(1 + \varphi(1 - \nu))]^{-1}$ . Under our assumptions about the Markov structure of shocks, one can solve this difference equation using the method of undetermined coefficients, obtaining the stable solution:

$$s_t = \delta s_{t-1} + \underbrace{\frac{\kappa\psi\chi[1 + \varphi(1 - \nu)]}{1 - \beta\psi[\delta + \mu]}}_{:=\Phi} y_t^* - \underbrace{\frac{\kappa\psi}{1 - \beta\psi[\delta + \mu]}}_{:=\Gamma} \varphi \hat{g}_t, \quad (21)$$

where  $\delta := \frac{1 - \sqrt{1 - 4\beta\psi^2}}{2\psi\beta}$ , with  $0 < \delta < 1$ , and  $\Phi \in (0, \chi)$ , and  $\Gamma > 0$ . This expression serves to make two important points. First, with fixed exchange rates, the sign of the effect of government spending on the terms of trade is opposite to the sign that obtains under flexible exchange rates absent the ZLB. In other words, government spending stimulus under fixed exchange rates appreciates the terms of trade. This hinders its effectiveness as a stabilization tool. The terms of trade unambiguously appreciate in response to the negative external demand shock. This is in contrast with the results for flexible exchange rates, when there was scope for the terms of trade to depreciate. Intuitively, with the nominal exchange rate fixed, the adjustment of the terms of trade depends on the relative adjustment of prices in Home and Foreign. It turns out that in response to the Foreign saving shock, Foreign prices decline more than in Home—hence the real appreciation.

Two other dimensions set the fixed exchange rate regime apart from the flexible exchange rate regime. First, if the Foreign demand shock persists, and so  $y_L < 0$ , the terms of trade will not only appreciate in first period of the shock but will continue to do so going forward. Second, the terms of trade will not automatically reset once the Foreign shock ceases to exist. Rather, the terms of trade appreciation of the small open Home economy will linger with detrimental results on output and inflation even once the rest of the world no longer suffers from the shock (and  $y_t^* = 0$ ). This can be best seen by iterating the expression for the terms of trade backward in time, assuming that prior to the first period the terms of trade were at their steady-state value ( $s_{-1} = 0$ ):

$$s_t = \sum_{k=0}^t \delta^{t-k} (\Phi y_k^* - \Gamma \hat{g}_k). \quad (22)$$

In other words, fixed exchange rates not only mean reduced competitiveness upon a negative foreign demand shock. Worse, fixed exchange rates can mean that these effects keep lingering after the rest of the world has already recovered from the shock. Similarly, the effect of reduced competitiveness that goes in hand with fiscal spending in Home will linger.

Last, we turn to effect of the Foreign shock on Home output. By equation (7), we have that

$$y_t = (1 - v)s_t + (1 - \chi(1 - v))y_t^* + \hat{g}_t.$$

Inserting the expression for the terms of trade under fixed exchange rates, we obtain:

$$y_t = [1 - (1 - v)\chi]y_t^* + (1 - v) \sum_{k=0}^t \delta^{t-k} \Phi y_k^* \quad (23)$$

$$+ \hat{g}_t - (1 - v)\Gamma \sum_{k=0}^t \delta^{t-k} \hat{g}_k. \quad (24)$$

**KK: I'll need to double-check the proof tomorrow** The impact of the external shock on Home output will tend to be large in absolute terms. Indeed, one can show that on impact output in Home will fall more in response to the foreign demand shock under the peg than in the ZLB scenario discussed earlier. Under floating exchange rates, the terms of trade change on impact. They are constant thereafter for as long as the negative demand shock persists. Under the peg, instead, not only is the adverse effect of the shock on Home output larger on impact, but also do the terms of trade continue to appreciate. Thus, for as long as shock persists, Home output will be lower under the peg than under the float (with or without ZLB). Since the demand shock persistently appreciates the terms of trade, then output remains lower under the peg than under floating exchange rates. At the same time, the spending multiplier is always smaller than one, and thereby smaller than under the ZLB. The government will need to commit more resources, on a more than one-to-one basis, to compensate for any given fall in output due to the external demand shock.

As analyzed in our previous work a credible exchange rate target amounts to a credible commitment to anchoring the Home price level to that of the Foreign country in the medium and long run (Corsetti et al., 2013a). In our scenario above, the Foreign country suffers from a deep deflationary downturn. Hence, as the Home country pegs its own currency, it anchors domestic expectations to a *falling* price level, causing domestic real interest rates to rise substantially in tandem with the foreign one.

Not only does the anchor to the foreign price level implicit in a peg exacerbate the transmission of the world recession. It is also the reason why fiscal stabilization is not particularly effective under the peg. This is because any inflationary effects that government spending has in the

short run are offset, over time, by the working of arbitrage in the goods market, causing enough (relative) deflation in Home to re-establish PPP.

## 4 Quantitative illustration

We now turn to model simulations in order to illustrate the quantitative relevance of our results. In doing so, we also assess to what extent our results are robust to relaxing the simplifying assumptions required to carry out our analytical derivations. For our numerical experiments we adopt the following parameter values. Since a period in the model corresponds to one quarter, the discount factor  $\beta$  is set to 0.99. We assume that the inverse of the Frisch elasticity of labor supply,  $\varphi$ , takes the value of one. The trade price elasticity  $\sigma$  is set equal to  $2/3$ . Home is assumed to be relatively open, corresponding to  $v = 0.3$ .<sup>9</sup> The average price duration is assumed to be four quarters, requiring the Calvo parameter to be set equal to  $\xi = 0.75$ . Finally, we set the average share of government spending in Home GDP to 20 percent.

For the sake of clarity, we consider the dynamic adjustment to the foreign shock separately from the dynamic adjustment to an increase in government spending. In the first experiment, we look at a saving shock in Foreign that cannot be stabilized by foreign monetary policy because of a zero-lower-bound problem. More specifically, we assume that the Foreign policy interest rate is fixed for 10 periods. Afterwards monetary policy in Foreign targets price stability ( $\pi_t^* = 0$ ). We assume that the shock follows an AR(1) process with the persistence parameter 0.5. This assumptions ensures that the ZLB in Foreign remains a binding constraint for as long as the shock has a significant impact. In the second experiment, we consider an increase of government consumption in Home, assuming again an AR(1) process and set the persistence parameter to 0.9. In all instances, we contrast the adjustment under the three policy scenarios analyzed above: an unconstrained monetary policy; the case in which the interest rate does not respond to the shock for 10 periods; and the case of a currency peg.

### 4.1 Domestic implications of a global recession

In Figure 2, we look at the transmission of the Foreign savings shock, which causes a sharp and persistent contraction in Foreign consumption and inflation (not shown). In each panel vertical axes measure deviations from the pre-shock path, in percent of steady-state output (in case of quantities) or percent (in case of prices). From the vantage point of the small open

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<sup>9</sup>These assumptions imply that the restriction imposed on the  $\sigma$  and  $v$  which imposed in our analytical derivations is not satisfied. Yet it turns out that our simulation results are fully in line with our analytical results. They also hold for a wide range of alternative values for  $\sigma$  and  $v$ .

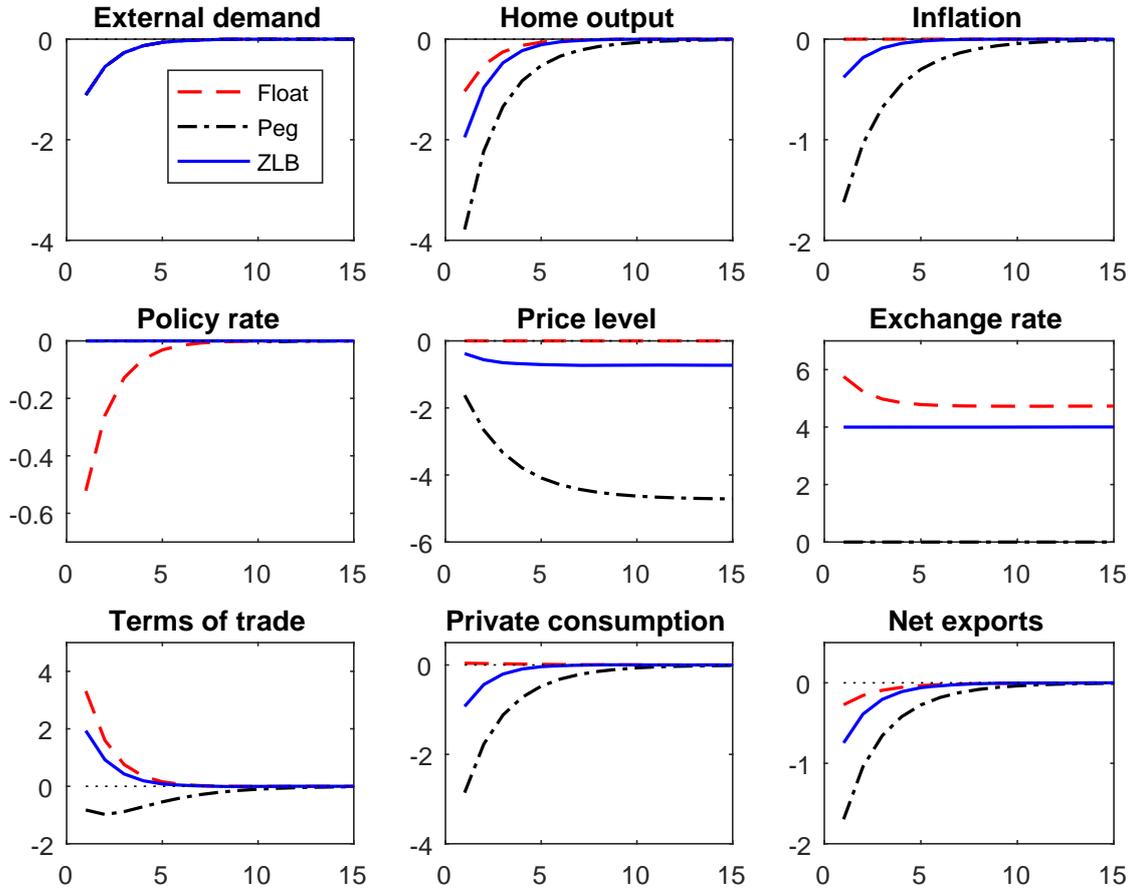


Figure 2: Adjustment to one-percent drop of external demand: unconstrained monetary policy in Home (dashed line) vs constant-interest-rate period of 10 quarters (solid line) and exchange rate peg (dash-dotted line). Horizontal axes measure time in quarters. Vertical axes measure deviations from the pre-shock path, in percent of steady state output (in case of quantities) or percent (in case of prices).

economy, the shock translates into a sharp fall in the external demand (upper-left panel). In equilibrium, the shock generates financial inflows corresponding to an external deficit in the trade balance (depicted in lower-right panel). Contrasting the three scenarios for Home monetary policy, we find the impact of the shock on Home output most adverse under a peg (marked by a dash-dotted line in the figure), intermediate under a float but with policy rates fixed for 10 quarters (solid line), and minimal under a float with an unconstrained monetary policy (dashed line). Our simulation also suggests that the differences across scenarios are quantitatively relevant.

Several aspects of the transmission mechanism are noteworthy. Starting from the scenario of unconstrained monetary policy (dashed line), observe that under a floating exchange rate regime the contraction in economic activity is only marginal. It turns out that the Home

country is able to insulate its economy from the external shocks via a large, upfront cut in interest rates (2nd row, left panel), associated to a large depreciation of the nominal exchange rate (2nd row, right panel). Internal demand (3rd row, middle panel) actually rises at the margin, since a regime of price stability means that expectations of inflation remain firmly anchored and the long-term real rate, relevant to the consumption decisions, falls substantially with the current and anticipated monetary stance. Despite nominal depreciation and weakening terms of trade (3rd row, left panel), the contraction in external demand causes a trade deficit. By pursuing price stability, monetary policy effectively tilts aggregate demand towards domestic consumption.

Exchange rate flexibility plays a crucial role also when Home monetary policy is constrained by the zero lower bound. The economic outlook worsens relative to that under an unconstrained monetary policy, since insufficient short-term monetary stimulus means that domestic demand remains inefficiently low. But the depth of the Foreign contraction and deflation translates into a Home permanent nominal depreciation. The exchange rate thus weakens the link with the deflationary drift in Foreign: dynamically, the Home price level falls somewhat (2nd row, middle panel), but not as strongly as in Foreign. The real exchange rate depreciates and the terms of trade worsens, although by less than in the previous case—net exports deteriorate by more. The contraction in both the internal and external demand causes sizeable drop in output.

Because of deflation in Foreign, the worst performing regime is the currency peg. If the foreign country were not at the ZLB and, hence, suffered no deflationary drift, a peg would in fact have desirable features. Indeed, to the extent that a credible peg is an implicit commitment to a stable price level, the transmission of *domestic* adverse demand shocks would be muted, because any short run fall in domestic prices associated with such shocks would in the medium and long run be offset by positive inflation (Corsetti et al., 2013a). When the Foreign country is at the ZLB, and the shock is a demand shock that originates in Foreign, instead, this conclusion is turned on its head. The implicit domestic commitment under a peg to follow the unstable foreign price level works perversely and amplifies the domestic downturn, by generating expectations of sustained domestic deflation. The terms of trade actually appreciate, exacerbating the contraction of domestic net exports in response to the shock to foreign demand.

## 4.2 The scope for fiscal stabilization

Figure 3 traces the effect of an increase of government spending (itself depicted in the upper-left panel). In the case of a free float, as long as monetary policy is unconstrained, the fiscal

expansion has moderate effects. With the monetary authority ensuring price stability, more government spending leads to a monetary contraction and real appreciation. It raises output, but only at the cost of crowding out domestic consumption and net exports. The multiplier is substantially below one. Conversely, fiscal policy is quite powerful when the domestic policy rates are temporarily constant at the ZLB. Persistently higher government spending raises expected inflation, thus lowering the long-term real rate: private consumption rises substantially. At the same time, the fall in long-term rates causes the nominal exchange rate to depreciate. Domestic consumption rises with domestic inflation. In addition, net exports rise on the back of real depreciation. Comparing the ZLB case across the Figures 2 and 3 illustrates the “benign coincidence” discussed above: under those circumstances in which the external shocks become more damaging because of the constraint on monetary policy, fiscal policy is a powerful substitute for monetary stabilization.

In a world recession at the zero lower bound, the benign coincidence breaks down when the country pursues a currency peg. The graphs in the figure shows that—contrary to conventional wisdom—fiscal policy is not particularly effective in a fixed exchange rate regime, that is, precisely in the one regime where the adverse external shock is most consequential for Home output and consumption—compare, again, Figures 2 and 3. The mechanism harnessing the transmission of fiscal policy, as discussed in Corsetti et al. (2013a), is illustrated by the panel in the middle of the figure: by the working of PPP in the medium and the long run, under a peg, the initial positive response of inflation to a government spending expansion, is offset over time: the price level reverts back to the initial level, which coincides with the price level in Foreign. This is in sharp contrast with the ZLB scenario under flexible exchange rate. There, the Home price level keeps increasing over the entire life of the fiscal expansion. Under a peg, the overall monetary stance, measured by the rise in the long-term real rates, therefore, is less rather than more accommodative than under a float with a ZLB; and the fiscal multiplier is correspondingly lower.

### 4.3 Financial frictions and sovereign risk

So far we have proceeded under the assumption of frictionless financial markets, both within a country and across borders. This assumption is necessary in order to obtain the closed-form results discussed in the previous section, but is also consequential for macroeconomic dynamics. In what follows, we perform a sensitivity analysis and relax the assumption of complete financial markets. We posit that cross-border trade is limited to non-contingent nominal bonds, and, in addition, we consider the possibility that Home is vulnerable to a deterioration in the agents’s assessment of sovereign risk.

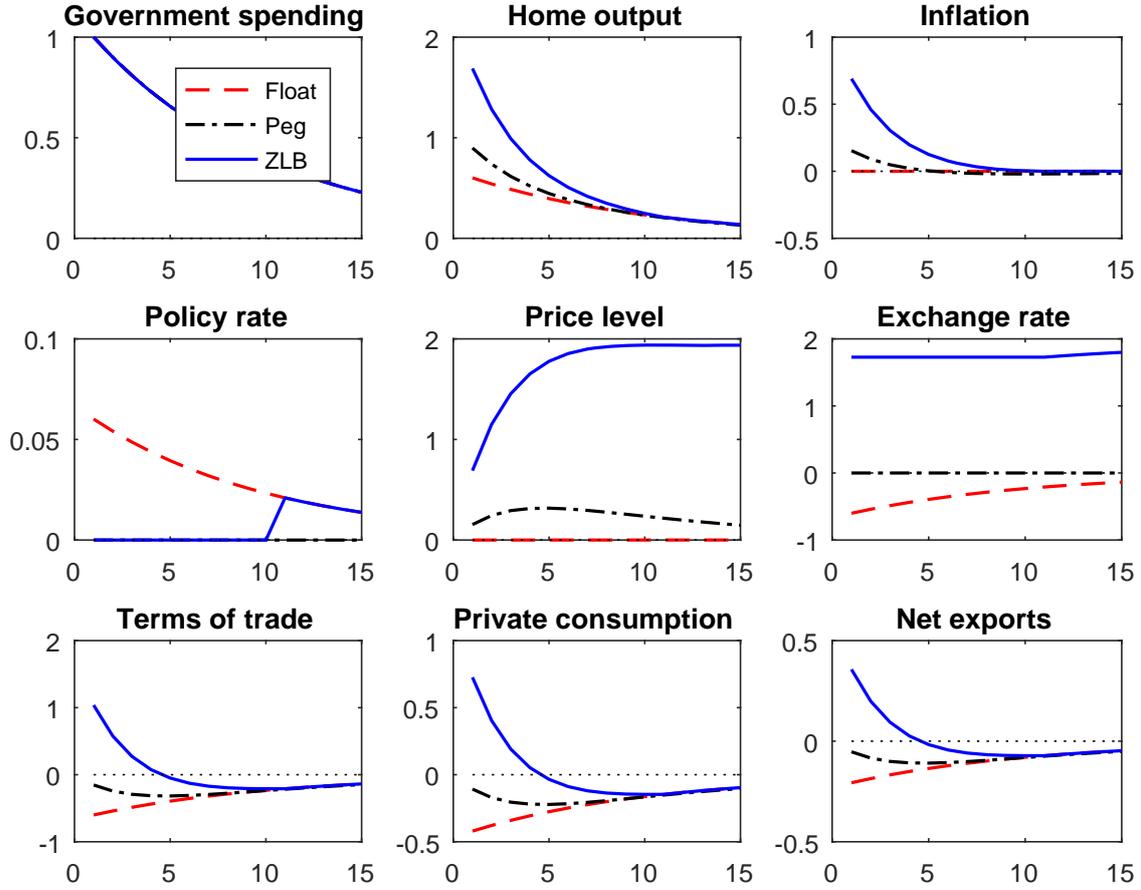


Figure 3: Effect of domestic government spending increase: unconstrained monetary policy (dashed line) vs constant-interest-rate period of 10 quarters (solid line) and exchange rate peg (dash-dotted line). Horizontal axes measure time in quarters. Vertical axes measure deviations from the pre-shock path, in percent of steady state output (in case of quantities) or percent (in case of prices).

Drawing on our previous work (Corsetti et al., 2013b, 2014), we assume that sovereign risk is increasing as public debt builds up. Higher sovereign risk, in turn, induces a rise of borrowing costs in the private sector (see also Bocola, forthcoming). This specification entails that sovereign risk premia result in a contraction of aggregate demand and therefore a drop in current economic activity, independently of whether sovereign default actually takes place or not. We provide some details on the modified model in Appendix A.5. Throughout we continue to assume that Home is small.

Using the extended model, we first establish that, in our parameterization, the propagation of the external-demand shock (triggered by Foreign saving shock) is not fundamentally different if we move from the complete-market economy to an economy where there is trade in nominally non-contingent bonds only. With cross-border trade in non-contingent assets, whether or not

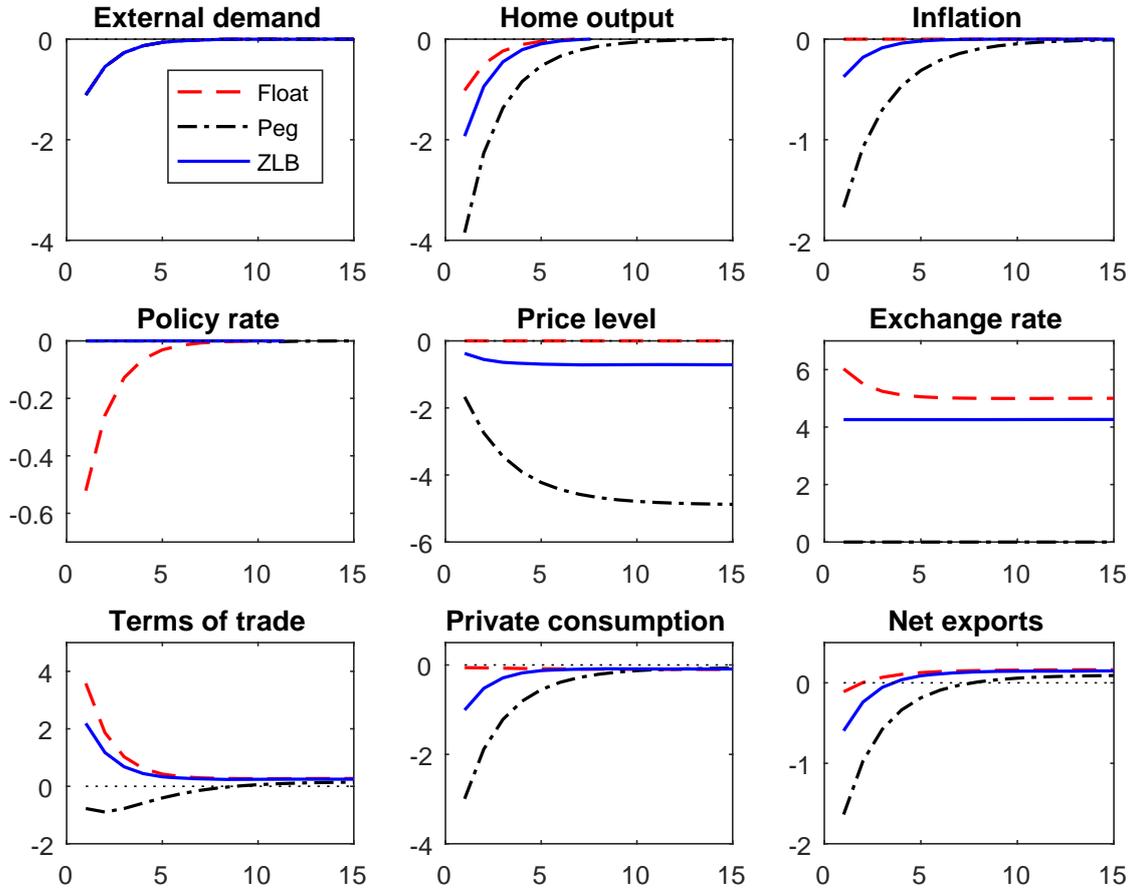


Figure 4: Adjustment to one-percent drop of external demand under incomplete international financial markets; unconstrained monetary policy in Home (dashed line) vs constant-interest-rate period of 10 quarters (solid line) and exchange rate peg (dash-dotted line); see Figure 2 for details.

markets price sovereign risk, the transmission of a world great recession is least damaging under a float and price stability, most damaging under a peg—the zero lower bound being the intermediate case.

Figure 4 shows the dynamic adjustment in case of incomplete markets, absent sovereign risk. Under our parameterization, the difference between the complete and incomplete market economy is trivial.<sup>10</sup> Intuitively, the global shock we place at the core of our analysis is temporary. Self-insurance via intertemporal trade in bonds and the equilibrium response of the terms of trade and the real interest rate at global level allow a small open economy to

<sup>10</sup>A qualitative difference worth mentioning concerns the response of net exports and consumption under a float with an unconstrained monetary policy. In the complete markets model, the saving shock in the Foreign country generates a larger financial inflow into the Home country. Correspondingly, Home consumption rises, if only at the margin, and the exchange rate depreciates. The capital inflow is less pronounced in the bond economy. Home consumption falls, while a more pronounced depreciation produces a small trade surplus over time.

achieve an allocation that is not too far from that with perfect risk sharing.

Sovereign risk has only a moderate effect on the transmission of external shocks—including the sovereign risk channel in the model results in a mild amplification of the adverse business cycle disturbances. Since numerical results are quite similar to Figure 4, we omit a graph but focus instead on summarizing the qualitative differences in our findings. Namely, relative to the previous experiment, as output collapses in response to the external shock, government debt builds up due to the working of the automatic stabilizers. The fiscal outlook worsens, affecting the probability of default. Markets, in turn, call for a higher sovereign risk premium which impacts private borrowing conditions adversely. This reduces aggregate demand and activates an adverse loop: lower demand translates into lower activity, hence higher deficits and debt; higher debt raises sovereign risk and borrowing costs further.<sup>11</sup>

There is however one dimension in which the sovereign risk channel is most consequential. This is the transmission and effectiveness of fiscal stabilization, which may be eroded by a loss of confidence in fiscal stability when the government pursues deficit-financed expansions. Figure 5 shows the adjustment to an increase of Home government consumption by one percent of GDP. The left column shows the responses of the economy under the float and unconstrained Home monetary policy. The middle column corresponds to a float with the ZLB constraint binding in Home. The panels on the right show the responses under the permanent peg. In each of the panels, a solid line marks the responses that would prevail absent the sovereign risk channel. The dashed line marks the responses with sovereign risk.

Focus on the panels in the fifth row, which show the response of consumption. Across the three scenarios for monetary policy, sovereign risk amplifies the crowding out effect of government spending on domestic demand. There is crowding out even at the zero lower bound, whereas in the model without the sovereign risk channel prospective inflation from public demand would crowd-in consumption (see Figure 3 above). Somewhat surprisingly, however, economic activity is not necessarily lower with sovereign risk (4th row). It is relatively stronger in the case of a float and price stability; it also becomes stronger over time in the other two scenarios in the figure. What drives this result is the dynamics of net exports (bottom row), which record large surpluses in all cases, either on impact (if exchange rates are flexible) or over time (under a peg), clearly helped by a large real depreciation (3rd row).

The consequences of sovereign risk for the exchange rate and economic dynamics is the sub-

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<sup>11</sup>Under a float and an unconstrained monetary policy, sovereign risk causes more current and/or future monetary accommodation, reflected by exchange rate depreciation upfront. Although consumption falls, it actually falls by less than in the absence of foreign risk—net exports are correspondingly lower. Monetary accommodation and upfront depreciation is instead lower in the ZLB case: the fall in consumption is now more pronounced than in the absence of sovereign risk, making room for a stronger net export dynamic. Under a peg, sovereign risk exacerbates and magnify the effects under the ZLB scenario.

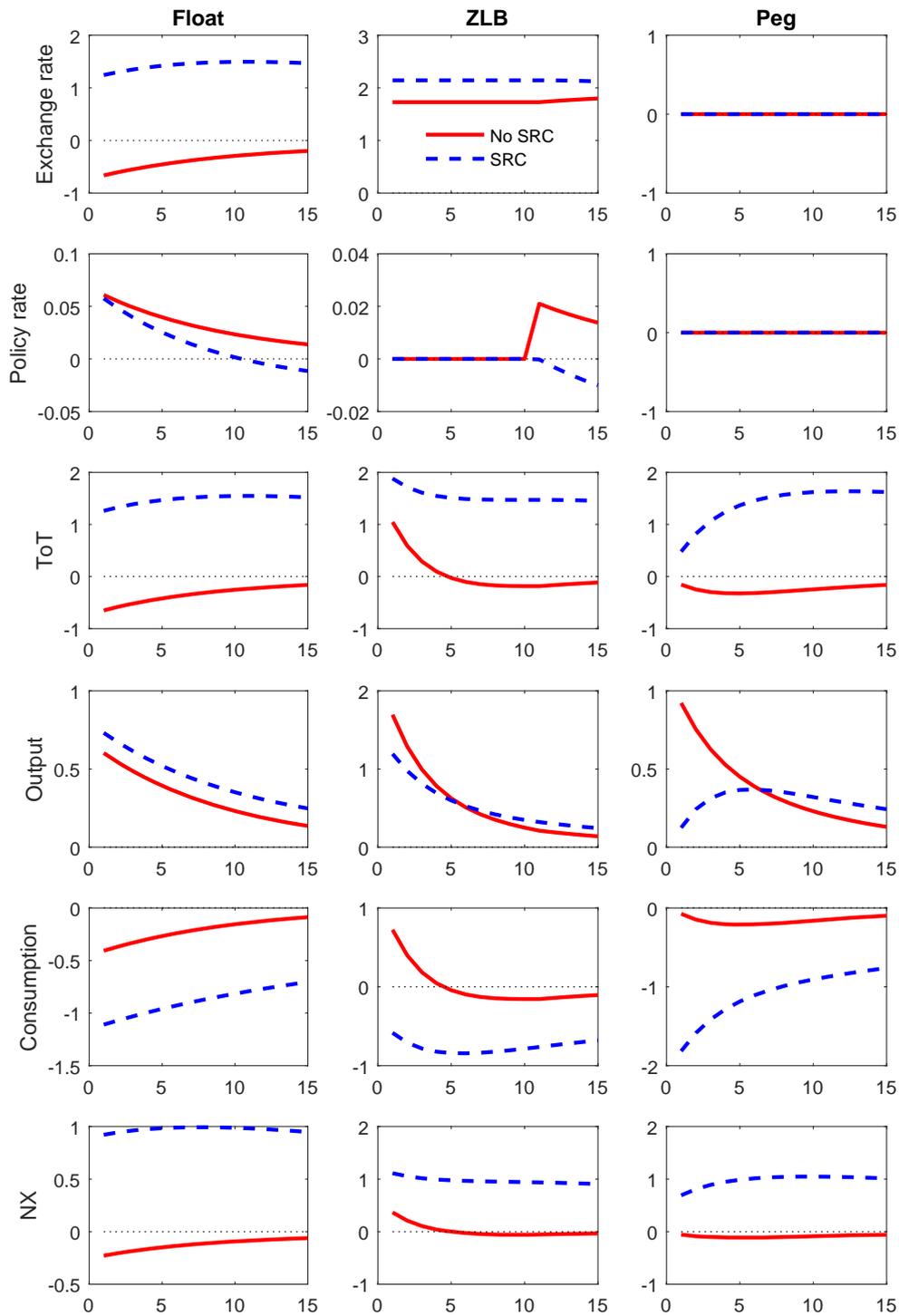


Figure 5: Effect of increase of government spending in Home w/ (dashed line) and w/o (solid line) sovereign risk: see Figure 3 for details; international financial markets assumed to be incomplete.

ject of a small but significant debate. Based on its consequences on the exchange rate, Krugman (2014) strongly argues that prospective sovereign risk should not be used as an argument against the use of countercyclical fiscal policy. If interest rates rise with a fiscal expansion—Krugman argues—their negative effects on output will be offset by a large depreciation boosting external demand. Figure 5 substantiates but also qualifies Krugman’s view.

Under a float, our results appear to lend support to Krugman (2014): the output multiplier of public spending is actually larger with sovereign risk. Nonetheless, it is worth stressing that the stronger expansion of output is accompanied by a sharp deterioration of domestic consumption—i.e., it corresponds to a sharp change in the composition of aggregate demand, whereas a boom in exports more than offset a contraction of internal component. The output expansion is largest when the policy rate is not constrained by the zero lower bound, since the central bank can engineer a stronger response to the collapse in internal demand, less pronounced when monetary policy is constrained. While a smaller monetary accommodation at the zero lower bound means less depreciation, the exchange rate still adjusts sharply upfront, favoring large external surpluses. These offset the crowding out effects of government spending on domestic demand via the sovereign risk channel (i.e. high private borrowing costs). Under a peg, there is no depreciation, hence the spending multiplier becomes very small.

Our reconsideration of the argument by Krugman—that sovereign risk can be expansionary—indeed clarifies that, first, the extent of exchange rate depreciation eventually reflects the degree of monetary accommodation. Second, while effective in preventing a contraction in economic activity, fiscal stimulus cannot prevent (actually it causes) a contraction in internal demand and deflation. In light of this observation, and especially given the limits of our understanding of financial and fiscal crises, the arguments for dynamic budget correction and policies maintaining a stable fiscal outlook remain strong.

The strong response of net export to government expansion is also noteworthy in light of the ongoing controversy on currency war. Our model suggests that, in a sovereign risk crisis, even fiscal stabilization—typically targeted to sustain internal demand—tends to increase net saving in the economy, and require currency depreciation to be effective.

In the previous section, we have entertained the notion that the stabilization of large external shocks under flexible exchange rates may rely on a “benign coincidence”: absent sovereign risk, fiscal policy becomes most effective when monetary policy is constrained by the zero lower bound. This benign coincidence breaks down in a currency peg, and becomes much less favorable and reliable in the presence of sovereign risk.

## 5 Conclusion

The risk of large global shocks causing once again the world to fall in a great recession is a challenge to policymaking in small open economies, which may be particularly vulnerable to external shocks. In this paper we have drawn on the recent literature to provide a stylized synthetic discussion of the effectiveness of different policy options in such circumstances, across alternative exchange rate regime. Qualifying features of our analysis are, first, the fact that we analyze alternative policies and regimes in a small open economy against the same background—a world saving shock causing a collapse of aggregate demand and a deflationary crawl, with the world policy rates to reach their zero lower bound. Second, in reassessing the relative importance of fiscal and monetary instruments, we explicitly account for potential constraints on either, in the form of a zero lower bound constraint on domestic monetary policy, or concerns with sovereign risk crises limiting the expansionary effects of fiscal stimulus. By doing so, we are able to emphasize the specific way in which a flexible exchange rates can act as shock absorbers in circumstances that, after the global crisis, may re-occur in the near future. Key to our results is the ability of policymakers to delink their economy from the deflationary crawl that may afflict the world economy in a great recession. This requires Home policymakers to manage a depreciation drift in the Home nominal exchange rate, on top and above the nominal and real depreciation needed to buffer the collapse in external demand.

Constraints on monetary policy raise the value of fiscal policy, but again this turns out to be effective only as long as the monetary regime can accompany fiscal stimulus with enough monetary accommodation, and the exchange rate regime can insulate the evolution of the domestic price level from the price level abroad. For this reason, fiscal policy turns out to be particularly effective when domestic rates are at the zero lower bound, but not in a peg. Modern monetary theory indeed questions the conventional wisdom from the textbook rendition of the Mundell-Fleming model, that fiscal policy is a reliable alternative to monetary policy in a currency peg or a monetary union. This is especially so, when policymakers face the risk of a loss of confidence in the debt market, eventually affecting the borrowing costs and conditions faced by all private agents, firms and households, residing in the country.

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## A A New Keynesian open-economy model

Our model is a simplified version of the two-country model put forward in Corsetti et al. (2012), as we abstract from investment and wage rigidities. Home trades with the rest of the world, consolidated in a Foreign country. Both countries produce a variety of country-specific intermediate goods, with the number of intermediate good producers normalized to unity. A fraction  $n$  of firms is located in Home, the remaining firms  $(n, 1]$  is located in Foreign. Analogously, Home accounts for a fraction  $n \in [0, 1]$  of the global population. Intermediate goods are traded across borders while final goods, which are bundles of intermediate goods, are not. Prices of intermediate goods are sticky in producer-currency terms. Households supply labor services only within the country where they reside, but trade assets internationally. For the sake of analytical tractability, in our baseline, they will trade a complete set of state-contingent assets.

Many of the features of the model are standard, so we keep the exposition short. We focus our exposition on Home. When necessary, we refer to foreign variables by means of an asterisk.

### A.1 Households

There is a representative household in each country. Letting  $C_t$  denote a consumption basket (defined below) and  $H_t$  labor supply, the objective of the household is

$$\max E_t \sum_{k=0}^{\infty} (e^{\xi_{t+k}} \beta^k) \left( \ln C_{t+k} - \frac{H_{t+k}^{1+\varphi}}{1+\varphi} \right), \quad (25)$$

where  $\xi_t$  is a zero-mean shock to the time-discount factor,  $\beta \in (0, 1)$  is the discount factor, and  $\varphi > 0$  is the inverse of the Frisch elasticity of labor supply.

In our baseline, the household trades a complete set of state-contingent securities with the rest of the world. Letting  $\mathcal{X}_{t+1}$  denote the payoff in units of domestic currency in period  $t+1$  of the portfolio held at the end of period  $t$ , the budget constraint of the household is given by

$$E_t \{ \rho_{t,t+1} \mathcal{X}_{t+1} \} - \mathcal{X}_t = (1 - \tau)(W_t H_t + \Upsilon_t) - T_t - P_t C_t.$$

Here  $\rho_{t,t+1}$  is the nominal stochastic discount factor.  $W_t$  is the nominal wage.  $\Upsilon_t$  are the domestic firms' nominal profits.  $\tau$  is a constant tax rate,  $T_t$  are lump-sum taxes.  $P_t$  is the price index for the final consumption basket. The consumption baskets themselves are not traded across borders. Their components are, however. The baskets consist of bundles  $A_t$  and  $B_t$  of, respectively, domestically and foreign produced intermediate goods. The final

consumption basket  $C_t$  ( $C_t^*$ ) is produced using the following aggregation technology

$$C_t = \left\{ [(1 - (1 - n)v)]^{\frac{1}{\sigma}} A_t^{\frac{\sigma-1}{\sigma}} + [(1 - n)v]^{\frac{1}{\sigma}} B_t^{\frac{\sigma-1}{\sigma}} \right\}^{\frac{\sigma}{\sigma-1}}, \quad (26)$$

$$C_t^* = \left\{ [nv]^{\frac{1}{\sigma}} (A_t^*)^{\frac{\sigma-1}{\sigma}} + [(1 - nv)]^{\frac{1}{\sigma}} (B_t^*)^{\frac{\sigma-1}{\sigma}} \right\}^{\frac{\sigma}{\sigma-1}}, \quad (27)$$

where  $\sigma$  measures the terms of trade elasticity of the relative demand for domestically produced goods and  $v \in [0, 1]$  measures the home bias.<sup>12</sup>

The bundles of domestically and imported intermediate goods are defined as follows

$$A_t = \left[ \left( \frac{1}{n} \right)^{\frac{1}{\epsilon}} \int_0^n A_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}}, \quad B_t = \left[ \left( \frac{1}{1-n} \right)^{\frac{1}{\epsilon}} \int_n^1 B_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}}, \quad (28)$$

where  $A_t(j)$  and  $B_t(j)$  denote intermediate goods produced in Home and Foreign, respectively, and  $\epsilon$  measures the elasticity of substitution between intermediate goods produced within the same country.

The household minimizes expenditures subject to (26) and (28). Specifically, let  $P_t(j)$  denote the price of an intermediate good expressed in domestic currency and  $\mathcal{E}_t$  the nominal exchange rate (the price of foreign currency in terms of domestic currency). We assume that the law of one price holds, so that

$$\mathcal{E}_t P_t^*(j) = P_t(j). \quad (29)$$

The household's expenditure minimization implicitly defines a demand function for intermediate goods. Assuming that government consumption,  $G_t$ , is a bundle isomorphic to final goods, but consisting of domestically produced goods only, global demand for a generic intermediate good produced in Home and Foreign is, respectively:

$$Y_t^D(j) = \left( \frac{P_t(j)}{P_{Ht}} \right)^{-\epsilon} \left\{ \left( \frac{P_{Ht}}{P_t} \right)^{-\sigma} \left[ (1 - (1 - n)v)C_t + (1 - n)vQ_t^\sigma C_t^* \right] + G_t \right\}, \quad (30)$$

$$Y_t^D(j)^* = \left( \frac{P_t^*(j)}{P_{Ft}^*} \right)^{-\epsilon} \left\{ \left( \frac{P_{Ft}^*}{P_t^*} \right)^{-\sigma} [nvQ_t^{-\sigma} C_t + (1 - nv)C_t^*] \right\}, \quad (31)$$

where price indices are given by

$$P_{Ht} = \left[ \frac{1}{n} \int_0^n P_t(j)^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}}, \quad P_{Ft} = \left[ \frac{1}{1-n} \int_n^1 P_t(j)^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}}, \quad (32)$$

<sup>12</sup>This specification follows Sutherland (2005) and De Paoli (2009). With  $v = 1$ , there is no home bias: if the relative price of foreign and domestic goods is unity, the fraction of domestically produced goods which ends up in the production of final goods is equal to  $n$ , while imports account for a share of  $1 - n$ . Importantly, final goods are identical across countries in this case. A lower value of  $v$  implies that the fraction of domestically produced goods in final goods exceeds the share of domestic production in the world economy. If  $v = 0$ , there is full home bias and no trade across countries.

$$P_t = [(1 - (1 - n)v)P_{Ht}^{1-\sigma} + ((1 - n)v)P_{Ft}^{1-\sigma}]^{\frac{1}{1-\sigma}}, \quad (33)$$

$$P_t^* = [nv(P_{Ht}^*)^{1-\sigma} + (1 - nv)(P_{Ft}^*)^{1-\sigma}]^{\frac{1}{1-\sigma}}, \quad (34)$$

and

$$Q_t = \frac{\mathcal{E}_t P_t^*}{P_t} \quad (35)$$

measures the real exchange rate.

## A.2 Firms

Intermediate goods producers sell under monopolistic competition, facing the demand function (30). The production function is Cobb-Douglas:

$$Y_t(j) = H_t(j) \quad (36)$$

where  $H_t(j)$  denotes labor services employed by firm  $j \in [0, n]$  in period  $t$ .

We assume that prices are set in the currency of the producer and that price setting is constrained exogenously à la Calvo, so that in each period only a fraction of intermediate good producers  $(1 - \alpha)$  may adjust its price. When firm  $j$  has the opportunity, it sets  $\tilde{P}_t(j)$  to maximize the expected discounted value of net profits:

$$\max_{\tilde{P}_t(j)} \sum_{k=0}^{\infty} \alpha^{t+k} E_t \rho_{t,t+k} \left\{ \tilde{P}_t(j) Y_{t+k}^D(j) - \Psi [Y_{t+k}^D(j)] \right\}$$

subject to the demand function (30) and the production function (36);  $\Psi [Y_{t+k}^D(j)]$  measures costs. Domestic households own the firms, so profits are discounted with the domestic households' stochastic discount factor.

## A.3 Monetary and fiscal policy

We assume that monetary policy is conducted by adjusting the short-term nominal interest rate:

$$R_t \equiv 1/E_t \rho_{t,t+1}.$$

As regards fiscal and budget policy, we assume that Home government spending falls on an aggregate of domestic intermediate goods only. We also posit that intermediate goods are assembled so as to minimize costs. Thus the price index for government spending is given by  $P_{H,t}$ . In the first part of the paper, without loss of generality, we assume that the government budget is balanced in each period by means of lump-sum taxes  $T_t$ . In the second part of the paper, we will consider a richer specification, so as to account for the possibility of sovereign risk.

## A.4 Equilibrium

In equilibrium, firms and households optimally choose prices and quantities subject to their respective constraints and initial conditions while markets clear. At the level of intermediate goods we have  $Y_t(j) = Y_t(j)^D$ . Defining an index for aggregate output  $Y_t = \left( \int_0^1 Y_t^{\frac{\epsilon-1}{\epsilon}}(j) dj \right)^{\frac{\epsilon}{\epsilon-1}}$ , we obtain

$$Y_t = \left( \frac{P_{Ht}}{P_t} \right)^{-\sigma} [(1 - (1 - n)v)C_t + (1 - n)vQ_t^\sigma C_t^*] + G_t. \quad (37)$$

Labor markets clear if

$$H_t = \int_0^n H_t(j) dj \quad (38)$$

Finally, asset markets clear by Walras' law.

In our analysis we below, we focus on the limiting case  $n \rightarrow 0$  for the size of the domestic economy:

$$\begin{aligned} Y_t &= \left( \frac{P_{Ht}}{P_t} \right)^{-\sigma} [(1 - v)C_t + vQ_t^\sigma C_t^*] + G_t, \\ Y_t^* &= C_t^*. \end{aligned}$$

This makes the Home economy de facto a small open economy. Foreign, instead, operates like a closed economy. But – importantly – it may be a source of shocks for Home.

## A.5 Incomplete financial markets

We also consider a variant of the model where financial markets are incomplete. Specifically, we in the modified model, we restrict asset trade to nominally non-contingent bonds only. Moreover, we relax the assumption that government debt is neutral and allow it to impact the economy through the sovereign risk channel. Denote with  $D_t$  the stock of nominal debt issued by the fiscal authorities, assumed to have a maturity of one period. The period budget constraint of the government reads as follows:

$$Q_{D,t}D_t = D_{t-1}[1 - \delta I(\text{default in } t + 1)] + G_t - \tau Y_t - T_t, \quad (39)$$

where  $\delta > 0$  is the fixed haircut that the government applies to private holders of its own debt in those states of the world in which it defaults.  $I(\text{default in } t + 1)$  is the indicator function that takes a value of one in case the government defaults and is zero otherwise. As in Corsetti et al. (2013b), the probability of default in period  $t$ ,  $p_t$ , may increase in the level of debt relative to steady-state output according to the following random function:

$$p_t = F_{\text{beta}} \left( \frac{D_t}{4Y} \frac{1}{d}; \alpha_{bg}, \beta_{bg} \right). \quad (40)$$

Here  $\bar{d}$  denotes the upper end of the support for the debt-to-GDP ratio and  $F_{\text{beta}}$  marks the CDF of the beta distribution. That is, from an *ex ante* perspective, the government applies the haircut  $\delta$  in the next period with probability  $p_{t+1}$ . With the opposite probability, the government will comply with its promises to pay.

Finally, we postulate that lump-sum taxes adjust to stabilize debt in the following way:

$$T_t = \phi_d D_t, \quad \text{with } \phi_d > 1 - \beta.$$

Households trade two discount bonds on international financial markets, one paying one unit of domestic currency in the next period, the other one unit of foreign currency. Specifically, letting  $B_t$  denote the domestic-currency bond and  $B_t^*$  the foreign-currency bond, traded at price  $Q_{B,t}$  and  $Q_{B^*,t}$ , respectively, the budget constraint of a household in Home reads as follows

$$Q_{B,t}B_t + Q_{B^*,t}B_t^*\mathcal{E}_t + P_t C_t = (1 - \tau)Y_t - T_t + B_{t-1} + B_{t-1}^*\mathcal{E}_t, \quad (41)$$

where  $\tau$  is a constant tax rate.

For tractability, we assume that sovereign default is possible only in the Home country and that the marginal investor in sovereign bonds is a small mass of risk-neutral investors in Foreign. Since Home bonds are subject to both outright sovereign default (a haircut), and the risk of changes in the price of currencies, the bond price schedule is

$$Q_{D,t} = \beta E_t \{ [1 - \delta I(\text{default in } t + 1)] \mathcal{E}_t / \mathcal{E}_{t+1} \}. \quad (42)$$

Sovereign default risk in the Home country, in turn, is assumed to spill over to private-sector bond prices as follows

$$Q_{B,t} = R_t^{-1} E_t [1 - \eta \delta I(\text{default in } t + 1)], \quad Q_{B^*,t} = \beta E_t [1 - \eta \delta I(\text{default in } t + 1)]. \quad (43)$$

where the parameter  $\eta \geq 0$  captures the degree of spillover of sovereign risk into private borrowing. Following Corsetti et al. (2013b) we rationalize a value of  $\eta$  larger than zero by the observation that private-sector contracts may not be fully enforced in the event of a sovereign default.<sup>13</sup> Importantly, however, we assume that even though lenders may not be fully serviced in the event of sovereign default, borrowers may not retain resources either. Rather, resources are lost in the process.<sup>14</sup>

We reconsider our earlier experiments in our modified model, based on simulations throughout. For this purpose we rely on a first order approximation to the equilibrium conditions

<sup>13</sup>Specification (43) follows Kriwoluzky et al. (2015).

<sup>14</sup>Hence, whether the sovereign defaults or not has no direct bearing on the household's budget constraint. Otherwise, borrowers' interest rate would rise with sovereign risk only *notionally*, not affecting behaviour up to first order, as explained in Cúrdia and Woodford (2009). Bocola (forthcoming) models the pass-through of sovereign risk while explicitly accounting for financial intermediation.

around a deterministic steady state. As before, there is no debt and inflation in steady state. The strength of the sovereign risk channel is captured three sets of parameters: the sensitivity of  $F_{\text{beta}}$  to the debt level (how steeply the default risk rises in debt), the size of the haircut in the event of default,  $\delta$ , and the spillover parameter  $\eta$ . Eventually, our assumptions imply that an increase of sovereign debt by one percent of GDP, raises the interest rates faced by the private sector by half a basis point. This corresponds to a scenario of severe fiscal stress, according to our earlier work (Corsetti et al., 2013b). We ensure stationarity by assuming that the private-sector interest rate is also elastic in the net foreign asset position of the private sector (Schmitt-Grohe and Uribe, 2003).

## B System of linear difference equations

A linear approximation to the equilibrium conditions of the complete markets model yields the following system of expectational difference equations. Small letters indicate the log deviation of a variable from its steady-state value. We first focus on the baseline model allowing for  $n \in [0, 1]$ .

### B.1 Baseline

Households supply labor according to

$$\tilde{w}_t = \varphi h_t + c_t + \frac{\tau}{1-\tau} \tilde{\tau}_t \quad (\text{B.1})$$

$$\tilde{w}_t^* = \varphi h_t^* + c_t^* + \frac{\tau}{1-\tau} \tilde{\tau}_t^*, \quad (\text{B.2})$$

where  $\tilde{w}_t$  is the (consumption) real wage. The optimal time path of consumption satisfies:

$$c_t = E_t(c_{t+1}) - (i_t - E_t\pi_{t+1}) \quad (\text{B.3})$$

$$c_t^* - \xi_t^* = E_t(c_{t+1}^* - \xi_{t+1}^*) - (i_t^* - E_t\pi_{t+1}^*). \quad (\text{B.4})$$

Under complete financial markets, we have the following risk-sharing condition:

$$(c_t - \xi_t) - (c_t^* - \xi_t^*) = q_t = (1 - v)s_t. \quad (\text{B.5})$$

Intermediate good firms' price-setting behavior is given by

$$\pi_{At} = \beta E_t \pi_{At+1} + \kappa m c_t \quad (\text{B.6})$$

$$\pi_{Bt}^* = \beta E_t \pi_{Bt+1}^* + \kappa m c_t^*, \quad (\text{B.7})$$

where marginal costs are given by

$$mc_t = \tilde{w}_t - q_{H,t} \quad (\text{B.8})$$

$$mc_t^* = \tilde{w}_t^* - q_{F,t}^*. \quad (\text{B.9})$$

The aggregate production function is given by

$$y_t = h_t \quad (\text{B.10})$$

$$y_t^* = h_t^*. \quad (\text{B.11})$$

Relative prices satisfy

$$\pi_{Ht} = q_{Ht} - q_{Ht-1} + \pi_t \quad (\text{B.12})$$

$$\pi_{Ft}^* = q_{Ft}^* - q_{Ft-1}^* + \pi_t^*, \quad (\text{B.13})$$

as well as

$$-q_t + q_{Ht} = q_{Ht}^* \quad (\text{B.14})$$

$$-q_t + q_{Ft} = q_{Ft}^*. \quad (\text{B.15})$$

From the definition of the real exchange rate we have

$$q_{Ft} - q_{Ft-1} = de_t + \pi_t^* - \pi_t + q_{Ft}^* - q_{Ft-1}^*. \quad (\text{B.16})$$

Deflated price indices

$$0 = (1 - (1 - n)\omega)q_{Ht} + (1 - n)\omega q_{Ft} \quad (\text{B.17})$$

$$0 = (1 - n\omega)q_{Ft}^* + n\omega q_{Ht}^*. \quad (\text{B.18})$$

Finally, there is market clearing:

$$y_t = (1 - n)v(c_y c_t^* + \sigma c_y q_t) - \sigma c_y q_{Ht} + (1 - (1 - n)v)c_y c_t + (1 - c_y)g_t \quad (\text{B.19})$$

$$y_t^* = nv(c_t - \sigma q_t) - \sigma q_{Ft}^* + (1 - nv)c_t^*. \quad (\text{B.20})$$

## B.2 Incomplete markets model

The incomplete markets model assumes  $n \rightarrow 0$ , that is, Home is small. Instead of the risk-sharing condition B.5, equilibrium require the following UIP condition to hold:

$$r_t - r_t^* = E_t e_{t+1} - e_t.$$

Also, we need to keep track private-sector bond holds. Assuming that foreign-currency bonds are in zero net supply we have:

$$\beta \hat{b}_t + \hat{c}_t = \hat{b}_{t-1} + (1 - \tau)y_t - \hat{c}_t - c_y q_{H,t} - \hat{t}_t. \quad (\text{B.21})$$

$$(\text{B.22})$$

If the sovereign risk-channel is operative, we need to keep track of government debt:

$$\beta \hat{d}_{t+1}^r = \hat{d}_t^r + \hat{g}_t - \hat{t}_t^r - \tau y_t \quad (\text{B.23})$$

$$\hat{t}_t = \psi_d \hat{d}_t. \quad (\text{B.24})$$

Here the second equation determines the adjustment of taxes to debt. Eventually, the sovereign risk channel alters the Euler equation in Home

$$c_t = E_t c_{t+1} - (i_t - E_t \pi_{t+1} + \chi d_t + \gamma \hat{b}_t),$$

where  $\chi$  captures the pass-through of sovereign risk (which rises in public debt) into private borrowing conditions;  $\gamma$  makes the effective interest rate dependent on the net foreign asset position.