Government spending shocks, sovereign risk and the exchange rate regime*

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Abstract

We analyse the effects of government spending shocks under different monetary regimes in the presence of sovereign default risk using a New Keynesian DSGE model for a small open economy. Default beliefs are introduced through a fiscal limit that determines the government's ability to service public liabilities. We find that an increase in government consumption generates positive output responses which are larger under flexible than fixed exchange rates, in contrast to the classical Mundell-Fleming paradigm. Intuitively, the increase in sovereign risk following the fiscal shock leads to a depreciation of the exchange rate that supports the trade balance under flexible exchange rates. Under fixed rates, however, the favourable relative price change induced by the increase in sovereign risk is eliminated by central bank intervention and only the crowding out effects of the fiscal expansion remain. When sovereign risk can worsen household's borrowing conditions, these results become more pronounced and we find that, under fixed exchange rates, the output response upon a government spending shock can even be negative for a sufficient degree of sovereign risk pass-through. Our results highlight the importance of sovereign risk in the transmission of fiscal policy changes and for the evaluation of macroeconomic stabilisation policy across monetary regimes.

JEL Classification: E32, E52, E62

Keywords: New Keynesian DSGE model, fiscal limit, sovereign risk, sovereign risk pass-through

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1 Introduction

One of the predictions of the traditional Mundell-Fleming model is that government spending multipliers are larger under fixed exchange rate regimes than under floating arrangements. This result depends on the crowding-out of net exports caused by the fiscal expansion, through an appreciation of the real exchange rate, and on the degree of monetary accommodation. Standard micro-founded New Keynesian models generally generate the same qualitative output responses to a government spending shock for different monetary regimes, albeit through different transmission mechanisms due to the forward-looking behaviour of agents embedded in these types of models (see e.g. Galí and Monacelli, 2008; Corsetti et al., 2011). In addition, the theoretical prediction of a larger fiscal multiplier under a peg than under a float has been confirmed empirically by Ilzetzki et al. (2010a) and Corsetti et al. (2012b). However, as is shown in Corsetti et al. (2012b), the impact responses of output to a government spending shock are lower under weak public finances. The possibility of even a *negative* fiscal multiplier, when government debt reaches unsustainable levels, has formerly been raised by Giavazzi and Pagano (1990) and Alesina and Perotti (1995) and more recently by Corsetti et al. (2012a). However, the role of the exchange rate has received insufficient consideration, despite its importance in evaluating the effects of discretionary fiscal policy in both traditional and New Keynesian open economy models, and it is yet unclear how fiscal policy effectiveness depends on the monetary regime in times of fiscal strain.

In this paper, we aim to revisit the main Mundell-Fleming results and analyse the effects of government spending shocks under flexible and fixed exchange rates in the presence of sovereign default risk. To this end, we augment an otherwise basic New Keynesian model for a small open economy, by including non-neutral government debt and a link between public and private credit conditions. The principal underlying motivation for this alternative framework is the increasing importance of sovereign debt in contemporary fiscal policies and the negative externalities associated with unsustainable levels of debt in both political and academic debate. We assume sovereign debt to be non-neutral in at least two ways. First, following Davig et al. (2010) and Schabert and van Wijnbergen (2011), among others, uncertainty about full repayment of public debt enters the model through a stochastic 'fiscal limit' which determines the sovereign's ability or willingness to service outstanding liabilities. Although this fiscal limit is unknown, it has a known distribution upon which default beliefs are formed and pricing decisions are made. Increases in government debt then raise the risk premium on bonds and affect the household's optimal intertemporal decisions through changes in the marginal effective real rate of return. Sovereign risk therefore generates an alternative to the traditional fiscal transmission mechanism. Second, following Corsetti et al. (2012a), the theoretical model allows for sovereign risk to pass through to private credit conditions. These asset market imperfections reflect heightened funding strains in the financial sector induced by fiscal stress. We model this 'sovereign risk channel' as a stylised endogenous risk premium on private external debt which is monotonically increasing in the degree of sovereign default risk.

The effects of government spending shocks are evaluated under both flexible and fixed exchange rate regimes. Under flexible exchange rates and in the presence of sovereign risk, the real exchange rate depreciates upon a fiscal shock, as foreign household's willingness to invest in domestic government debt falls with higher default beliefs, which supports output. The positive feedback between the exchange rate and aggregate output due to sovereign risk is absent under fixed exchange rates, as the central bank commits to keep the interest rate pegged to an exogenously determined foreign interest rate and thereby insulates the economy from changes in sovereign risk. Due to this absence, we obtain larger output responses under flexible exchange rates than under fixed rates, which stands in contrast to the Mundell-Fleming predictions and is the main result of the paper. In fact, our impulse response functions indicate that the difference between the size of the impact and cumulative multipliers across the two exchange rate regimes increases in the degree of country openness, the export elasticity and the elasticity of intertemporal substitution. Intuitively, the larger is the share of net exports in total output and the flatter is the foreign demand schedule for domestically produced goods, the more the production sector benefits from favourable relative price changes induced by a rise in sovereign risk. Under fixed exchange rates, these 'benefits' from sovereign risk are eliminated as the central bank intervenes to hold the peg, which is what causes the unconventional discrepancy in output multipliers across regimes. Furthermore, consumption increases upon a rise in government spending, which appears to be in line with the predictions of the Mundell-Fleming model, yet is generated by an entirely different transmission mechanism. Specifically, a deficit-financed fiscal expansion raises investor's perceived default risk and reduces the effective real rate of return causing households to intertemporally substitute future for current consumption.

In order to account for the recent empirical findings on sovereign risk pass-through (e.g. Acharya et al., 2011; Harjes, 2011), we allow for asset market imperfections reflected by a negative relationship between a private risk premium and unsustainable levels of government debt. Under this assumption, a deficit-financed government spending shock *lowers* household consumption due to the rise in sovereign risk and the risk premium on household loans. As sovereign risk crowds out private consumption under both regimes, fiscal policy is still more potent in terms of influencing aggregate output under flexible exchange rates than under fixed exchange rates. Hence, our main finding is robust to different assumptions regarding asset market characteristics.

Our results suggest the possibility of non-Keynesian effects of fiscal policy. Indeed, we show that a transient reduction in government spending can bring about a *positive* output response for a sufficiently high degree of sovereign risk pass-through, yet only under fixed exchange rates and only in the short-run. Particularly, an improvement in the fiscal balance allows for a reduction in the risk premium on household loans and hence an increase in private consumption. The larger is the feedback between public and private credit risk, the more likely it is that the fiscal consolidation will be expansionary. Furthermore, the fall in the probability of sovereign default leads to an increase in foreign demand for domestic assets and an appreciation of the exchange rate under a float. Due to price rigidity, firms are then forced to scale back production levels which exacerbates the decline in output. In fact, the stronger is the default elasticity with respect to changes in the steady state level of real debt, the greater is the output loss upon a fiscal contraction under flexible exchange rates. The effects of fiscal policy changes in the presence of sovereign risk therefore crucially depend on the type of monetary regime. Consequently, our findings are particularly relevant for countries who are contemplating to anchor their exchange rate or join a monetary union.

The remainder of this paper is structured as follows. In section 2, we discuss related literature on the implications of sovereign risk (pass-through) and the exchange rate for the effectiveness of discretionary fiscal policy. New empirical estimates of the fiscal effects on key macroeconomic variables are presented in section 3. The results suggest that, in an economy characterised by unsustainable levels of public debt, government spending shocks generate larger output multipliers under flexible exchange rates than under an exchange rate peg. In the two subsequent sections, we formally present the theoretical model that allows us to account for these empirical findings, while reconciling with the results of the traditional Mundell-Fleming model when sovereign risk is assumed to be absent. In order to isolate the effects of sovereign risk pass-through, we distinguish between two scenario's based on different assumptions regarding asset market characteristics. In section 4, we assume households have access to a complete set of internationally traded, state-contingent securities. In section 5, however, we introduce financial market incompleteness and imperfections, the latter arising from a risk premium on household loans that is increasing in the degree of sovereign risk. After discussing the calibration of the parameters in section 6, we evaluate the effects of an increase in government spending on the model's endogenous variables in section 7. We examine the implications of our results for the potential expansionary effects of a fiscal consolidation for different degrees of sovereign risk (pass-through) in section 8. Finally, section 9 summarises and provides a brief discussion on the merits of adopting a fixed versus a flexible exchange rate regime in light of our main findings.

2 Fiscal policy, (New) Keynesian economics and the implications of sovereign risk and the exchange rate

The effects of fiscal stimuli[1], through an increase in government consumption or a decrease in taxes or both, have been thoroughly analysed both theoretically and empirically, although consensus amongst economists on the quantitative, and even qualitative, effects has unfortunately not yet been attained.[2] Traditional Keynesian theory predicts, within the familiar text-book IS-LM model, that an exogenous increase in government spending raises aggregate demand, which allows firms to raise output and labour demand, and will, as prices are fixed in the short-run, increase private consumption. The Mundell-Fleming model carries the Keynesian transmission mechanism of fiscal policy over to a small open economy with perfect capital mobility and predicts larger fiscal multipliers under fixed exchange rate regimes than under floating arrangements. The underlying intuition is that, under a monetary regime of flexible exchange rates, an unanticipated fiscal stimulus increases

[1]With the 'effects of fiscal policy', and similar phrases, we refer to the dynamic responses of macroeconomic variables upon a fiscal policy change throughout the text. Hence, we abstain from the discussion on the welfare effects of fiscal policy.

[2]For a survey on the theoretical and empirical effects of discretionary fiscal policy, see Hebous (2011).

aggregate demand which raises demand for real money balances and, for a given money supply, the real interest rate. The consequent exchange rate appreciation crowds out net exports which *exactly* offsets the initial increase in aggregate output so as to restore equilibrium in the money market. This implies a zero net effect of fiscal policy on output. When, however, the central bank is committed to keep the nominal exchange rate fixed, it will prevent the domestic interest rate to deviate from an exogenously given world interest rate by expanding the money supply, thus allowing for a positive net output response to the fiscal shock.

The now standard New Keynesian models have been able to capture many of the conventional wisdom on fiscal policy effectiveness brought forth by Keynesian theory in a micro-founded framework with forward-looking, rational households, monopolistic competition and sticky prices. In most of these models, fiscal policy is Ricardian in the sense that the government commits to a strict balanced-budget type rule that ensures fiscal solvency in every period. Consequently, expectations regarding unsustainable levels of public debt are absent and do not affect the model's equilibrium allocations. This assumption makes these models ill-suited to assess the implications of sovereign default risk for fiscal policy effectiveness, which requires at least some form of government debt non-neutrality.

The recent sovereign debt crises in a number of European countries and other advanced economies have, however, prompted interest in the policy implications of sovereign risk, or more generally the economy's 'fiscal limit', for inflation and debt sustainability. Here, the fiscal limit is defined as a measure of the sovereign's ability or willingness to repay outstanding public liabilities and thus determines expectations of a sovereign default.[3] For example, in an environment where the economy is reaching its fiscal limit, Davig et al. (2010) study the effects of increasing debt on private sector expectations of future fiscal or monetary adjustments. They find that monetary policy becomes increasingly constrained in containing inflation when households consider monetisation of government debt to be more likely than large scale fiscal adjustments in order to avoid a breach of the fiscal limit. Schabert and van Wijnbergen (2011) propose a New Keynesian small open economy model including default beliefs and show that sovereign risk can induce high inflation and output volatility. Specifically, increases in default expectations (for example, due to a shock in public interest rate payments) reduce the effective real rate of return and lead to a rise in inflation as households lower their savings and raise current consumption. If the central bank then takes an active deflationary stance, or if the feedback between the level of debt and the primary budget surplus is sufficiently weak, government debt will follow an explosive path and equilibrium is left indeterminate.

Besides the effects of sovereign risk on macroeconomic stability, heightened fiscal strain could also adversely affect private credit conditions. Intuitively, as the probability of a sovereign default rises, the interest rate on and the price of the underlying bond rises and falls, respectively. This can affect private credit conditions in a number of ways. First, since banks often use sovereign bonds as collateral when acquiring (overnight) liquidity from the central bank, a reduction in the price

[3] The fiscal limit arises, for instance, from the economy's Laffer curve, where the limit depends on the maximum amount of tax revenue that can be generated, as in Bi (2012), or from strategic decisions in which the government balances the costs and benefits of a sovereign default, as in Eaton and Gersovitz (1981).

of bonds reduces the bank's collateral value and diminishes the scope to refinance existing debt at a given market interest rate. An increase in sovereign risk therefore raises private borrowing costs to the extent that the higher interest rate faced by banks is passed on to household and corporate loans. Second, a reduction in the value of sovereign debt also worsens the bank's capital adequacy ratio. Banks that operate under strict regulations which impose limits on the capital ratio and that risk falling below these limits are then forced to adjust their balance sheet in order to improve the ratio. Without a capital injection by the government, the banks then can either issue more equity or reduce their share of risky assets. Yet, because the former option tends to be quite expensive during times of financial crises (in terms of a higher required return on equity), banks are more likely to choose the latter, which includes extending less loans to households and firms, increasing retail interest rates and tightening borrowing conditions.[4]

This 'sovereign risk channel' has been shown to be present in the Euro area during 2007-2010 in Acharya et al. (2011). After a bank bailout by the government, the deterioration of a sovereign's creditworthiness results into a reduction of the probability of future bailout payments and subsidies and reduces the net present value of sovereign debt holdings, both of which tend to raise the financial sector's credit risk. Additionally, Harjes (2011) finds, for a sample of 11 Euro area countries in 2008-2011, that sovereign credit costs are closely related to private funding costs. In a theoretical contribution, Corsetti et al. (2012a) analyse the effects of a fiscal retrenchment in a variant of the New Keynesian model for a closed economy that also allows for a channel between public and private sector borrowing conditions through changes in sovereign risk. According to the authors, this channel *"captures the adverse effect of looming sovereign default risk on private sector financial intermediation."* (Corsetti et al., 2012a, p. 105). They find that, when monetary policy is constrained and unable to offset changes in the risk premium, the government spending multiplier becomes *negative* for a sufficient degree of sovereign risk such that fiscal consolidation could have potential expansionary effects. The sovereign risk channel therefore presents an alternative fiscal transmission mechanism through which increases in deficit-financed government spending, and associated increases in sovereign risk premia, crowd out household and firm consumption and investment through higher private credit risk.

These effects interact with the exchange rate regime in place. As described in De Grauwe (2012), for example, an increase in sovereign default expectations induces investors to substitute risky domestic sovereign bonds for relatively safe foreign bonds, causing the exchange rate to depreciate. This depreciation in turn boosts net exports and hence aggregate output. If, however, the currency is not allowed to depreciate, higher sovereign risk will not lead to favourable relative price changes such that only the unfavourable effects through the previously described sovereign risk channel prevail. A deficit-financed public spending shock, in the presence of sovereign risk, can therefore generate quite different output responses across monetary regimes.[5] For this reason, we consider

[4]Note that the pass-through of sovereign to private risk can also go the other way around. Particularly, an increased probability of a government bank bail-out raises the public's contingent liabilities and hence expectations of rising and unstable government debt. A reduction in a bank's credibility, and associated funding strains, can therefore raise doubts about fiscal solvency in the future.

[5]In a similar vein, Gagnon and Hinterschweiger (2011) argue that fiscal crises are more abrupt and severe under

the effects of government spending shocks under both fixed and flexible exchange rate regimes in the rest of the paper.

3 Empirical evidence

Although there exist numerous empirical estimates of the effects of exogenous fiscal innovations on output, its main components and other policy relevant variables, only a limited number of contributions considers the implications of the economic environment for the transmission of fiscal policy. Notable exceptions are Ilzetzki et al. (2010a), Corsetti et al. (2012b) and Nickel and Tudyka (2013) who examine the role of alternative economic conditions and policy regimes for the effectiveness of fiscal policy. However, the extent to which the latter is affected by sovereign risk *across monetary regimes* has not yet been examined. In this section, we briefly digress our discussion in an attempt to fill this gap and provide our own estimates of fiscal multipliers under different monetary regimes while conditioning for the effects of sovereign risk. Because this is not the main focus of the present paper, we keep the empirical analysis narrow and leave a more thorough treatment for future research.

We estimate the dynamic responses of key macroeconomic aggregates to an exogenous increase in government consumption under different economic environments. To this end, we follow the two-step methodology suggested by Corsetti et al. (2012b). Specifically, in the first step, a relatively simple government spending rule is estimated for each country in order to retrieve the cyclical and endogenous fiscal policy changes and to isolate the exogenous fiscal innovations.[6] The exogenous government spending shock is proxied by the residual obtained after estimating each regression.[7] Then, in the second step, we run a fixed-effects panel regression for a number of macroeconomic variables, using the (country-specific) residuals from the first step as explanatory variables. The residuals are conditioned for the monetary regime (peg or float) and the status of public finances (weak or strong) using dummy variables. These dummies are selected using the exchange rate regime classification provided by Ilzetzki et al. (2010b), while fiscal strain is indicated by having a debt to GDP ratio larger than 100% or deficit larger than 6% of GDP in the previous year. More details on the specification of the model and sample data can be found in the Appendix.

Figure 3.1 shows the impulse response functions for a shock in government consumption of 1% of total output. When the fiscal shocks are conditioned on weak public finances, the initial impact of

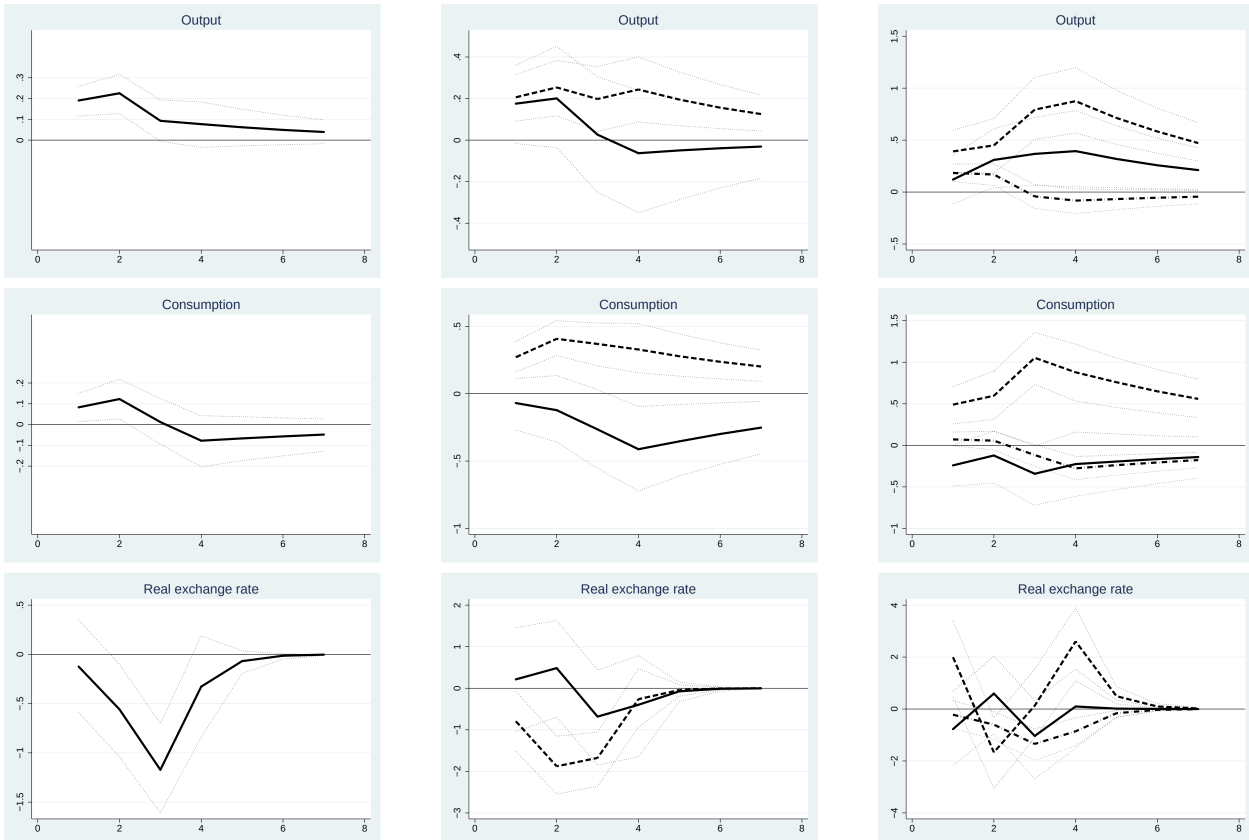
fixed exchange rate regimes than under flexible regimes since governments are unable to stabilize deficits through the monetisation of debt.

[6] This is a deliberately simple approach used to overcome the well-known endogeneity (or identification) problem in empirical studies on the effects of fiscal policy changes. Importantly, the two-step method provides a flexible framework in which fiscal policy effects can be examined as a function of alternative economic conditions. Other schemes that are used to identify exogenous fiscal shocks are the recursive approach or Cholesky decomposition (Fatás and Mihov, 2001), the structural vector auto regression (SVAR) methodology (Blanchard and Perotti, 2002), the sign restriction approach (Mountford and Uhlig, 2009) and the narrative approach (Ramey and Shapiro, 1998). For a comprehensive overview, see Perotti (2007).

[7] This empirical identification procedure corresponds well with the linearized solution to a New Keynesian model, as the identified fiscal policy innovations are orthogonal to linear combinations of the other variables and can thus be identified as shocks in the New Keynesian model as well.

Figure 3.1: Impulse responses to a government spending shock

(a) Unconditioned responses (b) Float versus peg (c) Weak public finances



Note: Output and consumption measured in %-points of output and the real exchange rate in percent deviation. Shock in government consumption of 1%-point of GDP at $t = 1$. Thick lines indicate point estimates; dotted lines indicate 1 standard deviation intervals. Left: unconditional effects (solid line); middle: float (dashed line) versus peg (solid line); right: unconditional effect (dash-dotted line) versus weak public finances and float (dashed line) and weak public finances and peg (solid line).

government spending on output and consumption *increases* under a floating exchange rate regime and *decreases* under a fixed regime. The impact on consumption increases as well for the floating regimes, whereas it stays flat for the fixed regimes. Government spending shocks have no impact on the real exchange rate under fixed regimes. For floating regimes, the real exchange rate appreciates without sovereign risk, yet with sovereign risk there is a *depreciation* on impact. The data thus confirm our prior: under fiscal stress, the output multiplier is higher under floating exchange rate regimes than under fixed regimes. This is due to a depreciation, rather than an appreciation, of the currency rate under the former regime.[8] In the next section, we present the theoretical framework

[8]Note that it is not *a priori* clear whether the standard New Keynesian or Mundell-Fleming model can provide the rationale underlying the results shown in Figure 3.1. Regarding the unconditioned output response upon a government spending shock under fixed exchange rates, the results are more in line with the New Keynesian model. However, corresponding to the Mundell-Fleming model, the results show a rise in consumption following a fiscal shock, at least under flexible exchange rates. See Born et al. (2012) for an extended comparison.

that we will use to account for these findings.

4 A New Keynesian model with sovereign risk

Our model builds on the New Keynesian small open economy model for monetary and fiscal policy analysis proposed by Galí and Monacelli (2008) by including government debt and sovereign default risk pass-through. In this section, we assume households have access to a complete set of internationally traded, state-contingent securities (which we abandon in the next section).

The model economy contains a continuum of small countries, each of size zero. The focus of our analysis will be on one country, named 'Home', whose infinitesimal size implies its domestic variables will not have significant spill-over effects on the economies of other countries, which we lump together under the heading 'Foreign'. Variables corresponding to Foreign are denoted by an asterisk superscript. We will continue by describing the Home environment and index Home and Foreign variables with H and F, respectively, where needed. In the following sub-sections, we discuss the behaviour of the households, firms and the public sector, and discuss the conditions for market clearing, steady state and equilibrium. We conclude with a log-linearized solution of the model.

4.1 Households

Our infinitely lived, representative household consumes foreign and domestic goods, is employed in the domestic economy and participates in international asset markets. It chooses consumption, C_t, and labour supply, N_t, such that expected lifetime utility is maximised, i.e.

$$E_0 \left\{ \sum_{k=0}^{\infty} \beta^k \left[\left(\frac{1}{1-\sigma} \right) C_{t+k}^{1-\sigma} - \left(\frac{1}{1+\varphi} \right) N_{t+k}^{1+\varphi} \right] \right\}, \tag{4.1}$$

where E_0 is the expectations operator conditional on the information set available at time 0, $\beta \in (0,1)$ is the household's subjective discount factor, $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution and $\varphi > 0$ is the inverse of the Frisch elasticity of labour supply. Furthermore, consumption is assumed to be a composite index consisting of total consumption on Home goods, C_{Ht}, and Foreign goods, C_{Ft}, given by:

$$C_t \equiv \left[(1-\alpha)^{\frac{1}{\eta}} \left(C_{Ht} \right)^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} \left(C_{Ft} \right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}. \tag{4.2}$$

In equation (4.2), $\alpha \in [0,1)$ measures the economy's degree of openness, such that $1-\alpha$ measures the degree of home bias in private consumption, and $\eta \geq 1$ is the constant elasticity of substitution between domestically produced and imported goods.

The household receives labour income, $W_t N_t$ with W_t the nominal wage rate, and profits from intermediate goods firms, $V_t = \int_0^1 V_t(i)di$ where $i \in [0,1]$ is the firm-index, and pays lump-sum taxes, T_t. Moreover, the household can save by investing in one-period, non-state contingent nominal government bonds, B_{Ht}, which pay a nominal interest rate of $R_t - 1$ set by the central bank and are subject to default risk. We assume there is full access to a complete set of internationally traded securities that pay one unit of Foreign currency contingent on the occurrence of a particular state of the economy. Let $Q_{t,t+1}$ be the stochastic discount factor for such one-period pay-offs which we call D_t. The household's budget constraint, in nominal terms and expressed in Home currency, can then be written as

$$e_t E_t \left[Q_{t,t+1} D_{t+1}\right] + B_{Ht} + P_t C_t + P_t T_t = (1 - \delta_t) R_{t-1} B_{Ht-1} + e_t D_t + W_t N_t + P_t V_t, \tag{4.3}$$

where e_t is the (effective) nominal exchange rate (that is, the domestic price of one unit of Foreign currency), P_t is the aggregate consumption price index (henceforth CPI) and $\delta_t \in [0, 1)$ measures the probability of sovereign default (see below). Subject to (4.2), (4.3), an appropriate transversality condition and taking prices, the tax rate, firm profits, the wage rate, the sovereign default probability and initial asset holdings, D_0 and B_{H-1}, as given, the household maximises (4.1). This leads to the following first-order conditions:

$$N_t^{\varphi} = C_t^{-\sigma} w_t, \tag{4.4}$$

$$E_t Q_{t,t+1} = \beta E_t \left[\frac{1}{\pi_{t+1}} \frac{e_{t+1}}{e_t} \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \right], \tag{4.5}$$

$$\frac{1}{R_t} = \beta E_t \left[\frac{1}{\pi_{t+1}} (1 - \delta_{t+1}) \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \right]. \tag{4.6}$$

where$\pi_t \equiv P_t/P_{t-1}$ is gross CPI inflation. Equation (4.4) describes the household's optimal intratemporal decision, relating the marginal rate of substitution between consumption and leisure to the real wage rate, $w_t \equiv W_t/P_t$. Equations (4.5) and (4.6) are the optimal decisions for the household's portfolio holdings of state-contingent securities and government bonds, respectively, relating expected consumption growth to the (effective) rate of return corresponding to the two assets. The non-arbitrage condition that arises from the possibility to invest in two different types of assets follows after combining (4.5) and (4.6):

$$\frac{1}{R_t} = E_t \left[\frac{e_t}{e_{t+1}} (1 - \delta_{t+1}) Q_{t,t+1} \right]. \tag{4.7}$$

That is, an increase in the default rate and the expected depreciation of the nominal exchange rate requires a higher short-term nominal interest rate.

For any given level of consumption expenditure, $P_t C_t$, the household chooses the optimal allocation between domestically produced and imported goods by solving the following problem:

$$\max_{C_{Ht}, C_{Ft}} \left[(1 - \alpha)^{\frac{1}{\eta}} (C_{Ht})^{\frac{\eta - 1}{\eta}} + \alpha^{\frac{1}{\eta}} (C_{Ft})^{\frac{\eta - 1}{\eta}} \right]^{\frac{\eta}{\eta - 1}}$$

subject to $P_t C_t \geq P_{Ht} C_{Ht} + P_{Ft} C_{Ft}$, where P_{Ht} and P_{Ft} are the aggregate domestic price levels of Home and Foreign, respectively, denominated in Home currency. This results in the following optimal demand schedules:

$$C_{Ht} = (1-\alpha)\left(\frac{P_{Ht}}{P_t}\right)^{-\eta} C_t, \qquad\qquad C_{Ft} = \alpha\left(\frac{P_{Ft}}{P_t}\right)^{-\eta} C_t, \tag{4.8}$$

and the CPI equation,

$$P_t = \left[(1-\alpha)\, P_{Ht}^{1-\eta} + \alpha P_{Ft}^{1-\eta}\right]^{\frac{1}{1-\eta}}. \tag{4.9}$$

Foreign household's preferences are similar to those of Home households: $\eta^* = \eta$, $\beta^* = \beta$, $\sigma^* = \sigma$ and $\varphi^* = \varphi$. Foreign demand for Foreign goods, C^*_{Ft}, and Home goods, C^*_{Ht}, is given by:

$$C^*_{Ht} = \alpha^*\left(\frac{P^*_{Ht}}{P^*_t}\right)^{-\eta} C^*_t, \qquad\qquad C^*_{Ft} = (1-\alpha)\left(\frac{P^*_{Ft}}{P^*_t}\right)^{-\eta} C^*_t,$$

where $\alpha^* \leq \alpha$ is a measure of Foreign's degree of openness, reflecting the relatively small size of Home. P^*_{Ht} is the aggregate domestic price level of Home, P^*_{Ft} is the aggregate domestic price level of Foreign and P^*_t is Foreign's aggregate CPI index, all denominated in Foreign currency, and C^*_t is Foreign aggregate consumption. As Foreign households have access to the same set of internationally traded, state-contingent securities as Home households and can also invest in Home government bonds, B_{Ft}, Foreign household's intertemporal first-order conditions read:

$$\frac{1}{R_t} = \beta E_t\left[\frac{e_t}{e_{t+1}}\frac{1}{\pi^*_{t+1}}(1-\delta_{t+1})\left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\sigma}\right], \tag{4.10}$$

$$E_t Q_{t,t+1} = \beta E_t\left[\frac{1}{\pi^*_{t+1}}\left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\sigma}\right], \tag{4.11}$$

where $\pi^*_t \equiv P^*_t/P^*_{t-1}$ is gross Foreign CPI inflation, denominated in Foreign currency. Furthermore, in order to simplify the analysis, we assume that Foreign households can invest in a risk-free, one-period discount bond, F_t, denominated in Foreign currency, which pays the gross world interest rate, R^*_t, satisfying $1/R^*_t = E_t Q_{t,t+1}$. Using this definition and the non-arbitrage condition (4.7), we have an alternative expression for the familiar uncovered interest rate parity (henceforth, UIP) condition:

$$(1 - E_t\delta_{t+1})\, R_t = \frac{E_t e_{t+1}}{e_t} R^*_t. \tag{4.12}$$

4.2 Firms

The production sector consists of two types of firms: final goods firms, operating in perfectly competitive markets, and intermediate goods firms, operating in monopolistically competitive markets.

The final goods firm combines the intermediate goods to produce the final good using the constant elasticity of substitution (CES) function

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}},$$

where $i \in [0,1]$ is the intermediate goods firm index and $\epsilon > 1$ is the constant elasticity of substitution between intermediate goods. The final goods firm aims to minimise total costs of assembling Y_t, subject to the CES function described above, given any amount of total expenditures $P_{Ht}Y_t = \int_0^1 P_{Ht}(i)Y_t(i)di$. This results in the optimal demand schedule for intermediate goods produced by firm i and the Home aggregate domestic price level:

$$Y_t(i) = \left[\frac{P_{Ht}(i)}{P_{Ht}} \right]^{-\epsilon} Y_t, \tag{4.13}$$

$$P_{Ht} = \left[\int_0^1 P_{Ht}(i)^{1-\epsilon} di \right]^{\frac{1}{1-\epsilon}}. \tag{4.14}$$

Intermediate goods firms, on the other hand, use the following linear, constant returns to scale production technology with only labour as an input in the production process:

$$Y_t(i) = N_t(i), \tag{4.15}$$

Optimal labour demand satisfies

$$mc_{Ht}(i) = \frac{P_t}{P_{Ht}} w_t, \tag{4.16}$$

where $mc_{Ht}(i)$ denotes real marginal costs. Rigidities are introduced in the prices of intermediate goods by assuming staggered price-setting (Calvo, 1983). Specifically, in every period, a randomly selected portion of intermediary goods firms, $1-\theta$, is able to adjust prices in response to demand and supply shocks, while the remaining share of firms, $\theta \in [0,1)$, is unable to adjust and keeps prices unchanged. Hence, θ, which is independent of the time elapsed since the previous price setting, is a measure of price rigidity and the average duration of a 'price contract' is $\sum_{k=0}^{\infty} \theta^k \Rightarrow 1/(1-\theta)$. Firms that are able to adjust prices do so with the aim of maximising profits, subject to (4.13) and (4.15) and taking the nominal wage rate and the probability of non-price adjustment in the future as given:

$$\max_{\overline{P}_{Ht}} E_0 \sum_{k=0}^{\infty} \theta^k Q_{t,t+k} \left[\overline{P}_{Ht} Y_{t,t+k}(i) - W_{t+k} N_{t+k|t}(i) \right],$$

where $\overline{P}_{Ht}$ is the optimal re-set price[9], $Q_{t,t+k} = \beta^k \frac{1}{\pi_{t+k}} \frac{e_{t+k}}{e_t} \left(\frac{C_{t+k}}{C_t} \right)^{-\sigma}$ is the stochastic discount factor for nominal pay-offs in period $t+k$ and $Y_{t,t+k}(i)$ is the amount of output produced by firm i who last re-set its price level in period t. The optimal re-set price that follows from the firm's profit maximisation problem is then a mark-up $\mathcal{M} \equiv \frac{\epsilon}{\epsilon-1}$ over current and expected real marginal costs,

[9]Note that the optimal re-set price is not firm-specific due to symmetry among firms.

given by

$$\overline{P}_{Ht} = \mathcal{M} \frac{E_0 \sum_{k=0}^{\infty} (\theta\beta)^k e_{t+k} P_{t+k}^{-1} P_{Ht+k}^{1+\epsilon} C_{t+k}^{-\sigma} Y_{t+k} mc_{Ht+k}}{E_0 \sum_{k=0}^{\infty} (\theta\beta)^k e_{t+k} P_{t+k}^{-1} P_{Ht+k}^{\epsilon} C_{t+k}^{-\sigma} Y_{t+k}}. \tag{4.17}$$

Note that, under flexible prices, i.e. $\theta \to 0$, (4.17) reduces to $\overline{P}_{Ht} = \mathcal{M} P_{Ht} mc_{Ht}$, or, since $\overline{P}_{Ht} = P_{Ht}$ for all t, $mc_{Ht} = 1/\mathcal{M}$.

4.3 The public sector

The public sector consists of a monetary authority, or 'central bank', and a fiscal authority, or 'government', each acting independently from each other.

The exchange rate regime, assumed to be fully credible, governs the behaviour of the central bank. Under a monetary regime of flexible exchange rates, the central bank follows a simple Taylor-type rule, relating the short-term nominal interest rate, $R_t - 1$, to changes in expected aggregate CPI inflation, π_t:

$$\ln\left(\frac{R_t}{R}\right) = \rho_r \ln\left(\frac{R_{t-1}}{R}\right) + (1-\rho_r)\,\phi_\pi \frac{E_t \pi_{t+1}}{\pi}, \tag{4.18}$$

where $\rho_r \in [0,1]$ measures the degree of interest rate smoothing, $\phi_\pi \geq 1$ reflects the aggressiveness with which the central bank responds to inflation, and hence characterises the monetary policy stance with respect to price stability, and R is the steady state gross nominal interest rate, chosen such that stability of steady state inflation, π, is guaranteed. Under a monetary regime of fixed exchange rates, however, we assume the central bank credibly commits to offset changes in the nominal exchange rate, i.e.

$$\ln\left(\frac{R_t}{R}\right) = \phi_e \left(\frac{e_t - e_{t-1}}{e}\right), \tag{4.19}$$

where e is the steady state nominal exchange rate and $\phi_e \geq 0$ is set large enough to ensure that the central bank responds heavily to changes in e_t (see Adolfson et al., 2008).

The government levies lump-sum taxes, T_t, and issues one-period sovereign bonds, B_t, in order to finance exogenous, non-productive government consumption, G_t. Bonds are internationally traded and are held either by Home households, B_{Ht}, or Foreign households, B_{Ft}, both denominated in Home currency. Therefore, bonds market clearing implies $B_t \equiv B_{Ht} + B_{Ft}$. As with household expenditures, government expenditures are on Home and Foreign goods and are summarized by the following aggregator:

$$G_t \equiv \left[(1-\alpha)^{\frac{1}{\eta}} (G_{Ht})^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} (G_{Ft})^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \tag{4.20}$$

where the government's optimal demand schedules for Home goods, G_{Ht}, and Foreign goods, G_{Ft}, are given by

$$G_{Ht} = (1-\alpha)\left(\frac{P_{Ht}}{P_t}\right)^{-\eta} G_t, \qquad G_{Ft} = \alpha \left(\frac{P_{Ft}}{P_t}\right)^{-\eta} G_t. \tag{4.21}$$

Furthermore, we assume that government spending follows an exogenous AR(1) process, i.e.

$$\ln\left(\frac{G_t}{G}\right) = \rho_g \ln\left(\frac{G_{t-1}}{G}\right) + \varepsilon_t^g, \tag{4.22}$$

where G is the level of steady state government consumption, $\rho_g \in [0,1]$ measures the persistence of government spending shocks and $\varepsilon_t^g \sim N(0, \sigma^g)$ is a random i.i.d. fiscal innovation.

The government's budget constraint, in real terms, reads:[10]

$$b_t + T_t = (1 - \Delta_t)\frac{1}{\pi_t}R_{t-1}b_{t-1} + G_t, \tag{4.23}$$

where $b_t \equiv B_t/P_t$ is total real government debt and Δ_t the default indicator. Solving this model requires a fiscal policy rule, which relates taxes to government debt, and a sovereign default rule. The fiscal policy rule is given by

$$T_t = \phi_b \frac{T}{b/\pi}\left(\frac{1}{\pi_t}b_{t-1} - \frac{1}{\pi}b\right), \tag{4.24}$$

where $\phi_b \geq 0$ and where the steady state tax rate, $T \equiv \left(\beta^{-1} - 1\right)b + G$, ensures a positive steady state real debt, b. Note that the parameter ϕ_b characterizes the government's preferences regarding tax- and deficit-financed expenditures.

Following Schabert and van Wijnbergen (2011), the decision to default depends on the economy's so-called 'fiscal limit', which is characterized by some threshold level of real debt, above which the government decides to default on its debt. The sovereign's default scheme is defined as

$$\Delta_t = \begin{cases} 0 & \text{if } \frac{1}{\pi_t}R_{t-1}b_{t-1} \leq \bar{b} \\ 1 & \text{if } \frac{1}{\pi_t}R_{t-1}b_{t-1} > \bar{b} \end{cases}. \tag{4.25}$$

If the current debt burden, $\frac{1}{\pi_t}R_{t-1}b_{t-1}$, exceeds the fiscal limit, $\bar{b}$, the government defaults. $\bar{b}$, must be unknown to all parties upon entering into the contract. If not, either default expectations play no role in our economy, or the government is not able to borrow at all. Rather than modelling $\bar{b}$ explicitly as a function of political bargaining or the economy's distance to the peak of the Laffer curve[11], we assume that the government and investors know the distribution of the fiscal limit and form their expectations on that basis. Upon maturity of the bond contract, $\bar{b}$ is drawn from this distribution. Default occurs if the current debt burden is larger than the fiscal limit. Hence, the probability of default, δ_t, equals the probability that $\frac{1}{\pi_t}R_{t-1}b_{t-1}$ exceeds the politically infeasible

[10] Recursive substitution of (4.23) results in the following intertemporal budget constraint:

$$(1-\Delta_0)\,b_0 = \sum_{s=0}^{\infty}\left\{\left[\prod_{j=0}^{s}\frac{\pi_{t+j+1}}{(1-\Delta_{t+j})\,R_{t+j}}\right](T_{t+s+1} - G_{t+s+1})\right\} + \lim_{k\to\infty}\left[\prod_{j=0}^{k}\frac{\pi_{t+j+1}}{(1-\Delta_{t+j})\,R_{t+j}}\right]b_{t+k+1}.$$

Note that, with lump-sum taxes, as in our model, there is no upper bound for debt, provided the growth in debt does not exceed the real interest rate.

[11] See Bi (2012) for the latter.

level $\bar{b}$ when debt repayment is due, i.e.

$$\delta_t = \int_0^{\frac{1}{\pi_t} R_{t-1} b_{t-1}} f\left(\bar{b}\right) d\bar{b} = F\left(\frac{1}{\pi_t} R_{t-1} b_{t-1}\right)$$

where $f\left(\bar{b}\right)$ is the probability density function of the fiscal limit and $F\left(\frac{1}{\pi_t} R_{t-1} b_{t-1}\right)$ is its integrand.

4.4 Market clearing

In equilibrium, the goods and labour market clear, the balance of payments holds and the international risk sharing condition is satisfied. Before discussing these conditions, let us first define international prices. We define the (effective) terms of trade as the ratio between Foreign's and Home's CPI indices, i.e. $S_t \equiv P_{Ft}/P_{Ht}$, and the (effective) real exchange rate as $q_t \equiv e_t P_t^*/P_t$. Since Home is a small country, its weight in Foreign's CPI is negligible and so $P_{Ft}^* = P_t^*$. Furthermore, we assume that the 'law of one price' holds such that $P_{Ht} = e_t P_{Ht}^*$ and $P_{Ft} = e_t P_{Ft}^*$.

Goods market clearing implies $Y_t = C_{Ht} + G_{Ht} + C_{Ht}^*$. After substituting in the demand schedules, $C_{Ht} = (1-\alpha)\left(\frac{P_{Ht}}{P_t}\right)^{-\eta} C_t$, $G_{Ht} = (1-\alpha)\left(\frac{P_{Ht}}{P_t}\right)^{-\eta} G_t$ and $C_{Ht}^* = (1-\alpha)\left(\frac{P_{Ht}^*}{P_t^*}\right)^{-\eta} C_t^*$, one obtains:

$$Y_t = \left(\frac{P_{Ht}}{P_t}\right)^{-\eta} \left[(1-\alpha)\left(C_t + G_t\right) + q_t^{\eta} \alpha^* C_t^*\right]. \tag{4.26}$$

Labour market clearing implies $N_t = \int_0^1 N_t(i) di$. When substituting in the intermediary goods firm's production technology, $Y_t(i) = N_t(i)$, and the final good firm's optimal demand schedule, $Y_t(i) = \left(P_{Ht}/P_t\right)^{-\epsilon} Y_t$, we can write

$$N_t = Y_t Z_t = Y_t, \tag{4.27}$$

where $Z_t \equiv \int_0^1 \left[\frac{P_t(i)}{P_t}\right]^{-\epsilon}$ is a measure of price dispersion whose equilibrium variations around a perfect foresight steady state are of second order, i.e. $Z_t \approx 1$ (see Galí and Monacelli, 2005).

Furthermore, the balance of payments follows from consolidating the household's and government's budget constraints, (4.3) and (4.23), substituting for firm's profits, $P_t V_t = P_{Ht} Y_t - W_t N_t$, and the labour market clearing condition (4.27) and assuming that the internationally traded securities consist solely of discount bonds, F_t, which pay the risk-free world interest rate, R_t^*:

$$\frac{P_{Ht}}{P_t} Y_t - C_t - G_t = q_t \left(\frac{1}{\pi_t^*} R_{t-1}^* f_{t-1} - f_t\right) + \left(1-\delta_t\right) \frac{1}{\pi_t} R_{t-1} b_{Ft-1} - b_{Ft}. \tag{4.28}$$

Here $f_t \equiv F_t/P_t^*$ and $b_{Ft} \equiv B_{Ft}/P_t$. Equation (4.28) indicates that net national savings must equal net capital outflow.

Finally, under the assumption of complete asset markets, households can insure themselves against idiosyncratic shocks to consumption. Combining the first-order conditions of Foreign and Home households, we derive the following international risk sharing condition:

$$C_t = C_t^* q_t^{\frac{1}{\sigma}} \vartheta, \tag{4.29}$$

where $\vartheta \equiv E_t \left[q_t^{-1/\sigma} C_{t+1}/C_{t+1}^* \right]$ is a constant which pins down the initial conditions regarding relative asset positions. Assuming symmetrical initial conditions, that is zero net foreign asset holdings, implies $\vartheta = 1$. The condition in (4.29) implies that a fall in Home consumption has to be associated with a real exchange rate appreciation.

4.5 Steady state and equilibrium

For constant consumption in steady state, i.e. $C_t = C$ for all t, (4.6) implies that the steady state gross real interest rate, $r \equiv R/\pi$, is determined by $1/\left[\beta\left(1-\delta\right)\right]$, where $\delta \in [0,1]$ is the steady state probability of default. Furthermore, constant Foreign consumption in steady state implies $r^* \equiv R^*/\pi^* = 1/\beta$ (see [4.11]). Also, in the flexible price equilibrium, i.e. for $\theta = 0$ and $P_{Ht}^* = P_{Ht}$ for all t, we have from (4.17) and (4.16) that $w_t = w = 1/\mathcal{M}$. Finally, we assume that Foreign and Home prices are equal in the steady state equilibrium such that $e = q = 1$.

Equilibrium is then given by a sequence of C_{t+k}, N_{t+k}, Y_{t+k}, w_{t+k}, b_{t+k}, f_{t+k}, π_{t+k}, π_{Ht+k}, q_{t+k}, e_{t+k}, S_{t+k}, R_{t+k} and T_{t+k} satisfying the household's first-order conditions, (4.4), (4.5) and (4.6), and budget constraint (4.3), the UIP condition (4.12), the aggregate price indices, (4.9) and (4.14), the intermediary goods firm's pricing decision (4.17), the public's budget constraint (4.23), the default scheme (4.25), the policy rules, (4.18) or (4.19) and (4.24), an exogenous sequence for government spending as given by (4.22), the market clearing conditions, (4.26), (4.27) and (4.28), and the international risk sharing condition (4.29), given sequences for C_{t+k}^*, R_{t+k}^* and π_{t+k}^*, for all k.

4.6 Log-linearization

We solve the model around the non-stochastic steady state using a log-linearization of the equilibrium conditions. Define variables with an accent circumflex (or hat) as the percentage deviation of that variable from its steady state level and variables without a t subscript as the steady state level of the corresponding variable, e.g. $\hat{X}_t \equiv (X_t - X)/X$, for any variable X_t. For simplicity, we assume all government bonds are held by Foreign households, such that $b_{Ht} = 0$ and $b_t = b_{Ft}$, and also that Foreign variables remain constant, i.e. $C_t^* = C^*$, $\pi_t^* = \pi^*$ and $R_t^* = R^*$ for all t. Then, the log-linearized version of the model is given by the following system of 11 linear (first-order difference) equations in 11 endogenous variables, $\hat{Y}_t$, $\hat{w}_t$, $\hat{C}_t$, $\hat{T}_t$, $\hat{\pi}_{Ht}$, $\hat{\pi}_t$, $\hat{q}_t$, $\hat{e}_t$, $\hat{R}_t$, $\hat{b}_{Ft}$ and $\hat{G}_t$ (see the Appendix for a brief derivation):

$$
\begin{aligned}
\hat{e}_t &= \hat{e}_{t-1} + \hat{q}_t - \hat{q}_{t-1} + \hat{\pi}_t, & (4.30)\\
\varphi \hat{Y}_t &= \hat{w}_t - \sigma \hat{C}_t, & (4.31)\\
\hat{C}_t &= E_t \hat{C}_{t+1} - \frac{1}{\sigma}\left[(1-\Phi)\left(\hat{R}_t - E_t \hat{\pi}_{t+1}\right) - \Phi \hat{b}_{Ft}\right], & (4.32)\\
\hat{\pi}_{Ht} &= \lambda\left(\hat{w}_t + \tilde{\alpha}\hat{q}_t\right) + \beta E_t \hat{\pi}_{Ht+1}, & (4.33)\\
\hat{b}_{Ft} &= \left(\frac{1-\Phi}{\beta}\right)\left(\hat{b}_{Ft-1} + \hat{R}_{t-1} - \hat{\pi}_t\right) + \frac{G}{b_F}\hat{G}_t - \frac{T}{b_F}\hat{T}_t, & (4.34)\\
\hat{T}_t &= \phi_b\left(\hat{b}_{Ft-1} - \hat{\pi}_t\right), & (4.35)\\
\hat{\pi}_t &= \hat{\pi}_{Ht} + \tilde{\alpha}\left(\hat{q}_t - \hat{q}_{t-1}\right), & (4.36)\\
\hat{Y}_t &= \Theta \hat{q}_t + (1-\alpha)\left(\frac{C}{Y}\hat{C}_t + \frac{G}{Y}\hat{G}_t\right), & (4.37)\\
\hat{C}_t &= \frac{1}{\sigma}\hat{q}_t, & (4.38)\\
\hat{G}_t &= \rho_g \hat{G}_{t-1} + \varepsilon_t^g, & (4.39)\\
\hat{R}_t &= \rho_r \hat{R}_{t-1} + (1-\rho_r)\phi_\pi E_t \hat{\pi}_{t+1}, & (4.40)
\end{aligned}
$$

where $\lambda \equiv (1-\theta)(1-\theta\beta)/\theta$, $\Phi \equiv \delta'\left[\left(\pi^{-1}Rb\right)/(1-\delta)\right]$ is the default elasticity with respect to the steady state value of real government outstanding liabilities, $\tilde{\alpha} \equiv \alpha/(1-\alpha)$ and $\Theta \equiv \eta\alpha\left(\frac{C+G}{Y}\right) + \left(\frac{\eta\alpha^*}{1-\alpha}\right)\frac{C^*}{Y}$. Under the fixed exchange rate regime, the monetary policy rule given by equation (4.40) is replaced by the log-linearized version of (4.19):

$$\hat{R}_t = \phi_e\left(\hat{e}_t - \hat{e}_{t-1}\right). \tag{4.41}$$

5 An incomplete asset market and sovereign risk pass-through

In this section, we extend the model from the previous section to consider the case where increases in sovereign risk raise, not only the risk premium on sovereign bonds, but also private borrowing costs through an endogenous risk premium on household loans. First, we assume the household no longer has access to a complete set of state-contingent securities. Instead, it only has access to an internationally traded, risk-free bond, F_t, on which the household pays the risk-free world interest rate, $R_t^* - 1$, plus a time-varying risk premium, Ξ_t, and government bonds, B_{Ht}, which, as before, pay the Home policy rate, $R_t - 1$. Second, we assume that the risk premium is determined by a monotonically increasing function of the amount of Home's outstanding private external liabilities plus a factor that takes into account the impact of a sovereign default, i.e. $\delta_t b_{Ft}$. Using the definition for the effective real exchange rate, we postulate this function as

$$\Xi_t = \exp\left(\frac{\chi_1 f_t q_t + \chi_2 \delta_t b_{Ft}}{Y}\right) \tag{5.1}$$

where χ_1 measures the elasticity of the risk premium with respect to net external household debt, χ_2 captures the strength of the pass-through between public and private credit risk and Y is the steady state level of output. Note that $\chi_1 > 0$ determines the steady state of net Foreign bond holdings. The sign restriction is required to induce stationarity in our small open economy model without a complete asset market (see Schmitt-Grohé and Uribe, 2003). The coefficient χ_2, on the other hand, has no sign restrictions. Comparing equilibrium dynamics upon a transient government spending shock under $\chi_2 = 0$ with $\chi_2 > 0$ will demonstrate the effect of sovereign risk pass-through.

A similar expression as in (5.1) can be found in Corsetti et al. (2012a). They develop a closed economy New Keynesian model with two types of households, savers and borrowers, who interact via financial intermediaries. Loan origination costs or fraud, which are dependent on the sovereign risk premium, introduce a private credit spread between savers and borrowers. Our elasticity of the risk premium with respect to private debt, χ_1, can be interpreted as a reduced form that represents a structural model with these characteristics in an open economy setting.

Under $\chi_2 > 0$, a higher probability of sovereign default reduces private creditworthiness and hence raises the private risk premium Ξ_t. This may reflect the adverse effects of sovereign risk and falling bond prices on bank's CDS spreads due to a reduction in the bank's collateral value and/or capital adequacy ratio (see section 2). It could also suggest that higher future taxes, which diminishes household's ability to repay their debt, become more likely, prompting Foreign lenders to raise the required rate of return on private loans. In any case, the result is a 'sovereign ceiling', whereby the sovereign credit rating poses an upper limit to private ratings. Note that, under the assumption of a complete asset market, as in section 4, households would be able to insure themselves against (temporary) losses of income (in this case, due to tax increases) such that there would be no feedback between government indebtedness and household credit risk.

Under these new assumptions, the household's budget constraint now reads

$$B_{Ht} + P_t C_t + P_t T_t + e_t \Xi_{t-1} R^*_{t-1} F_{t-1} = (1-\delta_t) R_{t-1} B_{Ht-1} + e_t F_t + W_t N_t + P_t V_t. \tag{5.2}$$

With household preferences unchanged, the first-order conditions are:

$$N_t^{\varphi} = C_t^{-\sigma} w_t, \tag{5.3}$$

$$\frac{1}{R_t^*} = \beta E_t \left[\frac{1}{\pi_{t+1}} \frac{e_{t+1}}{e_t} \Xi_t \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \right], \tag{5.4}$$

$$\frac{1}{R_t} = \beta E_t \left[\frac{1}{\pi_{t+1}} (1-\delta_{t+1}) \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \right]. \tag{5.5}$$

The optimal demand schedules of the Home and Foreign household, the final goods firm and the government, the optimal pricing condition of the intermediary goods firm[12], the price indices, the sovereign's default scheme and the policy rules all remain the same and will therefore not be

[12]Note that the stochastic discount factor, which follows from the household's Euler equation, depends on the *current* risk premium only and has therefore no impact on the forward looking behaviour of firms.

repeated here. The balance of payments condition, however, must be adjusted in order to include the time-varying risk premium:

$$\frac{P_{Ht}}{P_t}Y_t - C_t - G_t = q_t\left(\frac{1}{\pi_t^*}\Xi_{t-1}R_{t-1}^* f_{t-1} - f_t\right) + (1-\delta_t)\frac{1}{\pi_t}R_{t-1}b_{Ft-1} - b_{Ft}. \tag{5.6}$$

Also, in the case of incomplete asset markets, the international risk sharing condition given by (4.29) is no longer valid and is replaced by the non-arbitrage condition:

$$(1 - E_t\delta_{t+1})\,R_t = \frac{E_t e_{t+1}}{e_t}\Xi_t R_t^*. \tag{5.7}$$

Equation (5.7) implies that the effective rate of return on the Foreign discount bond and the domestic government bond must be the same.

The risk premium enters into the steady state policy rate by combining equations (5.4) and (5.5) as $R = R^*\Xi/(1-\delta)$. Equilibrium is then given by a sequence of C_{t+k}, N_{t+k}, Y_{t+k}, w_{t+k}, b_{t+k}, f_{t+k}, π_{t+k}, π_{Ht+k}, q_{t+k}, e_{t+k}, S_{t+k}, R_{t+k}, T_{t+k} and Ξ_{t+k} satisfying the household's first-order conditions, (5.3), (5.4) and (5.5), and budget constraint (5.2), the UIP condition (5.7), the aggregate price indices, (4.9) and (4.14), the intermediary goods firm's pricing decision (4.17), the public's budget constraint (4.23), the default scheme (4.25), the policy rules, (4.18) or (4.19) and (4.24), an exogenous sequence for government spending as given by (4.22), the market clearing conditions, (4.26), (4.27) and (5.6) and the risk premium, (5.1), given sequences for C_{t+k}^*, R_{t+k}^* and π_{t+k}^*, for all k.

Log-linearization of equations (5.1),(5.7) and (5.6) yields:

$$\begin{aligned}
\hat{\Xi}_t &= \chi_1\frac{f}{Y}\left(\hat{f}_t + \hat{q}_t\right) + \chi_2\frac{b_F}{Y}\left[(1-\delta)\,\Phi\left(\hat{b}_{Ft-1} + \hat{R}_{t-1} - \hat{\pi}_t\right) + \delta\hat{b}_{Ft}\right], && (5.8)\\
\hat{q}_t &= E_t\hat{q}_{t+1} - \left[(1-\Phi)\left(\hat{R}_t - E_t\hat{\pi}_{t+1}\right) - \Phi\hat{b}_{Ft}\right] + \hat{\Xi}_t, && (5.9)\\
\frac{f}{Y}\hat{f}_t &= \beta^{-1}\frac{f}{Y}\left(\hat{f}_{t-1} + \hat{\Xi}_{t-1}\right) + \left[\left(\beta^{-1}-1\right)\frac{f}{Y} + \tilde{\alpha}\right]\hat{q}_t - \frac{b_F}{Y}\hat{b}_{Ft}\\
&\quad + \frac{b_F}{Y}\left(\frac{1-\Phi}{\beta}\right)\left(\hat{b}_{Ft-1} + \hat{R}_{t-1} - \hat{\pi}_t\right) - \left(\hat{Y}_t - \frac{C}{Y}\hat{C}_t - \frac{G}{Y}\hat{G}_t\right). && (5.10)
\end{aligned}$$

Then, the log-linearized version of the model with incomplete asset markets is given by a system of 13 equations, (4.30)-(4.40) with the exception of (4.38) and replacing (4.41) for (4.40) under fixed exchange rates, and (5.8) - (5.10), in 13 endogenous variables, $\hat{Y}_t$, $\hat{w}_t$, $\hat{C}_t$, $\hat{T}_t$, $\hat{\pi}_{Ht}$, $\hat{\pi}_t$, $\hat{q}_t$, $\hat{e}_t$, $\hat{R}_t$, $\hat{b}_{Ft}$, $\hat{G}_t$, $\hat{\Xi}_t$ and $\hat{f}_t$.

6 Calibration

Our model is calibrated using the settings most common in the literature and has a quarterly frequency. The benchmark values of the model's parameters are summarized in Table 6.1. Here we will discuss the parameters in the benchmark calibration. Deviations from these parameters in our simulations or for robustness tests will be clearly mentioned.

For the elasticity of substitution between domestically produced and imported goods we use $\eta = 1.50$. The parameter measuring the economy's degree of openness is set to $\alpha = 0.60$, corresponding to the average import share in domestic output of advanced economies, while openness of the rest of the world with respect to Home is set to $\alpha^* = 0.01$. The elasticity of intertemporal substitution, σ, is set to 1.00, implying utility is logarithmic in consumption. Following Galí and Monacelli (2008), we assume $\varphi = 3.00$ such that the labour supply elasticity is 1/3. The probability of non-price-adjustment is chosen to be $\theta = 0.75$ such that prices are fixed for 4 quarters on average and the slope of the New Keynesian Phillips curve is $\lambda = 0.085$. We set the subjective discount probability to $\beta = 0.99$.

Regarding the policy parameters, equilibrium determinacy requires an active monetary authority and a passive fiscal authority. This implies that the central bank must respond to changes in expected inflation by adjusting the short-term nominal interest rate by more than one-to-one and that the government must ensure fiscal solvency in the long-run by raising taxes in response to increases in the level of outstanding public liabilities. We therefore set ϕ_π, the Taylor rule coefficient, equal to 1.50 and the interest rate smoothing parameter, ρ_r, to 0.80. Under fixed exchange rates, the central bank follows equation (4.19). In order to ensure constancy of the nominal exchange rate, we set the policy rule coefficient extremely large, i.e. $\phi_e = 1$ bn. The feedback between taxes and government debt, governed by ϕ_b, is set to 0.10, allowing for some deficit-financing of public expenditures. The autocorrelation coefficient of government consumption is set to $\rho_g = 0.90$.

Furthermore, we assume a steady state ratio of government debt to output of 0.60, which corresponds to the threshold level of government debt suggested by the Euro zone's Stability and Growth Pact, and a steady state private external debt to output ratio of 0.25, annually, such that $b/Y = 2.40$ and $f/Y = 1.00$. For a constant share of government consumption in total output of $G/Y = 0.25$, we then have a steady state tax to output ratio of $T/Y = 0.274$. The steady state consumption to output ratio is set to $C/Y = 0.75$, while the ratio of Foreign consumption on Home goods to (Home) output in steady state must reflect the relatively small size of Home and is therefore chosen to be $C^*/Y = 20.0$.

The unconventional parameters of the paper are those which determine the implications of sovereign risk for the effects of government spending on key macroeconomic variables, governed by Φ and δ, and those introducing capital market imperfections, i.e. χ_1 and χ_2. The default elasticity parameter, Φ, measures the percentage change in the default probability due to a change in real outstanding government liabilities in steady state, Rb/π. A growing literature on the determinants of sovereign risk in advanced economies provides estimates for Φ. Cottarelli and Jaramillo (2012), for example, focus on the effects of fiscal fundamentals on credit default swaps (CDS) spreads during the financial turmoil in 2011. The CDS spread is used as a proxy for the default probability as it reflects the market's assessment of sovereign credit risk. Their estimate of the impact of a one percent change in gross debt-to-GDP on sovereign CDS spreads is around 0.012. For our benchmark calibration, we choose $\Phi = 0.01$. The probability of sovereign default, δ, is found by

Table 6.1: Benchmark calibration

Parameter	Description	Value
η	Elasticity between Foreign and Home goods	1.50
α	Country openness	0.60
α^*	Foreign openness with respect to Home	0.01
σ	Inverse of the elasticity of intertemporal substitution	1.00
φ	Inverse of the Frisch labour supply elasticity	3.00
θ	Probability of non-price adjustment	0.75
β	Subjective discount factor	0.99
ϕ_π	Monetary policy rule coefficient, flexible exchange rate	1.50
ρ_r	Nominal interest rate smoothing parameter	0.80
ϕ_e	Monetary policy rule coefficient, fixed exchange rate	1 bn.
ϕ_b	Fiscal policy rule coefficient	0.10
ρ_g	Persistence in government spending innovations	0.90
$b_F/(4Y)$	Steady state real government debt held by Foreign to output ratio	0.60
$f/(4Y)$	Steady state real household external debt to output ratio	0.25
G/Y	Steady state government consumption to output ratio	0.25
T/Y	Steady state taxes to output ratio	0.274
C/Y	Steady state household consumption to output ratio	0.75
C^*/Y	Steady state Foreign consumption to output ratio	20.0
Φ	Sovereign default elasticity	0.01
δ	Sovereign default probability	0.002
χ_1	Risk premium elasticity w.r.t. household net foreign debt	0.0017
χ_2	Risk premium elasticity w.r.t. sovereign default losses	0.35

choosing appropriate values for the risk-free long-term real interest rate, $1/\beta - 1$, and the risk premium on sovereign bonds. Particularly, the annual long-term interest rate, free of default risk, is 4.10% for $\beta = 0.99$. We assume a risk premium of 1.00%, which is commensurate with the average sovereign risk spread in the Euro area.[13] The default probability, on a quarterly basis, is then calculated as $\delta = 1 - (1.0510)^{-1/4}/\beta = 0.002$.

The elasticity of the private risk premium with respect to changes in household net foreign borrowing, χ_1, is set to 0.0017. Here, we follow Bouakez and Eyquem (2011) who rely on estimates of Lane and Milesi-Ferretti (2002). Finally, the elasticity of the private risk premium with respect to the impact of a sovereign default for foreign lenders, χ_2, is set at 0.35. This value implies that the impact on the risk premium of an increase in private risk, $\chi_1 f/Y$, is equal to the impact of an increase in public risk, $\chi_2 \delta b_f/Y$ and reflects the assumption that foreign lenders can invest in the domestic economy via a financial sector, which is vulnerable to both private and public credit risk.

[13] An annual default probability of 1% corresponds to a sovereign credit rating at S&P and Fitch of BB and at Moody's of Ba (Source: own calculations following Table 3.1 in IMF (2010)).

7 The effects of government spending shocks

The effects of a government spending shock are discussed based on the impulse response functions of the endogenous variables generated by the log-linearized version of the model.[14] We apply a 1% shock to government spending at $t = 1$.[15] Unless stated otherwise, the horizontal axes indicate quarters and the vertical axes indicate the percentage change from steady state of the corresponding variable. We start by reconciling our results with the theoretical predictions of the basic New Keynesian model in the benchmark calibration, assuming a complete asset market and no sovereign risk. In section 7.1 we set $\Phi, \delta > 0$ and analyse the model's behaviour after a fiscal expansion under sovereign risk. Finally, in section 7.2, we discuss the implications of a positive feedback between public and private credit risk for the effects of fiscal policy by setting $\chi_1, \chi_2 > 0$ as well as $\Phi, \delta > 0$.

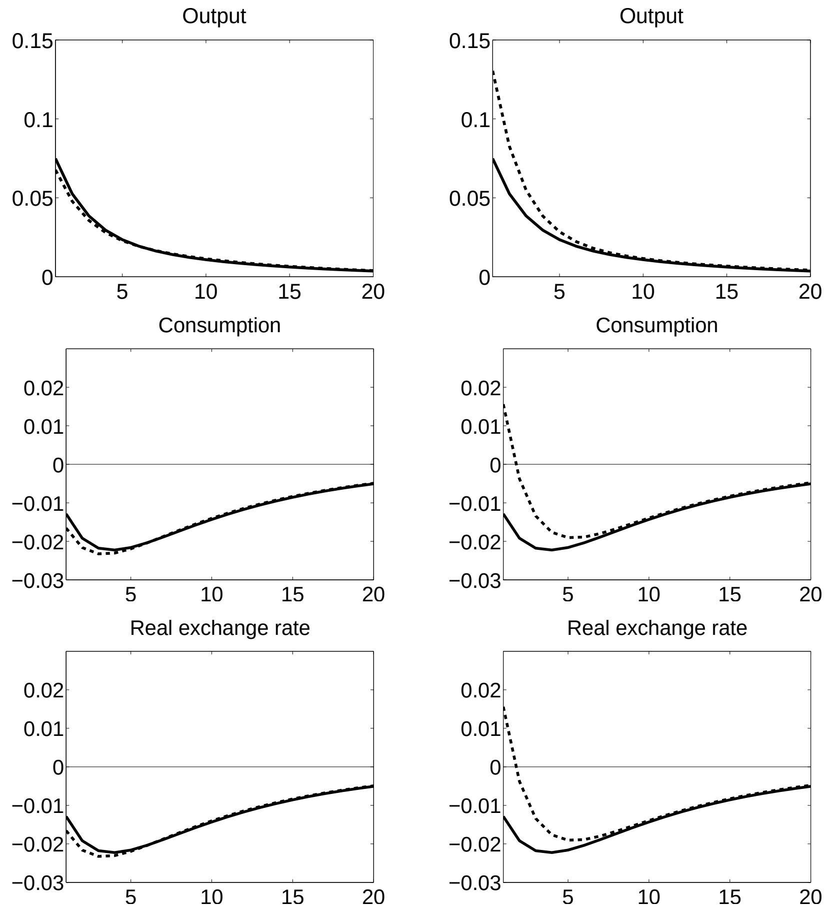
In the benchmark case, with complete asset markets and in the absence of sovereign risk, we obtain responses to a government spending shock which correspond, at least qualitatively, to conventional New-Keynesian predictions (see Figure 7.2a). Under flexible exchange rates, an increase in government consumption raises CPI inflation which induces the central bank to raise the nominal interest rate. This increase in the interest rate leads to an appreciation of the (nominal and) real exchange rate. Then, net exports fall which dampens the increase in output. Furthermore, as the rise in public outlays requires an increase in (future) taxes, private consumption falls below steady state since households aim to smooth the expected decrease in future net income. The net effect on output is positive, however, as the rise in public demand dominates the fall in private demand. For a fixed exchange rate, the rise in CPI inflation is followed by a more gradual appreciation of the real exchange rate via domestic inflation. The off-setting effects following a government spending shock are thus reduced and the response of output is stronger than under flexible exchange rates. Note that the differences in output responses across monetary regimes following a government spending shock in the New Keynesian model are much smaller than predicted by the traditional Mundell-Fleming model, which corresponds to the results in Corsetti et al. (2011) and the empirical findings in Born et al. (2012).[16]

[14]In order to preserve space, we will only show the impulse response functions of output, consumption and the real exchange rate throughout the text. The responses of the remaining variables are available upon request from the authors.

[15]Thus, to obtain fiscal multipliers, the reported effects should be multiplied by $Y/G = 4$ reflecting a shock with a size of 1% in output.

[16]The dynamical response of the trade balance upon a positive government spending shock (not shown) is almost identical across the two exchange rate regimes. Hence, the difference in the output response between fixed and flexible exchange rates is driven by private expenditure, which stands in contrast to the fiscal transmission mechanism suggested by the Mundell-Fleming model. As described in Born et al. (2012), private consumption is crowded out by the rise in public spending to a similar degree under *both* monetary regimes and, therefore, output dynamics across regimes differ only marginally. Under flexible exchange rates, the increase in inflation induced by the fiscal expansion raises the real interest rate, due to the assumed interest rate feedback rule of the central bank, which affects the household's intertemporal budget constraint and reduces private consumption. Under fixed exchange rates, the real interest rate declines on impact as the nominal interest rate is pegged. However, due to the implied assumption of PPP in the model and the inability of the nominal exchange rate to adjust, the real interest rate rises in the long-run such that current household consumption also falls.

Figure 7.1: Responses to a government spending shock under complete asset markets



(a) Without sovereign risk (b) With sovereign risk

Notes: Figures show responses to a 1% increase in government consumption from steady state. Dashed lines show responses under flexible exchange rates; solid lines show responses under fixed exchange rates. The figures in panel a are generated for $\Phi = \delta = 0.00$; the figures in panel b are generated for $\Phi = 0.01$ and $\delta = 0.002$.

7.1 Introducing sovereign risk

The dynamics differ markedly when the economy is near its fiscal limit (see Figure 7.2b). In this case, additional deficit-financed government spending prompts sovereign default beliefs. Under flexible exchange rates, these default beliefs lead to a *depreciation* of the real exchange rate upon impact. Furthermore, consumption now responds *positively* to an increase in government spending. Under fixed exchange rates, however, the interest rate is essentially pegged to the Foreign interest rate as the central bank strictly follows the UIP condition,

$$\hat{R}_t = \left(\frac{1}{1-\Phi}\right)\hat{R}_t^* + \left(\frac{\Phi}{1-\Phi}\right)\left(\hat{b}_{Ft} - E_t\hat{\pi}_{t+1}\right),$$

which prevents any change in the nominal exchange rate. This implies that the central bank 'imports' the *risk-free* interest rate from abroad and thereby insulates households from sovereign default risk (see Schabert, 2011). Hence, under fixed exchange rates, the dynamics following a government spending shock are independent of sovereign risk and we obtain the same results as in the benchmark case without sovereign risk.

The presence of sovereign risk seems to overturn conventional wisdom. Most notably, the impact and cumulative effects of a fiscal expansion on output are *higher* under flexible exchange rates than under fixed exchange rates. In addition, consumption is crowded *in* under flexible exchange rates, yet is crowded out under fixed rates. Hence, the consumption response is also higher under flexible exchange rates than under fixed rates.

Driving these results is the feedback effect between output and the real exchange rate and the intertemporal effects of sovereign risk on consumption. First, according to the goods market clearing condition, equation (4.26), an increase in the degree of country openness, α, and the elasticity of substitution between domestic and foreign goods, η, raise the sensitivity of aggregate output to changes in the real exchange rate. Indeed, as is shown in Figures C.2a, C.2b, C.2d and C.2e in the appendix, the difference between the output multipliers across monetary regimes (measured along the vertical axes) is monotonically increasing for larger values of η and α (horizontal axes). The more open is the economy, and the more foreign demand for domestically produced goods responds to changes in the exchange rate, the more the production sector benefits from the relative price change induced by the increase in the government debt level and the associated rise in sovereign risk.

Second, the probability of the government reneging on its liabilities reduces the effective rate of return on bonds which both affects the household's intertemporal decisions and the equilibrium allocation of the balance of payments. Since household's savings decisions are determined by the effective real rate of return, an increase in sovereign risk induces households to intertemporally substitute future for current consumption. As shown in Figures C.2c and C.2f in the appendix, a higher intertemporal elasticity of substitution (i.e. lower values of σ) raises the difference in the impact and cumulative output multipliers across regimes, since household consumption rises with sovereign risk under flexible exchange rates yet is unresponsive to sovereign risk under fixed rates. Additionally, as Home government debt becomes less attractive, optimizing risk-averse Foreign investors get rid of their holdings of risky sovereign bonds in exchange for relatively safer, foreign assets. An immediate depreciation of the real exchange rate is then required in order to satisfy the balance of payments condition. This can be seen by inserting the international risk sharing condition (4.29) into the household's Euler equation (4.5), and log-linearizing:

$$\hat{q}_t = E_t\hat{q}_{t+1} - \left[(1-\Phi)\left(\hat{R}_t - E_t\hat{\pi}_{t+1}\right) - \Phi\hat{b}_{Ft}\right].$$

Recall that $\Phi \equiv \delta' \left[\pi^{-1}Rb\,(1-\delta)^{-1}\right]$ is the default elasticity with respect to steady state real government debt. An increase in $\hat{b}_{Ft}$ (in our case, due to the fiscal expansion) raises the probability of default by $\Phi > 0$ which in turn reduces the effective real rate of return, $(1-\Phi)\left(\hat{R}_t - E_t\hat{\pi}_{t+1}\right) - \Phi\hat{b}_{Ft}$, and pushes up the real exchange rate, $\hat{q}_t$.

Moreover, the fiscal effects on consumption and the real exchange rate are larger for a higher degree of fiscal strain, that is for larger values of Φ. The positive response of consumption and the depreciation of the exchange rate support the increase in aggregate demand. Hence, we find that a higher default elasticity generates higher output multipliers under flexible exchange rates (see Figure C.2 in the appendix).

In the following section we introduce asset market imperfections in order to account for the possibility of a relationship between public and private credit risk that could potentially alter the fiscal transmission mechanism described in this section.

7.2 The implications of sovereign risk pass-through

With an incomplete asset market, households can only invest in two non-state contingent assets and are facing an endogenously determined risk premium on external borrowing. In order to assess the properties of this alternative model, and see how they relate to our previous specification, we first examine the model with an incomplete asset market without sovereign default risk and sovereign risk pass-through.

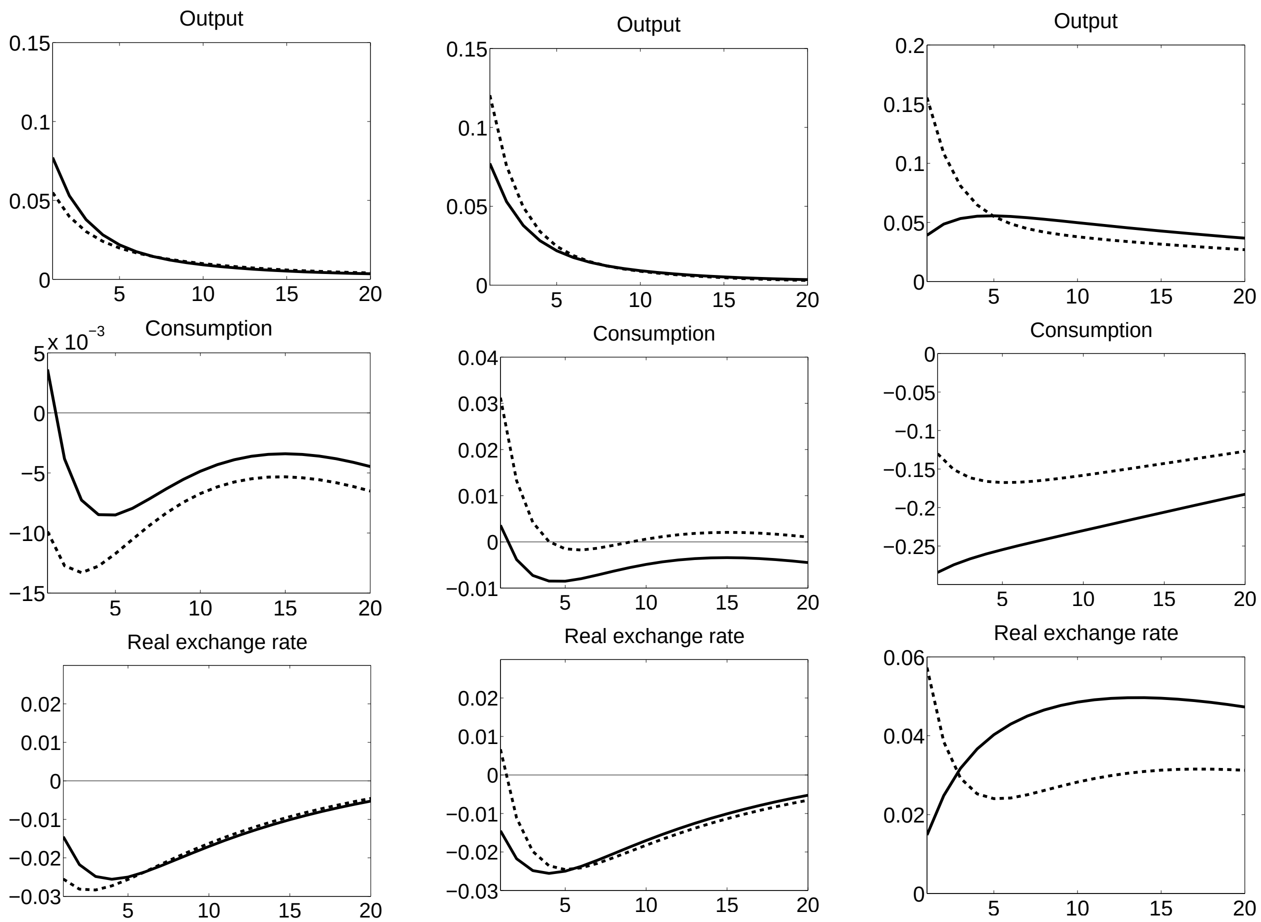
The dynamics following a positive government spending shock correspond with those found in the previous section under the scenario of complete asset markets and no sovereign risk (see Figure 7.3a). Particularly, output responds positively under both regimes, yet is higher under fixed exchange rates than under flexible exchange rates, and the exchange rate appreciates. Consumption and the real exchange rate no longer behave identically to each other, which was the case under complete asset markets due to the assumption of international risk sharing. However, consumption is still crowded out under both monetary regimes, although it moves above its steady state on impact under fixed rates.

Introducing sovereign risk reproduces our main result of a higher output multiplier under flexible rates than under an exchange rate peg, once again overturning conventional wisdom (see Figure 7.3b). As before, higher values of Φ generate larger output multipliers under flexible exchange rates (not shown), due to the exchange rate mechanism described earlier. In addition, we find that household consumption rises upon a government spending shock and that the real exchange rate depreciates on impact. As in the previous scenario, the equilibrium allocation is independent of changes in sovereign risk under fixed exchange rates as the central bank responds to changes in the effective rate of interest.

When the risk premium on household external debt depends on sovereign risk, thus $\chi_2 > 0$ in equation (5.1), we obtain that private consumption *falls* in response to a government spending shock under *both* flexible and fixed exchange rates. This result follows naturally after examining the log-linearized version of the household's Euler equation for Foreign loans:

$$\sigma\hat{C}_t = \sigma E_t\hat{C}_{t+1} - \left(\hat{R}^*_t - E_t\hat{\pi}^*_{t+1} + \hat{\Xi}_t\right) - \left(E_t\hat{q}_{t+1} - \hat{q}_t\right).$$

Figure 7.2: Responses to a government spending shock under incomplete asset markets



(a) Without sovereign risk

(b) With sovereign risk

(c) With sovereign risk pass-through

Notes: Figures show responses to a 1% increase in government consumption from steady state. Dashed lines show responses under flexible exchange rates; solid lines show responses under fixed exchange rates. The figures in panel *a* are generated for $\Phi = \delta = \chi_2 = 0.00$; the figures in panel *b* are generated for $\Phi = 0.01$, $\delta = 0.002$ and $\chi_2 = 0.00$; the figures in panel *c* are generated for $\Phi = 0.01$, $\delta = 0.002$ and $\chi_2 = 0.35$.

The increase in government debt and the resulting increase in the risk premium, $\hat{\Xi}_t$, raises the effective real interest rate on Foreign loans, $\hat{R}_t^* - E_t\hat{\pi}_{t+1}^* + \hat{\Xi}_t$, which prompts the household to save rather than borrow and hence to cut back on current consumption expenditures. As shown in Figure 7.3c, the output response to a government spending shock is still higher under flexible exchange rates than under fixed exchange rates, despite the negative fiscal effect on consumption via the sovereign risk pass-through.

The Foreign interest rate is not controlled by the Home central bank. Therefore, changes in the perceived sovereign riskiness, that induce changes in $\hat{\Xi}_t$ and the effective Foreign real rate of return, will now have an effect on the equilibrium allocation under both exchange rate regimes. Under flexible exchange rates, higher values for Φ generate larger output and exchange rate responses, which is due to bonds-portfolio switching by Foreign investors, as described in the previous section. Consumption, however, deteriorates by more with higher fiscal strain, owing to the presence of sovereign risk pass-through (see Figure C.3 in the appendix). Under fixed exchange rates, the consumption and real exchange rate responses as a function of Φ are qualitatively the same as under flexible exchange rates. Output, on the other hand, can even respond *negatively* with higher sovereign risk on impact under fixed exchange rates, as shown in panel c of Figure C.3.

Varying the degree of sovereign risk pass-through, governed by χ_2, has a similar effect on output, consumption and the real exchange rate as changes in fiscal strain, Φ. In Figure C.4 in the appendix, we vary χ_2 while keeping the default risk parameters fixed at $\Phi = 0.01$ and $\delta = 0.002$. For $\chi_2 = 0.35$ in panel b, we obtain our main results: in response to an increase in government spending, aggregate output rises above steady state under both monetary regimes and the increase is more prominent under flexible rates. Private consumption falls, under both regimes, as the risk premium on household debt rises with the current deterioration of the fiscal balance and the exchange rate depreciates under flexible exchange rates. For a higher degree of sovereign risk pass-through, $\chi_2 = 0.65$, we find that the output dynamics change under fixed exchange rates and, again, allows for a negative response to output on impact.

Note that, in panel c of figures C.3 and C.4, even though the *impact* response of output is negative under fixed exchange rates, the response becomes positive in the *long-run*. This is due to the assumed rigidity in intermediate goods prices and can be explained as follows. The increase in government spending and the associated rise in government debt have a positive effect on the risk premium on household loans and hence reduce private consumption. The effect becomes stronger for higher values of Φ and χ_2. Under flexible exchange rates, the fall in domestic demand is offset by an increase in foreign demand due to the nominal exchange rate depreciation. This allows for a positive effect on output in the short-run and a gradual decline in the long-run as firms are able to adjust their prices upwards. Under fixed exchange rates, however, the exchange rate is held constant and, without the ability of firms to change their prices immediately, the reduction in consumption is translated into an overall fall in output. In the long-run, however, prices become more flexible and are reduced such that private spending and total output rise.

The findings displayed in Figure 7.3c correspond to the results in Corsetti et al. (2012a): countries experiencing high fiscal strain and without access to an exchange rate mechanism to absorb changes in sovereign risk will find it increasingly difficult to stabilise the economy through discretionary fiscal policy. Our model also shows that the extent to which public financial instability affects private sector interest rates matters for the effectiveness of fiscal policy.

8 Application: expansionary fiscal contractions?

Our discussion thus far is somewhat related to the literature on expansionary fiscal consolidation, prompted by Giavazzi and Pagano (1990). In their influential paper, Giavazzi and Pagano make an excellent account of the increase in private consumption that occurred during substantive fiscal adjustments in Denmark and Ireland during the 1980s. Such potential *non-Keynesian* effects of fiscal policy can be explained by the 'credibility channel' as in Sutherland (1997), Alesina and Ardagna (1998) and Perotti (1999). The underlying mechanism works as follows: a credible fiscal retrenchment that puts government debt on a sustainable footing can bring about a reduction in default beliefs, and hence the risk premium on government bonds and the real interest rate, which boosts private consumption and investment.[17] This credibility effect is found to be more pronounced for high or rapidly increasing levels of debt. Conversely, an expansionary fiscal regime that leads to prolonged periods of exceptionally high levels of government debt raises interest rates such that fiscal policy might even become contractionary.

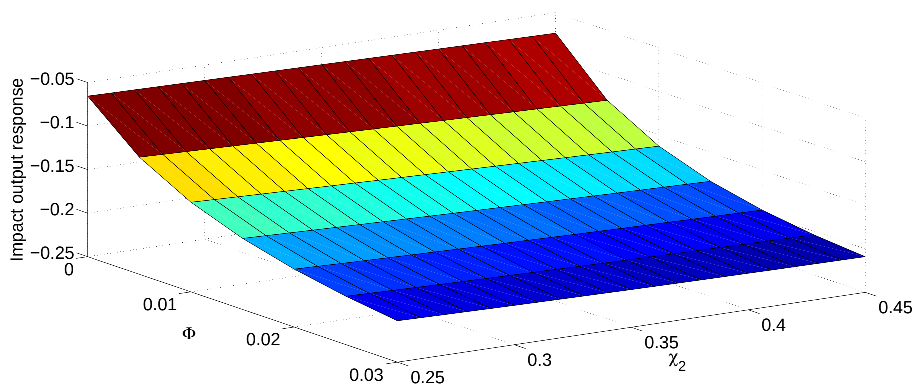
Our model can be used to assess the expansionary fiscal consolidation hypothesis by simulating the response of output upon a reduction in government spending. According to this hypothesis, the strength of the credibility channel depends (amongst other things) on the relationship between the level of government debt and the real interest rate, which is one of the main features of our model. We therefore examine the effects of a fiscal contraction for different values of Φ and χ_2. In particular, we ask: how much fiscal strain (captured by Φ) and sovereign risk pass-through (captured by χ_2) is required in order for a fiscal consolidation to become expansionary? Also, what is the role of the monetary regime?[18]

Figure 8.2a suggests that, under flexible exchange rates, a reduction in government consumption leads to greater output losses on impact for both a higher amount of fiscal strain and a stronger feedback between public and private credit risk. This follows from our discussion in section 7.1, in which we showed that the real exchange rate is positively correlated with the probability of sovereign risk and the level of government debt. As the fiscal contraction reduces the stock of debt, the risk premium on sovereign bonds falls such that foreign investors are induced to increase their holdings of Home bonds. This puts downward pressure on the real exchange rate, that is the real exchange rate *appreciates*, which in turn has a negative effect on output (see equation [5.9]). Moreover, the larger is the default elasticity with respect to public debt, the stronger will be the response of

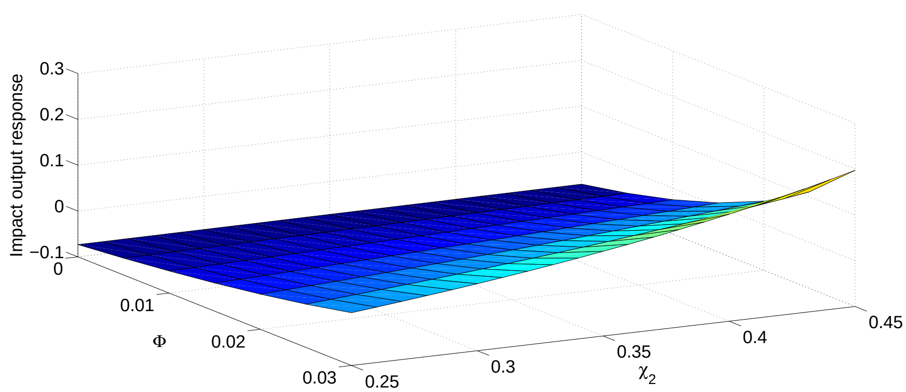
[17] Recently, for example, Alesina and Ardagna (2010) show that fiscal consolidations can be expansionary. The paper has, however, received both praise and criticism in policy circles. See Leigh et al. (2011).

[18] Of course, one must keep in mind that the effects of fiscal consolidation might also depend on the *type* of fiscal instrument, or the *composition* of various instruments, used during the course of the consolidation spell.

Figure 8.1: Impact output responses to a fiscal contraction



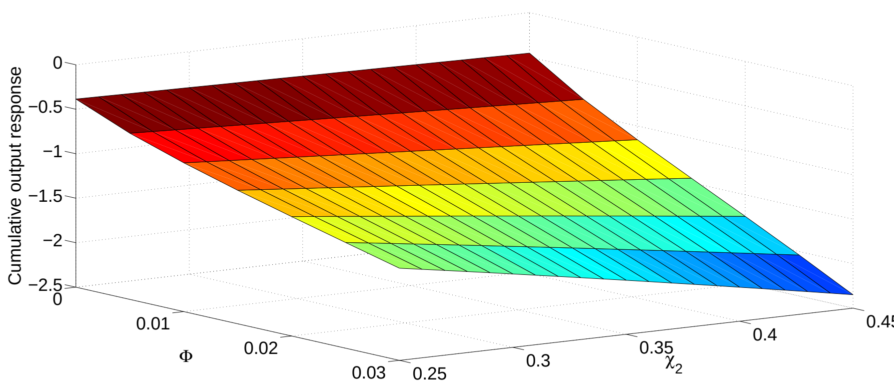
(a) Flexible exchange rates



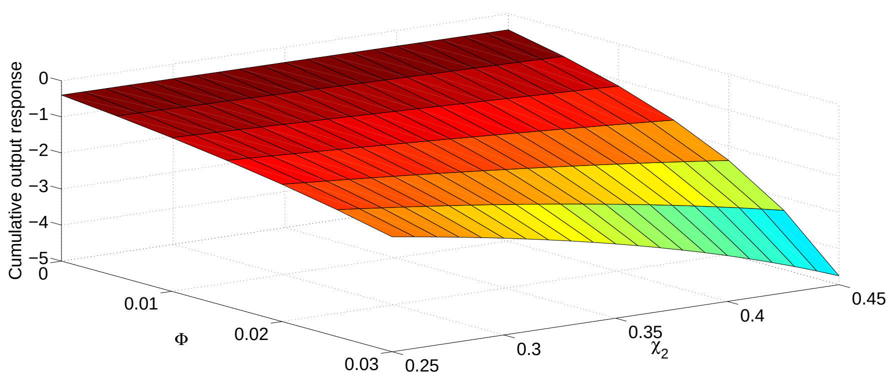
(b) Fixed exchange rates

Notes: Figures show impact output responses (vertical axes) upon a fiscal contraction of 1% for $\chi_2 \in [0.25, 0.45]$ and $\Phi \in [0.00, 0.03]$.

Figure 8.2: Cumulative output responses to a fiscal contraction



(a) Flexible exchange rates



(b) Fixed exchange rates

Notes: Figures show the (undiscounted) cumulative output response (vertical axes) over 20 periods (5 years) upon a fiscal contraction of 1% for $\chi_2 \in [0.25, 0.45]$ and $\Phi \in [0.00, 0.03]$.

foreign investors to an improvement of the fiscal balance and the greater will be the pressure on the exchange rate and aggregate production.

Under fixed exchange rates, however, fiscal consolidation can generate *positive* output responses, at least for high degrees of sovereign risk pass-through and fiscal strain. As before, the reduction in the public debt level restores confidence in financial markets and raises demand for Home bonds by foreign investors. When the exchange rate is allowed to float, the rise in foreign demand for domestic assets causes an appreciation of the exchange rate and a fall in CPI inflation, in particular for large values of Φ. Due to price stickiness, firms are unable to adjust prices accordingly and must therefore scale down production. When the currency rate is fixed, however, the effect on the nominal exchange rate is eliminated and output dynamics are determined by the response of household consumption. The latter *rises* upon a fall in public spending due to a reduction in the risk premium on household loans. Therefore, if the pass-through between sovereign risk and the private risk premium is large enough, that is if χ_2 is very high, and the consequent rise in private consumption is sufficiently strong, the net effect on output following the fiscal consolidation can become positive (see 8.2b).

The fiscal consolidation hypothesis also rests on the assumption of forward-looking behaviour of agents.[19] For instance, fiscal consolidation admits a positive response to consumption if households expect a reduction in taxes and/or an increase in government transfers in the future. As shown by Coenen et al. (2008), a fiscal retrenchment that leads to a reduction in outstanding government debt and lower total interest rate payments can raise the possibility of a drop in the level of distortionary taxes which increases investment and output in the long-run. As is similar to our analysis, these positive effects become more pronounced when allowing for a relationship between the level of government debt and the equilibrium real interest rate. Since Figure 8.1, which shows the impact responses of output, might conceal these potential positive long-run effects of fiscal consolidation, we will also consider the cumulative output responses after a fall in government consumption, again for different degrees of fiscal strain and sovereign risk pass-through.

The results are shown in Figure 8.2. Under flexible exchange rates, the cumulative effects on output are again dictated to a large extent by the sovereign default elasticity and its interactions with the real exchange rate. Higher measures of this elasticity result into greater output losses for a given reduction in spending by the government, even in the long-run (see Figure 8.3a). Under fixed exchange rates, we observe that the long-run output response to a government spending cut is negative for all combinations of Φ and χ_2 and the effects are stronger for higher values of these parameters. This follows from our discussion in section 7.2. We have already seen that, for a high degree of sovereign risk pass-through and fiscal strain, the impact response of output can be positive under fixed exchange rates. This is due to the reduction in the risk premium on household loans and the associated increase in private spending. Due to price stickiness, firms respond by raising

[19] Note that, in our model, we implicitly assume financial market participants to be forward-looking as both the parameter governing fiscal strain, $\Phi \equiv \partial\Delta\left(\frac{1}{\pi}Rb\right)/\partial\left(\frac{1}{\pi}Rb\right)\left[\pi^{-1}Rb\,(1-\delta)^{-1}\right]$, and the equation describing the risk premium on household loans, (5.1), are dependent on the steady state values of real government debt and output, respectively, rather than their contemporary counterparts.

production which allows for an increase in aggregate output. In the long-run, prices become more flexible and firms raise their prices in order to benefit from the increase in private demand. The higher price level, however, causes spending to fall and pushes output below steady state, completely offsetting the initial positive effect on output (see Figure 8.3b).

Our application qualifies the results found by Giavazzi and Pagano (1990). Mainly, it is possible for a fiscal consolidation to generate a positive output response, yet only in the presence of *considerable* sovereign risk pass-through and fiscal strain. In addition, a fiscal contraction is only favourable in terms of output gains under *fixed* exchange rates and only in the *short-run*. Long-run adjustment costs could, however, be avoided by stimulating demand through expansionary fiscal policy once expectations regarding sovereign risk are sufficiently subdued. Under flexible exchange rates, the fiscal adjustment and the concomitant exchange rate appreciation and deflation lead to output losses for any measure of sovereign risk pass-through and in particular for higher default elasticities with respect to public debt. The effects of fiscal policy, in the presence of weak public finances, are therefore more Keynesian under flexible exchange rates and non-Keynesian in countries that have adopted a pegged currency regime.

9 Conclusion and discussion

The effects of government consumption on output and other key economic variables have received ample attention in both the neoclassical and (New) Keynesian branches of macroeconomics. Recent sovereign debt crises in a number of advanced economies have highlighted the importance of public debt sustainability for both fiscal and monetary stabilisation policy. In this paper, we have examined the implications of sovereign risk for fiscal policy effectiveness under different monetary regimes. Specifically, we have shown that, in the presence of sovereign risk, a government spending shock can generate higher output responses under flexible than under fixed exchange rates, which is in contrast to both the traditional Mundell-Fleming paradigm as conventional New Keynesian wisdom. Intuitively, an increase in the probability of a sovereign default, following a rise in deficit-financed public expenditures, leads to a fall in foreign demand for domestic assets. The consequent exchange rate depreciation under a float supports aggregate output, especially when the import share in total output and the elasticity of substitution between foreign and domestic goods are large. Under fixed exchange rates, however, the favourable relative price change induced by the increase in sovereign risk is eliminated due to central bank intervention. Hence, only the crowding out effect of the fiscal expansion remains and the output response on impact falls below that under flexible exchange rates. In fact, when introducing capital market imperfections in the form of a positive relationship between sovereign risk and a private risk premium, the output response can even be negative in the short-run and under fixed exchange rates.

These results are in line with De Grauwe (2012), who argues that a rise in sovereign default beliefs can have 'positive externalities' provided sovereign debt is largely denominated in domestic currency and the exchange rate is allowed to act as a natural adjustment mechanism. Countries experiencing fiscal strain and whose external debt is denominated in foreign currency, however, face a higher probability of falling into unstable equilibria, characterised by explosive debt developments. The discussion is therefore particularly relevant for countries that are contemplating to anchor their exchange rate or adopt a common currency.

The choice between fixed and floating exchange rates hinges on the benefits of reduced exchange rate volatility under fixed rates versus monetary policy independence under flexible rates. This 'Mundellian trade-off', originally emphasized by Mundell (1961), has been examined more closely by Cooper and Kempf (2004). In their paper, Cooper and Kempf provide for a role of fiscal policy in diminishing, or even eliminating, the costs of monetary union in terms of stabilisation losses that might arise when countries waive their control over monetary policy. In a two-country, overlapping generations model, they show that the government can perfectly insure households against country-specific income losses through tax-financed unemployment benefits and thereby effectively substitute fiscal for monetary stabilisation. We have seen that, under fixed exchange rates and the assumption of complete asset markets, the private sector is completely insulated from the effects of sovereign risk. Under such conditions, it could therefore be possible for fiscal policy to eliminate the costs of monetary union, as in Cooper and Kempf (2004). However, our findings also suggest that it might not be possible for fiscal policy to generate sufficiently large or even positive output multipliers if government debt levels are critically high, there is a strong feedback between public and private risk and there is no offsetting exchange rate channel. In this case, monetary union can bring about much larger costs (in terms of higher output and inflation volatility) than initially anticipated. Whether or not fiscal policy can improve the Mundellian trade-off under (prolonged episodes of) fiscal strain is a topic we leave for future research.

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A Data and empirical specification

We closely follow Corsetti et al. (2012b) and use the data as described in Table 2 of their paper[20], estimate the first step following the specification of equation (1) in their paper and the second step following equation (2) for the unconditional effects and the peg versus float analysis. For the analysis where we distinguish weak public finances under a peg and a float, we specify the following second step equation:

$$\begin{aligned}
x_{t,i} \quad = \quad & \alpha_i + \mu_i \mathrm{trend}_t + \xi_i x_{t-1,i} + \sigma_1 \hat{\epsilon}_{t,i} + \sigma_2 \hat{\epsilon}_{t-1,i} + \sigma_3 \hat{\epsilon}_{t-2,i} + \sigma_4 \hat{\epsilon}_{t-3,i} \\
& + \kappa_1 (\hat{\epsilon}_{t,i} * \mathrm{wp}_{t,i}) + \kappa_2 (\hat{\epsilon}_{t-1,i} * \mathrm{wp}_{t-1,i}) + \kappa_3 (\hat{\epsilon}_{t-2,i} * \mathrm{wp}_{t-2,i}) + \kappa_4 (\hat{\epsilon}_{t-3,i} * \mathrm{wp}_{t-3,i}) \\
& + \lambda_1 \mathrm{wp}_{t,i} + \lambda_2 \mathrm{wp}_{t-1,i} + \lambda_3 \mathrm{wp}_{t-2,i} + \lambda_4 \mathrm{wp}_{t-3,i} \\
& + \gamma_1 (\hat{\epsilon}_{t,i} * \mathrm{wf}_{t,i}) + \gamma_2 (\hat{\epsilon}_{t-1,i} * \mathrm{wf}_{t-1,i}) + \gamma_3 (\hat{\epsilon}_{t-2,i} * \mathrm{wf}_{t-2,i}) + \gamma_4 (\hat{\epsilon}_{t-3,i} * \mathrm{wf}_{t-3,i}) \\
& + \delta_1 \mathrm{wf}_{t,i} + \delta_2 \mathrm{wf}_{t-1,i} + \delta_3 \mathrm{wf}_{t-2,i} + \delta_4 \mathrm{wf}_{t-3,i} + u_{t,i},
\end{aligned}$$

where x is the macroeconomic variable of interest, α a country specific fixed effect, μ captures the trend, σ captures the unconditional effect of a government spending shock $\hat{\epsilon}$, κ captures the effect of a government spending shock conditional on weak public finances and a peg (wp), λ captures the fixed effect of weak public finances and a peg, γ captures the effect of a government spending shock conditional on weak public finances and a float (wf), δ captures the fixed effect of weak public finances and a float and u is the residual.

[20] There are some minor modifications: we use the OECD as a primary source for the general government debt level, have more periods with weak public finances, slightly different periods for pegs and we have no data on Ireland prior to 1990.

B Log-linearization

Here we derive the non-trivial log-linearized equilibrium conditions of the model.

We start with the expressions for (international) prices. The aggregate price level, P_{Ht}, consists of prices from firms that are able to set a new price, i.e. $\bar{P}_{Ht}$, and those who cannot, i.e. $P_{Ht}(i) = P_{Ht-1}(i)$. We can therefore rewrite equation (4.14) as

$$\begin{aligned} P_{Ht} &= \left[\int_0^{1-\theta} \left(\bar{P}_{Ht}\right)^{1-\epsilon} di + \int_{1-\theta}^{1} \left(P_{Ht-1}\right)^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}} \\ \left(P_{Ht}\right)^{1-\epsilon} &= (1-\theta)\left(\bar{P}_{Ht}\right)^{1-\epsilon} + \theta\left(P_{Ht-1}\right)^{1-\epsilon}. \end{aligned}$$

Divide by $\left(P_{Ht-1}\right)^{1-\epsilon}$:

$$\left(\frac{P_{Ht}}{P_{Ht-1}}\right)^{1-\epsilon} = (1-\theta)\left(\frac{\bar{P}_{Ht}}{P_{Ht-1}}\right)^{1-\epsilon} + \theta.$$

Then, log-linearization yields

$$\hat{\pi}_{Ht} = (1-\theta)\left(\hat{\bar{P}}_{Ht} - \hat{P}_{Ht-1}\right). \tag{B.1}$$

where $\hat{\pi}_{Ht} \equiv \hat{P}_{Ht} - \hat{P}_{Ht-1}$. Log-linearization of the CPI equation, (4.9), gives

$$\hat{P}_t = \hat{P}_{Ht} + \alpha \hat{S}_t \tag{B.2}$$

or, in differences,

$$\hat{\pi}_t = \hat{\pi}_{Ht} + \alpha\left(\hat{S}_t - \hat{S}_{t-1}\right), \tag{B.3}$$

where we used $\hat{S}_t = \hat{P}_{Ft} - \hat{P}_{Ht}$ for $S = 1$. The expression for the real exchange rate can be re-written using the assumption of the law of one price, i.e. $P_{Ht} = e_t P^*_{Ht}$ and $P_{Ft} = e_t P^*_{Ft}$, and $P^*_{Ft} = P^*_t$:

$$q_t = \frac{e_t P^*_t}{P_t} \tag{B.4}$$

$$= \frac{e_t P^*_{Ft}}{P_t} = \frac{P_{Ft}}{P_t}. \tag{B.5}$$

Log-linearization of (B.5), using $\hat{S}_t = \hat{P}_{Ft} - \hat{P}_{Ht}$ and (B.2) and assuming $q = 1$, yields

$$\begin{aligned} \hat{q}_t &= \hat{P}_{Ft} - \hat{P}_t = \hat{S}_t + \hat{P}_{Ht} - \left(\hat{P}_{Ht} + \alpha \hat{S}_t\right) \\ &= (1-\alpha)\hat{S}_t. \end{aligned} \tag{B.6}$$

Then, rewrite (B.3) using (B.6) to obtain (4.36):

$$\hat{\pi}_t = \hat{\pi}_{Ht} + \left(\frac{\alpha}{1-\alpha}\right)\hat{q}_t. \tag{B.7}$$

Note that (4.30) is obtained by log-linearizing (B.4), taking differences and using the assumption that $P_t^* = P^*$, for all t:

$$\begin{aligned} \hat{q}_t &= \hat{e}_t + \hat{P}_t^* - \hat{P}_t \\ \Leftrightarrow \hat{e}_t &= \hat{e}_{t-1} + \hat{q}_t - \hat{q}_{t-1} + \hat{\pi}_t. \end{aligned} \tag{B.8}$$

The intermediary firm's optimal re-set price, given by (4.17), can be written as:

$$\frac{\overline{P}_{Ht}}{P_{t-1}} E_t \sum_{k=0}^{\infty} (\theta\beta)^k e_{t+k} P_{t+k}^{-1} C_{t+k}^{-\sigma} P_{Ht+k}^{\epsilon} Y_{t+k} = \frac{1}{P_{t-1}} \mathcal{M} E_t \sum_{k=0}^{\infty} (\theta\beta)^k e_{t+k} P_{t+k}^{-1} C_{t+k}^{-\sigma} P_{Ht+k}^{1+\epsilon} Y_{t+k} mc_{Ht+k}$$

After log-linearization, while considering that in the flexible price equilibrium $mc_H = 1/\mathcal{M}$, one obtains

$$\hat{\overline{P}}_{Ht} = (1-\theta\beta) E_t \sum_{k=0}^{\infty} (\theta\beta)^k \left(\hat{P}_{Ht+k} + \hat{mc}_{Ht+k} \right).$$

Subtracting $\hat{P}_{Ht-1}$ from both sides and taking out the terms for $k = 0$, we have

$$\begin{aligned} \hat{\overline{P}}_{Ht} - \hat{P}_{Ht-1} &= (1-\theta\beta) E_t \sum_{k=0}^{\infty} (\theta\beta)^k \left(\hat{P}_{Ht+k} - \hat{P}_{Ht-1} + \hat{mc}_{Ht+k} \right) \\ &= (1-\theta\beta) E_t \sum_{k=0}^{\infty} (\theta\beta)^k \hat{mc}_{Ht+k} + E_t \sum_{k=0}^{\infty} (\theta\beta)^k \hat{\pi}_{Ht+k} \\ &= (1-\theta\beta) \hat{mc}_{Ht} + \hat{\pi}_{Ht} + \theta\beta E_t \left(\hat{\overline{P}}_{Ht+1} - \hat{P}_{Ht} \right). \end{aligned}$$

Now, using (B.1), we derive the New Keynesian Phillips curve:

$$\begin{aligned} \left(\frac{\theta}{1-\theta} \right) \hat{\pi}_{Ht} &= (1-\theta\beta) \hat{mc}_{Ht} + \beta \left(\frac{\theta}{1-\theta} \right) E_t \hat{\pi}_{Ht+1} \\ \hat{\pi}_{Ht} &= \frac{(1-\theta)(1-\theta\beta)}{\theta} \hat{mc}_{Ht} + \beta E_t \hat{\pi}_{Ht+1}. \end{aligned}$$

Finally, using the log-linearized version of the optimal labour demand condition, (4.16), we can rewrite further to obtain (4.33):

$$\begin{aligned} \hat{\pi}_{Ht} &= \lambda \left(\hat{w}_t + \hat{P}_t - \hat{P}_{Ht} \right) + \beta E_t \hat{\pi}_{Ht+1} \\ &= \lambda \left(\hat{w}_t + \tilde{\alpha} \hat{q}_t \right) + \beta E_t \hat{\pi}_{Ht+1}, \end{aligned} \tag{B.9}$$

where $\lambda \equiv (1-\theta)(1-\theta\beta)/\theta$ and $\tilde{\alpha} \equiv \alpha/(1-\alpha)$.

Regarding the household's optimal intertemporal decision for investment in sovereign bonds, given by (4.6), we first log-linearize $1-\delta_t$, where $\delta_t = \Delta\left(\frac{1}{\pi_t}R_{t-1}b_{t-1}\right)$:

$$\begin{aligned}
1-\delta_t &\approx (1-\delta) - \frac{\partial\Delta\left(\frac{1}{\pi}Rb\right)}{\partial\left(\frac{1}{\pi}Rb\right)}\left(\frac{1}{\pi_t}R_{t-1}b_{t-1} - \frac{1}{\pi}Rb\right) \\
\frac{(1-\delta_t)-(1-\delta)}{1-\delta} &\approx -\frac{\partial\Delta\left(\frac{1}{\pi}Rb\right)}{\partial\left(\frac{1}{\pi}Rb\right)}\left(\frac{\frac{1}{\pi}Rb}{1-\delta}\right)\left(\frac{\frac{1}{\pi_t}R_{t-1}b_{t-1} - \frac{1}{\pi}Rb}{\frac{1}{\pi}Rb}\right) \\
&= -\Phi\left(\hat{b}_{t-1} + \hat{R}_{t-1} - \hat{\pi}_{t-1}\right),
\end{aligned}$$

where $\Phi \equiv \frac{\partial\Delta\left(\frac{1}{\pi}Rb\right)}{\partial\left(\frac{1}{\pi}Rb\right)}\left(\frac{\frac{1}{\pi}Rb}{1-\delta}\right)$ is the elasticity of the probability of default with respect to changes in $\frac{1}{\pi}Rb$. Then, log-linearzation of (4.6) gives us (4.32):

$$\hat{C}_t = E_t\hat{C}_{t+1} - \frac{1}{\sigma}\left[(1-\Phi)\left(\hat{R}_t - E_t\hat{\pi}_{t+1}\right) - \Phi\hat{b}_{Ft}\right] \tag{B.10}$$

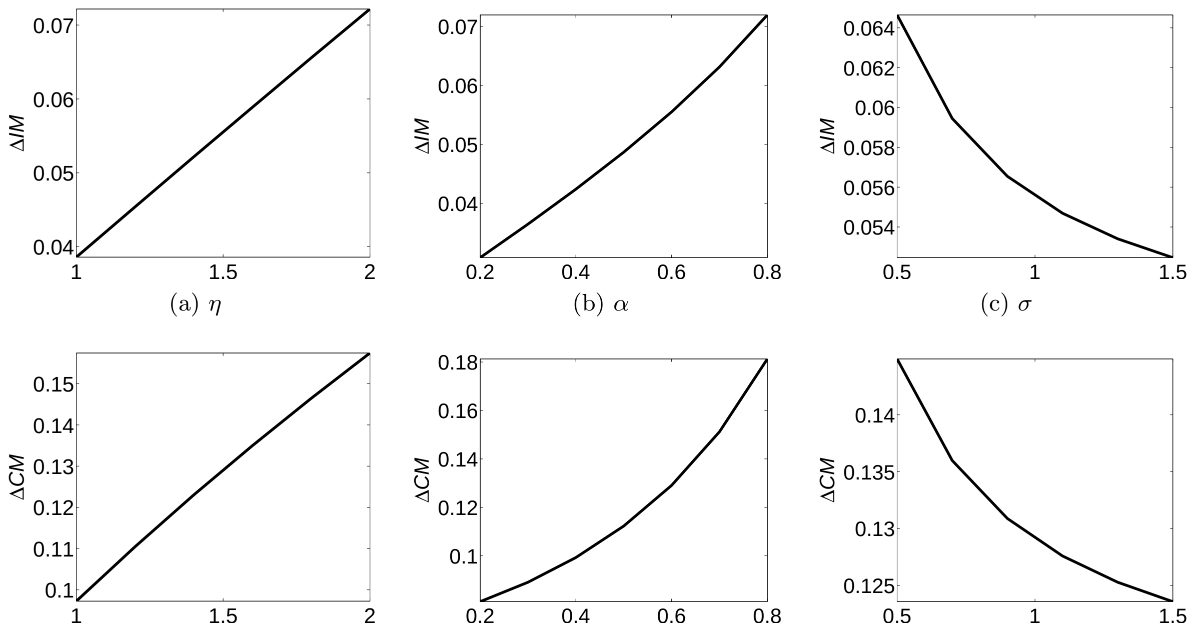
The log-linearized versions of the remaining equilibrium conditions, (4.4), (4.23), (4.24), (4.26), (4.29), (4.22), (4.18), (4.19), (4.28) including the risk premium on private debt, (5.1) and (5.7), are respectively

$$\begin{aligned}
\varphi\hat{Y}_t &= \hat{w}_t - \sigma\hat{C}_t && \text{(B.11)}\\
\hat{b}_{Ft} &= \left(\frac{1-\Phi}{\beta}\right)\left(\hat{b}_{Ft-1} + \hat{R}_{t-1} - \hat{\pi}_t\right) + \frac{G}{b_F}\hat{G}_t - \frac{T}{b_F}\hat{T}_t && \text{(B.12)}\\
\hat{T}_t &= \phi_b\left(\hat{b}_{Ft-1} - \hat{\pi}_t\right) && \text{(B.13)}\\
\hat{Y}_t &= \Theta\hat{q}_t + (1-\alpha)\left(\frac{C}{Y}\hat{C}_t + \frac{G}{Y}\hat{G}_t\right) && \text{(B.14)}\\
\hat{C}_t &= \frac{1}{\sigma}\hat{q}_t && \text{(B.15)}\\
\hat{G}_t &= \rho_g\hat{G}_{t-1} + \varepsilon_t^g && \text{(B.16)}\\
\hat{R}_t &= \rho_r\hat{R}_{t-1} + (1-\rho_r)\,\phi_\pi E_t\hat{\pi}_{t+1} && \text{(B.17)}\\
\hat{R}_t &= \phi_e\left(\hat{e}_t - \hat{e}_{t-1}\right) && \text{(B.18)}\\
\frac{f}{Y}\hat{f}_t &= \beta^{-1}\frac{f}{Y}\left(\hat{f}_{t-1} + \hat{\Xi}_{t-1}\right) + \left[\left(\beta^{-1}-1\right)\frac{f}{Y} + \tilde{\alpha}\right]\hat{q}_t - \frac{b_F}{Y}\hat{b}_{Ft} \\
&\quad + \frac{b_F}{Y}\left(\frac{1-\Phi}{\beta}\right)\left(\hat{b}_{Ft-1} + \hat{R}_{t-1} - \hat{\pi}_t\right) - \left(\hat{Y}_t - \frac{C}{Y}\hat{C}_t - \frac{G}{Y}\hat{G}_t\right) && \text{(B.19)}\\
\hat{\Xi}_t &= \chi_1\frac{f}{Y}\left(\hat{f}_t + \hat{q}_t\right) + \chi_2\frac{b_F}{Y}\left[(1-\delta)\,\Phi\left(\hat{b}_{Ft-1} + \hat{R}_{t-1} - \hat{\pi}_t\right) + \delta\hat{b}_{Ft}\right] && \text{(B.20)}\\
\hat{q}_t &= E_t\hat{q}_{t+1} - \left[(1-\Phi)\left(\hat{R}_t - E_t\hat{\pi}_{t+1}\right) - \Phi\hat{b}_{Ft}\right] + \hat{\Xi}_t && \text{(B.21)}
\end{aligned}$$

which correspond to the equations (4.31), (4.34), (4.35), (4.37), (4.38), (4.39), (4.40), (4.41), (5.10), (5.8) and (5.9) in section 4.6.

C Graphs

Figure C.1: Float vs. peg: impulse and cumulative output multipliers under sovereign risk

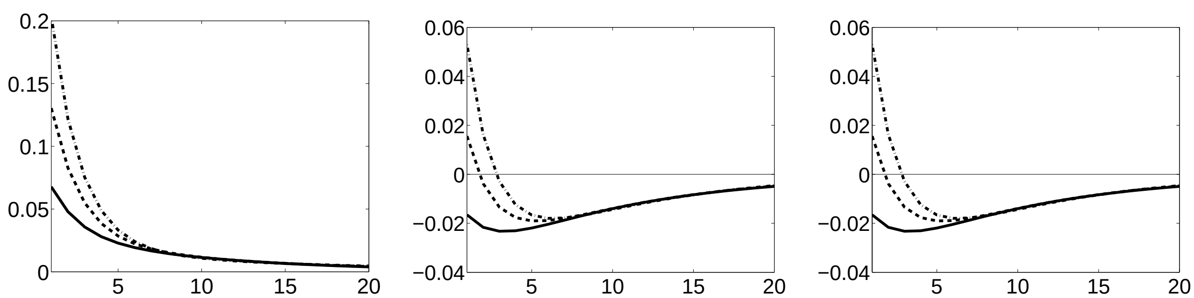


(a) η (b) α (c) σ

(d) η (e) α (f) σ

Notes: IM indicates 'impact multiplier' and measures the output response at $t = 1$; CM indicates 'cumulative multiplier' and measures the (undiscounted) cumulative output response over 20 periods (5 years). $\Delta IM = IM_{flex} - IM_{fixed}$ measures the difference between the impact multiplier under flexible and fixed exchange rate regimes; $\Delta CM = CM_{flex} - CM_{fixed}$ measures the difference between the cumulative output multiplier under flexible and fixed exchange rates. The horizontal axes show the intervals of the corresponding parameter while keeping $\Phi = 0.01$ and $\delta = 0.002$.

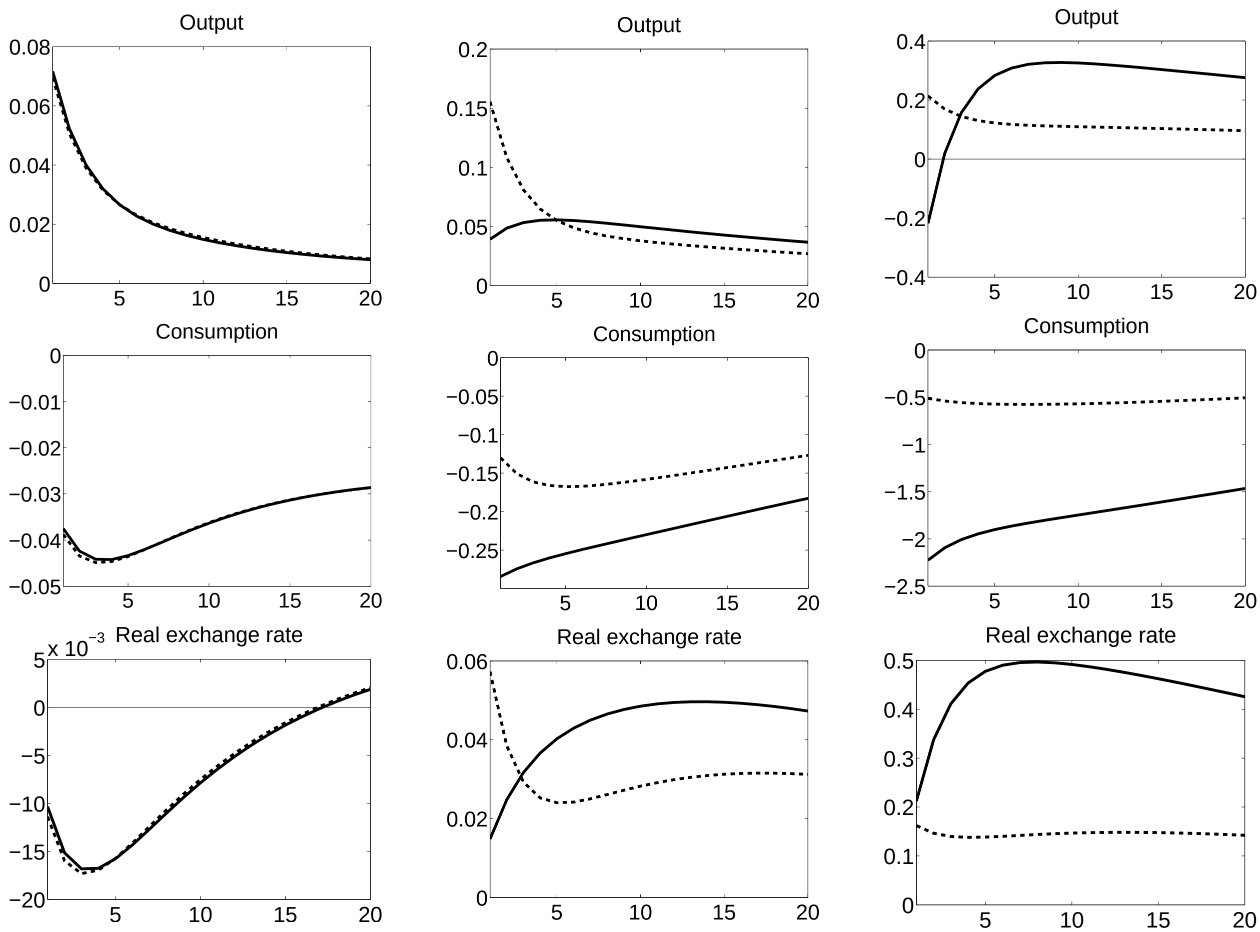
Figure C.2: Complete asset markets: effect of Φ under flexible exchange rates



(a) Output (b) Consumption (c) Real exchange rate

Notes: Figures show responses to a 1% increase in government consumption from steady state. The solid lines present the benchmark case with $\Phi = 0.00$; the dashed lines show responses for $\Phi = 0.01$; the dashed-dotted lines show responses for $\Phi = 0.04$. The steady state probability of sovereign default is set to $\delta = 0.002$ for $\Phi = 0.00$ and $\delta = 0.002$ for $\Phi = 0.01, 0.04$.

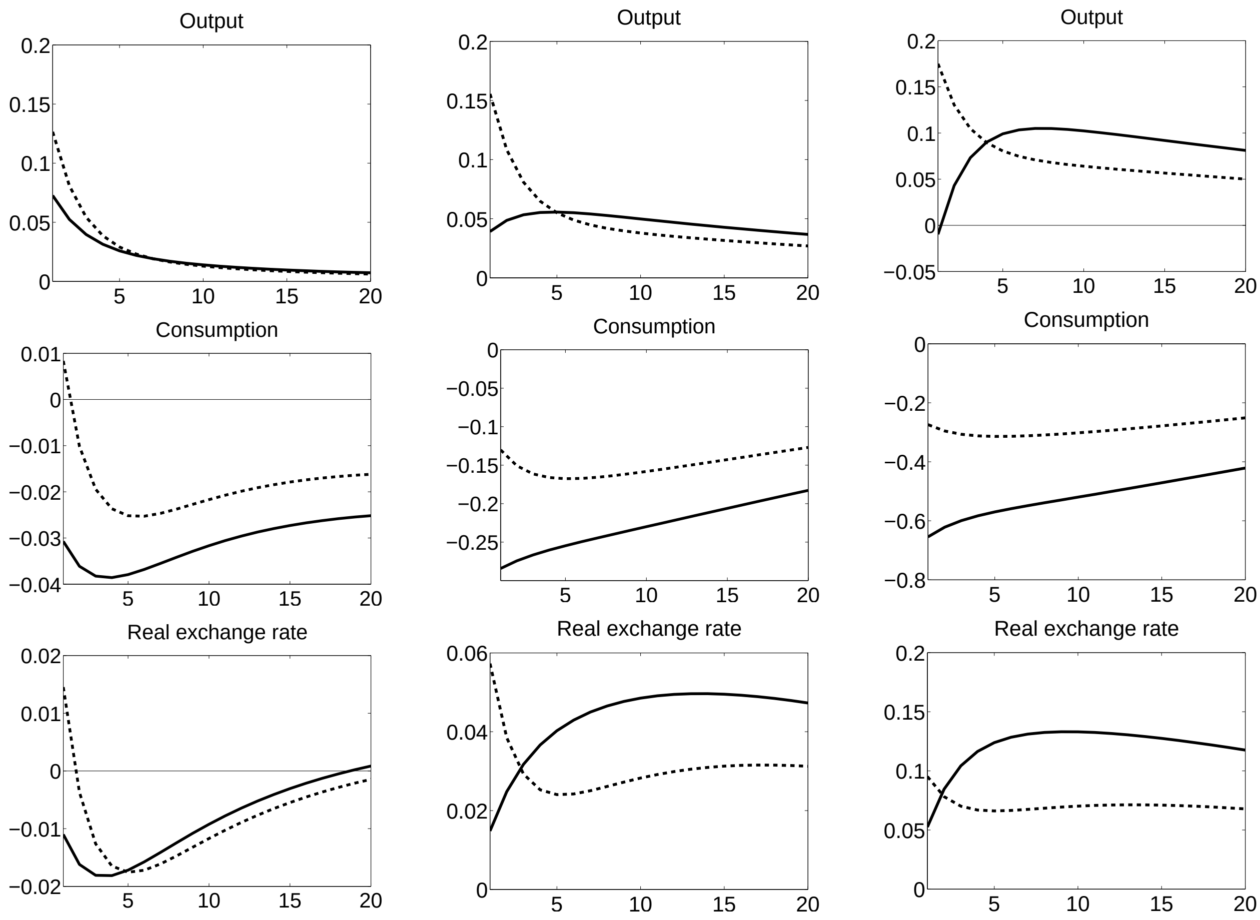
Figure C.3: Incomplete asset markets: effect of Φ



(a) $\Phi = 0$ (b) $\Phi = 0.01$ (c) $\Phi = 0.04$

Notes: Figures show responses to a 1% increase in government consumption from steady state. Dashed lines show responses under flexible exchange rates; solid lines show responses under fixed exchange rates. In all figures, we assume$\delta = 0.002$ and $\chi_2 = 0.35$.

Figure C.4: Incomplete asset markets: effect of χ_2



(a) $\chi_2 = 0.05$ (b) $\chi_2 = 0.35$ (c) $\chi_2 = 0.65$

Notes: Figures show responses to a 1% increase in government consumption. Dashed lines show responses under flexible exchange rates; solid lines show responses under fixed exchange rates. In all figures, we assume$\Phi = 0.01$ and $\delta = 0.002$.