Macroeconomic implications of Eurobonds

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Abstract: Member states of the euro area disagree over proposals for issuing common sovereign bonds (Eurobonds) with full joint liability. Some of them fear that heavy indebted countries will no longer care about fiscal discipline once Eurobonds are implemented. We build a two-country monetary union DSGE model to compare three scenarios of government debt issuance: National bonds, Eurobonds, and Limited Eurobonds (a cap on the issuance of Eurobonds). Assuming that a country decides to increase public spending and cares little about debt stabilization, we find that its spending multiplier would be the highest with Eurobonds and the lowest with Limited Eurobonds. The spillover effects on output in the rest of the union would be negative with Eurobonds but positive with Limited Eurobonds. Our findings hence support the case for limited joint liability.

Keywords: Eurobonds, sovereign debt, euro area, monetary union

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1. Introduction

During the global financial crisis and the subsequent sovereign debt crisis in the euro area, some countries were faced with a surge in sovereign bond yields and lost access to financial markets. Borrowing costs then increased much for both the public sector and the private sector. A severe recession ensued with dire financial and economic consequences. In the end, financial assistance was provided to distressed countries (Greece, Ireland, Portugal, Cyprus and Spain) to avoid sovereign default, contagion effects and ultimately a collapse of the European monetary union. Financial support has taken various forms, among which conditional loans by the European Stability Mechanism (ESM), and bond purchases through Outright Monetary Transactions (OMT) by the European Central Bank (ECB).

Member states of the European Union (EU) disagreed about appropriate policy responses, and in particular about the interpretation of EU law. The Treaty of Lisbon (former Treaty of Maastricht) forbids joint liability of sovereign borrowers, that is a member state of the euro area cannot take on the liabilities of another member state. A strict enforcement of this “no bail-out” clause was not endorsed by all member states. It is in this context that proposals of creating sovereign Eurobonds started to emerge.1 Since 2010, the idea of pooling sovereign debt instruments has been met with enthusiasm in some member states (e.g. France, Italy) and skepticism in some others (e.g. Germany, Netherlands). The latter mostly fear that the existence of Eurobonds would impair commitment to fiscal discipline and are reluctant to assume the debt of spendthrift governments.

In this paper, we are interested in studying the implications of Eurobonds in terms of fiscal policy.2 What would happen for instance if a member state, say Greece, began to increase government spending and issue Eurobonds? Would fiscal policy in this country be more effective? What would be the consequences for other member states, among them Germany? Would cross-border spillover effects on output be negative or positive?

There is certainly political disagreement between member states in the matter of Eurobonds. Yet, academic research has provided some strong arguments in support of joint liability in sovereign borrowing (Basu and Stiglitz, 2015; Tirole, 2015; Baglioni and Cherubini, 2016; Basu, 2016; Favero and Missale, 2016), albeit with some reservations (Beetsma and Mavromatis, 2014; Esteves and Tunçer, 2016; Hatchondo et al., 2017).3 So, what is it all about?

A sovereign Eurobond is a debt instrument that would be issued and backed by all euro area countries. It would enable member states to borrow funds. It can be seen as a form of debt mutualisation inasmuch as member states would collectively guarantee repayments. The nationality of the sovereign issuer would not be known. Hence, interest rates on Eurobonds would be the same whatever the sovereign issuer. The risk premium, in principle, would depend on the average level of sovereign debt in the euro area and on the perception of financial market participants upon the credibility of the joint guarantee of repayment.

The main advantage of Eurobonds would be the existence of a large and liquid market for sovereign bonds. The most indebted member states would benefit from a decrease in borrowing costs because they would no longer issue debt with a country-specific risk premium. In addition, as long as changing risk perceptions among financial market participants play a significant role

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1 For a review of the various Eurobonds proposals, see De La Dehesa (2011), Eijfinger (2011), Claessens et al. (2012), and Basu (2016).

2 From 2012, there has also been a debate about the idea of creating a common euro area budget. For a discussion of this issue, see Farvaque and Huart (2016).

3 Issing (2009) formulates a critical position on the topic.
in sovereign spreads, the creation of Eurobonds could protect heavily indebted member states against contagion effects during financial turmoil, and this will benefit fiscally responsible member states as well (Favero and Massale, 2012). It could also prevent debt dynamics from getting into (or staying in) an unsustainable path (Tielens et al., 2014). This outcome holds if moral hazard does not prevail though.

Indeed, moral hazard is a critical issue. Sovereign Eurobonds could raise some incentive problems in terms of fiscal discipline because higher public deficits would no longer be bound to be sanctioned by higher borrowing costs. Furthermore, if some governments were to become profligate, this could be costly for the least indebted member states (and particularly for those which enjoy a triple A credit rating). The latter would face a higher public borrowing cost if the average euro area sovereign risk premium were higher than theirs.

Some solutions to the problem of moral hazard have been put forward in the literature about joint liability in the context of sovereign debt. A third party could impose costs if a sovereign borrower reneges on its commitments (Basu and Stiglitz, 2015), but sanctions should be feasible (Tirole, 2015). A debt management agency could issue insurance bonds with country-specific risk premia that would be based on national economic fundamentals (Muellbauer, 2013). Eurobonds could be used to finance projects that benefit all member states (Favero and Missale, 2016) or they should cover only a fraction of government debt (Baglioni and Cherubini, 2016).

In this respect, Delpla and Von Weizsäcker (2010) made a concrete proposal to pool only a share of public debts. Each member state would be allowed to issue Eurobonds (“blue bonds”), but up to a limit corresponding to 60 percent of its GDP (the Maastricht criterion). Blue bonds could be issued with low interest rates, because all member states would collectively guarantee the repayment. Furthermore, they would be senior debt. Any member state that would need to borrow more than 60 percent of its GDP would have to issue its own bonds (“red bonds”). The latter would be junior debt that would be honored only after the senior debt has entirely been serviced. Red bonds would not be guaranteed by other member states, and as a result, they would likely be issued with higher interest rates. Furthermore, they would not be eligible for the refinancing operations of the ECB.

There are, however, downsides. Esteves and Tunçer (2016) studied five experiences that they consider as being early forms of debt mutualisation in the pre-1914 period. The first case ended up with a default of Greece, and the loan was ultimately paid by the guarantors (Britain, France, Russia). The other cases were implemented with some international financial control and/or some write-downs of existing debt. Moreover, Hatchondo et al. (2017) show that if non-defaultable debt (Eurobonds) and defaultable debt (national bonds) coexist, the decrease in the interest rate spread is short-lived, because the government still has to issue defaultable debt. In other respects, Beetsma and Mavromatis (2014) demonstrate that the guarantee of repayment by other countries should not be 100% and should be sufficiently low to incite a government not to put into more debt than if it had no guarantee at all. However, Badarau et al. (2017) argue that if the joint guarantee of repayment is not full, the institutional framework of Eurobonds might lack credibility, and, as a consequence, macroeconomic outcomes might not be favorable.

In this paper, we compare the different proposals found in the literature about the Eurobonds implementation, by analyzing their macroeconomic implications in an asymmetric monetary union. We build a dynamic stochastic general equilibrium (DSGE) model to describe a

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4 This problem would not arise if the European fiscal rules were effective in the first place.

5 In the proposals made by Hild et al. (2014) and Brunnermeier et al. (2016), Eurobonds would be designed as structured financial instruments in the form of asset-backed securities (a portfolio of sovereign bonds) with different tranches (Eurobonds would constitute the senior tranche).
monetary union composed of two countries with different size and different fiscal policy preferences. We study the effects of a positive country-specific public spending shock to investigate what would happen if one government were no longer fiscally responsible in a monetary union with sovereign risk pooling. To do so, we compare three scenarios of government debt issuance. In the baseline scenario with national bonds only, each country issues its own sovereign bonds with country-specific risk premia. There is thus no risk pooling. In the scenario with Eurobonds, by contrast, there is full risk pooling and both countries share a common risk premium. And in the third scenario with “Limited Eurobonds”, there is a cap on the issuance of Eurobonds up to 60 percent of GDP in each country. Beyond this limit, countries must issue national bonds. This last scenario corresponds to the proposal of Delpla and Von Weizsäcker (2010).

Assuming that a country decides to increase public spending and cares little about debt stabilization, we find that its spending multiplier would be the highest with Eurobonds and the lowest with Limited Eurobonds. The spillover effects on output in the rest of the union would be negative with Eurobonds but positive with Limited Eurobonds. Our findings hence support the proposal of Delpla and Von Weizsäcker (2010) for limited joint liability.

In the literature, Badarau et al. (2017) have also provided similar results in a DSGE model of a monetary union, but they have not taken into account the size heterogeneity of the member countries. However, this feature is at the heart of the recent debate about Eurobonds in the euro area. Here, we propose a generalization of their model, by introducing an adjustable size parameter. This extension allows for a more realistic analysis of Eurobond and a better consideration of the euro area structural heterogeneity. Four novelties are to be noted.

First, we introduce imported goods in government consumption. This assumption is based on the observation that, according to EU law, public procurements must be open to competition between businesses of all member states. Admittedly, this assumption makes the cross-border spillover effects of an increase in government consumption more likely to be positive (see Blanchard et al., 2017). However, to keep the model analytically tractable, we refrain from incorporating usual assumptions in the model, which would make spillover effects positive, such as habit persistence or liquidity-constrained households (as in Naraidoo et al., 2017). We do not describe explicitly the role of financial intermediaries either. It follows that our model does not account for the impact of sovereign risk on the cost of borrowing for firms (see Corsetti et al., 2013; Badarau et al., 2014), but it allows for an impact of sovereign risk on the expected return of household portfolios. So instead, we put special emphasis on the definition of government budget constraints and debt issuance in the three scenarios under consideration.

Second, we consider that changes in governments’ behavior may occur because of changes in the regime of debt financing. A government may not care about debt stabilization as much as it used to if the cost of borrowing is no longer dependent on the level of its own debt alone. In particular, the response of public spending to government debt in the fiscal policy rule, which in principle is needed to stabilize debt, is assumed to be lower in the spendthrift country once Eurobonds are implemented.

Third, thanks to the adjustable size parameter introduced in the model, we check the sensitivity of our results to heterogeneity across countries with regard to policy preferences and country size. In particular, we look at cases where public spending is procyclical in the spendthrift country and counter-cyclical in the rest of the union. We also explore the case where this country is a small country and explain the implications in terms of spending multiplier and spillover effects. Additionally, we examine various monetary policy rules.

Finally, we also carry out a welfare analysis to compare outcomes under the three scenarios of government debt issuance in which countries differ in size.
The paper is organized as follows. Section 2 presents the model by paying special attention to the determinants of government debt issuance and sovereign risk premia in each scenario. Section 3 outlines the calibration. Section 4 explains the results of the simulations of a country-specific public spending shock under the three scenarios. Section 5 provides the sensitivity analysis. Section 6 concludes.

2. The model

The theoretical framework is a dynamic stochastic general equilibrium (DSGE) model of a two-country monetary union (MU). It is based on the model developed by Badarau et al. (2017) that we extend in order to take into account the structural heterogeneity of the member countries. Indeed, in Badarau et al. (2017), the only source of heterogeneity across countries is the asymmetry of a fiscal shock. Here, we extend the model to account for other sources of heterogeneity such as differences in country size and differences in government behaviour and policy preferences (fiscal policy rules).

The basic structure of the model is standard (Smets and Wouters, 2003). Since we focus on the specification of government budget constraint under various cases of government debt issuance, we keep the core structure of the model simple.\(^6\)

The monetary union, whose size is normalized to one, is thus composed of two countries that differ in population size: the size of the Home country \((H)\) is \(n\), and the size of the Foreign country \((F)\), also called Rest of the Union \((RoU)\), is \((1-n)\), where \(0 < n < 1\).

Each economy \(H\) and \(F\) is populated by a continuum of infinitely-lived households distributed on the intervals \([0, n]\) and \([n, 1]\) respectively. Moreover, each economy \(H\) and \(F\) uses labour to produce tradable goods distributed on the intervals \([0, n]\) and \([n, 1]\) respectively. Goods are produced by firms under monopolistic competition, nominal prices are sticky (adjusted à la Calvo), and the law of one price is assumed to hold for export prices (Erceg and Lindé, 2013; Corsetti et al., 2014; Blanchard et al., 2017).

We also extend the model of Badarau et al. (2017) by adding an assumption about government consumption: as in Blanchard et al. (2017), a share of public spending may be imported. We make this assumption to account for EU rules that aim at promoting cross-border public procurement. Public authorities must award public contracts by respecting some principles about the publication of tenders (transparency, equal treatment and non-discrimination). Hence, all EU businesses have free access to public market procurements in all EU member states. Still, the import content of government consumption is low. On average, it is 11 percent against 29 percent for private consumption in euro area countries (Bussière et al., 2013).

The two MU countries share a common central bank that is assumed to conduct monetary policy according to a Taylor-type policy rule. In our baseline model, the MU central bank sets the MU nominal interest rate in response to changes in the MU inflation rate and MU output gap (Gomes et al., 2012; Dieppe et al., 2012; Erceg and Lindé, 2013; Corsetti et al., 2014; Blanchard et al., 2017). In the sensitivity analysis, amid different specifications of the monetary policy rule, we

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\(^6\) Thus, we skip some features, which are used to strengthen the effects of a fiscal expansion, such as wage rigidity, habit persistence in consumption, adjustment costs in investment, and non-Ricardian households (Erceg and Lindé, 2013; Blanchard et al., 2017; Naraidoo et al., 2017).
also consider a case in which the central bank only cares about inflation (as in Naraidoo et al., 2017).

As for fiscal policy, there are independent national fiscal authorities in the monetary union. Governments purchase domestic and foreign goods, make lump-sum transfers to households, and levy taxes on labour income and consumption. They do not need to balance their budget at each period. They can finance public deficits by issuing debt. We consider three different cases of government debt issuance: country-specific sovereign bonds (no risk pooling), Eurobonds (full risk pooling), and Limited Eurobonds (partial risk pooling with the issuance of Eurobonds up to a limit of 60 percent of GDP in each country and, beyond this limit, the issuance of country-specific bonds).

A fiscal policy rule is needed to stabilize the debt/GDP ratio. Public consumption is used as a policy instrument. In this respect, the MU countries differ in terms of the conduct of fiscal policy and the calibration of the fiscal policy rule: it is assumed that the government of the Home country raises public consumption exogenously (positive fiscal shock) and is less concerned about debt stabilization than her counterpart in the Rest of the Union. Debt sustainability aside, public consumption may also be adjusted to stabilize output.\(^7\) In our baseline model, fiscal policy is a-cyclical. In the sensitivity analysis, it may be procyclical or counter-cyclical. In particular, knowing that fiscal policy tends to be procyclical in countries with high levels of public debt (Combes et al., 2017), we investigate the case in which the response of public consumption to output is positive and stronger in the fiscal policy rule of the Home country.

Since the two economies have similar structures but differ in size (and policy preferences in the calibration), this section mostly presents the details of the model for the Home country. Variables for the Foreign country (RoU) are denoted by an asterisk (*).

2.1. Households and sovereign bond holdings

The representative household chooses consumption \((C_t)\) and supplies labour \((L_t)\) to firms in order to maximize the following expected discounted sum of utilities:

\[
U = E_0 \sum_{t=0}^{\infty} \beta^t \{U_t(C_t, L_t)\} \tag{1}
\]

where \(U_t(C_t, L_t)\) denotes the utility function, the operator \(E\) represents the conditional expectation based on the information available at time \(t\), and \(0 < \beta < 1\) is the discount factor. The household derives utility from consumption and leisure (or disutility from work):

\[
U_t(C_t, L_t) = \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\eta}}{1+\eta} \tag{2}
\]

where parameters \(\sigma > 0\) and \(\eta > 0\) are the inverse of the intertemporal elasticity of substitution and the inverse of the Frisch elasticity of labour supply, respectively.

The household’s consumption preferences are embodied in a composite consumption good \((C_t)\), which is an aggregate of Home \((C_{H,t})\) and Foreign \((C_{F,t})\) goods:

\(^7\) In Corsetti et al. (2014), tax revenue instead of government spending is used as a policy instrument and is adjusted to deviations of output and public debt from their respective steady-state values.
where \( \alpha_1 \) is the weight of tradable goods produced in the Home country in the Home consumption basket, and \( \theta > 0 \) denotes the constant elasticity of substitution between Home and Foreign goods. The parameter \( \alpha_1 \) captures home bias in consumption and is related to the degree of trade openness (see Faia and Monacelli, 2008).

Each bundle of goods, \( C_{H,t} \) and \( C_{F,t} \), is composed of imperfectly substitutable varieties, with \( \varepsilon \) the elasticity of substitution:

\[
C_{H,t} = \left[ \left( \frac{1}{n} \right) \int_0^n C_{H,t}(j) \frac{\varepsilon-1}{\varepsilon} \, dj \right]^\varepsilon \quad (4)
\]

\[
C_{F,t} = \left[ \left( \frac{1}{1-n} \right) \int_n^1 C_{F,t}(j) \frac{\varepsilon-1}{\varepsilon} \, dj \right]^\varepsilon \quad (5)
\]

Given the household’s demand for the composite consumption good, the demand for Home and Foreign goods can be determined by solving the expenditure minimization problem. The resulting demand functions are given by:

\[
C_{H,t} = \alpha_1 \left( \frac{P_{H,t}}{P_t} \right)^{-\theta} C_t \quad (6)
\]

\[
C_{F,t} = (1 - \alpha_1) \left( \frac{P_{F,t}}{P_t} \right)^{-\theta} C_t \quad (7)
\]

where \( P_{H,t} \) and \( P_{F,t} \) are the prices of Home and Foreign composite goods respectively. The consumer price index \( P_t \) is defined as:

\[
P_t = (\alpha_1 (P_{H,t})^{1-\theta} + (1 - \alpha_1)(P_{F,t})^{1-\theta})^{\frac{1}{1-\theta}} \quad (8)
\]

The household’s budget constraint is:

\[
(1 + \tau_c)C_t + \frac{b_{t+1}^N}{p_t} + \frac{b_{t+1}^E}{p_t} = (1 - \tau_w) \frac{W_tL_t}{p_t} + B_t^N R_t \Psi_t^N + B_t^E R_t \Psi_t^E + \frac{\tau R_t}{p_t} + \Delta_t \quad (9)
\]

where \( W_t \) denotes nominal wage, \( \Delta_t \) are real profits received from ownership of firms, \( B_{t+1}^N \) is the household’s portfolio of national sovereign bonds purchased in \( t \), \( B_{t+1}^E \) is the household’s portfolio of Eurobonds, \( R_t \Psi_t^N \) gives the real return on household’s portfolio of sovereign national bonds, composed of the real risk-free interest rate \( R_t \) and a risk premium \( \Psi_t^N \) on

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8 Similarly, consumption preferences in the RoU are described as:

\[
C^*_t = \left[ \left( \frac{1}{n} \right) \int_0^n C^*_t(j) \frac{\varepsilon-1}{\varepsilon} \, dj \right]^\varepsilon \quad (3)
\]
national sovereign bonds, $R_t \Psi_t^E$ is the real return on household’s portfolio of Eurobonds with $\Psi_t^E$ a risk premium on Eurobonds, and $TR_t$ denotes transfers from government.

The representative household maximizes her intertemporal utility function (1) subject to the budget constraint (9). Her first order conditions imply:

$$\frac{-U_{C,t}(C_t,L_t)}{U_{C,t}(C_t,L_t)} = \frac{W_t}{P_t}$$

$$\frac{u_{C,t}(C_t,L_t)}{(1 + \tau_c)} = \beta (1 + i_{t+1}) \Psi_{t+1} \frac{P_{t+1} u_{C,t+1}(C_{t+1},L_{t+1})}{(1 + \tau_c)}$$

where $\frac{W_t}{P_t}$ is the real wage, and $i_t$ is the nominal risk-free interest rate. Equation (10) represents the optimal consumption and labour supply household’s decisions. Equation (11) describes her intertemporal optimal consumption choice between the current and future periods (Euler equation).

Under complete markets, optimal risk sharing implies that the ratio of Foreign to Home marginal utility of consumption is equal to the real exchange rate:

$$\frac{u_{C,t}(C_t,L_t)/(1 + \tau_c)}{u_{C,t}(C_t,L_t)/(1 + \tau_c)} = \frac{P_t^*}{P_t}$$

where $\frac{P_t^*}{P_t} \equiv RER_t$ is the real exchange rate.

Equation (12) defines the full risk sharing condition across countries. It predicts that relative consumption is positively and highly correlated with the real exchange rate (Backus and Smith, 1993). Foreign household’s preferences and choices can be defined symmetrically.

The representative household’s portfolio of national sovereign bonds, $B_t^N$, is an aggregate of Home $B_{H,t}$ and Foreign $B_{F,t}$ bonds that are issued in the Home market, with $\theta_{b} > 0$ the constant elasticity of substitution between Home and Foreign bonds:

$$B_t^N = \left( b_1 \frac{1}{\theta_b} \left( B_{H,t}^{*} \right)^{\theta_{b-1}} \frac{\theta_{b-1}}{\theta_b} + (1 - b_1) \frac{1}{\theta_b} \left( B_{F,t}^{*} \right)^{\theta_{b-1}} \frac{\theta_{b-1}}{\theta_b} \right)^{\theta_{b-1}}$$

The parameter $b_1$ denotes the share of Home bonds in the household’s portfolio of national bonds.

In an analogous way, in the Foreign country, the Foreign representative household’s portfolio of national bonds is an aggregate of bonds issued in the Foreign market by the Foreign country’s government $B_{F,t}^{*}$ and by the Home country’s government $B_{F,t}$:

$$B_t^{N*} = \left( b_1 \frac{1}{\theta_b} \left( B_{F,t}^{*} \right)^{\theta_{b-1}} \frac{\theta_{b-1}}{\theta_b} + (1 - b_1) \frac{1}{\theta_b} \left( B_{F,t}^{*} \right)^{\theta_{b-1}} \frac{\theta_{b-1}}{\theta_b} \right)^{\theta_{b-1}}$$
The parameter $b_1$ may be interpreted as representing a home bias in the household’s behaviour (with $b_1 > 1/2$, for $n = 1/2$).\(^9\)

As for Eurobonds holdings, the household’s Eurobonds portfolio, $B^E_t$, is composed of Eurobonds that are issued by the Home country’s government ($B^E_t^{H,t}$) and the Foreign country’s government ($B^E_t^{F,t}$):

$$B^E_t = \left( b_2 \frac{1}{\theta_b} (B^E_t^{H,t})^{\frac{\theta_b-1}{\theta_b}} + (1 - b_2) \frac{1}{\theta_b} (B^E_t^{F,t})^{\frac{\theta_b-1}{\theta_b}} \right)^{\frac{\theta_b}{\theta_b-1}}$$  \(15\)

Likewise, in the Foreign country, the household’s Eurobonds portfolio, $B^E_t^{*}$, comprises Eurobonds issued by the Foreign country’s government ($B^E_t^{F,t}$) and the Home country’s government ($B^E_t^{H,t}$):

$$B^E_t^{*} = \left( b_2 \frac{1}{\theta_b} (B^E_t^{F,t})^{\frac{\theta_b-1}{\theta_b}} + (1 - b_2) \frac{1}{\theta_b} (B^E_t^{H,t})^{\frac{\theta_b-1}{\theta_b}} \right)^{\frac{\theta_b}{\theta_b-1}}$$  \(16\)

In contrast to national bonds, there is no home bias in Eurobonds holdings, because households don’t know the nationality of the issuer. Insofar as the two MU countries differ in size, the value of $b_2$ in equation (15) is given by the weight of Eurobonds issued by the Home country’s government in the total issuance of Eurobonds in the monetary union at steady state. In the same way, the value of $b_2^*$ in equation (16) is derived from the share of Eurobonds issued by the Foreign country’s government in the total issuance of Eurobonds in the monetary union at steady state.\(^10\)

The risk premium $\Psi^N_t$ associated with the national bonds index $B^N_t$ in (13) is given by:

$$\Psi^N_t = \left( b_1 (\Psi^*_t)^{1-\theta_b} + (1 - b_1) (\Psi^*_t)^{1-\theta_b} \right)^{\frac{1}{1-\theta_b}}$$  \(17\)

where $\Psi_t$ and $\Psi^*_t$ are the sovereign risk premia on Home and Foreign bonds respectively (defined in sub-section 2.4 infra).

Since there is no distinction between Eurobonds issued by different governments, a single risk premium $\Psi^E_t$ is applied to Eurobonds.

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\(^9\) Home bias in asset holdings is well documented in the literature. For Euro area investors, see Floreani and Habib (2018). Home bias is often given exogenously in empirical models (Portes and Rey, 2005) or derived endogenously in theoretical models resulting in a linear function for equity portfolio choices (Coeurdacier, 2009; Hnatkovska, 2010). Such linear function is a particular case of the more generalized constant elasticity of substitution (CES) functional form considered in our paper. A CES function is also used in Alpanda and Kabaca (2015), and Auray et al. (2018).

\(^10\) The condition of absence of home bias in holding Eurobonds ($b_2 = 1 - b_2^*$) is thus implicitly verified for the two countries of the union.
We also compute a global risk premium, $\Psi_t^G$, which is related to the total household’s holdings of national bonds and Eurobonds:

$$\Psi_t^G = (1 - \Theta_t)\Psi_t^N + \Theta_t\Psi_t^E$$

Thus, $\Psi_t^G R_t$ gives the real return on households’ savings.

The share allotted to Eurobonds in the household’s portfolio, $\Theta_t$, is determined as follows:

$$\Theta_t = \frac{B^E_{H,t} + B^E_{L,t}}{B^E_{H,t} + B^E_{L,t} + B^N_{H,t} + B^N_{L,t}}$$

It is endogenous and varies over time depending on investment opportunities.

### 2.2. Terms of trade and real exchange rate

We define the terms of trade, $S_t$, as:

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

Since the law of one price holds, the Foreign country’s terms of trade, $S^*_t$, can be defined by:

$$S^*_t = \frac{P_{H,t}}{P_{F,t}} = \frac{1}{S_t}$$

Given the definition of the terms of trade, we can also write:

$$\frac{p_t}{p_{H,t}} = \left( a_1 + (1 - a_1)(S_t)^{1-\theta} \right)^{\frac{1}{1-\theta}} \equiv f(S_t)$$

$$\frac{p_t}{p_{F,t}} = \frac{f(S_t)}{S_t}$$

Finally, the real exchange rate is related to the terms of trade as follows:

$$RER_t = \frac{p^*_t}{p_t} = \frac{f(S^*_t)}{f(S_t)} S_t$$

### 2.3. Firms and price setting

In the Home and Foreign countries, a continuum of monopolistically competitive firms, indexed on the intervals $[0,n]$ and $[n,1]$ respectively, produce differentiated goods $j$ using the technology $Y_t(j)$:

$$Y_t(j) = A_t L_t(j)$$

where $L_t$ denotes hours worked, and $A_t$ is a technological shock. The latter is common to all firms and is assumed to follow a first-order autoregressive process AR(1):

$$\log(A_t) = \rho A \log(A_{t-1}) + \epsilon_{A,t} \sim i.i.d. (0, \sigma^2_A)$$, a serially uncorrelated shock.
Cost minimization by firms implies that the real marginal cost of production is:

\[ mc_t = \frac{W_t}{\lambda_t p_t} \]  

(26)

Following Calvo (1983), we assume that firms set nominal prices on a staggered basis: at each period, a fraction \((1 - \phi)\) of firms are randomly selected to set new prices \(P_t^n(j)\), while the remaining fraction \(\phi \in [0,1]\) of firms keep their prices unchanged. The optimal price setting problem for a firm \(j\) that is able to reset its price at time \(t\) is given by the maximization of the intertemporal expected profits of the firm subject to the demand constraint imposed by the market conditions:

\[
\max_{P_t^n(j)} \mathbb{E}_t \left\{ \sum_{s=0}^{\infty} (\phi)s \lambda_{t+t+s} \left[ \frac{P_t^n(j)}{p_{t+s}} \right]^{-\varepsilon} Y_{t+s} - mc_{t+s} \left( \frac{P_t^n(j)}{p_{t+s}} \right)^{-\varepsilon} Y_{t+s} \right\} 
\]  

(27)

The term \(\lambda_{t+t+s} = \beta^s \frac{U_{C_t+C_{t+s}}(C_{t+s}+I_{t+s})}{U_{C_t+C_{t+i}}}\) is the discount factor for future real profits and \(\varepsilon > 1\) the elasticity of substitution between varieties of goods.

The first order condition implies:

\[
P_t^n(j) = \frac{\varepsilon}{\varepsilon - 1} \mathbb{E}_t \left\{ \sum_{s=0}^{\infty} (\phi)s U_{C_t+C_{t+s}}(C_{t+s}+I_{t+s}) \lambda_{t+t+s} Y_{t+s} \left[ \frac{P_t^n(j)}{p_{t+s}} \right]^{-\varepsilon} \right\} mc_{t+s} \left( \frac{P_t^n(j)}{p_{t+s}} \right)^{-\varepsilon} Y_{t+s} \]  

(28)

where \(\frac{\varepsilon}{\varepsilon - 1}\) is the steady-state markup. The optimal price is a desired markup over a weighted average of current and discounted expected marginal costs.

The aggregate domestic price index evolves according to the following law of motion:

\[
P_t^{1-\varepsilon} = (1 - \phi)(P_t^n)^{1-\varepsilon} + \phi P_{t-1}^{1-\varepsilon} \]  

(29)

The Foreign economy has an analogous price setting mechanism.

Since the law of one price is assumed to hold for tradable goods, exporters in each country set the same price in both MU countries, that is: the prices of Home goods sold in the Foreign country and those of Foreign goods sold in the Home country are given, respectively, by: \(P_{H,t}^* = P_{H,t}\) and \(P_{F,t}^* = P_{F,t}\).

2.4 Fiscal policy

2.4.1. Government debt issuance

Home government purchases goods (\(G_t\)) and make transfers to households (\(TR_t\)). The public consumption aggregate, \(G_t\), is defined as follows:

\[
G_t = \left( a_2 \frac{\theta}{\theta-1} (G_{H,t})^{\frac{\theta-1}{\theta}} + (1 - a_2) \frac{\theta}{\theta-1} (G_{F,t})^{\frac{\theta-1}{\theta}} \right) \]  

(30)
where $G_{H,t}$ denotes public consumption of Home goods and $G_{F,t}$ public consumption of Foreign goods, with $a_2$ the weight of Home goods in the public consumption basket.\textsuperscript{11}

As in Blanchard et al. (2017), a fraction of government consumption can thus be imported. However, evidence shows that the import content of government spending is lower than that of private spending (Bussière et al., 2013), so that we have: $a_2 > a_1$.

The government also collects tax revenues on consumption and wages. It is allowed to finance deficits by issuing bonds on the Home and Foreign markets in the monetary union. Government budget constraint and debt accumulation differ according to debt financing instruments: national bonds, Eurobonds, and Limited Eurobonds. These three cases (scenarios) are described hereafter.

\textbf{i) National Bonds}

In the first scenario, governments of the MU countries finance their debt only by issuing national bonds. There are no Eurobonds. The sovereign risk premium is therefore country-specific. The government budget constraint, the government debt dynamics, the government debt issuance and the determination of the sovereign risk premium in the Home country are described by the set of equations (31) to (34), and those in the Foreign country (denoted by an asterisk) by the set of equations (35) to (38):

\begin{align*}
PS_t &= \tau_c nC_t P_t + \tau_w nW_t L_t - nTR_t - nG_t P_t \\
D_t &= (1 + i_t)\Psi_t D_{t-1} - PS_t \\
D_t^* &= nB_{H,t} + (1 - n)B_{F,t} \\
\Psi_t &= \exp\left[\psi_N \left(\frac{D_{t-1}}{nP_t Y_t - 0.6}\right)\right]
\end{align*}

\begin{align*}
PS_t^* &= \tau_c^* (1 - n)C_t^* P_t^* + \tau_w^* (1 - n)W_t^* L_t^* - (1 - n)TR_t^* - (1 - n)G_t^* P_t^* \\
D_t^* &= (1 + i_t)\Psi_t^* D_{t-1} - PS_t^* \\
D_t^* &= (1 - n)B_{F,t}^* + nB_{H,t}^* \\
\Psi_t^* &= \exp\left[\psi_N^* \left(\frac{D_{t-1}^*}{(1 - n)P_t Y_t^* - 0.6}\right)\right]
\end{align*}

In a monetary union with two countries of different sizes, the nominal GDP of the Home country is denoted by $nP_t Y_t$ and that of the Foreign country by $(1 - n)P_t Y_t^*$. The primary budget surplus of the Home government, $PS_t$, is the difference between government tax revenue (on consumption and labour income) and government primary expenditure (public consumption and transfers). The stock of public debt at time $t$, $D_t$, depends on the primary deficit (the negative of $PS_t$), the previous period’s debt, $D_{t-1}$, and interest payments $i_t \Psi_t D_{t-1}$. It is

\textsuperscript{11} For technical reasons, we here consider that $G_t$ is the public consumption index for a unit size government. But it is, in fact, adjusted to country size in order to work with a correct measure of expenditure in each country. Country size is explicitly considered in all other variables that are related to governments.
financed by national bonds that are issued on the Home market $B_{H,t}$ and on the Foreign market $B_{F,t}$. The sovereign risk premium, $\Psi_t$, depends on the deviation of the debt/GDP ratio from the 60% limit of the Maastricht Treaty. The parameter $\psi_N$ is the sensitivity coefficient of the risk premium to public indebtedness. More precisely, a higher public debt level can raise the sovereign risk premium because it can raise the probability of sovereign default (see Bi, 2012). The value of $\psi_N$ is relatively higher in the case of national bonds than in the case of risk pooling if investors believe that there is a joint guarantee of repayment in the latter case.

### ii) Eurobonds

In the second scenario, the public debt of each country is entirely financed by Eurobonds. There are no national bonds. The risk premium is common to all governments. Debt accumulation with Eurobonds is described by the following set of equations:

\[
D_t = (1 + i_t)\Psi_t D_{t-1} - PS_t
\]
\[
D_t = nB_{H,t} + (1 - n)B_{F,t}
\]
\[
D_t^* = (1 + i_t)\Psi_t D_{t-1} - PS_t^*
\]
\[
D_t^* = (1 - n)B_{F,t} + nB_{H,t}^*
\]
\[
\Psi_t^E = \exp \left[ \psi_E \left( \frac{D_{t-1}^{UM}}{P_{t-1}Y_{t-1}} - 0.6 \right) \right]
\]
\[
D_t^{UM} = D_t + D_t^*
\]
\[
Y_t^{UM} = nY_t + (1 - n)Y_t^*
\]

where $P_{t-1}Y_{t-1}^{UM}$ represents the nominal GDP of the union. Equations (39) and (40) describe debt dynamics in the Home country, equation (41) and (42) debt dynamics in the Foreign country, equation (43) the risk premium on Eurobonds, equation (44) the union-wide stock of public debt, and equation (45) union-wide output. In the Home country, for example, public debt is financed by Eurobonds that are issued in the Home market ($B_{H,t}^E$) and in the Foreign market ($B_{F,t}^E$). The risk premium on Eurobonds $\Psi_t^E$ reacts to the deviation of the union-wide debt/GDP ratio from the 60% limit of the Maastricht Treaty. It is assumed that Eurobonds are credible so that the value of $\psi_E$ is very low.\(^{12}\) It follows that $\psi_E < \psi_N$.

### iii) Limited Eurobonds

In the third scenario, public debt of each government is financed by Eurobonds in the limit of 60% of GDP, the rest being financed by the issuance of national bonds. In this case, Eurobonds are risk-free assets ($\Psi_t^E = 1$) and the risk premium on national bonds is given by equations (34) and (38) supra for Home and Foreign countries respectively. Debt dynamics and debt financing in this scenario are described by the following set of equations:

\[^{12}\text{Alternatively, Eurobonds could not be credible, if lenders on financial markets suspect that there could be a lack of solidarity (a partial guarantee of repayment). The value of } \psi_E \text{ would then be higher. Such a case is detailed in Badarau et al. (2017).}\]
\[ D_t = (1 + i_t) \left[ \psi_t \left[ nB_{ht-1} + (1 - n)B_{ft-1} \right] + \Psi^E_t \left[ nB_{ht-1}^E + (1 - n)B_{ft-1}^E \right] \right] - PS_t \] 
(46)

\[ D_t = nB_{ht,t} + (1 - n)B_{ft,t} + nB_{ht,t}^E + (1 - n)B_{ft,t}^E \] 
(47)

\[ D_t^* = (1 + i_t) \left[ \psi_{t}^* \left[ (1 - n)B_{ft-1}^* + nB_{ht-1}^* \right] + \Psi_{t}^E \left[ (1 - n)B_{ft-1}^E* + nB_{ht-1}^E* \right] \right] - PS_t^* \] 
(48)

\[ D_t^* = (1 - n)B_{ft,t}^* + nB_{ht,t}^* + (1 - n)B_{ft,t}^{E*} + nB_{ht,t}^{E*} \] 
(49)

2.4.2. Fiscal policy instrument

The government needs to adjust revenue or expenditure to stabilise the debt/GDP ratio. We choose public consumption as the fiscal policy instrument. Government spending adjustments in response to output and public debt/GDP deviations from their respective steady-state values are endogenously made according to the following fiscal policy rule:

\[
\log(G_t) = \rho_g \log(G_{t-1}) + (1 - \rho_g) \log(Y) - (1 - \rho_g) \rho_g \psi_c \log(Y_t) - \log(Y) - (1 - \rho_g) \rho_g \psi_c \log(d_t) - \log(d) + z_t
\]
(50)

where \( \rho_g, \rho_g \psi_c, \rho_g \psi_c \) capture, respectively, the degree of public spending inertia, the fiscal reaction to real output \((Y_t)\) and the fiscal reaction to debt/GDP ratio \((d_t)\). The (log-linearized) government spending shock, \(z_t\), is assumed to follow an AR(1) process:

\[ z_t = \rho z_{t-1} + \varepsilon_{g,t} \] 
(51)

where \(0 < \rho < 1\), and \(\varepsilon_{g,t} \sim i. i. d. (0, \sigma_g^2)\).

The parameter \(\rho_g\) represents some inertia in the implementation of spending programs due to institutional constraints (e.g. voting procedures) or some irreversibility in some public expenditures (e.g. social benefits).

The parameter \(\rho_g \psi_c\) measures the extent of the reaction of public consumption to the business cycle (output gap) and its sign captures the cyclical behaviour of public consumption: if it is positive (resp. negative), public consumption is counter-cyclical (resp. procyclical) in the sense that public consumption is lower (resp. higher) than its steady-state level when output is higher (resp. lower) than its steady-state level.

We also assume that public consumption is adjusted in response to the public debt/GDP ratio for the sake of debt stabilization as it is commonly done in the literature about fiscal policy rules following the seminal paper of Bohn (1998). Specifically, public consumption is lowered if the public debt/GDP ratio is higher than its steady-state level. The size of the parameter \(\rho_g \psi_c\) depends on the willingness of the government to care (more or less) about debt stabilization. We assume that the Home country’s government cares less about debt stabilization than the Foreign country’s government: \(\rho_g \psi_c < \rho_g^{*} \psi_c\). Besides, as in Tielens et al. (2014), the size of this parameter may differ depending on how debt is financed. To illustrate the moral hazard problem (fewer incentives of fiscal discipline), we assume that it is lower in the Eurobonds scenario than in the other scenarios for the Home country only. Note, however, that the value of this parameter must be large enough to eventually stabilize the debt/GDP ratio (Corsetti et al., 2014).
2.5. Monetary policy

The central bank sets the short-term nominal interest rate of the union according to the following Taylor-type policy rule:

\[ i_t = \beta_i i_{t-1} + (1 - \beta_i) [i + \beta_\pi (E_t \pi^{MU}_{t+1} - \pi^{MU}_t) + \beta_\gamma [\log(Y^{MU}_t) - \log(Y^{MU})]] + \nu_{i,t} \]  

(52)

The policy rate \( i_t \) is adjusted in response to deviations of the expected future MU inflation rate \( E_t \pi^{MU}_{t+1} \) from its steady-state value \( \pi^{MU}_t \), and deviations of real MU output \( Y^{MU}_t \) from its steady-state value \( Y^{MU} \). It is equal to \( i \) at steady state. The term \( \nu_{i,t} \) is monetary policy shock which is assumed to follow an AR(1) process \( \nu_{i,t} = \rho \nu_{i,t-1} + \xi_{i,t} \) with an exogenous serially uncorrelated component, \( \xi_{i,t} \sim i.i.d. (0, \sigma^2) \). The parameter \( \beta_i \in [0,1] \) captures the degree of interest rate smoothing (or inertia), and the parameters \( \beta_\pi \) and \( \beta_\gamma \) measure the central bank’s reaction to MU inflation and real output respectively. The latter are weighted averages of country variables\(^{13}\):

\[ \pi^{MU}_t = n \pi_t + (1 - n) \pi^{*}_t \]  

(53)

\[ Y^{MU}_t = n Y_t + (1 - n) Y^{*}_t \]  

(54)

The presence of interest rate smoothing in the monetary policy rule can represent the central bank’s preference for a gradual adjustment of the policy rate to changing macroeconomic conditions or unexpected shocks. Interest rate variability may indeed have adverse effects on financial markets and is therefore perceived as undesirable.

The policy response to future expected inflation rather than current inflation is an essential element for macroeconomic stability. The response to current output gap can be justified by the predictive content of output growth for future inflation. Moreover, inflation and output are defined in deviation from their steady-state levels so that the interest rate is adjusted towards the target (its long-term equilibrium value) as the economy approaches steady state.

From a theoretical standpoint, describing the central bank behaviour by a Taylor-type monetary policy rule provides a convenient way to analyse the transmission of fiscal policy (Corsetti et al., 2010; Erceg and Lindé, 2013; Kollmann et al., 2013; Blanchard et al., 2017).\(^{14}\) Such a rule has been used in estimated models of the euro area or in models of the euro area developed at the ECB (e.g. Smets and Wouters, 2003; Coenen et al., 2008; Dieppe et al., 2012). From an empirical point of view, recent findings confirm that the ECB’s behaviour in interest rate setting can be described by a Taylor-type rule, although the degree of policy response to inflation and output changed during the global financial crisis (Gerlach and Lewis, 2014; Rühl, 2015; Caputo and Díaz, 2018).\(^{15}\)

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\(^{13}\) The weighted average is based on country size, which can be expressed by population size or GDP. A similar definition of MU variables can be found in Erceg and Lindé (2013), Blanchard et al. (2017), Naraidoo et al. (2017).

\(^{14}\) Corsetti et al. (2013, 2014) replace the output gap with the spread between lending and deposit rates in the Taylor rule because they study the role of credit spreads in the transmission of fiscal policy.

\(^{15}\) Using real time data, Hughes Hallett and Lewis (2015) found that the ECB has even reacted to the expected level of debt.
2.6. Market clearing

Aggregate goods market clearing in the Home country implies:

\[ nY_t = nC_t + (1 - n)X_t + nG_t \]  
\[ X_t = C_{H,t}^* + G_{H,t}^* = (1 - a_1^*) \left( \frac{P_{H,t}}{P_t} \right)^{-\theta} C_t^* + (1 - a_2^*) \left( \frac{P_{H,t}}{P_t} \right)^{-\theta} G_t^* \]

\[ Y_t \equiv \left( \frac{1}{n} \right)^{\frac{1}{\varepsilon}} \int_0^1 Y_t(j) \, d\varepsilon \]  
\[ \varepsilon = \frac{\theta}{\theta - 1} \]

where \( X_t \) denotes total exports of Home country to Foreign country, and \( Y_t \) denotes aggregate output. Imports are embodied in aggregate private consumption (equation (3)) and aggregate public consumption (equation (30)). Market clearing conditions are symmetrically defined in the Foreign economy.\(^{16}\)

The market clearing condition in the labour market requires:

\[ L_t = \int_0^n L_t(j) \, dj \]  
\[ L_t = \frac{\nu_t}{\lambda_t} \]

where \( \nu_t = \frac{1}{n} \int_0^n \left( \frac{P_{H,t}(j)}{P_t} \right)^{-\theta} d\varepsilon \) is a measure of price dispersion (output) across firms. So, aggregate output can be written as follows:

\[ Y_t = \frac{A_t \lambda_t}{\nu_t} \]

Higher price dispersion across firms implies a lower aggregate output because of an inefficient allocation of labour.

The balance of payments equilibrium condition at the union-wide level takes a different form depending on the scenario of government debt financing:

**National bonds**

\[ (1 - n)B_{F,t} - nB_{H,t} = (1 - n)B_{F,t-1} \Psi_t R_t - nB_{H,t-1} \Psi_t R_t + nM_t - (1 - n)X_t \]

**Eurobonds**

\[ (1 - n)B_{F,t}^E - nB_{H,t}^E = (1 - n)B_{F,t-1}^E \Psi_t^E R_t - nB_{H,t-1}^E \Psi_t^E R_t + nM_t - (1 - n)X_t \]

**Limited Eurobonds**

\[ (1 - n)B_{F,t} - nB_{H,t}^* + (1 - n)B_{H,t}^* = \]

\[ (1 - n)B_{F,t-1} \Psi_t R_t - nB_{H,t-1} \Psi_t R_t + (1 - n)B_{F,t-1}^E \Psi_t^E R_t - nB_{H,t-1}^E \Psi_t^E R_t + nM_t - (1 - n)X_t \]

where \( X_t = C_{H,t}^* + G_{H,t}^* \) and \( M_t = C_{F,t} + G_{F,t} \) are Home country’s exports and imports respectively.

\(^{16}\) For Foreign country, equation (55) becomes: \( (1 - n)Y_t^* = (1 - n)C_t^* + nX_t^* + (1 - n)G_t^*. \)
3. Calibration

We solve the non-linear stochastic model and then run simulations by using the program Dynare (Adjemian et al., 2014). The benchmark calibration of the model is displayed in Table A1 in the Appendix. We hereafter discuss the key parametrization of the model. For standard parameters, which are related to the behaviour of households and firms (preferences and technology), we choose plausible values by drawing on the literature about DSGE models and estimates for the euro area (e.g. Smets and Wouters, 2003; Christiano et al. 2005; Coenen et al., 2008; Jondeau and Sahuc, 2008; Kollmann et al., 2013).

The parameter of home bias in private consumption is set at 0.75, and the parameter of home bias in public consumption is set at 0.89. These values are derived from import contents of private consumption and government consumption, which are respectively 29% and 11% on average in euro area countries (Bussière et al., 2013). As for the value of the parameter of home bias in sovereign bond holdings, it is 0.70. We computed it by using ECB data on the share of securities issued by euro area governments in total securities held by euro area monetary and financial institutions.

The elasticity of substitution between domestic and foreign bonds is set at 3.4. It is taken from Alpanda and Kabaca (2015). It is higher than the elasticity of substitution between domestic and foreign goods (1.5).

The benchmark calibration of the monetary policy rule is made following estimates by Kollmann et al. (2013). We allow for a strong degree of inertia in the fiscal policy rule, which is also consistent with estimated parameters in Kollmann et al. (2013). In the baseline model, we disregard any cyclical response of public consumption in order to focus on the impact of the public consumption shock. As for the response of public consumption to public debt, a reference value of 0.1 corresponds to the estimated response of primary expenditure to government debt in Holm-Hadulla et al. (2012). Gomes et al. (2012) use this value for the response of taxes to debt/GDP ratio. We use a slightly higher value to make sure that the government debt/GDP eventually stabilises (Corsetti et al., 2014). We also allow for country-specific values of this parameter to account for heterogeneity in government behaviour: Home country’s government is assumed to care less about debt stabilisation ($\rho_{gd} = 0.15$) than Foreign country’s government ($\rho_{gd}^* = 0.2$). In addition, the implementation of sovereign risk pooling may lessen incentives to stabilise the government debt (moral hazard issues). We therefore consider lower values of $\rho_{gd}$ in the Home country’s only, and this in the case of Eurobonds (0.11), with a slightly different value in the case of Limited Eurobonds (0.13).

The steady-state government debt-to-GDP ratio is set at 100%. This value is not far from the average government debt/GDP ratio in the euro area, which has been above 90 percent since 2012 (AMECO database of the European Commission). The steady-state government consumption/GDP ratio is set at 0.20, which is the average in the euro area (AMECO). Tax rates are taken from the European Commission (2011): the implicit tax rates on labour income and consumption in the euro area are respectively 0.33 and 0.20. As regards the elasticity of the risk premium to deviation of the government debt-GDP ratio from its steady-state value, it is different under the three cases of government debt issuance. To get an idea of its size, we use the results of Corsetti et al. (2013): they found that the slope of the risk premium with respect to debt varies from 0.0005 when the debt level is 60 percent of GDP to 0.0083 when the debt level is 150 percent of GDP. We set the elasticity at 0.009 for national bonds and at 0.002 for

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17 It is worth noting that import contents of private and public consumption in Germany and Greece for example are much alike: 23% and 9% respectively in Germany, 24% and 10% respectively in Greece.
Eurobonds (in any case, the elasticity should be higher in the former case than in the latter case). For the partial pooling case, since Eurobonds are limited to 60 percent of GDP in each country, we consider them as risk-free bonds and we set their elasticity with regard to the debt level at zero.

Finally, country size $n$ is $\frac{1}{2}$ in the benchmark calibration, but it will vary on the interval $[0, 1]$ in the sensitivity analysis (Section 5).

4. Simulations and results

The model is run to simulate a positive public spending shock in the Home country under different scenarios of government debt issuance: National bonds (baseline scenario), Eurobonds, and Limited Eurobonds. The size of the shock is 1 percent deviation from steady state and its persistence is high (the autoregressive term $\rho_z$ is set at 0.80). Figure 1 displays impulse reaction functions (IRFs) in the baseline scenario. We examine the effects of the shock on the Home country and its spillover effects on the Foreign country. The latter from now on stands for the Rest of Union (RoU).

The government spending multiplier is quite modest, be it at the impact of the shock or over time (the cumulative change in Home output being small comparatively to the shock on public expenditures). This is explained by the crowding out effect of the shock on private consumption, and the real exchange rate appreciation with negative impact on exports. Private consumption is crowded out in the RoU as well, but the stronger demand for RoU exports limits its impact on output. Now, it is worth exploring the transmission channels, because this will be useful afterwards, when we will interpret outcomes of the other scenarios.

The increase in government consumption in the Home country is a demand shock to which domestic firms react by increasing labour demand. Wages increase, inflation as well, thus explaining the crowding out effect on consumption. The MU inflation goes up. The central bank raises the policy rate. With some interest rate inertia, the increase in the nominal rate is lower than the increase in domestic inflation, and as a result, the real interest rate is below its steady-state level.

Therefore, the households’ consumption dynamics mostly relies on the dynamics of the real return on savings. At the impact of the shock, the real return on savings falls below its steady-state level. As long as the return on savings is lower than its steady-state level, private consumption continue to falls. Then, a few quarters after the shock, as inflation goes down and the real interest rate goes up, the real return on savings gets higher than its steady-state level, which translates into higher future consumption and helps the adjustment of consumption back to equilibrium.

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18 Variables are in deviation from their steady-state level.

19 The real return on savings is negatively impacted by a lower real interest rate and increases with a higher sovereign risk premium. In the immediate aftermath of the shock, the first effect predominates, because the variation in the risk premium is negligible.
The negative effect of the shock on private consumption is at first stronger in the Home country than in the RoU. This is so, because the initial increase in inflation is slightly stronger in the Home country than in the RoU\textsuperscript{20}. The gap in consumption in the MU countries then diminishes as Home country's households enjoy better returns on sovereign bonds due to the increasing sovereign risk premium. The latter is, in turn, explained by the combination of an increase in public spending and a fall in consumption tax receipts, which cause a primary public deficit (despite higher labour income tax receipts) and a rising public debt/GDP ratio.

**Figure 1. Positive public spending shock in the Home country with national bonds (baseline scenario)**

Given the risk sharing condition (12) between MU countries, the stronger decrease in Home consumption than in RoU consumption leads to a real appreciation and lower exports in Home country. The RoU thus enjoys a real depreciation and higher exports. The resulting expected competitiveness gains in bilateral trade make RoU firms (those which can change prices) optimally increase their prices, which causes a higher price dispersion. As explained in the description of the model (sub-section 2.6), an increase in price dispersion causes inefficiency in resource allocation at the aggregate level of the economy. Output losses for a given quantity of labour used in the production process. This distortion in aggregate output leads to an increase in labour demand (to recover output losses) and wages.

In contrast to Badarau et al. (2017), RoU output is not much affected by the shock in the baseline calibration. Indeed, we here allow for a share of government consumption to be imported.

\textsuperscript{20} The shock directly affects the Home country demand and only indirectly the RoU by means of international trade.
(according to EU rules). Therefore, RoU exporters benefit from the increase in Home government consumption. This positive spillover effect on exports counterbalances the negative spillover effect on private consumption. Still, the overall effect is negative (the peak response is -0.01).  

Figure 2 compares the impact of the shock under the three scenarios of government debt issuance. The impact of the shock on Home country’s output is positive in all cases, the strongest with Eurobonds, the lowest with Limited Eurobonds. In contrast, the spillover effects on the RoU’s output are negative in the Eurobonds scenario and positive in the Limited Eurobonds scenario.

Figure 2. Home public spending shock under different scenarios of government debt issuance

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21 This is in line with results in Blanchard et al. (2017), who found that the spillover effects are small and negative if the import content in government consumption is low, but positive in a liquidity trap. In Naraidoo et al. (2017), spillovers are positive because of habit persistence in consumption and liquidity-constrained households, not to mention the lack of monetary policy response to MU output.

22 RoU variables are denoted with an asterisk. To save space, the RoU real exchange rate is not displayed (it is the symmetry of Home real exchange rate).
In the Eurobonds scenario, the dynamics of the sovereign risk premium is the same in both MU countries. Households in the Home country and in the RoU expect similar returns on their savings, private consumption adjusts in a very similar way, and the response of the real

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23 It is, admittedly, hard to tell from the graphs. This is due to the fact that the scale of the vertical axis has been configured differently in the two countries to enhance visibility.
exchange rate is therefore more muted than in the other scenarios. Home real appreciation is less strong than in the other scenarios, and so is the fall in Home exports. The real depreciation is evidently less strong for the RoU, and so is the increase in RoU exports. Moreover, there is also a negative financial spillover effect. Rising interest payments on government debt are caused by two things: the central bank raises the nominal interest rate more in the Eurobonds scenario than in the other scenarios because the increase in Home output is stronger; and the risk premium on Eurobonds increases as Home public debt rises. At some point, RoU public debt becomes higher than its steady-state level (given lower consumption tax receipts and higher interest payments). Since the RoU government is assumed to care about debt stabilisation, it decreases public consumption, which adversely affects RoU output.

In the Limited Eurobonds scenario (partial sovereign risk pooling), household portfolios in the two MU countries are composed of national bonds and Eurobonds. But there is a cap on the issuance of Eurobonds (60 percent of each country’s GDP). As the public spending shock in the Home country causes a rise in Home government debt, and since there is a domestic bias in the holdings of national bonds, Home households end up with a higher share of risky domestic bonds in their portfolios (in deviation from steady state), whereas RoU households have a higher share of Eurobonds (Figure 3). This generates different variations in expected returns on savings and divergence in consumer behaviour among countries, which explains why the real exchange rate adjustment is stronger in this scenario than in the others. The RoU benefits from a stronger real depreciation. The combination of a smaller decrease in private consumption and higher increase in exports leads to higher expected aggregate demand in the RoU. The firms, which can reset their prices, do not need to increase prices much to maximize the expected discounted value of profits. As a result, price dispersion is lower than at steady state, and a better allocation of resources leads to higher output.

Figure 3. Eurobonds holdings in household portfolios (Limited Eurobonds scenario)
5. Sensitivity analysis

In this section, we check robustness to various policy rules and to country size.

5.1. Government preferences

We first examine various government preferences for output stabilization. In Table 1, we look at the implications of procyclical public spending in the Home country. In the fiscal policy rule described by equation (50), the response of government consumption to the deviation of output from its steady-state level is procyclical if \( \rho_{gy} < 0 \). Besides, in all cases, it is assumed that RoU government consumption remains a-cyclical as in the benchmark calibration (\( \rho_{gd}^* = 0 \)). Differences in output effects, albeit small, show that procyclical government consumption in the Home country reinforces the domestic effects of the fiscal stimulus, but at the expense of the RoU. The benchmark results are confirmed: the shock has a stronger positive impact on Home output in the Eurobonds scenario, and it produces positive spillover effects on RoU output in the Limited Eurobonds scenario.

### Table 1. Robustness to Home government consumption response to output

<table>
<thead>
<tr>
<th>( \rho_{gd}^* = 0 )</th>
<th>Home output (y)</th>
<th>RoU output (y*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>National bonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \rho_{gy} = 0 )</td>
<td>0.104</td>
<td>-0.0125</td>
</tr>
<tr>
<td>( \rho_{gy} = -1 )</td>
<td>0.1045</td>
<td>-0.0139</td>
</tr>
<tr>
<td>( \rho_{gy} = -2 )</td>
<td>0.105</td>
<td>-0.0155</td>
</tr>
<tr>
<td>Eurobonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \rho_{gy} = 0 )</td>
<td>0.1104</td>
<td>-0.0237</td>
</tr>
<tr>
<td>( \rho_{gy} = -1 )</td>
<td>0.1105</td>
<td>-0.0247</td>
</tr>
<tr>
<td>( \rho_{gy} = -2 )</td>
<td>0.1106</td>
<td>-0.0257</td>
</tr>
<tr>
<td>Limited Eurobonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \rho_{gy} = 0 )</td>
<td>0.072</td>
<td>0.059</td>
</tr>
<tr>
<td>( \rho_{gy} = -1 )</td>
<td>0.075</td>
<td>0.053</td>
</tr>
<tr>
<td>( \rho_{gy} = -2 )</td>
<td>0.078</td>
<td>0.047</td>
</tr>
</tbody>
</table>

Notes: Peak responses to a positive public spending shock in the Home country (percentage deviation from steady state). A negative value of \( \rho_{gy} \) means that Home government consumption is procyclical.

In Table 2, we consider various cases in which government consumption is counter-cyclical in the RoU (\( \rho_{gd}^* > 0 \)) but strongly procyclical in the Home country (\( \rho_{gy} = -2 \)). Our benchmark results are here again confirmed. Interestingly, a strong counter-cyclical fiscal policy in the RoU is ineffective to counteract negative spillover effects in national bonds and Eurobonds scenarios, but effective to reinforce positive spillover effects in the Limited Eurobonds scenario. In the first case, the increase in RoU government consumption exacerbates RoU inflation, and hence reduces the real depreciation and the increase in exports. In addition, MU inflation is higher, which leads to a bigger rise in the common nominal interest rate and affects negatively both RoU and Home output. In the second case, the counter-cyclical response of fiscal policy reduces inflation.
**Table 2. Robustness to RoU government consumption response to output**

<table>
<thead>
<tr>
<th>ρ_{gg} = -2</th>
<th>Home output (y)</th>
<th>RoU output (y')</th>
</tr>
</thead>
<tbody>
<tr>
<td>National bonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ρ_{gd} = 0</td>
<td>0.1050</td>
<td>-0.0155</td>
</tr>
<tr>
<td>ρ_{gd} = 1</td>
<td>0.1049</td>
<td>-0.0158</td>
</tr>
<tr>
<td>ρ_{gd} = 2</td>
<td>0.1048</td>
<td>-0.0161</td>
</tr>
<tr>
<td>Eurobonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ρ^*_{gd} = 0</td>
<td>0.1106</td>
<td>-0.0257</td>
</tr>
<tr>
<td>ρ^*_{gd} = 1</td>
<td>0.1101</td>
<td>-0.0257</td>
</tr>
<tr>
<td>ρ^*_{gd} = 2</td>
<td>0.1096</td>
<td>-0.0258</td>
</tr>
<tr>
<td>Limited Eurobonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ρ_{gd} = 0</td>
<td>0.0782</td>
<td>0.047</td>
</tr>
<tr>
<td>ρ_{gd} = 1</td>
<td>0.0789</td>
<td>0.049</td>
</tr>
<tr>
<td>ρ_{gd} = 2</td>
<td>0.0794</td>
<td>0.052</td>
</tr>
</tbody>
</table>

Notes: Peak responses to a positive public spending shock in the Home country (percentage deviation from steady state). A positive value of ρ_{gd} means that RoU government consumption is counter-cyclical.

5.2. Central bank preferences

We now study sensitivity of results to various monetary policy rules. Table 3 shows the sensitivity of the results to the interest rate response to inflation. If the central bank puts more weight on stabilising inflation, the positive effects of the shock on Home output are reduced whereas the negative spillover effects on RoU output are amplified (national bonds and Eurobonds scenarios) or the positive cross-border spillover effects are diminished (Limited Eurobonds scenario). In any case, the benchmark results still hold: in the case of a country-specific positive public spending shock, Eurobonds bring about the highest increase in domestic output (peak response in deviation from steady state) and Limited Eurobonds the lowest increase, whereas the spillover effects on RoU output are negative with Eurobonds but positive with Limited Eurobonds.

**Table 3. Robustness to monetary policy response to inflation**

<table>
<thead>
<tr>
<th>β_{i} = 0.9; β_{y} = 1</th>
<th>Home output (y)</th>
<th>RoU output (y')</th>
</tr>
</thead>
<tbody>
<tr>
<td>National bonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>β_{π} = 2.2</td>
<td>0.104</td>
<td>-0.012</td>
</tr>
<tr>
<td>β_{π} = 3</td>
<td>0.093</td>
<td>-0.025</td>
</tr>
<tr>
<td>β_{π} = 3.5</td>
<td>0.079</td>
<td>-0.041</td>
</tr>
<tr>
<td>Eurobonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>β_{π} = 2.2</td>
<td>0.110</td>
<td>-0.023</td>
</tr>
<tr>
<td>β_{π} = 3</td>
<td>0.097</td>
<td>-0.038</td>
</tr>
<tr>
<td>β_{π} = 3.5</td>
<td>0.082</td>
<td>-0.057</td>
</tr>
<tr>
<td>Limited Eurobonds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>β_{π} = 2.2</td>
<td>0.072</td>
<td>0.059</td>
</tr>
<tr>
<td>β_{π} = 3</td>
<td>0.063</td>
<td>0.049</td>
</tr>
<tr>
<td>β_{π} = 3.5</td>
<td>0.052</td>
<td>0.037</td>
</tr>
</tbody>
</table>

Note: Peak responses to a positive public spending shock in the Home country (percentage deviation from steady state).
Table 4 compares results with different interest rate responses to output. If the central bank does not care output stabilization, the positive effects of the public spending shock on domestic output are stronger and the spillover effects on the RoU economy are positive, because the increase in the common nominal interest rate is smaller. Benchmark results are again verified: the positive effects of the shock on Home output are the strongest with Eurobonds and the lowest with Limited Eurobonds, whereas the spillover effects on RoU output are negative with Eurobonds but positive with Limited Eurobonds.

Table 4. Robustness to monetary policy response to output

<table>
<thead>
<tr>
<th>$\beta_i = 0.9; \beta_\pi = 2.2$</th>
<th>Home output (y)</th>
<th>RoU output (y$^*$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>National bonds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_y = 0$</td>
<td>0.123</td>
<td>0.012</td>
</tr>
<tr>
<td>$\beta_y = 0.5$</td>
<td>0.108</td>
<td>-0.009</td>
</tr>
<tr>
<td>$\beta_y = 1$</td>
<td>0.104</td>
<td>-0.012</td>
</tr>
<tr>
<td><strong>Eurobonds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_y = 0$</td>
<td>0.14</td>
<td>0.015</td>
</tr>
<tr>
<td>$\beta_y = 0.5$</td>
<td>0.116</td>
<td>-0.017</td>
</tr>
<tr>
<td>$\beta_y = 1$</td>
<td>0.110</td>
<td>-0.023</td>
</tr>
<tr>
<td><strong>Limited Eurobonds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_y = 0$</td>
<td>0.078</td>
<td>0.061</td>
</tr>
<tr>
<td>$\beta_y = 0.5$</td>
<td>0.074</td>
<td>0.058</td>
</tr>
<tr>
<td>$\beta_y = 1$</td>
<td>0.072</td>
<td>0.058</td>
</tr>
</tbody>
</table>

Note: Peak responses to a positive public spending shock in the Home country (percentage deviation from steady state).

5.3. Country size

We also want to analyze the influence of country size on the effects of Home government spending shock on Home output (spending multiplier) and RoU output (spillover effects) in the Eurobonds scenario and Limited Eurobonds scenario in comparison with the baseline scenario (national bonds with two MU countries of equal size). Results are displayed in Figure 4.

The spending multiplier is always higher with Eurobonds than with national bonds, and especially higher for small countries than large countries. Government spending is indeed not very effective to boost output in large countries in the case of Eurobonds. This can be explained by a stronger response of the common nominal interest rate and a progressively larger impact on the risk premium on Eurobonds, which causes higher future expected returns on savings and lower private consumption. In addition, for large countries, export markets in the RoU are of limited size. From RoU standpoint, the negative spillover effects are always stronger with Eurobonds than with national bonds, especially in cases where the Home country is small. This is due to the fact that in this case RoU households are more numerous than Home households in holding Eurobonds. The negative effect of a rising risk premium on private consumption is hence intensified in the RoU.
Figure 4. Home government spending shock and country size

Note: effects of a positive government spending shock in Home country on Home output and RoU output under Eurobonds or Limited Eurobonds scenario in comparison with the baseline scenario (national bonds).

The spending multiplier is furthermore always lower with Limited Eurobonds than with national bonds, especially for small countries. At the same time, output spillover effects are always positive with Limited Eurobonds, and more so if the Home country is small. A financial channel and a trade channel explain these results. First, if the RoU is larger than the Home country, RoU households have relatively more Eurobonds than Home households in their portfolios. They are less subject to a rising risk premium on national bonds. The negative effect on private consumption is hence weakened. Second, given the stronger fall in private consumption in the Home country than in the RoU, the risk sharing condition implies a stronger RoU real depreciation. RoU exporters expect that the real depreciation along with an increase in Home government consumption (with import contents) will raise RoU export volumes. Given the small size of export markets, they do not need to increase their prices to maximize profits. There is even a downward adjustment in export prices as the size of Home country gets smaller. It follows that the smaller Home country is, the lower RoU inflation is (Figure 5). Price dispersion is hence lower than at steady state, and output is higher. Since the law of one price is assumed to hold for tradable goods, Home inflation is also lower as country size gets smaller. Lower prices ultimately prevent private consumption from falling much in both MU countries.
Finally, we conduct a welfare analysis to assess the role of country size in the effects of the Home public spending shock in the three scenarios of government debt issuance. Following Lucas (1987), we use a measure of welfare losses in terms of business cycles. This measure corresponds to the fraction of steady state consumption that households would need in the deterministic world (at steady state) to yield the same welfare as the one that would be achieved in the stochastic world (under the shock).

Formally, the unconditional welfare metric is $u$ that solves:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \epsilon_t \left[ c_t^{1-\sigma} \left( \frac{1}{1-\sigma} - \frac{1}{1+\eta} \right) \right] \right\} = \frac{1}{1-\beta} \left[ \frac{1}{1-\sigma} \left( 1 + \frac{u}{100} \right) c_t \right]^{1-\sigma} - \frac{l_t^{1+\eta}}{1+\eta}$$

(64)

where variables without subscript $t$ are steady state variables. For $u$ positive, there is a welfare gain: households prefer the stochastic allocation compared to that of the steady state as long as consumption in steady state must be raised in order to yield the same utility as under the shock. In contrast, a negative value of $u$ represents a welfare loss: households prefer the non-stochastic allocation and are willing to give up a percentage of consumption to get the same utility as under the shock. Table 5 reports the welfare gains (+) or losses (-).

In contrast to the analysis based on spending multipliers, which showed that the positive Home output effects would be the strongest with Eurobonds, the welfare analysis based on household utility shows that Home households would be worse off with Eurobonds. Welfare losses would be even higher for RoU households in the Eurobonds scenario. This is due to a bigger fall in private consumption (see Figure 2).

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24 Further details are available upon request.
Table 5. Country size and welfare

<table>
<thead>
<tr>
<th></th>
<th>$n = 1/2$</th>
<th>$n = 1/3$</th>
<th>$n = 1/4$</th>
<th>$n = 1/5$</th>
<th>$n = 1/7$</th>
</tr>
</thead>
<tbody>
<tr>
<td>National bonds</td>
<td>Home</td>
<td>RoU</td>
<td>Home</td>
<td>RoU</td>
<td>Home</td>
</tr>
<tr>
<td></td>
<td>-1.84</td>
<td>-1.44</td>
<td>-0.80</td>
<td>-1.47</td>
<td>-0.46</td>
</tr>
<tr>
<td>Eurobonds</td>
<td>-1.85</td>
<td>-1.50</td>
<td>-0.83</td>
<td>-1.76</td>
<td>-0.49</td>
</tr>
<tr>
<td>Limited Eurobonds</td>
<td>-1.67</td>
<td>-0.90</td>
<td>1.48</td>
<td>13.72</td>
<td>1.66</td>
</tr>
</tbody>
</table>

Note: to ease comparisons of results with IRFs, computations are made over 20 periods.

The Limited Eurobonds scenario is the only scenario that brings welfare gains for both MU countries (except in the baseline calibration with $n = 1/2$). This is mainly explained by the downward adjustment in export prices, lower inflation and lower decrease in private consumption. Interestingly, welfare gains increase up to a point where $n = 1/4$, and then they decrease. The intuition for this result is the following. The shock leads to an increase in public debt, and as Home country size decreases, the debt/GDP ratio increases, and the risk premia on Eurobonds and national bonds as well. Home households save more, and therefore consume fewer domestic and imported goods. RoU exporters have fewer incentives to keep prices low, and along the path to equilibrium, inflation goes up and remains over its steady-state level for some time (Figure 5).

6. Conclusion

Proposals of pooling sovereign risk through the creation of Eurobonds have not led member states of the euro area to move in that direction so far. The main point of contention stems from a lack of trust. Healthy member states, such as Germany, Finland or the Netherlands, fear that heavily indebted member states, such as Greece or Italy, would not abide by the EU rules of fiscal discipline any more if they benefited from full joint liability. Actually, the proposal of limited joint liability by Delpla and von Weizsäcker (2010) merits consideration. It consists of allowing each member state to issue Eurobonds up to a limit of 60 percent of GDP. Above this limit, national bonds would have to be issued. Our analysis of the implications of what we called “Limited Eurobonds” supports such an idea (without necessarily endorsing the 60 percent threshold though).

Our main findings are indeed the following. We have compared the effects of a positive public spending shock in the Home country in three scenarios of government debt issuance: national bonds, Eurobonds, and Limited Eurobonds. We found that the positive impact of the shock on Home output would be the strongest with Eurobonds and the weakest with Limited Eurobonds. In contrast, the spillover effects on output in the rest of the union (RoU) would be negative with Eurobonds but positive with Limited Eurobonds. These effects are reinforced if the Home country is a small country. They are mainly explained by the response of private consumption to the rise in the risk premium on Eurobonds and the government’s behaviour in reaction to the rise in government debt.

In the scenario with Eurobonds, the spillover effects are negative, and more so than in the scenario with national bonds, because the increase in the common risk premium implies a higher expected return on savings and private consumption is reduced accordingly. The negative impact is reinforced if the RoU is large (Home country is small): as RoU households
are more numerous than Home households in holding Eurobonds, the negative effect of the rising common risk premium on RoU private consumption is intensified. Besides, RoU government reduces public consumption to counteract higher interest payments on government debt, which depresses output. In this respect, a strong counter-cyclical fiscal policy in the RoU would not be effective to counteract such effects, because it would increase inflation.

In the scenario with Limited Eurobonds, the spillover effects are positive because RoU households have a higher share of Eurobonds with lower risk premia in their asset portfolios. This is due to a domestic bias in bond holdings (Home households have a relatively higher share of Home sovereign bonds in their portfolios). But this can also be explained by country size: if the Home country is small, RoU households are less vulnerable to the consequences of a rise in Home government debt and in the risk premium on Home sovereign bonds, because the relative weight of Home sovereign bonds in their asset portfolios would be negligible. The fall in private consumption is consequently lower (and consequently, the real depreciation is stronger).

Finally, our welfare analysis shows that the scenario with Limited Eurobonds is the only scenario that brings welfare gains for both countries as long as the Home country is smaller than the rest of union.

For further research, it could be interesting to add in the model a common fiscal authority that levies taxes to pay for the debt issued by member states.

References


Hughes Hallett A. and J. Lewis (2014), “Monetary policy and sovereign debt: Does the ECB take the eurozone’s fiscal risks into account?” Empirica, 42(3), 499-520.


# Appendix

Table A1. Benchmark calibration

<table>
<thead>
<tr>
<th>Description</th>
<th>Notation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Households and firms</strong></td>
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<td></td>
</tr>
<tr>
<td>Inverse of the intertemporal elasticity of substitution</td>
<td>$\sigma$</td>
<td>2</td>
</tr>
<tr>
<td>Inverse of the Frisch elasticity of labour supply</td>
<td>$\eta$</td>
<td>1</td>
</tr>
<tr>
<td>Subjective discount factor</td>
<td>$\beta$</td>
<td>0.99</td>
</tr>
<tr>
<td>Elasticity of substitution between differentiated goods</td>
<td>$\epsilon$</td>
<td>10</td>
</tr>
<tr>
<td>Home bias in private consumption</td>
<td>$a_1$</td>
<td>0.75</td>
</tr>
<tr>
<td>Home bias in public consumption</td>
<td>$a_2$</td>
<td>0.89</td>
</tr>
<tr>
<td>Home bias in holding national sovereign bonds</td>
<td>$b_1$</td>
<td>0.7</td>
</tr>
<tr>
<td>Elasticity of substitution between domestic and imported goods</td>
<td>$\theta$</td>
<td>1.5</td>
</tr>
<tr>
<td>Elasticity of substitution between domestic and foreign bonds</td>
<td>$\theta_{b}$</td>
<td>3.4</td>
</tr>
<tr>
<td>Fraction of firms keeping their prices unchanged</td>
<td>$\phi$</td>
<td>0.75</td>
</tr>
<tr>
<td><strong>Governments</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steady-state government consumption/GDP ratio</td>
<td>$G/Y$</td>
<td>0.20</td>
</tr>
<tr>
<td>Steady-state government debt/GDP ratio</td>
<td>$D/(nY)$</td>
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<td>Consumption tax rate</td>
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</tr>
<tr>
<td>Labour income tax rate</td>
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<td>Government consumption inertia</td>
<td>$\rho_g$</td>
<td>0.9</td>
</tr>
<tr>
<td>Government consumption sensitivity to output</td>
<td>$\rho_{gy}$</td>
<td>0</td>
</tr>
<tr>
<td>Government consumption sensitivity to debt in Home country</td>
<td>$\rho_{gd}$</td>
<td>0.15</td>
</tr>
<tr>
<td>- National bonds</td>
<td>$\rho_{gd}$</td>
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</tr>
<tr>
<td>- Eurobonds</td>
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<td>0.13</td>
</tr>
<tr>
<td>Government consumption sensitivity to debt in Foreign country</td>
<td>$\rho_{gd}$</td>
<td>0.20</td>
</tr>
<tr>
<td>- All cases of government debt issuance</td>
<td>$\rho_{gd}$</td>
<td>0.11</td>
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<td>Risk premium sensitivity to debt</td>
<td>$\psi_N$</td>
<td>0.009</td>
</tr>
<tr>
<td>- National bonds</td>
<td>$\psi_E$</td>
<td>0.002</td>
</tr>
<tr>
<td>- Eurobonds</td>
<td>$\psi_{N}$</td>
<td>0</td>
</tr>
<tr>
<td>Persistence of the fiscal policy shock</td>
<td>$\rho_z$</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Central bank</strong></td>
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<tr>
<td>Interest rate inertia</td>
<td>$\beta_l$</td>
<td>0.9</td>
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<td>Interest rate sensitivity to inflation</td>
<td>$\beta_{\pi}$</td>
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<td>Interest rate sensitivity to output</td>
<td>$\beta_Y$</td>
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