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Proposals for implementing Eurobonds have emerged. Their technical details have been presented to the European Parliament. However, there has not been any assessment of the macroeconomic implications of pooling sovereign risk. This paper aims at filling the gap. We build a DSGE model of a two-country currency union and compare macroeconomic outcomes under three scenarios: governments bear their own risk premia by issuing their own national bonds; they share the same risk premium by issuing Eurobonds; they have different risk premia as long as they are not allowed to issue Eurobonds more than 60 percent of their GDP.

Keywords: Eurobonds, euro area, sovereign debt, DSGE

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INTRODUCTION

There is no single sovereign bond market in the Euro area (EA). As a consequence, interest rates on sovereign bonds may differ across countries depending on the level of public indebtedness and risk premia. Before the financial crisis of 2008, sovereign spreads between EA member countries were extremely low though, and this, despite marked differences in public debt-GDP ratios. Lenders could have thought that there was no sovereign default risk in the Euro area or that there would be a collective bail-out if so. Anyway, in 2009, spreads started to widen considerably for Greece, after the announcement of very bad figures in public finance, and for some other distressed countries (Ireland, Portugal, Spain, and to a lesser extent, Italy).

Interest rates reached so high a level that governments of these countries were hardly able to face interest payments or debt repayment. In such a context, from 2010, a debate has arisen in the European public arena about the opportunity to create sovereign Eurobonds.

A sovereign Eurobond is a debt instrument that would be issued by the Euro area as a whole. It would enable member states to borrow funds. The nationality of the sovereign issuer would not be known. The risk premium, in principle, would depend on the average level of public indebtedness in the Euro area and of the perception of financial market participants upon the credibility of the system (the latter being dependent on the joint guarantee of repayment). Interest rates of Eurobonds would be the same whatever the sovereign issuer. The main advantage of Eurobonds would be a large and liquid market for sovereign bonds, and hence lower borrowing costs. This would especially be beneficial to the currently most indebted member states: their cost of public borrowing would be lower than that borne on country-specific bond markets as long as a country-specific risk premium would not be attributed to them. However, there could be a cost for the least indebted member states (and particularly for those which enjoy a triple A credit rating): the latter could face a higher public borrowing cost if the Euro area average sovereign risk premium were higher than theirs.

Furthermore, sovereign Eurobonds could raise some incentive problems in terms of fiscal discipline as long as higher public deficits would no longer be bound to be sanctioned by higher borrowing costs (moral hazard).

Does sovereign risk pooling (debt mutualisation) create negative spillover effects on the least indebted governments?

In this paper, we build a dynamic stochastic general equilibrium (DSGE) model of a two-country currency union in order to analyze theoretically the macroeconomic implications of sovereign risk pooling with a common risk premium for member countries. We compare three scenarios: a baseline scenario where each country issues its own bonds with country-specific risk premia, a full pooling scenario where both countries share a common risk premium, and a partial pooling scenario where there are constraints on the issuance of Eurobonds. We study these scenarios by simulating a public spending shock in one country of the union and looking at the effects on output and public debt in each member country.

In analyzing the effects of such a shock, we want to investigate what would happen if one government were no longer fiscally responsible in a currency union with sovereign risk pooling. Indeed, some EA member states (in particular, Germany) are currently reluctant to create a single market for Eurobonds because of the fear that some member states would no longer have incentives to stick to the European rules of fiscal discipline.

In addition, in the full pooling scenario, we investigate the implications of the credibility of such an institutional arrangement. Specifically, we assume that if the latter is credible, then financial market participants would consider Eurobonds as being safe assets. Otherwise, Eurobonds would be perceived as risky assets.[1]

The literature deals mainly with the features of Eurobonds, the pros and cons, and most of the time, the analysis is essentially a financial one or set in a partial equilibrium framework (with a political economy perspective)[2]. The most publicly known and thorough proposal is that of Delpla and Von Weizsäcker [2010, 2011]. They propose to pool only a share of public debts.

Each member state would be allowed to issue Eurobonds, but up to a limit corresponding to 60 percent of its GDP (the Maastricht criterion). These "blue bonds" could be issued with low interest rates, because all member states would collectively guarantee the repayment. Furthermore, they would be senior debt that is repaid before any other public debt (but after the IMF). Otherwise, any member state, which would need to borrow more than 60 percent of its GDP, would have to issue its own bonds dubbed "red bonds". The latter would be junior debt that would be honored only after the blue 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. In addition, they would not be eligible for the refinancing operations of the European central bank (ECB).

There is, however, opposition to Eurobonds.[3] Among others, Issing [2009] argues that Eurobonds are nothing more than a placebo for the most indebted countries (moral hazard) and would be costly for taxpayers in the least indebted countries.

From an empirical perspective, Favero and Massale [2012] use a Global VAR to test the main determinants of sovereign spreads. A significant role is played by changing risk perceptions among financial market participants. They conclude that the creation of Eurobonds could protect countries against contagion effects and could hence also benefit fiscally responsible member states. Moreover, in a VAR framework, Tielens et al. [2014] find that Eurobonds could help some countries (such as Greece, Ireland and Portugal) to prevent debt dynamics from getting into (or staying in) an unsustainable path. However, this result holds if moral hazard does not prevail.

From a theoretical perspective, there is little work on the macroeconomic effects of Eurobonds.

Beetsma and Mavromatis [2012] built a political economy model of public deficits (with strategic choices over two periods) which describes a small country participating in a currency union. They showed that the guarantee of repayment by other countries should not be 100%. The maximum guaranteed should be sufficiently low to incite a government not to put into more debt than if it had no guarantee at all. Unlike these authors, we do not analyze strategic interactions in a game theoretical framework nor the issue of moral hazard. We instead focus on spillover effects in a two-country macroeconomic framework and look at the issue of credibility of debt mutualisation.

More recently, Hatchondo et al. [2014] proposed a model of equilibrium default in which they assume that the government of a small economy is allowed to issue Eurobonds (non-defaultable debt) up to a low limit of 10 percent of trend income and can commit to a fiscal rule imposing a defaultable-debt limit of 55 percent of trend income. They found that the

1. In this paper, the notion of credibility is not used as in the optimal policy framework. We do not model the determinants of credibility. We simply identify it through risk perceptions of financial market participants.
2. For a review, see De La Dehesa [2011], Eijfinger [2011]. Claessens et al. [2012] assess the existing proposals of Eurobonds in terms of incentives for both lenders and borrowers.
3. The Junker-Tremonti proposal was officially rejected by France and Germany in December 2010 (De La Dehesa, 2011).

decrease in the interest rate spread (i.e. the difference between the sovereign bond yield and the risk-free interest rate) is short-lived, because the government still has to issue defaultable debt.

To our knowledge, there is currently no work that studies the macroeconomic implications of Eurobonds within the framework of a currency union DSGE model. Our work is the first to study the effects of different risk pooling scenarios for government debt on the transmission of government spending shocks in a currency union. As such it adds to the literature on currency unions as well as to the work on Eurobonds.

The paper is organized as follows. In section 2, we describe the model and explain the determinants of risk premia in both countries depending on the scenario: i) national governments bear their own risk premia (there are not any Eurobonds); ii) national governments share the same risk premium (there is full risk pooling); and iii) national governments cannot issue an unlimited amount of Eurobonds (there is partial risk pooling). In the last scenario, we add the constraint that any country cannot issue Eurobonds more than 60 percent of GDP. In doing so, we follow the proposal of Delpla and Von Weizsäcker [2010]. In section 3, we simulate a positive shock on public spending in one country of the union and compare the results under the three scenarios. In section 4, we conduct a welfare analysis in order to compare outcomes under all scenarios, and in section 5, we conclude.

2. The model

The paper is based on a simple model of a currency union closed with regard to the rest of the world (RoW). The union consists of two countries of equal size and with symmetrical structure: Home (H) and Foreign (F), the latter standing for the rest of the union (RoU).

Each economy is populated by a continuum of unit mass households with infinite life, and produces tradable goods using labour. Monopolistic competition and sticky prices are also introduced. The law of one price holds at exports level (producer currency pricing, henceforth PCP).

We consider integrated governments bonds markets at the union level. Three scenario of bonds are analyzed, as well as their implications on the real economy of member countries: i) no risk pooling where governments finance their public debt only by issuing national bonds (National bonds scenario); ii) full risk pooling, where every public debt is entirely financed by Eurobonds issues (Pure Eurobonds scenario); and iii) partial risk pooling, in which the public debt of each government is financed by Eurobonds issues in the limit of 60% of GDP, all the rest being subjected to issuance of national bonds (Limited Eurobonds scenario).

In the baseline version of the model (developed hereafter), we assume that only households consume imported goods, while governments consume only goods produced in their own economies. For robustness check, we also consider the case where both households and governments consume domestic and foreign goods. We then assume the same structure for private and public consumption index.

Since the general setup for the foreign country (RoU) is similar and symmetrical to that for the Home country, this section presents the details of the model for the latter. Variables for the foreign country (RoU) are denoted by an asterisk (*).

2.1. Households

Each country is populated by a continuum of unit mass households with infinite life. The representative household derives utility from consumption (C_t) of goods and disutility from hours worked (N_t) and maximizes the following expected discounted sum of utilities:

$$U = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \{U_t(C_t, N_t)\} = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\eta}}{1+\eta} \right) \qquad (1)$$

Where $U_t(C_t, N_t)$ denotes the utility function and $0 < \beta < 1$ is the intertemporal discount factor. The parameters $\sigma > 0$ and $\eta > 0$ are, respectively, the inverse intertemporal elasticity of substitution and the inverse of the Frisch elasticity of labour supply.

The final consumption index is an aggregate of home ($C_{H,t}$) and foreign ($C_{F,t}$) goods with $\theta > 0$ as the constant elasticity of substitution:

$$C_t = \left(a_1^{\frac{1}{\theta}} . (C_{H,t})^{\frac{\theta-1}{\theta}} + (1-a_1)^{\frac{1}{\theta}} . (C_{F,t})^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \qquad (2)$$

Where a_1 is the share of tradable goods produced in the Home country.

The associated price index is given by

$$P_t = \left(a_1 . (P_{H,t})^{1-\theta} + (1-a_1).(P_{F,t})^{1-\theta} \right)^{\frac{1}{1-\theta}} \qquad (3)$$

Where $P_{F,t}$ is the price of the foreign consumption good and $P_{H,t}$ denotes the price of domestic good.

The baskets of home ($C_{H,t}$) and foreign ($C_{F,t}$) goods are made up of a continuum of differentiated varieties of goods

$$C_{H,t} = \left(\int_0^1 C_{H,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} d_j \right)^{\frac{\varepsilon}{\varepsilon-1}} \text{ and } C_{F,t} = \left(\int_0^1 C_{F,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} d_j \right)^{\frac{\varepsilon}{\varepsilon-1}},$$

respectively, with the corresponding price indices

$$P_{H,t} = \left(\int_0^1 P_{H,t}(j)^{1-\varepsilon} d_j \right)^{\frac{1}{1-\varepsilon}} \text{ and } P_{F,t} = \left(\int_0^1 P_{F,t}(j)^{1-\varepsilon} d_j \right)^{\frac{1}{1-\varepsilon}} .$$

And $\varepsilon > 1$ the elasticity of substitution between varieties. By the expenditure minimization problem, the following optimal demands for different goods yield:

$$C_{H,t} = a_1 \left(\frac{P_{H,t}}{P_t} \right)^{-\theta} C_t \qquad (4)$$

$$C_{F,t} = (1-a_1) \left(\frac{P_{F,t}}{P_t} \right)^{-\theta} C_t \qquad (5)$$

The household faces the following period-by-period budget constraint (in real terms):

$$(1-\tau_C)C_t + \frac{B_{t+1}}{P_t} = (1-\tau_W)\frac{W_t\,N_t}{P_t} + B_t R_t\,\Psi_t^G + \frac{TR_t}{P_t} + \Delta_t$$

where W_t denote household's nominal wage, Δ_t are profits rebated equally to the households by firms, B_{t+1} is the household's portfolio of sovereign bonds, $R_t\,\Psi_t^G$ gives the global real return on household's portfolio of sovereign bonds, composed by the real risk-free interest rate R_t and a global risk premium attached to the portfolio Ψ_t^G, and TR_t denotes transfers from government.

The solution to the household problem implies the following optimality conditions:

$$\frac{-U_{N,t}(C_t, N_t)}{U_{C,t}(C_t, N_t)} = \frac{W_t}{P_t} \qquad (7)$$

$$\frac{U_{C,t}(C_t, N_t)}{(1-\tau_C)} = \beta\,(1+i_{t+1})\Psi_{t+1}^G\,\frac{P_t}{P_{t+1}}\,\frac{U_{C,t+1}(C_{t+1}, N_{t+1})}{(1-\tau_C)} \qquad (8)$$

Where i_t is the nominal risk free interest rate.

Under complete markets, the optimal risk sharing implies:

$$\frac{U_{C,t}^{*}(C_t^{*}, N_t^{*})/(1-\tau_C^{*})}{U_{C,t}(C_t, N_t)/(1-\tau_C)} = \frac{P_t^{*}}{P_t} \qquad (9)$$

Where $\frac{P_t^{*}}{P_t} \equiv RR_t$ is the real exchange rate. The relation (9) states that the relative consumption across countries is proportional to real exchange rate and predicts a positive high cross-correlation between the real exchange rate and the relative consumption. Foreign household preferences and choices can be defined symmetrically.

As for the household's portfolio of sovereign bonds B_t, it is composed of (domestic or foreign) national bonds and (if applicable) Eurobonds:

$$B_t = B_t^N + B_t^E \qquad (10)$$

B_t^N is an aggregate index of investment in national bonds, and B_t^E the household's investment in Eurobonds (independent of the issuer). Thus B_t^N is an aggregate of home ($B_{H,t}$) and foreign ($B_{H,t}^{*}$) bonds issued on the home market, with $\theta_b > 0$ the constant elasticity of substitution between home and foreign bonds:

$$B_t^N = \left(b_1^{\frac{1}{\theta_1}}.(B_{H,t})^{\frac{\theta_b-1}{\theta_b}} + (1-b_1)^{\frac{1}{\theta_b}}.(B_{H,t}^{*})^{\frac{\theta_b-1}{\theta_b}} \right)^{\frac{\theta_b}{\theta_b-1}} \qquad (11)$$

b_1 denotes the share of domestic bonds in the household's portfolio of national bonds.

Symmetrically, for the foreign country, this index becomes: [4]

$$B_t^{N*} = \left(b_1^{\frac{1}{\theta_1}} . \left(B_{F,t}^*\right)^{\frac{\theta_b - 1}{\theta_b}} + (1 - b_1)^{\frac{1}{\theta_b}} . \left(B_{F,t}\right)^{\frac{\theta_b - 1}{\theta_b}} \right)^{\frac{\theta_b}{\theta_b - 1}}$$

The parameter b_1 can be used in order to introduce a domestic bias in the household's behaviour ($b_1 > 0{,}5$)[5].

As for Eurobonds, households cannot distinguish the nationality of the issuer and equally hold Eurobonds issued by the domestic government ($B_{H,t}^E$) and by the RoU government ($B_{H,t}^{E*}$)[6]:

$$B_t^E = B_{H,t}^E + B_{H,t}^{E*} \qquad (12)$$

The corresponding global risk premium Ψ_t^G related to the household's portfolio of bonds comes from the maximization of the portfolio return given the composition of indexes previously defined in (10), (11) and (12):

$$\Psi_t^G = (1 - \Theta_t)\Psi_t^N + \Theta_t \Psi_t^E \qquad (13)$$

where Ψ_t^E denotes the risk premium attached to Eurobonds. $\Theta_t = \dfrac{B_{H,t}^E + B_{H,t}^{E*}}{B_{H,t}^E + B_{H,t}^{E*} + B_{H,t} + B_{H,t}^*}$ gives the share of Eurobonds in the households' portfolio; it is endogenous and varies over time depending on investment opportunities. The variable Ψ_t^N is the risk premium attached to the index of national bonds B_t^N, given by :

$$\Psi_t^N = \left(b_1 . \Psi_t^{1-\theta_b} + (1 - b_1) . \left(\Psi_t^*\right)^{1-\theta_b}\right)^{\frac{1}{1-\theta_b}} \qquad (14)$$

where Ψ_t and Ψ_t^* are the sovereign risk premia for national bonds issues in the Home country and the RoU respectively (defined in section 2.4 infra).

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4. It is an aggregate of the RoU national bonds $B_{F,t}^*$ (see *) and of the home country $B_{F,t}$ bonds issued on the RoU (foreign) market, with $\theta_b > 0$ the constant elasticity of substitution between different national bonds.

5. Home bias in asset holdings is well documented in the literature and 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 CES functional form considered in our paper. For Euro area investors, see Floreani and Habib [2015].

6. Symmetrically, for the Eurobonds portfolio of the household in the Foreign country, we have: $B_t^{E*} = B_{F,t}^{E*} + B_{F,t}^E$ where $B_{F,t}^{E*}$ denotes Eurobonds issued by their government (defined as Foreign and denotes by *) and $B_{F,t}^E$ stands for Eurobonds issued by the other country (defined previously as Home) .

2.2. Open economy expressions

Let us define the terms of trade T_t as $T_t = \frac{P_{F,t}}{P_{H,t}}$. Since the law of one price holds,

$$T_t^* = \frac{P_{H,t}}{P_{F,t}} = \frac{1}{T_t}$$

Given the definition for the terms of trade, the following equation holds:

$$\frac{P_t}{P_{H,t}} = \left(a_1 + (1-a_1).(T_t)^{1-\theta}\right)^{\frac{1}{1-\theta}} \equiv f(T_t) \qquad (15)$$

$$\frac{P_t}{P_{F,t}} = \frac{f(T_t)}{T_t} \qquad (16)$$

Finally, we can relate the real exchange rate to the terms of trade as follows:

$$RR_t = \frac{P_t^*}{P_t} = \frac{f^*(T_t^*)}{f(T_t)} T_t \qquad (17)$$

2.3 Firms and Price Setting

For each country, we assume that the production comes from a continuum of monopolistically competitive firms of measure unity, indexed by j,

which produce output $Y_t(j)$ using the technology:

$$Y_t(j) = A_t\, N_t(j) \qquad (18)$$

where N_t denotes hours worked; A_t is a technological shock that is common to all firms and follows a stationary first-order autoregressive process:

$\log A_t = \rho_A \log A_{t-1} + \varepsilon_{A,t}$, with $\varepsilon_{A,t} \sim i.i.d.(0, \sigma^2_{\varepsilon_A})$.

Cost minimization by firms implies that the real marginal cost of production is (in real terms):

$$mc_t = \frac{W_t}{A_t\, P_t} \qquad (19)$$

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:

$$\max_{P_t^n(j)} \mathrm{E}_t \left\{ \sum_{s=0}^{\infty} \phi^s \Lambda_{t,t+s} \left[\frac{P_t^n(j)}{P_{t+s}} \left(\frac{P_t^n(j)}{P_{t+s}} \right)^{-\varepsilon} Y_{t+s} - mc_{t+s} \left(\frac{P_t^n(j)}{P_{t+s}} \right)^{-\varepsilon} Y_{t+s} \right] \right\} \qquad (20)$$

Where $\Lambda_{t,t+s} = \beta^s \frac{U_{C,t+s}(C_{t+s}, N_{t+s})}{U_{C,t}(C_t, N_t)}$ is the discount factor for future real profits.

The first order condition implies:

$$P_t^n(j) = \frac{\varepsilon}{\varepsilon - 1} E_t \frac{\sum_{s=0}^{\infty} (\beta\varphi)^s U_{C,t+1}(C_{t+s}, N_{t+s}) Y_{t+s} P_{t+s}^{\varepsilon} \ mc_{t+s}}{\sum_{s=0}^{\infty} (\beta\varphi)^s U_{C,t+1}(C_{t+s}, N_{t+s}) Y_{t+s} P_{t+s}^{\varepsilon-1}} \qquad (21)$$

Given the Calvo-type setup, the aggregate domestic price index evolves according to the following law of motion,

$$P_t^{1-\varepsilon} = (1-\varphi)(P_t^n)^{1-\varepsilon} + \varphi P_{t-1}^{1-\varepsilon} \qquad (22).$$

The foreign economy has an analogous price setting mechanism.

Since the assumption that prices are set in the producer currency for exports and that the international law of one price holds for the tradable goods in this baseline model, the prices of home goods sold abroad and those of foreign goods sold in home country are given, respectively, by: $P_{H,t}^* = P_{H,t}$ and $P_{F,t} = P_{F,t}^*$.

2.4 Government

Home government spends in purchases of aggregate goods G_t and transfers to households TR_t. The government collects tax revenues on consumption and wages, and it is allowed to issue bonds on both markets of the union, according to three different scenarios. The debt accumulation and the budgetary constraint equations are specific to each scenario.

i) ***Under National Bonds***, governments finance their public debt only by issuing national bonds. There are no Eurobonds and the risk premium of each government only depends on its own debt/GDP ratio deviation from the 60% limit defined by the Maastricht Treaty. The dynamics of public debt, the budgetary constraint, the financing scenario of debt and the definition of the risk premium are respectively described in relations (23), (24), (25) and (26):

$$D_t = D_{t-1} \Psi_t R_t - PS_t \qquad (23)$$

$$PS_t = \tau_C C_t P_t + \tau_w W_t - TR_t - G_t P_t \qquad (24)$$

$$D_t = B_{H,t} + B_{F,t} \qquad (25)$$

$$\Psi_t = \exp\left[\Psi_N \left(\frac{D_{t-1}}{Y_{t-1}} - 0{,}6\right)\right] \qquad (26)$$

PS_t stands for primary budget surplus, D_t public debt financed by national bonds issued on the home market $B_{H,t}$ and on the Foreign market $B_{F,t}$ and Ψ_N is the sensibility coefficient of the risk premium to public indebtedness. The value of this coefficient is relatively higher under national bonds than under risk pooling. 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). This effect is less strong if investors believe in the joint guarantee of repayment.

ii) ***Under Pure Eurobonds***, public debt of each country is entirely financed by Eurobonds.

There are no national bonds and the risk premium of all governments simply depends on the union-wide debt/GDP ratio deviation from the 60% limit defined by the Maastricht Treaty. The dynamics of public debt, the budgetary constraint, the financing scenario of debt and the definition of the risk premium are respectively described in relations (23'), (24'), (25') and (26'):

$$D_t = D_{t-1}\Psi_t^E R_t - PS_t \qquad (23')$$

$$PS_t = \tau_C C_t P_t + \tau_w W_t - TR_t - G_t P_t \qquad (24')$$

$$D_t = B_{H,t}^E + B_{F,t}^E \qquad (25')$$

$$\Psi_t^E = \exp\left[\Psi_E\left(\frac{D_{t-1}^{UM}}{Y_{t-1}^{UM}} - 0{,}6\right)\right] \qquad (26')$$

Public debt is financed only by Eurobonds issued on the home market ($B_{H,t}^E$), and on the Foreign market ($B_{H,t}^E$), Ψ_t^E is the risk premium on Eurobonds and $\Psi_E \leq \Psi_N$ is the sensibility coefficient of this risk premium to union-wide public indebtedness. We assume that if Eurobonds are credible, the value of Ψ_E is very low. 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). In this case, Ψ_E would be higher, for example as high as in the case of national bonds in a worst case scenario.

iii) Under Limited Eurobonds, public debt of each government is financed by Eurobonds in the limit of 60% of GDP, all the rest being subjected to the issuance of national bonds. In this case, Eurobonds are risk-free assets and the risk premium on national bonds is defined by the relation (26) from the national bonds scenario. The dynamics of public debt, the budgetary constraint, the financing scenario of debt and the definition of the risk premiums are respectively described in relations (23"), (24"), (25") and (26"):

$$D_t = \left(B_{H,t-1} + B_{F,t-1}\right)\Psi_t R_t + \left(B_{H,t-1}^E + B_{F,t-1}^E\right)\Psi_t^E R_t - PS_t \qquad (23'')$$

$$PS_t = \tau_C C_t P_t + \tau_w W_t - TR_t - G_t P_t \qquad (24'')$$

$$D_t = B_{H,t}^E + B_{F,t}^E + B_{H,t} + B_{F,t} \qquad (25'')$$

$$\Psi_t^E = 1 \text{ and } \Psi_t = \exp\left[\Psi_N\left(\frac{D_{t-1}}{Y_{t-1}} - 0{,}6\right)\right] \qquad (26'')$$

Equations for the foreign government are symmetrical to those written for the Home government.

Fiscal policy instrument

The government needs to adjust tax revenues or expenditure to finance its deficit and stabilize its debt. We choose public spending 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 rule:

$$G_t = G\left(\frac{G_{t-1}}{G}\right)^{\rho_g}\left(\frac{Y_t}{Y}\right)^{\rho_y}\left(\frac{D_t/Y_t}{D/Y}\right)^{-(1-\rho_g)\rho_{gd}}\varepsilon_{g,t} \qquad (27)$$

Where $\rho_g, \rho_y, \rho_{gd}$ capture, respectively, the degree of public spending smoothing, the fiscal reaction to output and the fiscal reaction to debt/GDP ratio; $\varepsilon_{g,t}$ is an exogenous shock to government spending ($\varepsilon_{g,t} \sim i.i.d.(0, \sigma^2_{\varepsilon_g})$.

The parameter ρ_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 ρ_y would measure 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 negative (resp. positive), public consumption is counter-cyclical (resp. procyclical) in the sense that public consumption is lower (resp. stronger) than its steady-state level when output is stronger (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 sustainability as it is commonly done in the literature about fiscal policy rules (following the seminal paper of Bohn, [1998]). Specifically, primary public consumption is lowered if the public debt/GDP ratio is higher than its steady-state level. The size of the parameter depends on the willingness of the government to care (more or less) about debt sustainability. [7]

2.5. Monetary policy rule

The common central bank sets the short term nominal interest rate by reacting to the unionwide endogenous variables (active monetary policy), according to the following Taylor-type interest rate rule:

$$\log\left(\frac{R_t}{R}\right) = \beta_0 \log\left(\frac{R_{t-1}}{R}\right) + (1-\beta_0)\left[\beta_1 \log\left(\frac{\mathrm{E}_t \pi^{um}_{t+1}}{\pi^{um}}\right) + \beta_2 \log\left(\frac{Y^{um}_t}{Y^{um}}\right)\right] + \varepsilon_{r,t} \quad (28)$$

with $\varepsilon_{r,t} \sim i.i.d.(0, \sigma^2_{\varepsilon_r})$.

R, π^{um} and Y^{um} are the steady-state values of R_t, π^{um}_t and Y^{um}_t that are, respectively, the nominal interest rate, the inflation rate and output of the union. The variables π^{um}_t and Y^{um}_t are the average values of inflation and output of the two equal-size countries:

$$\pi^{um}_t = \frac{1}{2}(\pi_t + \pi^*_t) \text{ and } Y^{um}_t = \frac{1}{2}(Y_t + Y^*_t) \quad (29)$$

$\beta_1 > 1$ and $\beta_2 < 1$ are coefficients that measure central bank responses to expected inflation and output deviations. The parameter $0 < \beta_0 < 1$ captures the degree of interest rate smoothing.

7. In Tielens *et al.* [2014], the parameter ρ_{gd} (ψ_3 in their framework) is lowered in the Eurobonds scenario in order to illustrate the moral hazard problem (fewer incentives of fiscal discipline). Here, we do not consider different values of the parameter across scenarios and focus instead on the public spending shock and borrowing constraints.

2.6. Market clearing

The aggregate goods market clearing satisfies,

$$Y_t = C_{H,t} + X_t + G_t \qquad (30)$$

where $X_t = C^*_{H,t} = (1-a_1)\left(\frac{P_{H,t}}{P^*_t}\right)^{-\theta} C^*_t$ denotes total exports to foreign country. The foreign market clearing conditions are symmetrical.

Market clearing in the labor market requires $N_t = \int_0^1 N_t(j)dj$. Using (18), this yields: $N_t = \frac{Y_t}{A_t}\int_0^1\left(\frac{P_{H,t}(j)}{P_t}\right)^{-\theta} dj = \frac{Y_t}{A_t} v_t$, where $v_t = \int_0^1\left(\frac{P_{H,t}(j)}{P_t}\right)^{-\theta} dj$ is a measure of price dispersion (output) across firms. So, the aggregate output becomes: $Y_t = \frac{A_t N_t}{v_t}$. Higher price dispersion across firms induces a lower aggregate output because of an inefficient allocation of labour.

The balance of payments equation takes a different form under the three scenarios:

i) ***National Bonds***

$$B_{F,t} - B^*_{H,t} = B_{F,t-1}\Psi_t R_t - B^*_{H,t-1}\Psi^*_t R_t + M_t - X_t \qquad (31)$$

where $X_t = C^*_{H,t}$ and $M_t = C_{F,t}$ are exports and imports of home country respectively.

ii) ***Pure Eurobonds***

$$B^E_{F,t} - B^{E*}_{H,t} = B^E_{F,t-1}\Psi^E_t R_t - B^{E*}_{H,t-1}\Psi^E_t R_t + M_t - X_t \qquad (31')$$

iii) ***Limited Eurobonds***

$$B_{F,t} - B^*_{H,t} + B^E_{F,t} - B^{E*}_{H,t} = B_{F,t-1}\Psi_t R_t - B^*_{H,t-1}\Psi^*_t R_t + B^E_{F,t-1} R_t - B^{E*}_{H,t-1} R_t + M_t - X_t \quad (31'')$$

Equations (31), (31’) and (31”) depict simultaneously the balance of payment for the two countries of the union.

3. Simulations and results

We solve the non-linear stochastic model and then run simulations by using the program Dynare (Adjemian *et al.* [2014]). The calibration of the model is displayed in Table 1. For the parameter of home bias in consumption ($a_1 = 0{,}75$), we derived it from import contents of private consumption on average in Euro Area (EA) countries (Buissière et al. [2011]). The parameter of home bias in asset holdings ($b_1 = 0{,}70$) is computed using data from the ECB on the share of securities issued by EA governments in total securities held by EA MFIs (Monetary and Financial Institutions).The elasticity of substitution between domestic and foreign bonds is set at 3.4. It is higher than that between domestic and foreign goods (1.5) and is taken from Alpanda and Kabaca [2015]. The parameters of the monetary policy rules are taken from Kollmann *et al.* [2013]. For the fiscal policy rule, we assume that the persistence parameter is as high as in the case of monetary policy. We disregard any cyclical response of public spending in order to focus on the impact of the discretionary public spending shock. As for the response of public consumption to public debt, we use a result in Holm-Hadulla *et al.* [2010]. The steady-state ratio of public debt-to-GDP is set at 100%, approximately the average of this ratio in Euro area countries in 2014 (97% based on AMECO database of the European Commission).

Tax rates are computed using data from the European Commission [2011]: we used the implicit tax rates in the Euro area in 2009 for labour income (τ_w = 0,33) and consumption (τ_c = 0,2). Finally, we set the elasticity of the risk premium to deviation of the public debt-GDP ratio from steady-state at different values under the three scenarios. To get an idea of its size, we use the results of Corsetti *et al.* [2013] with regard to the slope of the risk premium with respect to debt which varies from 0,0005 when the debt level is 60 percent to 0,0083 when the debt level is 150 percent. We set the elasticity at 0,009 under national bonds and at 0,001 under credible Eurobonds (in any case, the elasticity should be higher in the former case than in the latter case). For the partial pooling scenario, 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 0.

As a baseline, we first look at the effects of a positive public spending shock (1 percent deviation from the steady state) in the domestic country under the scenario of national bonds (*cf.* figure 1)[8].

The baseline case scenario (financing of public debt by issuance of national bonds) is displayed in Figure 1.

Insert Figure 1. National bonds scenario (baseline)

The increase in public spending in the domestic country is a demand shock to which firms react by increasing labour demand. Wages increase, inflation as well, but so does inflation in the union as a whole. The central bank raises its interest rate. With interest rate smoothing, the increase in the nominal rate is not as much as that of inflation, and as a result, real interest rates are below their steady-state level just after the shock. This adjustment in the real interest rate explains much of the impact of the shock on household consumption via the effect on the future expected global return of portfolio and hence on expected return of savings.[9] Indeed, with a higher future expected return on savings, households reduce their present consumption (substitution effect). As long as this return is lower than its steady-state level, households continue to reduce their consumption over time. As soon as this return exceeds its steady-state level, consumption behaviour changes towards higher future consumption, which helps the adjustment back to equilibrium.

This effect on consumption is at first larger in the domestic country, given the stronger initial fall in the real interest rate. The discrepancy between both countries then diminishes, due to

[8] Variables are in deviation from their steady-state level.

[9] This return also depends on the dynamics of the sovereign risk premium. But, in the first quarters following the shock, the change in the risk premium is negligible.

better gain opportunities for domestic households. This is due to the fact that the return on public bonds increases as the sovereign risk premium increases (higher public debt-to-GDP ratio following the increase in public spending).

Given the risk-sharing condition (9) between both countries of the union, a stronger decrease in consumption in the domestic country leads to a real appreciation and lower exports (loss of competitiveness) while the rest of union enjoys a real depreciation (competitiveness gain).

In the rest of union, the expected gain in competitiveness makes retailers optimally increase their prices (those who change their prices), which causes a higher price dispersion after the shock (see Figure 4 infra). As explained in the description of the model (section 2.6), an increase in price dispersion creates an inefficient resource allocation at the aggregate level of the economy, which causes a loss of output (for a given quantity of labour used in the production process). This distortion in aggregate output eventually leads to an increase in labour demand (Figure 4) to recover output losses and to an increase in wages. Note that aggregate demand decreases at the impact of the shock and then increases back to equilibrium. Specifically, given the increase in inflation and the adjustment of the real interest rate, private consumption decreases (wealth effect) while public consumption hardly changes and exports decrease (the fall in consumption in the domestic country outweighs the gain in competitiveness for the RoU).

The main difference between the three scenarios is the financing of the public debt and the related adjustment in the sovereign risk premium. This influences the global risk premium in the portfolio of the households and as such their consumption behaviour.

Sovereign risk premium would be lower in the full (and credible) risk-pooling scenario than in the baseline case (national bonds). As a consequence, households would expect lower return on saving and private consumption would decrease less than in the baseline case (Figure 2).

Insert Figure 2. Macroeconomic impact under different financing debt scenarios

In the partial risk pooling scenario, the sovereign risk premium increases less in the domestic country than under the baseline case scenario. This is so because public debt is now partly financed by the issuance of risk-free Eurobonds. However, as sovereign debt is also partly financed by national bonds and as there is a domestic bias in holdings of national bonds in both countries, households in the domestic country end up with a higher share of risky domestic bonds in their portfolio whereas households in the rest of union will have a higher share of Eurobonds (Figure 3). This explains why the global risk premium in households' portfolio is higher in the domestic country and lower in the RoU. […]

Insert Figure 3. Share of Eurobonds in households' portfolio (partial pooling scenario)

Indeed, the share of national bonds will increase in domestic households portfolio, while it decreases for foreign households. This justifies why domestic households take greater risk in this scenario compared to the baseline scenario (higher global risk premium in Figure 2), while the risk is much lower for foreign households. With insufficient expected return on saving, these households will have no incentive to save and do not significantly reduce their consumption, contrary to the other two scenarios (see the adjustment of private consumption in Figure 2). Consequently, given the condition of optimal risk sharing in the union, the depreciation of the real exchange rate for the rest of the union (and implicitly the real appreciation in the country affected by the shock) will be much higher in the partial pooling scenario. The competitiveness gains for the RoU are significant, while the domestic country loses competitiveness. As shown in Figure 4, exports from the rest of the union will increase in this scenario. Combined with sustained domestic consumption, this means a significant increase in aggregate demand. By anticipating this demand, entrepreneurs will adjust both their output and prices. Those adopting optimal behavior will seek to benefit from the quantitative increase in demand and will choose a lower optimum price. Given this individual behavior, price dispersion will decrease in the economy, thus ensuring a better allocation of resources and achieving higher output with less work than before the shock.

Insert Figure 4. Macroeconomic impact under different financing debt scenarios

The labour demand thus decreases at the aggregate level, leading to lower wages in the economy (Figure 5), low inflation compared to the two previous scenarios, and a real interest rate that does not decrease significantly after the shock. This contributes to the greater stability of the return on household savings, which once again explains the stability of private consumption.

Insert Figure 5. Macroeconomic impact under different financing debt scenarios

In Figure 6, we are interested in the eurobonds credibility. We add one more scenario to the previous study. This corresponds to a full risk pooling, but Eurobonds are no longer perceived by the market as risk-free securities ($\Psi_E = 0{,}001$). They will therefore be treated in the same way as domestic securities and the sensitivity coefficient of the risk premium to the Union's debt-to-GDP ratio will be the same as for national bonds ($\Psi_E = \Psi_N = 0{,}009$). Figure 6 depicts the macroeconomic implications of three scenarios of debt mutualization (two scenarios of full risk pooling: risk-free Eurobonds and risky Eurobonds and the scenario of partial risk pooling, respectively) compared to the base scenario (national bonds) who becomes our reference.

Insert Figure 6. Comparison of different risk pooling scenarios

From the point of view of the country affected by the shock, when looking at the fiscal multiplier, full pooling seems to be the best scenatio, as long as Eurobonds remain credible (perceived as risk-free by investors). The effect of the public expenditure shock on output is stronger than in the national bonds scenario. However, if Eurobonds are no longer perceived to be risk-free (see a loss of credibility, for example), full pooling becomes less attractive than national bonds. Partial pooling appears to be the worst scenario, leading to a strong real appreciation in relation to the RoU, a sharp drop in exports, which hampers growth. On the contrary, from the point of view of the RoU, partial pooling seems the best option. Thanks to higher exports and stable private consumption, the shock has a positive spillover on the output of the RoU.

In terms of debt, the increase in public spending will lead to an increase in debt and in the debt-to-GDP ratio for the country affected by the shock. However, compared to the national bonds scenario, the debt pooling may limit its increase over time. The lower taxes on wages explain why the debt-to-GDP ratio is not even lower in the case of full pooling scenario with risk-free Eurobonds, or why the debt-to-GDP ratio would be higher under partial pooling scenario just after the shock (see also the fall in output).

Interestingly, it is the partial pooling scenario that would stabilize the longer-term debt / GDP in the country affected by the shock, thanks to a lower loss of consumption taxes and to a lower sovereign risk premium compared to the national bonds scanario. As for the RoU, it is still the partial pooling scanario which seems to be the best option, as its debt-to-GDP ratio decreases in this scenario (even compared to the steady state), thanks to the output increase and to a lower sovereign risk premium. For the other scenarios, there is an increase in the debt/GDP ratio, mainly due to lower taxes levied on consumption and to the output drop. Any full pooling scenario is less attractive in terms of the stabilization of the debt-to-GDP ratio compared to a national debt financing situation.

As an extension of the model, we consider that the public expenditure is used for consuming domestic but also imported goods, with the same bias as for the private consumption. As shown in Figure 7, the previous results about the benefits of the different scenarios for the two countries of the Union do not change. The only difference is that the effect of the shock on the output in the RoU would be positive under all scenarios, thanks to exports toward the country affected by the shock.

Insert Figure 7. Comparison of different risk pooling scenarios (extended model)

4. Welfare analysis

We, finally, lead a welfare analysis in order to compare the welfare costs (or gains) in all scenarios under the positive shock on public spending in the domestic country. Following Lucas (1987), we use a measure of the welfare costs in terms of business cycles given by the fraction of steady state consumption that households would need in the deterministic world (at the steady state) to yield the same welfare as would be achieved in the stochastic world (under the shock).

Formally, the unconditional welfare metric is u that solves:

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \varepsilon_t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\eta}}{1+\eta} \right] \right\} = \frac{1}{1-\beta} \left[\frac{1}{1-\sigma} \left(\left(1 + \frac{u}{100} \right) C \right)^{1-\sigma} - \frac{N_t^{1+\eta}}{1+\eta} \right] \qquad (32)$$

Where variables without subscript t are the steady state variables.[10]

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

10. Further details are available upon request.

welfare cost: 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.

The welfares costs (or gains) in each scenario are computed for the monetary union as a whole. They are reported in table 2. We find that the shock causes welfare costs in all scenarios. Welfare costs are the lowest in the scenario of credible pure Eurobonds and the highest in the scenario of national bonds. In the extended model with foreign goods in public purchases (the spillover effects via the trade channel are reinforced), the welfare costs are still the lowest in the scenario of credible pure Eurobonds, but the strongest if Eurobonds are not credible. The scenario of limited Eurobonds appears to be a good intermediate option where the welfare loss is higher than under credible pure Eurobonds but much lower than under non-credible pure Eurobonds.

5. CONCLUSION

In studying the proposal of creating Eurobonds, we compared two cases of pure Eurobonds and one case of limited Eurobonds. We first considered that Eurobonds are safe assets and that the institutional arrangement (joint guarantee by all sovereign issuers) is credible. In this case, we assumed that the sensitivity of the risk premium to deviation of the average public debt/GDP ratio from the 60 percent norm is lower than that for national bonds. We then considered instead that Eurobonds lacks credibility if participants in financial markets perceive that some member states are not willing to back-up other member states known to be less fiscally responsible. In such a case, participants in financial markets would react more to any variation in the public debt/GDP ratio in setting risk premia. The sensitivity parameter would be higher than initially assumed, and as high as under national bonds under a worst case scenario. We finally considered a limited Eurobond scenario which relies on the proposal made by Delpla and von Weiszäcker [2010], namely imposing a cap on the issuance of Eurobonds.

We analyzed the effects of a positive public spending shock in one country. For a big spending government, pure Eurobonds would be the best option in terms of output as long as the framework is credible. In contrast, for the other country (or fiscally responsible country), the proposal made by Delpla and von Weiszäcker [2010] would be the best option in terms of the spillover effects of the shock on output and public debt. Our welfare analysis confirm that the pure Eurobonds framework would be the best if it were credible, and if not, limited Eurobonds would be less costly from the union-wide point of view.

It is worth noting that for the rest of the union, the limited Eurobonds framework is better than the national bonds framework. Thus, the current concerns about the implementation of Eurobonds are not warranted (one has to take into account the exchange rate channel).

Furthermore, as regards pure Eurobonds, our results illustrate a kind of trade-off between credibility and moral hazard: Beetsma and Mavromatis [2014] concluded that the joint guarantee by all sovereign issuers should not be complete, because there would be few incentives to be fiscally responsible. However, our work shows that if the joint guarantee is not full and the framework lacks credibility, the macroeconomic outcomes are the least favorable. We conclude that if Eurobonds are to be credible, there should be a full joint guarantee of repayment along with enforceable rules of fiscal discipline, whatever they are.

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Table 1. Calibration

Description	Parameter	Value
Inverse intertemporal elasticity of substitution	σ	2
Inverse of the Frisch elasticity of labour supply	η	1
Subjective discount factor	β	0,99
Home bias in consumption	a_1	0,75
Home bias in holding national bonds	b_1	0,7
Elasticity of substitution between domestic and imported goods	θ	0,8
Elasticity of substitution between domestic and foreign bonds	θ_b	3,4
Fraction of firms keeping their prices unchanged	ϕ_i	0.75
Sensibility coefficient of the risk premium for national bonds to public indebtedness	Ψ_N	0,009
Sensibility coefficient of the credible Eurobonds' risk premium to public indebtedness	Ψ_E	0,001
Sensibility coefficient of the non-credible Eurobonds' risk premium to public indebtedness	Ψ_E	0,009
Sensibility coefficient of the Eurobonds' risk premium to public indebtedness (in the Limited Eurobonds scenario)	Ψ_E	0
Public expenditures/GDP ratio	G/Y	0,20
Smoothing coefficient in the public expenditure rule	ρ_r	0,9
Inflation coefficient in the monetary rule	ρ_π	2,2
Output coefficient in the monetary rule	ρ_y	1
Smoothing coefficient in the public expenditure rule	ρ_g	0,9
Output coefficient in the public expenditure rule	ρ_{gy}	0
Debt coefficient in the public expenditure rule	ρ_{gd}	0,1
Tax rate on consumption	τ_c	0,20
Tax rate on wages	τ_w	0,33
Steady-state public debt	D/Y	1
Autoregressive coefficient shock	ρ	0,8

Table 2. Welfare analysis

	National Bonds	Credible Pure Eurobonds	Non-Credible Pure Eurobonds	Limited Eurobonds
Baseline model	-1,4572	-0,1448	-1,1687	-0,4559
Extended model	-1,1693	-0,1037	-1,2490	-0,3519

Figure 1. National bonds scenario (baseline)

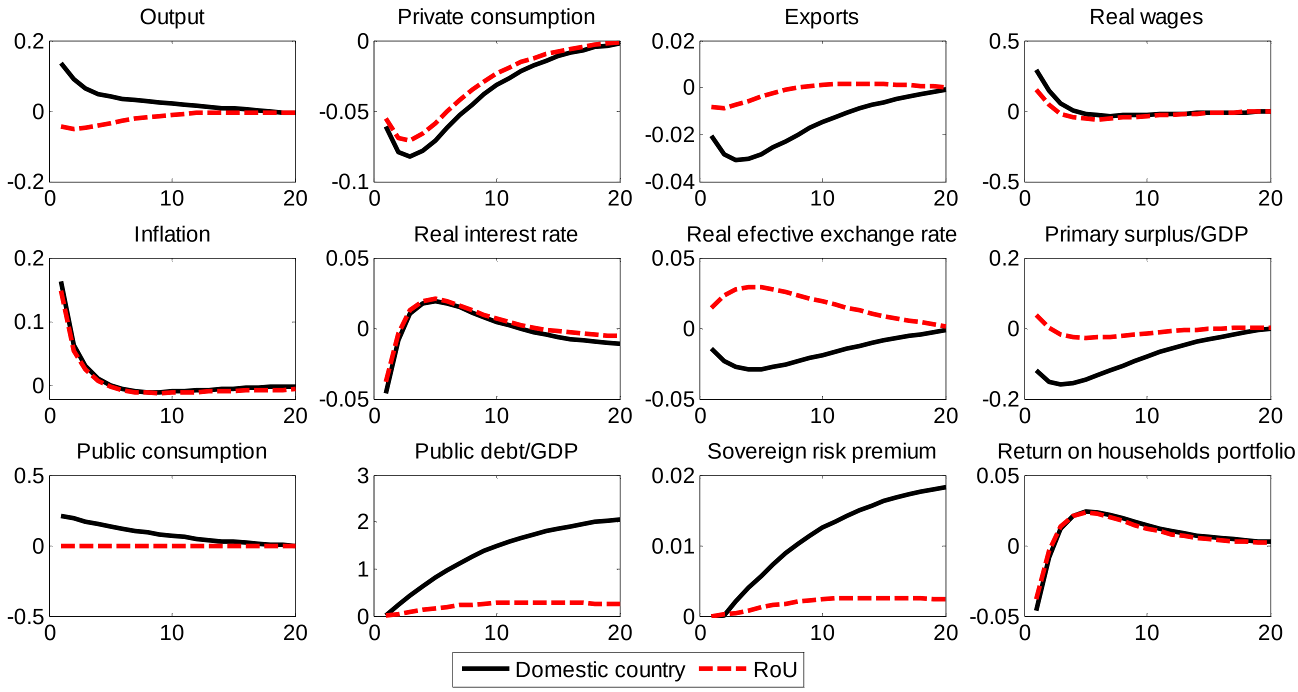

Figure 2. Macroeconomic impact under different financing debt scenarios

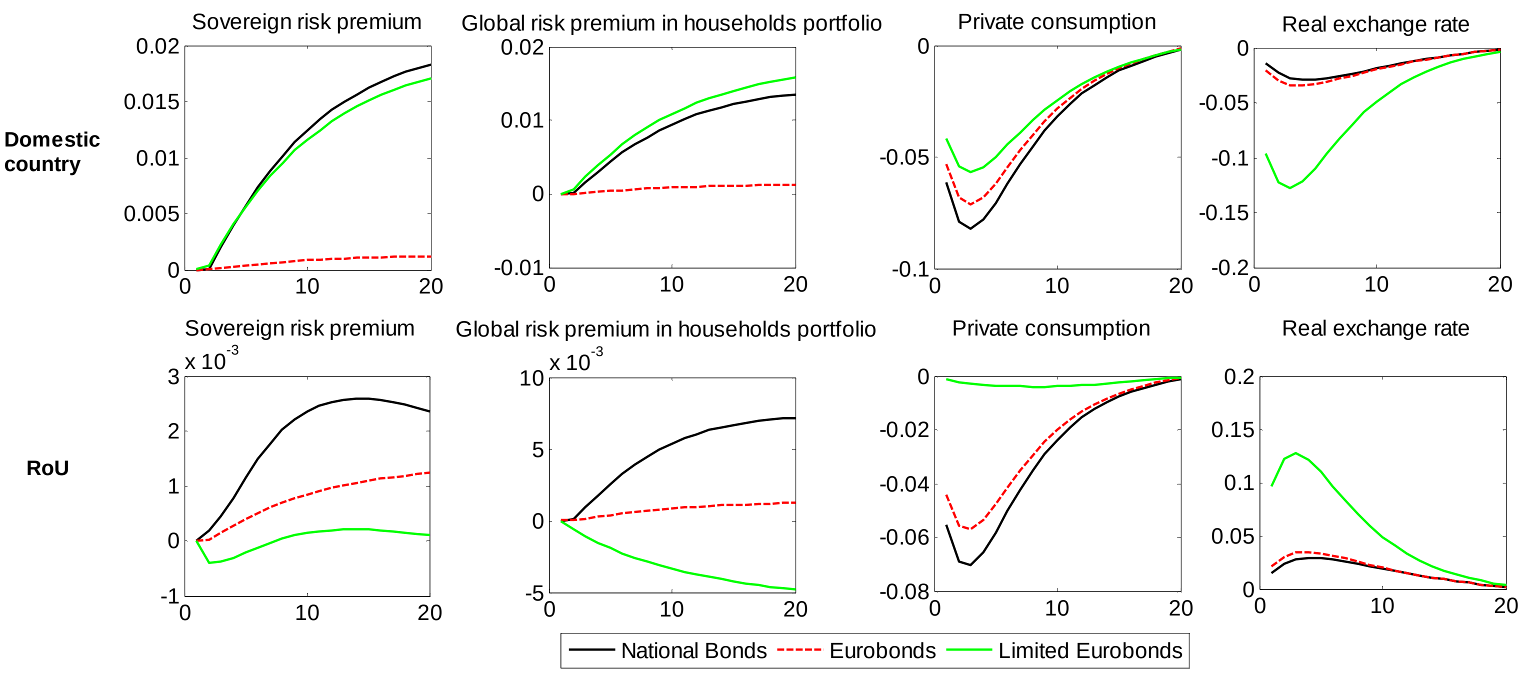

Figure 3. Share of Eurobonds in households' portfolio (partial pooling scenario)

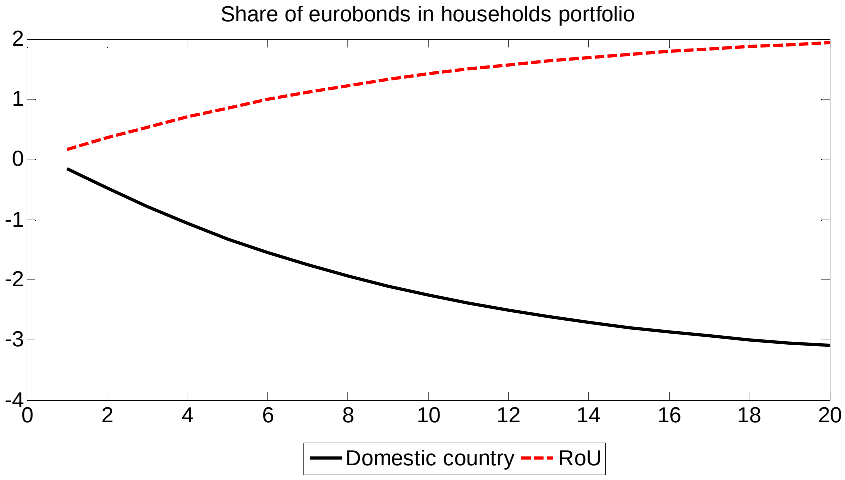

Figure 4. Macroeconomic impact under different financing debt scenarios

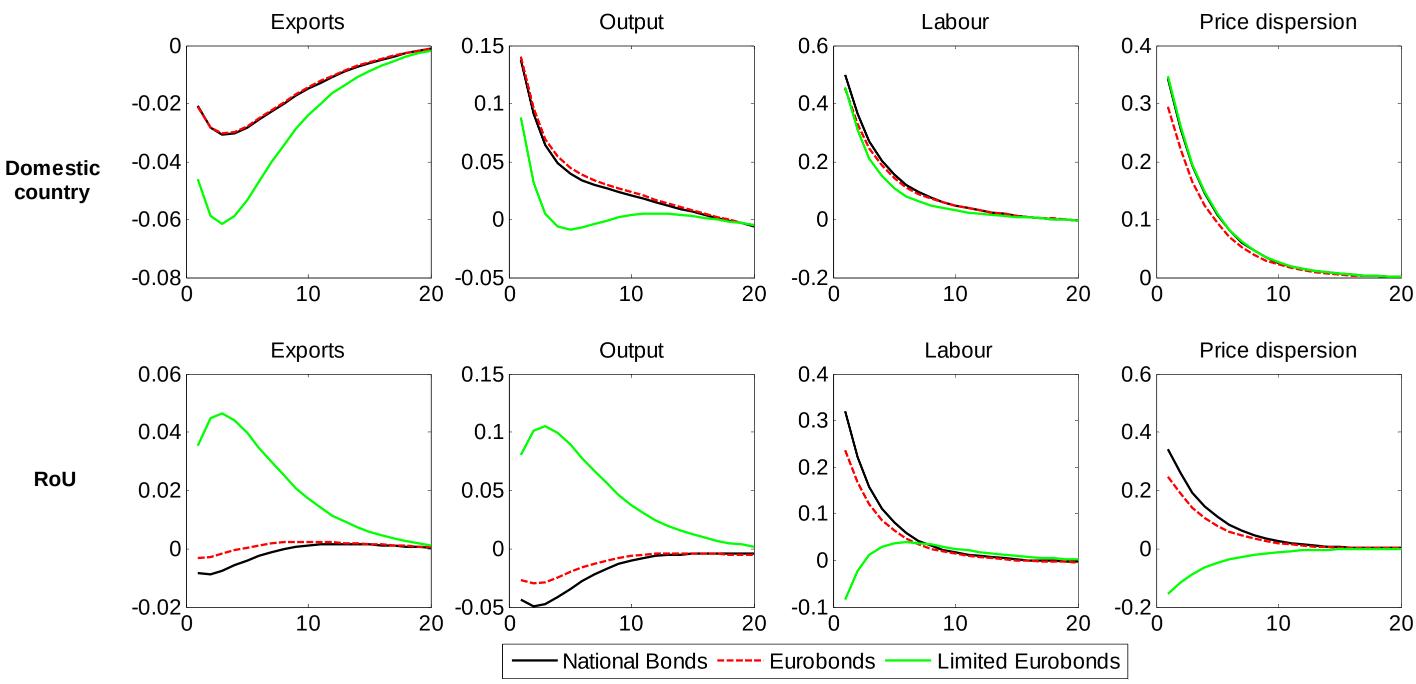

Figure 5. Macroeconomic impact under different financing debt scenarios

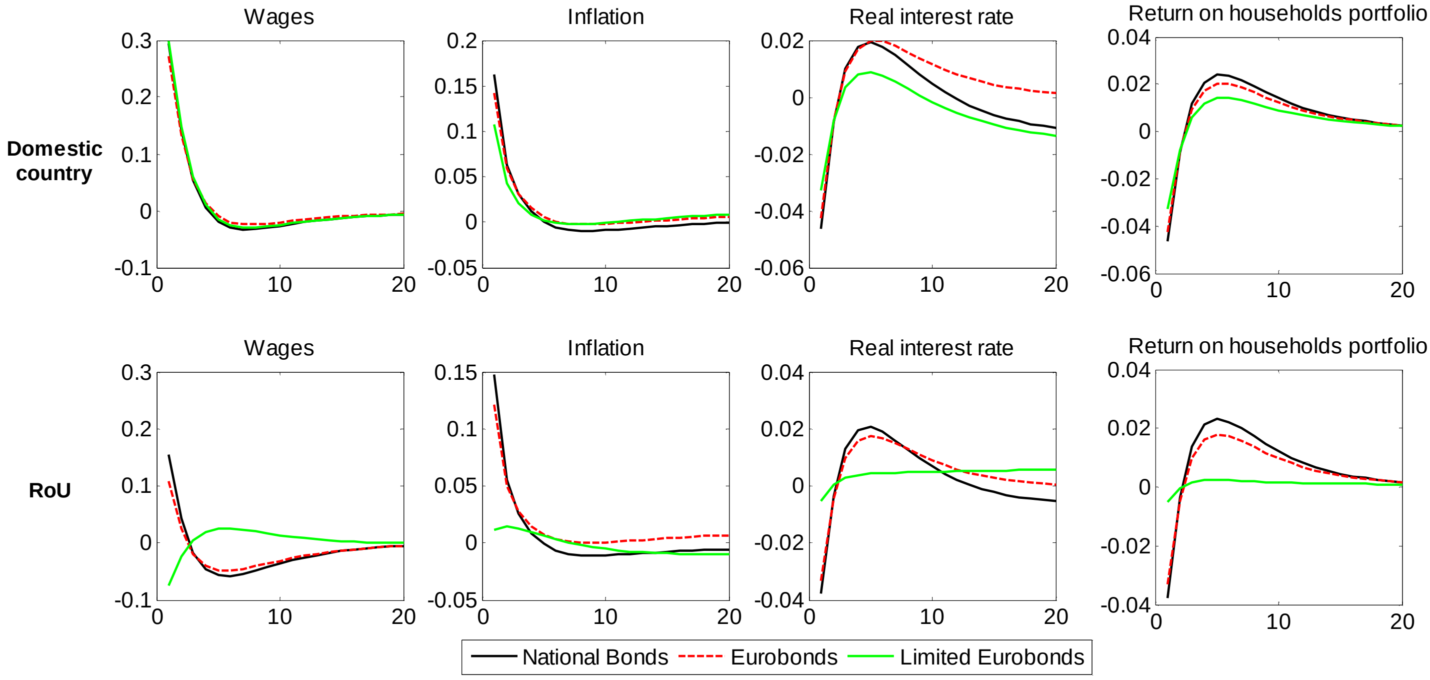

Figure 6. Comparison of different risk pooling scenarios

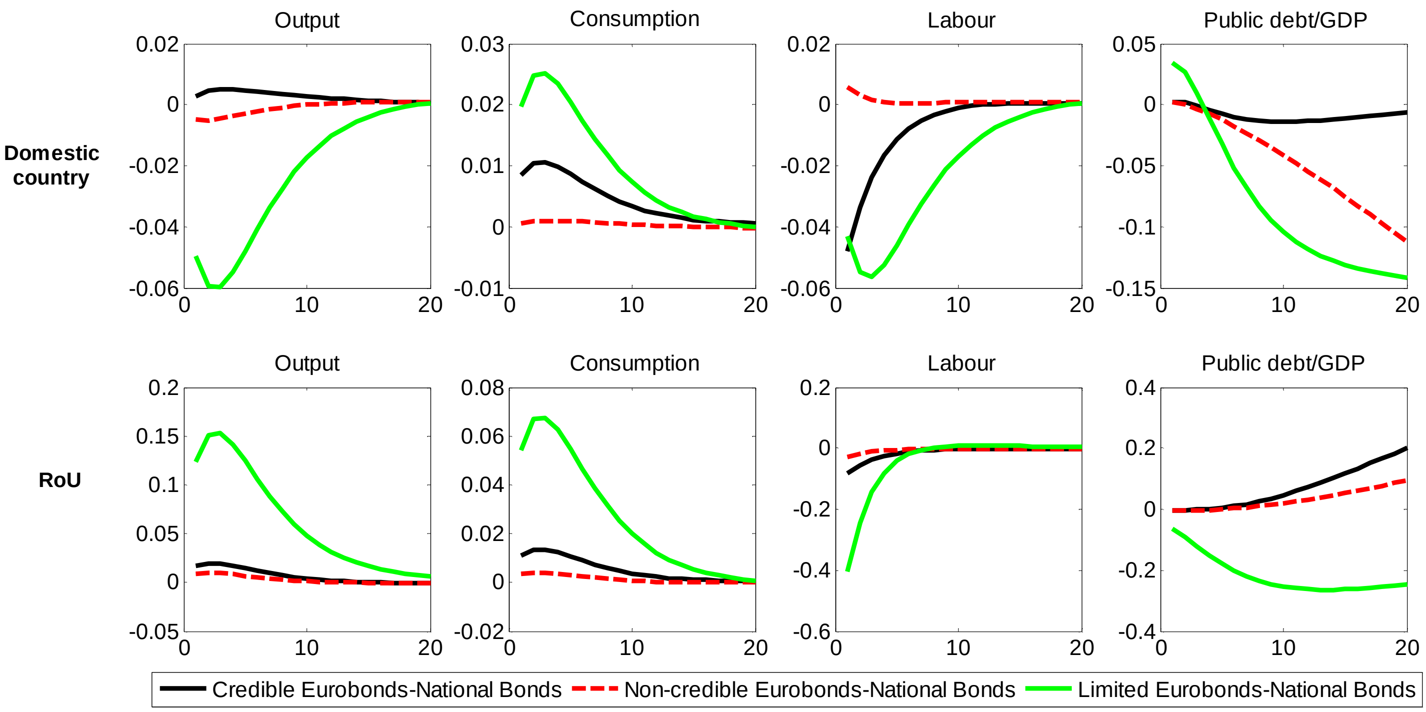

Figure 7. Comparison of different risk pooling scenarios (extended model)