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Fiscal Transfers in a Monetary Union with Sovereign Risk

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Abstract

This paper considers a scheme of fiscal transfers between member states of a monetary union subject to sovereign spread shocks. The scheme consists of a set of cross-country transfer rules triggered when sovereign spreads widen. I study its implementation in a two-country model with financial frictions estimated for Portugal and the Eurozone. The model illustrates how domestic fiscal policy is unable to buffer the widening of sovereign spreads when public debt is high and spreads are responsive to the fiscal outlook. On the contrary, because transfers are made between governments, they alleviate the strain caused on the fiscal stance directly and reduce the pass-through of sovereign risk to private lending to firms. I find that, for welfare to improve for all member states, their relative size and fiscal profile need to be nearly symmetric. Nevertheless, I show that for a cost to the remaining members states significantly smaller than the benefits they derive from being part of the union, a small country like Portugal can secure sizeable increases in life-time consumption.

Keywords*:* Sovereign risk, banks, monetary union, fiscal transfers.

Jel codes: E62, F15, F41, F42, F45.

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1 Introduction

The debate over the architecture of a robust monetary union between countries attracted renewed interest during the recent sovereign debt crisis in Europe. The asymmetrical nature of sovereign interest rate shocks, coupled with the inherent constraints they pose on domestic fiscal policy, exposed a painful fault in the design of the European Monetary Union (EMU). This fault concerns the lack of adequate risk sharing mechanisms to facilitate the economic adjustments of individual member states facing idiosyncratic shocks. As seen during the crisis, soaring sovereign spreads forced a number of countries, including Greece, Ireland, Portugal, Italy and Spain, to undertake sudden fiscal

consolidation while implementing deep structural reforms. For the first three cases, the extent of the crisis required them to resort to institutional rescue programmes put in place by the International Monetary Fund (IMF) and the European Institutions. The dramatic economic toll of the crisis and the dubious response from within the EMU called into question the irreversibility of the common currency.

In this paper I propose a two-country model of a monetary union where sovereign spreads affect private borrowing costs due to financial frictions. My contribution is twofold. First, I provide a consistent narrative of the events during the sovereign debt crisis, illustrating how domestic fiscal policy is constrained by the responsiveness of sovereign spreads to the fiscal conditions and by the ratio of public debt to GDP. Second, I show that a simple fiscal transfer scheme between governments is an efficient buffer to sovereign spread shocks and discuss the conditions under which such a scheme can be implemented.

During the sovereign debt crisis, banks were pivotal in passing the rise in sovereign spreads to the real economy. The fall in government bond prices and the down-grading of these assets by credit rating agencies severely weakened banks' balance sheets. As a consequence of their direct exposure to sovereign credit risk, banks' ability to raise market-based funding was adversely affected. The increase in funding costs forced them to strengthen their equity ratios and to sharply reduce overall credit provision to firms, which ultimately ignited the recession.

I capture the role of banks during the crisis by introducing a banking sector similar to that proposed in Gertler and Karadi (2011) into a two-country general equilibrium model of a monetary union. Banks serve as financial intermediaries between households, from which they take short-term deposits, and firms, to which they make long-term loans. Due to agency problems between banks and their depositors, banks are forced to moderate their leverage in order to attract deposits from households. I extend the banking sector by assuming that banks also lend to the government. In good times, the sovereign obtains funds at the risk-free interest rate. However, a spread can arise on top of the risk-free rate reflecting the credit worthiness of the government. Because banks hold sovereign bonds in their portfolios, their net worth is exposed to sovereign credit risk. Therefore, a shock to sovereign spreads deteriorates the equity value of banks and forces them to contract credit supply and to raise lending rates at the same time as they retain funds to build up the value of their net worth.

In the model, when the ratio of public debt to GDP is calibrated to 60%, I find that a 10% increase in sovereign spreads leads to an increase of about 3.5% in the borrowing costs for firms. However, when the ratio of public debt to GDP equals 120%, the increase in private spreads is more than three quarters of the initial rise in sovereign spreads. The drop in the supply of credit to firms and the increase in borrowing costs adversely impacts investment and ignites the recession. At the trough, real GDP falls between 2% and nearly 6%, depending on the size of the ratio of public debt to GDP. These effects are magnified when sovereign spreads respond to the fiscal outlook. After the initial shock, an increase in the public deficit feeds back to sovereign spreads and further increases firms' borrowing rates. The size of the feedback loop also has implications for fiscal policy. For

instance, for a public debt to GDP ratio of 120%, it is impracticable for the government to engage in counter-cyclical fiscal policy as it is forced to consolidate in order to stabilize public debt and to prevent sovereign spreads from rising further. As seen in the periphery of the EMU during the crisis, when sovereign spreads are sensitive to the fiscal outlook, there is no leeway for the government to provide a stimulus to the economy in order to countervail the recession.

The idea that the EMU should be completed with a federal fiscal arrangement is hardly a novelty in policy and academic circles. When its design was being discussed, it was clear that a system of fiscal transfers crafted to countervail idiosyncratic shocks would be crucial for the success of the single currency.[1] The argument behind a federal-like transfer mechanism drew directly on the literature of optimal currency areas.[2] With the creation of the EMU, member-states would no longer be able to use monetary policy or the exchange rate to buffer country-specific shocks. Moreover, to the extent that production factors are immobile across countries and movements in nominal prices and wages are slow, fiscal policy would become a key instrument to fuel the necessary adjustments. With this in view, the Maastricht Treaty incorporated limits on budget deficits and public debts in order to preserve sound domestic fiscal stances capable of reacting if required.

Yet, the political process aimed at endowing the EMU with an area-wide fiscal capacity lay dormant for decades until the sovereign debt crisis when domestic fiscal policies failed to operate the required adjustments. In response the severe consequences left by the crisis and the inability of the EMU to respond adequately and promptly, the leaders of the European Institutions drew up a road map to create an area-wide fiscal stabilization capacity. The proposed mechanism, to be implemented before 2025, would be deployed when domestic fiscal policy cannot, on its own, counteract large asymmetric shocks.[3] In this paper, I examine the design and implementation of such a federal fiscal capacity. I investigate the extent to which fiscal transfers can effectively smooth the effects of sovereign spread shocks by considering a mechanism that affects the fiscal stance of the country. Because sovereign spreads constrain domestic fiscal policy, foreign transfers can step in and both support economic activity and mitigate the fiscal burden.

I use the model to quantify the effects on welfare of a cross-country fiscal transfer scheme that is actioned in response to a widening in sovereign spreads. I first show that in a monetary union with equal-sized regions, there are unambiguous welfare gains from implementing the scheme. Because transfers are processed between governments, they alleviate the fiscal burden directly. The scheme proves to be particularly important in bad times when the public debt to GDP ratio is high and sovereign spreads are highly responsive to the fiscal outlook. However, the distribution of welfare gains is very sensitive to asymmetries between the two regions. Notably, I find that, in order to obtain positive welfare gains for all regions, the minimum relative size for the smaller region is still higher than 48% of the entire union. This is an important challenge for the implementation of the scheme: if some countries incur welfare costs, they will likely not participate.

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[1]See, for instance, the MacDougall report (European Commission, 1977) as well as the Delors (1989) report.

[2]See the seminal articles by Mundell (1961), McKinnon (1963), and Kenen (1969).

[3]The 5 Presidents Report (Juncker et al., 2015) is the last high level policy contribution. It draws on and updates earlier proposals, namely by Van Rompuy et al. (2012). See also IMF (2013) for discussion.

In order to provide a relevant and representative case study, I estimate the parameters of the model for Portugal and the Eurozone. I limit the set of schemes I consider to those under which potential welfare costs cannot exceed the welfare benefits generated by the introduction of the single currency. In other words, the alternative scenario to the transfers countries can compare to is the *status quo* pre EMU. Considering the impact of the scheme in isolation, I show that Portugal can secure welfare gains in the range of $1.44 - 7.80\%$ of lifetime consumption, while the Eurozone incurs welfare losses of $0.03 - 0.15\%$. Because the scheme is designed in a way in which it excludes net losses from entering the EMU, these results render strong support for its implementation. Regarding the role of the transfers in mitigating the real effects of sovereign spread shocks, I show that for a level of transfers that reduces the pass-through of sovereign spreads in about $1/2$ percentage points, the trough of the recession is reduced by at least 1%. In bad times, the effects generated by the fiscal transfer scheme are considerably larger and, therefore, the dimension of the recession can be effectively reduced.

Literature: This paper is related to two strands of the literature. On the one hand, it relates to a number of papers investigating the implications of sovereign spreads for economic stability. Schabert and van Wijnbergen (2011) and Bonam and Lukkezen (2013), for instance, focus on the interactions between fiscal, monetary, and exchange rate policies, in an environment where sovereign spreads are introduced as a preemptive game between the government and speculators. The parsimonious way they model sovereign spreads is also used in the present paper. Corsetti et al. (2012), who study how the sovereign risk channel exacerbates cyclical shocks in an environment where monetary policy can be constrained at the zero-lower bound, analyse the effects of fiscal retrenchment in alleviating macroeconomic fluctuations. Bocola (2013) and Pancrazi et al. (2014) also investigate the pass-through of sovereign risk to private borrowing costs and evaluate the effectiveness of asset purchases by the central bank in stabilizing real activity. Kollmann et al. (2013) introduce a banking sector with capital requirements into an open economy model and investigate whether government provision of support to banks can stabilize the economy. The present paper draws on this literature of the pass-through of sovereign risk, but diverts from it by focusing on the implications it has on fiscal policy itself and by considering instead cross-country fiscal transfers as a means to smooth shocks.

On the other hand, this paper contributes to the literature on federal fiscal arrangements within monetary union. There is a growing literature on optimal policy and international coordination using domestic fiscal instruments for countries sharing a common currency.[4] However, less attention has been given to federal fiscal schemes. Among the exceptions, Farhi and Werning (2012) show that fiscal transfers can improve risk sharing in an environment with complete asset markets. Costain and de Blas (2012) compare fiscal policy rules that stabilize public debt through either income taxation or spending on wages and unemployment benefits and find that a policy of procyclical spending on wages and transfers decided by a federal agency brings the market economy closer to the planner's solution. Kletzer and von Hagen (2000), Evers (2012) and Kim and Kim

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[4]Evers (2012) and Pappa and Vassilatos (2007) provide references.

(2013) investigate different federal transfers schemes and their potential to achieve welfare gains for members of a monetary union. I expand this literature by focusing on asymmetric shocks that not only cause real fluctuations, but also constrain domestic fiscal policy. Besides presenting an actual scenario where federal fiscal arrangements can act as a stabilization mechanism, this paper adds to the literature by quantifying and discussing the welfare trade-off such policies entail in a realistic set-up.

The remainder of the paper is structured as follows. In the next section I describe the model and motivate the main extensions I have introduced. Section 3 discusses the estimation strategy and the results I obtain. I dedicate section 4 to the policy analysis. I begin by investigating the dynamic effects of sovereign spread shocks in a baseline scenario. I then discuss how domestic fiscal policy is constrained by the fiscal stance and by the behaviour of sovereign spreads. Finally, I investigate the welfare consequences of the proposed fiscal transfers scheme and discuss its dynamic impacts during episodes of sudden increases in sovereign spread. The last section concludes.

2 Model

In this section I lay out a general equilibrium model of a monetary union. The union is composed of two small open economies with habits in consumption, sticky prices and wages, financial frictions, and investment adjustment costs. The model presented here is an extension of the one used by Lama and Rabanal (2014). The two countries, which I call home and foreign, are of sizes n and $1 - n$, respectively. Households in each country deposit their savings in domestic banks and provide labour to domestic producer firms. Households in one country can also trade bonds with households in the other country, having, however, to account for the real exchange rate. Banks serve as intermediaries between households and borrowers. They sell long-term loans to wholesale firms and to the government. Each country produces a continuum of tradeable intermediate goods that are aggregated into a final non-tradeable good. The latter is consumed by households, the government, and used for investment. Governments can raise taxes and issue long-term bonds to finance public expenditure, while the area-wide central bank sets the nominal interest rate according to a feed-back rule targeting aggregate inflation and output growth.

The following subsections describe the home economy in more detail. The description of the foreign economy is omitted for brevity since its structure is analogous to the home country, except for the government which is assumed to run zero fiscal deficits every period.[5] All variables are in *per capita* terms, the conventional ⋆ denotes foreign variables or parameters, and the subscript h (f) denotes goods produced in the home (foreign) country and respective prices.

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[5]Without loss of generality, I impose zero fiscal deficits for the foreign economy for simplicity. When I compare two symmetric regions in section 4, I mean total symmetry, that is, the foreign government is also allowed to issue debt.

2.1 Households

There is a continuum of infinitely lived households and within each household there are two types of members: a fraction $1 - f$ are workers and a fraction f are bankers. The former supply labour to non-financial firms and receive wages, while the latter manage a financial intermediary for profits. Household members switch between the two occupations but keep the relative proportion of each type constant. Hence, with probability λ_f a banker remains active in the following period, which implies that each period a fraction $(1 - \lambda_f) f$ bankers retire and become workers. Conversely, each period the same number of workers randomly become bankers. Bankers' limited tenure avoids overaccumulation of retained earnings and ensures the financial frictions remain operative, as explained below.

Household members are assumed to pool consumption risk perfectly. Their life-time utility is given by

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t u\left(c_{i,t}, l_{i,t}\right) \qquad \text{for } i \in [0, n]$$

with

$$u\left(c_{i,t}, l_{i,t}\right) \;=\; log\left(c_{i,t} - \varrho c_{t-1}\right) - \zeta \frac{(l_{i,t})^{1+\varphi}}{1 + \varphi}$$

and where E_0 denotes the rational expectations operator conditional on the information available up to $t = 0$ and $\beta \in (0, 1)$ is the household's subjective discount factor. Households derive utility from consumption, which is subject to external habit formation $\varrho \in (0, 1)$, and disutility from labour, where $\varphi > 0$ is the inverse elasticity of labour supply and $\zeta > 0$ its relative weight. The consumption good is an aggregate good composed of domestic and foreign intermediate goods, as explained below. Households can deposit their savings with domestic banks and can trade foreign bonds in international financial markets. The budget constraint of home households in real terms is given by

$$(1 + \tau_t^c) c_{i,t} + b_{i,b,t} + e_t r_{f,t-1} b_{i,f,t-1} \;\leq\; w_{i,t} l_{i,t} + r_{h,t-1} b_{i,b,t-1} + e_t b_{i,f,t} + V_t - T_t \tag{1}$$

where $b_{i,b}$ denotes deposits with domestic banks which pay the real interest rate $r_{h,t-1}$, and $b_{i,f}$ denotes bonds traded with households abroad and which pay the real interest rate $r_{f,t-1}$. For ease of exposition, the budget constraint is written such that $b_{i,b} > 0$ implies positive savings from the households, while $b_{i,f} > 0$ implies that the household is a net borrower in international markets. As a consequence of being in a monetary union, the nominal exchange rate between the two countries is fixed and therefore the real exchange rate, e_t, is simply equal to the ratio of consumer prices in both countries. Households receive labour income at the real wage rate $w_{i,t}$ and real profits from firms denoted by V_t. Finally, they pay lump-sum and distortionary taxes, T_t and $\tau_t^c c_{i,t}$ respectively, to the government.

The first-order conditions for consumption and for financial asset holdings are

$$\varsigma_t = \frac{1}{(1 + \tau_t^c)} \frac{1}{c_t - \varrho c_{t-1}} \tag{2}$$

$$1 = \beta \Lambda_{t,t+1} r_{h,t} \tag{3}$$

$$1 = \beta \Lambda_{t,t+1} \frac{e_{t+1}}{e_t} r_{f,t} \tag{4}$$

where $\Lambda_{t,t+1} = \varsigma_{t+1}/\varsigma_t$ is the ratio of marginal utilities of consumption between t and $t + 1$, and ς_t is the multiplier on the budget constraint.

I introduce nominal rigidities in wages as in Erceg et al. (2000) by assuming that households are monopolistic suppliers of differentiated labour services. As such, each household has market power to negotiate wages with intermediate good producers. In turn, intermediate good producers use a composite labour input in production, l_t, which they obtain by aggregating differentiated labour services according to

$$l_t = \left(\int_0^n (l_{i,t})^{\frac{\tau_w - 1}{\tau_w}} di \right)^{\frac{\tau_w}{\tau_w - 1}}$$

The demand curve for labour services from household i is thus given by

$$l_{i,t} = \left(\frac{w_{i,t}}{w_t} \right)^{-\mu_w} l_t \tag{5}$$

where $w_{i,t}$ is the real wage household i charges in order to supply $l_{i,t}$, and $w_t = \left(\int_0^1 (w_{i,t})^{1-\tau_w} di \right)^{1/(1-\tau_w)}$ is the real price index of the composite labour input. The elasticity of substitution between labour services supplied by different households is given by μ_w.

In each period, only a fraction $1 - \lambda_w$ of households can re-optimize their posted nominal wage. When able to adjust its wage, household i solves

$$\underset{w_{i,t}}{\text{Max}} \ \ \mathrm{E}_t \sum_{s=0}^{\infty} (\beta \lambda_w)^s \left[log \left(c_{i,t+s} - \varrho c_{t+s-1} \right) - \zeta \frac{\left(l_{i,t+s|t} \right)^{1+\varphi}}{1 + \varphi} \right]$$

subject to the respective demand curve for labour services and the budget constraint. The first-order condition with respect to the optimal nominal wage w_t^* is given by

$$\mathrm{E}_t \sum_{s=0}^{\infty} (\beta \lambda_w)^s \varsigma_{t+s} l_{i,t+s|t} \left[\frac{w_t^*}{P_{t+s}} - \frac{\tau_w}{\tau_w - 1} \frac{\zeta \left(l_{i,t+s|t} \right)^{\varphi}}{\varsigma_{t+s}} \right] = 0 \tag{6}$$

where ς_t is the multiplier on the budget constraint and $l_{i,t+s|t} == (w_t^*/w_{t+s})^{-\tau_w} l_{t+s}$ is the labour

supplied in period $t + s$ for those households that last negotiated their nominal wage at t.

2.2 Banks

As described earlier, every period a fraction f of household members are bankers who run a domestic financial intermediary. I extend the banking sector described in Gertler and Karadi (2011) by allowing banks to provide funds to the government. Hence, banks raise deposits from domestic households and lend to domestic non-financial firms and to the government. As in Lama and Rabanal (2014), bankers do not engage in cross-border deposits or investment activities.[6] I also assume that the domestic banking sector holds the total amount of public debt issued by the government.

I motivate these two assumptions with the following stylized facts. In 2011, around 80% of the sovereign debt claims on countries in the periphery of the Eurozone was held in the balance sheets of national banks. In these same countries, domestic government bond holdings accounted for 93% of bank's equity. On the other hand, domestic banks represented roughly 75% of external financing to private firms. As a result, from 2008 to 2013, the lending volume of newly issued loans fell by more than 50% in the periphery of the EMU.[7]

Therefore, each period a continuum of banks indexed by $i \in [0, f]$ obtain deposits $b_{i,b,t}$ from households and lend funds to wholesale producers and to the government, $a_{i,x,t}$ and $a_{i,b,t}$ respectively. Denoting by $n_{i,t}$ the net worth of financial intermediary i and by $\mathcal{W}_{i,t}$ the total value of its assets, the balance sheet of bank i is then given by

$$\mathcal{W}_{i,t} = q_{x,t} a_{i,x,t} + q_{b,t} a_{i,b,t} = n_{i,t} + b_{i,b,t} \tag{7}$$

where $q_{j,t}$ is the relative price of claims $a_{i,j,t}$. The cost of deposits is given by the interest rate $r_{h,t}$, whereas banks require a return of $r_{x,t}$ on the loans they make to firms. The interest rate on government bonds, $r_{b,t}$, is assumed to equal the risk-free rate adjusted by a default risk premium δ_t. Expanding (7) forward, I obtain the evolution of equity capital as the difference between earnings on assets and interest payments on liabilities

$$\begin{aligned} n_{i,t} &= (r_{x,t-1} - r_{h,t-1}) q_{x,t-1} a_{i,x,t-1} + ((1 - \delta_t) r_{b,t-1} - r_{h,t-1}) q_{b,t-1} a_{i,b,t-1} \\ &\quad + r_{h,t-1} n_{i,t-1} \end{aligned} \tag{8}$$

Growth in equity above the risk-free return $r_{h,t}$ depends on the premium $(r_{x,t} - r_{h,t})$ earned on the loans to firms and on the return on sovereign debt.

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[6]Dedola et al. (2013) extend the framework of Gertler and Karadi (2011) to allow banks to take deposits from foreign households and to lend to foreign firms.

[7]The figures were taken from Uhlig (2013), Acharya et al. (2014), and Bocola (2013). A report by the Bank for International Settlements, BIS(2011), provides a comprehensive discussion on the link between sovereign credit risk and banks funding conditions.

The objective of bankers is to maximize their expected terminal net worth

$$\mathcal{N}_{i,t} \;=\; \mathrm{E}_0 \sum_{s=0}^{\infty} \left(1-\lambda_f\right)\lambda_f^s \beta^{s+1}\Lambda_{t,t+1+s} n_{i,t+1+s} \tag{9}$$

To the extent that the expected discounted returns on his assets are higher than the risk-free rate, the banker will want to raise deposits and build its net-worth indefinitely. Gertler and Karadi (2011) introduce a moral hazard problem in order to limit overaccumulation of retained earnings by assuming that at any given period bankers can divert a fraction ι of available assets. Having knowledge of this, depositors can force the bank into bankruptcy, but can only recover the remaining $1 - \iota$ of funds. Hence, depositors will only supply funds to the bank if the following incentive-compatibility constraint is satisfied

$$\mathcal{N}_{i,t} \;\geq\; \iota \mathcal{W}_{i,t} \tag{10}$$

that is, the value of carrying on doing business must be higher than the value of diverting funds. Absent financial frictions, the risk premium on non-financial firms would be zero. With imperfect capital markets, however, the premium may be positive due to constraints on the ability of banks to raise external funds.

I solve the banker's problem by defining the leverage ratio of financial intermediaries, $\phi_{i,t}$, as

$$\mathcal{W}_{i,t} \;=\; \phi_{i,t} n_{i,t} \tag{11}$$

and by making an educated guess over the functional form of bankers' net worth. In particular, I guess that $\mathcal{N}_{i,t} = \nu_t \mathcal{W}_{i,t} + \eta_t n_{i,t}$, where ν_t is the marginal value of expanding assets, holding $n_{i,t}$ constant, and η_t is the marginal value of the bank's net worth, holding its portfolio $\mathcal{W}_{i,t}$ constant. The expressions for ν_t and η_t are given by

$$\eta_t \;=\; \mathrm{E}_0 \Omega_{t,t+1} r_{h,t} \tag{12}$$

$$\nu_t \;=\; \Omega_{t,t+1}\left(\left(r_{x,t}-r_{h,t}\right) - \left(r_{x,t}-r_{b,t}\left(1-\delta_{t+1}\right)\right)\alpha_t^{\mathcal{W}}\right) \tag{13}$$

where $\alpha_t^{\mathcal{W}} = q_{b,t} a_{i,b,t}/\mathcal{W}_{i,t}$ is the share of government debt in the bank's portfolio. $\Omega_{t,t+1}$ is the banker effective discount factor which is given by

$$\Omega_{t,t+1} \;=\; \beta\Lambda_{t,t+1}\left\{1+\theta\left[\eta_{t+1}+\nu_{t+1}\phi_{i,t+1}-1\right]\right\} \tag{14}$$

The effective discount rate of bankers differs from that of the households due to the financial friction.

As Gertler and Karadi (2011) show, when (10) binds the leverage ratio is common to all

bankers and equal to

$$\phi_t = \frac{\eta_t}{\iota - \nu_t} \tag{15}$$

That is, the amount of funds banks can intermediate is limited by their net worth due to the borrowing constraint. For positive values of net worth, the constraint binds only if $0 < \nu_t < \iota$. With $\nu_t > 0$, it is profitable to expand $\mathcal{W}_{i,t}$. However, if $\nu_t > \iota$, the incentive constraint does not bind since the value from intermediation exceeds the gain from diverting funds. In the equilibria studied below, the incentive-compatibility constraint always binds within a neighbourhood of the steady state.

Finally, aggregate net worth in any given period is the sum of the net worth of existing banks plus the start-up funds of entering banks. Surviving banks carry their total net-worth into the next period, whereas new banks receive a fraction $\epsilon / (1 - \lambda_f)$ of the assets of exiting banks in order to start business. Aggregate net worth is then given by

$$
\begin{aligned}
n_t &= \lambda_f \left\{ \left[(r_{x,t-1} - r_{h,t-1}) - (r_{x,t-1} - r_{b,t-1}(1 - \delta_t)) \alpha_{t-1}^{\mathcal{W}} \right] \phi_{t-1} + r_{h,t-1} \right\} n_{t-1} \\
&\quad + \epsilon \left\{ q_{x,t} a_{x,i,t-1} + q_{b,t} \delta_t a_{b,i,t-1} \right\}
\end{aligned}
\tag{16}
$$

In the set up just presented, the share of government bonds in the balance sheets of banks, $\alpha_t^{\mathcal{W}}$, is not an optimizing variable for bankers. I assume instead that the banking sector provides funds to the government as the latter requires each period, without entering into optimal portfolio choices.[8] The appeal of this approach is that it gives me the flexibility to introduce sovereign risk in a transparent and parsimonious way. In particular, because I model sovereign default risk as a preemptive game between the government and speculators, the pricing of government bonds is not pinned down by banks.[9] Hence, government bonds are priced according to

$$r_{h,t} = \mathrm{E}_t r_{b,t} (1 - \delta_{t+1}) \tag{17}$$

that is, the sovereign interest rate is equal to the risk-free rate adjusted by the default risk premium, which I describe shortly.

2.3 Production

Capital producers: At the end of each period, perfectly competitive capital producers buy undepreciated capital from wholesale firms and repair it. At the same time, they also invest in

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[8]For some references, Devereux and Sutherland (2007) describe how to implement optimal portfolio choice in an open economy setting, while Dedola et al. (2013) apply this method to their model of banks with cross-border linkages. Kollmann et al. (2013) assume that banks bear real costs on government and private bond holdings in order to pin down their portfolio composition.

[9]Bocola (2013) develops a model similar to mine where the government can actually default on its debt, generating a pass-through of sovereign risk to private borrowing rates. The strategic default literature is growing rapidly after the seminal work by Eaton and Gersovitz (1981), and includes Aguiar and Gopinath (2006), Arellano (2008), Cuadra and Sapriza (2008), among many others. Two recent papers that expand this literature by including a banking sector are Gennaioli et al. (2013) and Sosa Padilla (2014).

new capital by purchasing and transforming domestic final goods. The repaired and newly created capital is then sold to wholesalers as an input to production. The discounted real profits of capital producers, Π_{CP}, are given by

$$\underset{z_t}{\text{Max}} \ \ E_t \sum_{s=0}^{\infty} \beta^{t+s} \Lambda_{t,t+s} \left\{ q_{x,t+s} \left(k_{t+s} - \left(1 - \sigma \left(u_t\right)\right) k_{t-1+s}\right) - z_{t+s} \right\}$$

where $q_{x,t}$ is the value of one unit of new capital, z_t denotes the amount of final goods that is invested to generate new capital, and $\sigma\left(u_t\right)$ denotes the rate of capital depreciation, which depends on capital utilization.

Capital producers are assumed to incur adjustment costs when investing in new capital. The law of motion of capital is thus given by

$$k_t \ \ = \ \ \left[1 - \frac{\psi}{2} \left(\frac{z_t}{z_{t-1}} - 1 \right)^2 \right] z_t + \left(1 - \sigma\left(u_t\right)\right) k_{t-1} \tag{18}$$

whit ψ governing investment adjustment costs. Substituting (18) in the objective function of capital producers, the optimal level of investment is given by

$$1 \ \ = \ \ q_{x,t} \left(1 - \frac{\psi}{2} \left(\frac{z_t}{z_{t-1}} - 1 \right)^2 - \psi \left(\frac{z_t}{z_{t-1}} - 1 \right) \frac{z_t}{z_{t-1}} \right)$$

$$+ \beta \Lambda_{t,t+1} q_{x,t+1} \psi \left(\frac{z_{t+1}}{z_t} - 1 \right) \frac{z_{t+1}^2}{z_t^2} \tag{19}$$

Wholesale firms: Perfectly competitive wholesale firms use the composite labour input and capital in order to produce a homogeneous good. They purchase capital from capital producers at the real price $q_{x,t}$, and finance their capital acquisition by borrowing from domestic banks. Banks thus need to issue claims $a_{x,t}$ equal to the number of units of capital acquired k_t, pricing each claim at the price of a unit of capital. After production, wholesalers sell their capital to capital producers and pay the return $r_{x,t}$ over their loans. The homogeneous good is sold to domestic retailers at the real price $p_{x,t}$.

The production function of wholesale firms is given by

$$x_t \ \ = \ \ \xi_t^s \left(u_t k_{t-1}\right)^\alpha \left(\xi_t^u l_t\right)^{1-\alpha} \tag{20}$$

where ξ_t^s is the total factor productivity at home, ξ_t^u a drifting labour-augmenting technology common to both countries and α is the weight of capital in production. Following the discussion in Albonico et al. (2014), I allow wholesalers to vary the effective rate of capital utilization in production, u_t. However, a higher effective use of capital increases its depreciation rate, as I assume that

$\sigma'(u_t) \geq 0$. The optimal utilization rate of capital satisfies

$$p_{x,t} \alpha \frac{x_t}{u_t} = \sigma'(u_t) k_t \tag{21}$$

whereas the demand curve for composite labour services can be expressed as

$$w_t = p_{x,t}(1-\alpha)\frac{x_t}{l_t} \tag{22}$$

Perfect competition imposes zero profits and therefore the ex-post real return paid to banks is given by

$$r_{x,t-1} = \frac{p_{x,t}\alpha x_t/k_{t-1} + q_{x,t}(1-\sigma(u_t))}{q_{x,t-1}} \tag{23}$$

Retail firms: A continuum of retail firms indexed by $i \in [0,n]$ purchase the homogeneous good produced by wholesalers at the price $p_{x,t}$ and differentiate it into a continuum of domestic and foreign retail goods. Retailers follow a type of local currency pricing, so that prices vary depending on the destination market. The differentiated goods they produce are sold to final good firms at home and abroad at the price $p_{i,h,t}$ and $p_{i,h,t}^\star$, respectively. Hence, retailer i faces two demand curves

$$y_{i,h,t} = \left(\frac{p_{i,h,t}}{p_{h,t}}\right)^{-\mu_p} y_{h,t} \quad \text{and} \quad y_{i,h,t}^\star = \left(\frac{p_{i,h,t}^\star}{p_{h,t}^\star}\right)^{-\mu_p^\star} y_{h,t}^\star \tag{24}$$

from home and foreign final good producers, respectively. Retail firms are subject to Calvo price stickiness. Every period, a retailer is able to adjust prices in both markets with probability $1 - \lambda_p$. When retail firms do not reoptimize prices, they simply update them to lagged inflation in the destination market. Retail prices follow

$$p_{i,h,t+s} = \begin{cases} p_{i,h,t+s}^* & \text{with prob. } 1 - \lambda_p \\ p_{i,h,t}^* \left(\Pi_{k=1}^s \pi_{h,t+k-1}\right)^\vartheta & \text{with prob. } \lambda_p \end{cases}$$

$$\tag{25}$$

$$p_{i,h,t+s}^\star = \begin{cases} p_{i,h,t+s}^{**} & \text{with prob. } 1 - \lambda_p \\ p_{i,h,t}^{**} \left(\Pi_{k=1}^s \pi_{h,t+k-1}^\star\right)^\vartheta & \text{with prob. } \lambda_p \end{cases}$$

where indexation is governed by $\vartheta \in [0,1]$, which measures the extent to which prices fully adjust to past inflation. When allowed to adjust prices, retailer i maximizes the stream of real discounted profits, $\Pi_R(i)$, given by

$$\underset{p_{i,h,t}\, p_{i,h,t}^\star}{\text{Max}} \; E_t \sum_{s=0}^\infty (\beta\lambda_p)^s \Lambda_{t,t+s} \left\{ \left[\frac{p_{i,h,t}}{p_{t+s}} - \frac{p_{x,t+s}}{p_{t+s}}\right] y_{i,h,t+s} + \left[\frac{e_{t+s}p_{i,h,t}^\star}{p_{t+s}} - \frac{p_{x,t+s}}{p_{t+s}}\right] y_{i,h,t+s}^\star \right\}$$

subject to (24) and (25). Due to differences in consumer price inflation at home and abroad, the price of retail goods sold to foreigners needs to be adjusted by the real exchange rate e_t. The numeraire

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p_t is the consumer price index. Solving for the optimal prices retailer i quotes in the two markets yields

$$\frac{p_{i,h,t}^*}{p_{h,t}} = \frac{\mu_p}{\mu_p - 1} \frac{\mathrm{E}_t \sum_{s=0}^{\infty} (\beta\lambda_p)^s \Lambda_{t,t+s} y_{h,t+s} \frac{p_{x,t+s}}{p_{t+s}} \left(\frac{p_{h,t}}{p_{h,t+s}} \left(\Pi_{k=1}^s \pi_{h,t+k-1}\right)^{\vartheta}\right)^{-\mu_p}}{\mathrm{E}_t \sum_{s=0}^{\infty} (\beta\lambda_p)^s \Lambda_{t,t+s} y_{h,t+s} \frac{p_{h,t+s}}{p_{t+s}} \left(\frac{p_{h,t}}{p_{h,t+s}}\right)^{1-\mu_p} \left(\Pi_{k=1}^s \pi_{h,t+k-1}\right)^{\vartheta(1-\mu_p)}}$$

(26)

and

$$\frac{p_{i,h,t}^{**}}{p_{h,t}^*} = \frac{\mu_p^*}{\mu_p^* - 1} \frac{\mathrm{E}_t \sum_{s=0}^{\infty} (\beta\lambda_p)^s \Lambda_{t,t+s} y_{h,t+s}^* \frac{p_{x,t+s}}{p_{t+s}} \left(\frac{p_{h,t}^*}{p_{h,t+s}^*} \left(\Pi_{k=1}^s \pi_{h,t+k-1}^*\right)^{\vartheta}\right)^{-\mu_p^*}}{\mathrm{E}_t \sum_{s=0}^{\infty} (\beta\lambda_p)^s \Lambda_{t,t+s} y_{h,t+s}^* \frac{e_{t+s} p_{h,t+s}^*}{p_{t+s}} \left(\frac{p_{h,t}^*}{p_{h,t+s}^*}\right)^{1-\mu_p^*} \left(\Pi_{k=1}^s \pi_{h,t+k-1}^*\right)^{\vartheta(1-\mu_p^*)}}$$

(27)

Although the elasticities of substitution between retail goods consumed domestically and exported, μ and μ^*, can vary, the parameters reflecting the degree of nominal rigidity λ_p and φ are common to domestic and export inflation.

Final good producers: Perfectly competitive firms produce a non-tradeable final good by aggregating a continuum of domestic and foreign intermediate goods. The aggregation technology for the final good is given by

$$y_t = \left[(\varpi)^{\frac{1}{\gamma}} (y_{h,t})^{\frac{\gamma-1}{\gamma}} + (1-\varpi)^{\frac{1}{\gamma}} (\bar{\tau} y_{f,t})^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}}$$

(28)

where $\bar{\tau} \equiv (1-n)/n$ normalizes the amount of imported goods into *per capita* terms. In the above CES aggregator, the home-bias parameter ϖ denotes the fraction of goods produced at home that is used in the production of the final good. The elasticity of substitution between home-produced and imported intermediate goods is given by γ.

The two composite goods, $y_{h,t}$ and $y_{f,t}$, are an ensemble of domestic and foreign retail goods which are aggregated using a technology given by

$$y_{h,t} = \left(\int_0^n (y_{i,h,t})^{\frac{\mu_p-1}{\mu_p}} di\right)^{\frac{\mu_p}{\mu_p-1}} \quad \text{and} \quad y_{f,t} = \left(\int_n^1 (y_{i,f,t})^{\frac{\mu_p-1}{\mu_p}} di\right)^{\frac{\mu_p}{\mu_p-1}}$$

where μ_p denotes the elasticity of substitution between intermediate goods produced in each country. These two expressions give rise to the price indices $p_{h,t}$ and $p_{f,t}$ of the composite goods.

Final good producers maximize profits $p_t y_t - p_{h,t} y_{h,t} - p_{f,t} \bar{\tau} y_{f,t}$ each period, subject to (28).

The resulting optimal demand functions are given by

$$y_{h,t} = \varpi \left(\frac{p_{h,t}}{p_t} \right)^{-\gamma} y_t \tag{29}$$

$$y_{f,t} = (1 - \varpi) \left(\frac{p_{f,t}}{p_t} \right)^{-\gamma} \frac{n}{1-n} y_t \tag{30}$$

The consumer price index, p_t, is obtained by replacing $y_{h,t}$ and $y_{f,t}$ in (28) with the respective demand function, which implies

$$p_t = \left[\varpi \, (p_{h,t})^{1-\gamma} + (1 - \varpi) \, (p_{f,t})^{1-\gamma} \right]^{\frac{1}{1-\gamma}} \tag{31}$$

2.4 Government

The government levies lump-sum and consumption taxes, T_t and τ_t^c, and issues sovereign bonds $d_{g,t}$ to finance exogenous non-productive government consumption g_t of the domestic final good. Government debt is entirely held by domestic financial intermediaries, which are assumed to provide the government with the amount of funds it requires. Hence, in the aggregate, the number of claims held by banks must equal the total amount borrowed by the government, $a_{b,t} = d_{g,t}$.

Government expenditure is given by the following rule

$$g_t = (\bar{g})^{1-\rho_g} \, (g_{t-1})^{\rho_g} \left(\frac{gdp_t}{gdp} \right)^{\kappa_g} \varepsilon_t^g \tag{32}$$

where k_g governs the response of public expenditures to the cycle. In turn, lump-sum taxes are set according to

$$T_t = \overline{T} \left(\frac{d_{g,t-1}/gdp_{t-1}}{\tilde{d}_g} \right)^{\kappa_\tau} \tag{33}$$

where κ_τ characterises the government's preferences between tax- and debt-financed expenditures and $\tilde{d}_g$ is the target level for the stock of debt as a percentage of GDP. The tax rule embedded in (33) represents the effort the government needs to make, via taxes, to maintain public debt away from an explosive path. In order to induce a direct cost in terms of welfare derived from raising taxes, I follow the discussion in Kim and Kim (2013) and let the tax rate on consumption vary depending on the effort the government makes to control public debt. Hence, distortionary taxation is defined as

$$\tau_t^c c_t = \kappa_c T_t \tag{34}$$

where κ_c is the share of consumption taxes in the total tax revenue of the government.

I follow Chatterjee and Eyigungor (2013) and Bocola (2014), and assume that the government issues long-term securities. Each period, government bonds mature with probability λ_b, which implies an average duration of bonds of $1/\lambda_b$ periods. When bonds reach maturity, the government pays back the principal; otherwise investors receive the coupon μ_b and retain the right to obtain the principal in the future. The government's ex post budget constraint is therefore given by

$$(\lambda_b + (1 - \lambda_b) \mu_b) d_{g,t-1} + g_t = T_t + q_{b,t} (d_{g,t} - (1 - \lambda_b) d_{g,t-1}) \tag{35}$$

where $q_{b,t}$ is the price of loans to the government. Conversely, the return on government bonds is given by

$$r_{b,t-1} = \frac{\lambda_b + (1 - \lambda_b)(\mu_b + q_{b,t})}{q_{b,t-1}} \tag{36}$$

I define sovereign default in a manner similar to Schabert and Wijnbergen (2011) and Corsetti et al. (2012) by assuming that the government's decision to default depends on a *fiscal limit* above which the fiscal burden is deemed to be politically unacceptable.[10] Sovereign spreads are generated as the result of a preemptive game between the government and speculators. Agents know the distribution $f(\cdot)$ of the *fiscal limit* and form their expectations on that basis. Our modelling choice is not innocuous however. On the one hand, I abstain from a complete characterization of strategic default, which is beyond the scope of this paper, and instead assume that the *fiscal limit* is stochastically determined.[11] On the other hand, I abstract from any distributional consequences of default, including its effects on the fiscal stance. In fact, actual default is neutral, as can be deduced from expression (35), in the sense that I do not consider *de facto* asset losses in the model. Instead, the probability of default is crucial for the dynamics of sovereign bond prices and, consequently, for the net worth of banks. Hence, the model attempts to provide a consistent characterization of asset dynamics, but is mute with regards to the decision of actually declaring default and its consequences.[12]

Every period the *fiscal limit*, or the politically bearable maximum level of the tax burden or of the public debt, is drawn from $f(s_t)$. The probability of default is equal to the probability the fiscal stance exceeds the *fiscal limit*. Let $\Delta(s_t)$ be a default indicator equalling 1 when the fiscal stance goes beyond the *fiscal limit*, and zero otherwise. As shown in Schabert and Wijnbergen (2011) and Bonam and Lukkezen (2013), I can approximate the expectation over the probability of

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[10]Davig and Leeper (2010) introduced the notion of "fiscal limit" used here.

[11]Corsetti et al. (2012) provide some motivation for this assumption by appealing to political considerations surrounding the decision to declare default. A previous note already made useful references to the literature on strategic default.

[12]Gertler and Karadi (2011), Dedola et al. (2013) and Lama and Rabanal (2014), just to name a few recent works, explore the effects of capital shocks that affect the *actual* quantity of assets in general equilibrium models with banks. The crucial difference between shocks to the *stock* of capital and shocks to its *price* lies on the real effects of reducing effective capital in production.

default by

$$\hat{\delta}_t \;\; = \;\; \left(\Theta/\overline{\delta}\right)\hat{s}_t + \varepsilon_t^d \tag{37}$$

where $\hat{}$ denotes first-order log-linear approximations, s_t is the fiscal stance, ε_t^d is an exogenous shock that captures the market's perception regarding the possibility of a sovereign default and $\overline{s}$ is pinned down in the steady state. The parameters Θ denotes the elasticity of the probability of default with respect to changes in the fiscal stance, that is $\partial \Delta\left(s_t\right)/\partial s_t$. I intentionally left the fiscal stance s_t undefined in (37) for there are various potential candidates for the most adequate measure. The expressions *fiscal stance* and *fiscal outlook*, which I use interchangeably in this paper, refer not only to the present fiscal conditions (as measured by the public deficit, the tax burden or the share of government expenditures to GDP, to name a few), but also, and probably more importantly, to the future sustainability of current fiscal policy (as measured, for instance, by the ratio of public debt to GDP). I have experimented with the ratio of public debt to GDP, as in Schabert and Wijnbergen (2011), and with a measure of the fiscal strain, as in Corsetti et al. (2012). Both produce similar outcomes and here I show the results for $s_t = d_{g,t}/gdp_t$.

2.5   Central Bank

The single central bank in the monetary union is assumed to follow a Taylor-type rule where the nominal interest rate responds to the aggregate consumer price index and to the area-wide real GDP growth according to

$$i_t^\star \;\; = \;\; \left(\overline{i}^\star\right)^{1-\rho_i}\left(i_{t-1}^\star\right)^{\rho_i}\left(\left(\frac{\tilde{\pi}_t}{\bar{\pi}}\right)^{\rho_\pi}\left(\frac{\tilde{gdp}_t}{\tilde{gdp}_{t-1}}\right)^{\rho_g}\right)^{1-\rho_i}\varepsilon_t^i \tag{38}$$

where $\rho_i \in (0,1)$ is the smoothing parameter, ρ_π and ρ_g are the usual response coefficients. The nominal interest rate is given by the Fisher equation

$$r_t^\star \;\; = \;\; \frac{i_t^\star}{\pi_{t+1}^\star}$$

I have assumed the foreign nominal interest rate to be the policy instrument given the small size of the home country I consider in the next sections. The aggregate variables in the Taylor rule are denoted with a $\sim$ and are the sum of the respective country variables weighted by their population size.

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2.6 Market Clearing

There are two types of markets for goods in each country that must clear in equilibrium. For intermediate goods, production by the wholesaler firms equals demand by retailers

$$x_t \;=\; \Upsilon_{h,t} y_{h,t} + \Upsilon_{h,t}^\star y_{h,t}^\star \tag{39}$$

Note that, due to price dispersion, retailers incur real losses during price setting. On the other hand, the non-tradeable domestic final good is sold to households, the government and to capital producers

$$y_t \;=\; c_t + z_t + g_t \tag{40}$$

From the aggregate budget constraint of households I obtain the following law of motion for net foreign assets

$$e_t \left(r_{f,t-1} b_{f,t-1} - b_{f,t} \right) \;=\; e_t p_{h,t}^\star y_{h,t}^\star - p_{f,t} \frac{1-n}{n} y_{f,t} \tag{41}$$

where $y_{h,t}^\star$ are exports of the home-produced intermediate composite good and $y_{f,t}$ are imports of the foreign-produced intermediate goods.

Because financial markets are incomplete, I follow Schmitt-Grohé and Uribe (2003) and ensure the model is stationary by setting $r_{f,t}$ equal to the real interest rate abroad plus a risk premium that is sensitive to the total net foreign asset position as a percentage of GDP

$$r_{f,t} \;=\; r_t^\star \Xi exp \left\{ \Gamma \left(e_t \frac{b_{f,t}}{gdp_t} - \tilde{b}_f \right) \right\} \tag{42}$$

and where GDP is defined as

$$gdp_t \;=\; p_{h,t} y_{h,t} + e_t p_{h,t}^\star y_{h,t} \tag{43}$$

3   Bayesian Estimation

In this section I estimate the model for Portugal and the Eurozone. Portugal is an illustrative example of a country that has been subject to considerable shocks to its sovereign interest rates. In the spring of 2011, Portugal became the third EMU member to request external finance assistance, after Greece and Ireland. At the time, the Portuguese government was facing a sharp increase in the costs to finance public debt, while Portuguese banks, heavily dependent on external financing, were being cut-off from market-based funding. When the assistance programme was signed in April, the 10-year yield of Portuguese government bonds were rapidly approaching the 10% mark, public debt to GDP was around 110%, and the fiscal deficit had reached 11.2% the previous year. With the program, Portugal received €78 billion, or about 43% of GDP, under the conditionality of

implementing measures towards fiscal consolidation and pursuing structural reforms.[13]

I estimate the model using standard Bayesian techniques. First, the equilibrium conditions are log-linearised around a deterministic, zero-inflation steady state. As I explain in more detail, I reduce the number of parameters to estimate by calibrating some that are weakly identified by data. For the remaining parameters, I specify the priors for estimation based on previous studies. I then employ the Metropolis-Hastings algorithm with two chains of 125.000 draws to obtain the posterior distributions.[14]

3.1 Calibrated Parameters

The parameters I calibrate can be arranged into four different groups. The first group includes those usually calibrated in the literature and for which I pick consensual values. The second group contains the parameters related to the banking sector, which are not estimated because of the lack of long and reliable data series I could use to identify them. Regarding these two sets of parameters, I further impose their values to be equal across countries. The parameters that pin down steady state ratios constitute the third group and their values are chosen to match long-run averages in the data. Finally, the parameters at the core of the policy analysis in section 4 form the forth group.

Table 1 reports the values for the calibrated parameters. Hereafter, the home country represents Portugal, the Euro Area is the foreign country, and one period in the model corresponds to one quarter. The values for the first set of parameters are mostly taken from Lama and Rabanal (2014). The exception is the elasticity of capital depreciation with respect to utilization, for which I use the estimate obtained by Albonico et al. (2014). The values for the parameters related to the banking sector are taken from Gertler and Karadi (2011). Lama and Rabanal (2014) and Bocola (2013) estimate some of these parameters and obtain very close estimates to the values used here. On the other hand, the spread on the sovereign interest rate is only meant to be illustrative and therefore I assume a relatively small value, below the one used by Schabert and Wijnbergen (2011) and more in line with what the data from before 2009 suggests.

Regarding the third group, I set the share of the population living in Portugal to 3% of the total of the Eurozone; the ratio of *per capita* GDP between the EMU and Portugal to 1.7; and the share of imports to GDP in Portugal, which corresponds to $1 - \omega$ in the model, to 30%. Plugging these figures into the steady state version of the demand equations for final goods in both countries and using the aggregate resource constrain, I obtain an extremely high degree of home bias in the Euro Area ($\omega^\star = 0.995$). Hence, while Portugal is relatively sensitive to shocks pertaining to the currency area, the Eurozone is almost immune to shocks originating in Portugal. Although the degree of openness of the Eurozone is undoubtedly higher than the one implied by my calibration,

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[13]Figures and further discussion about the Portuguese adjustment program can be found in a report by the European Commission of 2014.

[14]The non-linear equilibrium conditions of the model where coded in Dynare 4.4.2, with the model's solution, estimation and welfare analysis being performed using Dynare's interface. Estimation was performed under a first-order log-linear approximation, whereas the welfare analysis was done on a second-order log-linear approximation to the model's equilibrium conditions.

I nevertheless decided to stick to these values to guarantee the consistency of the estimates for Portugal.[15]

For the policy parameters, I decided to be rather conservative and followed the standard calibration used in the literature. The ratio of public debt to annual GDP is set equal to the upper limit imposed by the Maastricht Treaty of 60%, which is close to the sample average for Portugal when I exclude the last half decade. I assume a standard $AR(1)$ process for government expenditures and set $\kappa_g = 0$. For the share of consumption taxes in the total taxation, I set κ_c equal to 40% based on Eurostat (2014). I then obtain a steady state effective tax rate of $\tau_{ss}^c = 16.58\%$, which is slightly below the estimates computed in Eurostat (2014), but in line with the estimate used by Kim and Kim (2013).

3.2 Data and Priors

I use a sample of 14 quarterly time series - 7 for each region - spanning between the first quarter of 1995 and the last quarter of 2014. I use nominal GDP, household consumption, investment, government expenditures, compensation of employees, the consumer price index and a nominal interest rate I define shortly. National accounts data for Portugal is taken from the Eurostat, whereas for the Euro Area I use the ECB Area Wide Model. Because Portugal accounts for just 3% of the currency area, it seems unlikely that using aggregate data for the entire Eurozone, including Portugal, constitutes a significant source of estimation bias. I obtain consumer prices from the ECB (I use the HICP indices). I use the 10-year government bond yield from the Eurostat for Portugal[16] and choose the Euribor 3-month series from the ECB for the Euro Area. All variables are already seasonally adjusted from the source except for consumer prices, which are adjusted using the X-13ARIMA procedure developed by the US Census Bureau.

To be consistent with the model, I convert the national account aggregates into *per capita* quantities using quarterly population series from the Eurostat. The same is done for wages, which I obtain dividing compensation of employees by the number of employees, also from the Eurostat. The reason behind using nominal variables relates to model consistency as well. Given that all aggregates have the same deflator in the model, I ensure the resource constraints in each region are met by using the consumer price index to convert all nominal quantities into real variables. Lastly, I take logs and

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[15]Some notes are in order. First, the value for $\omega^\star$ is perfectly consistent with the way I model the monetary union: Portugal represents indeed a very small share of Eurozone trade. Second, the mismatch of $\omega^\star$ with the data has two sources. On the one hand, I do not model countries outside the EMU, despite the large share they represent in terms of trade flows with the Eurozone. On the other hand, aggregate trade data for the Eurozone includes exports and imports within member states, magnifying the final values of net-exports. Third, because I use aggregate data for the Eurozone, parameter estimates need to be analysed with caution. There are a number of studies running Bayesian estimation for the Eurozone and using the same data set, which allows me to compare and evaluate the results I obtain here. On the contrary, given that previous estimates for Portugal are rare, I decided to use a calibration that is as consistent as possible with Portuguese time series in order to minimize the chances of obtaining blurred estimates. Fourth, as I discuss later, I add measurement errors to the net exports of both countries to minimize the potential bias caused by the calibration and study the robustness of the estimates I obtain.

[16]Accordingly, I set $\lambda_b = 0.025$, which implies an average maturity of government bonds of 40 quarters, and calibrate the value of the coupon, μ_b, such that in the steady state the price of government bonds equals the price of loans to firms, $\overline{q_b} = \overline{q_x}$.

first differences of real quantities and wages in order to render them stationary. With one exception though: Portuguese government expenditures remain non-stationary after these transformations. I therefore use the share of government expenditure to GDP and implement the corresponding changes in the model. Regarding the nominal variables, I obtain consumer price inflation by taking logs and first differences of the price level series and divide the nominal interest rates by 400 to convert them to quarterly series. I use nominal interest rates in levels because they are stationary both in the data and in the model. Finally, all variables are demeaned before estimation.

Due to the inclusion of a world technology shock with a unit root, real quantities and wages are also non-stationary in the model. Consequently, I divide these variables by the level of world technology and match actual variables to their model counterpart by noting that $\Delta y_t^o = \Delta \tilde{y}_t + \varepsilon_t^u$, where Δy_t^o corresponds to the first-difference of the log of observable real variables, $\Delta \tilde{y}_t$ is the growth of its counterpart in the model ($\tilde{y}_t$ denotes the detrended log-deviations from the steady state), and ε_t^u the innovation to the stochastic trend in logs. In total, I match the following 14 variables: Δgdp_t, Δgdp_t^*, Δc_t, Δc_t^*, Δz_t, Δz_t^*, Δg_t, Δg_t^*, Δw_t, Δw_t^*, π_t, π_t^*, $i_{b,t}$, and i_t^*.

I define the prior distributions based on the literature preforming Bayesian estimation of DSGE models of the Euro Area. In particular, I focus on studies that use the same dataset for the Eurozone as the one used here. Given that the literature on Portugal is comparatively less proficuous, I decided to have prior distributions for Portuguese parameters identical to their Euro Area counterparts. Nevertheless, due to the significantly higher volatility of Portuguese time-series, I let the priors for the standard deviations to be generally more diffuse than in previous studies. Prior distributions are shown in Table 2 to Table 4.

I use the gamma distribution for parameters assumed to be positive. Priors for the habit parameters and for the labour disutility coefficient are taken from Lama and Rabanal (2014). I let investment adjustment costs to vary across regions and set its prior mean to 2. For parameters bounded between 0 and 1, I use the beta distribution. I use the same prior distribution for price and wage lotteries as Smets and Wouters (2002). They set the prior mean to 0.75, which implies average contract durations of one year. For the price indexation coefficient, I set prior means of 0.20, which is in line with the estimates found in previous studies. The prior for the inflation coefficient in the Taylor rule follows a normal distribution centred at 1.7 as in Smets and Wouters (2002), while the prior mean for the coefficient on output growth is set at 0.20, which is within the range of values typically used. I proceed in the same way and set the prior means of the smoothing coefficient in the Taylor rule and the persistence of shocks to 0.75, which lies between the 0.5 and 0.85 found in the literature. The prior distributions for the standard deviations of the shocks are again based on Lama and Rabanal (2014), although relatively more diffuse for the reason mentioned above. The prior mean for the standard deviations of intratemporal preference shocks is significantly higher than for the remaining shocks, which is also the case in Smets and Wouters (2002). Also worth noting that technology and cost-push shocks are assumed to be less volatile than investment specific shocks, but more volatile than intertemporal preference shocks.

3.3 Estimation Results

Table 2 and Table 3 show the posterior means and the 90% credible set of the estimated parameters.[17] The baseline estimates can be found under *spec.* 1. Looking first at the estimates for the Eurozone, the posterior mean for the habit persistence and the labour disutility parameters are identical to those found by Smets and Wouters (2002). Regarding nominal rigidities, I find that price contracts are, on average, shorter than wage contracts. The mean estimates are very close to those in Lama and Rabanal (2014), with prices adjusting every 3 quarters on average while wages take 5 quarters. In general, the estimates for Portugal differ by little from their Euro Area counterparts. Among the exceptions is ψ, found to be significantly higher, and the survival rates of nominal contracts, with prices adjusting more slowly than wages. The estimates for price indexation are small for both regions and around 10%, which is in line with what Lama and Rabanal (2014) obtain. Finally, our estimates for the area-wide Taylor rule are also very similar to those in the literature.

Regarding the shock processes, I estimate intertemporal preference shocks to be more persistent compared to intratemporal (or labour supply) shocks, a result also obtained by Adolfson et al. (2007) and Lama and Rabanal (2014). On the contrary, the persistence coefficients of stationary technology, investment specific technology, and cost-push shocks are relatively lower than what is found in the literature. Government expenditure shocks both in Portugal and in the Eurozone appear to be quite persistent and very similar to the values estimated by Smets and Wouters (2002), while the coefficient on the risk premium is in line with Adolfson et al. (2007). The estimates for the standard deviations reported in Table 4 are generally in line with our prior expectations. Comparing both regions, Portuguese shocks are systematically more volatile than Euro Area ones, and this is particularly visible for investment specific technology and cost-push shocks.

While I only model trade between the two regions, Eurozone countries have multiple trading partners and, inclusively, trade with regions outside the monetary union. Hence, the aggregate resource constraint in the model is inconsistent with actual national accounts for it excludes exports and imports vis-à-vis regions outside the model. This is particularly troublesome given that Portugal accounts for only a slim fraction of total net exports originating in the Euro Area. In order to account for trade other than between the two regions, I added measurement errors to the net exports in the model. I compare this methodological choice to the approach taken by Lama and Rabanal (2014), who estimate the model without measurement error and without including government expenditures in the set of observables. The results, reported under *spec.* 2, show virtually no changes in parameter estimates except for a smaller persistence of Portuguese government expenditures and a higher volatility of Portuguese and Euro Area government expenditure shocks. It thus seems that government expenditures are not only capturing actual shocks to public spending, but also residual volatility coming from trade outside the model. I also explore the impact of misspecification when I include government expenditures to the set of observables without adding measurement error to net exports. Not only the parameter estimates deliver very different results, as can be seen under

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[17]The estimation results shown here were obtained holding capital utilization and consumption taxes fixed and equal to their steady state values. Further work is being undertaken to allow these features to vary during estimation.

spec. 3, I also find a striking mismatch between the volatility of the observable time series implied by the model and actual figures.

Turning to the second moments, the first two columns of Table 5 report the standard deviations the data and those implied by the model evaluated at the posterior mean under to the baseline estimation. The match is satisfactory for most variables, with two exceptions. On the one hand, Eurozone GDP is predicted to be more volatile, a result that is also obtained by Lama and Rabanal (2014). On the other hand, the model delivers a smaller standard deviation of Portuguese wages despite the high estimated volatility of labour supply shocks. Note also that, although in the data the volatility of Portuguese GDP is only slightly smaller than the volatility of consumption, the model delivers the inverse ordering, with GDP predicted to be more volatile.

Table 5 also presents the unconditional variance decomposition of the variables I use for estimation. I have aggregated some shocks in order to make the presentation neat.[18] Similarly to Lama and Rabanal (2014), the international transmission of shocks appears negligible for most variables, apart from Portuguese inflation and the sovereign interest rate. Regarding the former, this finding indicates that shocks in the Eurozone feed mostly through prices and do not have a significant direct impact in real quantities. On the other hand, as sovereign spreads are exogenous in the baseline scenario, the sovereign rate is mostly explained by spread shocks themselves and by foreign shocks which feed through the common Taylor rule. Interestingly, sovereign spread shocks have negligible effects in the real economy, a result that does not seem to have been influenced by the events taking place in the very last part of the sample. In line with Ratto et al. (2008), I also find that monetary policy shocks explain only a small fraction of the volatility of Euro Area variables. All in all, and similarly to previous studies, preference and technology shocks represent the main source of fluctuations in both regions.

4   Sovereign Spreads and Fiscal Transfers

In this section, I start by analysing the transmission mechanism of sovereign spread shocks in the model and by assessing its conformity with actual events during the sovereign debt crisis in Portugal. In the context of asymmetric shocks within a currency area, as have been sovereign risk shocks in the Eurozone, fiscal policy becomes a crucial tool to stabilize the economy. I show, however, that sovereign risk and the fiscal outlook of a country constrains the set of actions of the government. I then run a number of policy experiments exploring the possibility of a new fiscal architecture within the EMU. In particular, I analyse the potential benefits of implementing a fiscal transfers scheme (FTS) among Eurozone member-states. Although still exotic, fiscal federalism has been subject of previous academic research. Importantly, however, it now appears to be a matter of serious consideration within policy circles as well.

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[18]Preference shocks include both inter- and intratemporal shocks, whereas technology shocks include the stationary and the unit root technology shocks. The two measurement errors are also shown together. Moreover, for each variable the table reports the decomposition with respect to local shocks. For instance, Portuguese variables are decomposed across different shocks originating in Portugal. All the remaining shocks are aggregated under the banner *Abroad*.

4.1 Inspecting the Mechanism

Figure 1 presents the impulse responses of selected variables to a shock that raises the sovereign spread by 10% in annual terms, as seen in Portugal during 2011. The increase in uncertainty regarding the ability of the government to service its debt lowers the value of government securities and, therefore, raises the return on government bonds required by investors. As interest payments become heavier, the government incurs a budget deficit and the stock of public debt increases. Under the baseline specification, government expenditures do not respond to the cycle[19], whereas lump-sum taxes track the ratio of public debt to GDP. As such, taxes are automatically raised and the government is induced to run a primary surplus. Comparing to the actual deficit of 7.4% for Portugal in 2011, the jump in the budget deficit predicted by the model seems small. Note however that between 2010 and 2013, taxes and social contributions fell by more than 2%, while unemployment benefits, pensions, and other financial liabilities all increased (European Commission, 2014). Therefore, the baseline scenario serves as a lower bound in what respects the deteriorating effects of sovereign spread shocks on the fiscal stance.

As the price of government bonds plunges, bankers, who hold these securities in their portfolios, see their total net worth contract. This triggers a jump in the leverage ratios of banks that persists over time. In terms of magnitudes and recovery time, the model compares well with reality. Using the loan-to-deposits ratio as a measure of leverage, the figure for Portuguese banks at the beginning of 2011 was equal to 157%. It took 15 quarters to reach 117%, a fall of about 25% and similar to Figure 1. Banks' equity also went through a slow recovery, with the average Core Tier 1 adjusting from 8.1% to 12% over the same period.[20] Because of the leverage constraint, banks are forced to reduce lending and to increase the premium on loans to private firms in order to build up the value of their equity. In terms of the pass-through of sovereign spreads to firm's borrowing costs, an increase of 10% in the former leads to a 3.5% increase in the latter.

The drop in credit supplied by banks and the increase in borrowing costs induce a collapse in investment (of more than 10% at the trough). As firms face higher costs of capital, labour demand also contracts and total employment falls. Consequently, real output falls, dropping more than 2% at the trough. The marked contraction in domestic demand due to the fall in investment induces prices to fall. However, given the small size of Portugal relative to the EMU, the nominal interest rate is cut by less than 10 basis points. Clearly, monetary policy is not designed to address country-specific shocks, with the negligible policy loosening doing nearly nothing to buffer the recession in Portugal.

Figure 1 also shows that higher ratios of public debt intensify the magnitude of the recession. In fact, doubling of the stock of public debt leads to a fall in GDP more than twofold. When domestic banks hold a larger stock of government securities in their balance sheets, a fall in the price of sovereign bonds generates a relatively higher loss in their portfolio. As a consequence, the premium between the risk free rate and the interest rate on loans to private firms can reach more

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[19]As a matter of fact, government expenditures as a share of GDP are constant. As GDP falls, total government expenditures will fall as well.

[20]Figures taken from European Commission (2014).

than 3/4 of the spread originally generated on the sovereign rate. This number represents quite a substantial pass-through. When public debt reaches 120% of GDP, the collapse in investment and the drop in labour demand are sizeable too. Actual figures for Portugal were not any less impressive: from 2011 to 2013, investment fell nearly 30%, while the unemployment rate went from 12.2% to 17.3%.

4.2   Constraints on Domestic Fiscal Policy

During the sovereign debt crisis, there was no room for counter-cyclical policy. European governments were forced to run sharp fiscal consolidation to avoid rampant sovereign interest rates, despite the economic outlook remaining weak. In this respect, the model provides informative insights on how sovereign interest rates and the fiscal outlook constrain the set of fiscal responses. Figure 2 shows the determinacy regions of the model for a range of parameter values governing fiscal policy, given the ratio of public debt to annual GDP and the elasticity of sovereign spreads to the fiscal outlook. In the figure, the values for κ_τ are within the range used in the literature (e.g. see Pappa, 2009); $\kappa_g < 0$ corresponds to the government running counter-cyclical policy; and regarding Θ, the elasticity of sovereign spreads to the fiscal stance, I consider the range of values computed by Corsetti et al. (2012). The white areas in the figure correspond to regions in the parameter space for which public debt grows unbounded.

As shown in the left panel, as Θ increases, taxes need to react more swiftly to changes in public debt in order to keep it away from an explosive path. Since higher spreads imply higher deficits, and deficits lead to widening spreads, the government needs to raise taxes rapidly to avoid further increases in sovereign interest rates.

The government can either raises taxes or lower public expenditure in order to control public debt. The last panel to the right shows the trade-off between how government expenditure can respond to the cycle and how taxes are used to control public debt. Firstly, counter-cyclical policy is only possible when taxes are sufficiently firm in targeting public debt. On the other hand, pro-cyclical public spending is not enough, *per se*, to stabilize public debt either. In fact, the two fiscal tools work through different channels. While taxes reduce public debt directly, public spending affects GDP via a demand effect.[21] Consequently, spending alone might fail to bring sustainability to the ratio of public debt to GDP.

Both grey areas in Figure 2 represent the determinacy regions of the model when the ratio of public debt to annual GDP equals 60%. When this ratio equals 120%, determinacy only occurs within the dark grey areas. As all panels attest, a higher stock of public debt requires fiscal discipline to be stricter. Importantly, the scope for counter-cyclical government expenditures is reduced dramatically, as shown in the central panel. In particular, when Θ increases, the feedback effects of counter-cyclical expenditure on sovereign spreads dwarf any attempts to stimulate production via public spending. In effect, in these cases, counter-cyclical spending raises the ratio of public debt to

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[21]In the case of taxes, the effects on GDP are of second order and depend of households' consumption smoothing.

GDP unambiguously, therefore failing to keep it on a sustainable path.

Clearly, the ratio of public debt to annual GDP is key to determine the range of sustainable fiscal policies that can be implemented by the government. As low debt countries are better placed to use domestic fiscal policy as a tool to absorb idiosyncratic shocks, it is not surprising the emphasis put on public debt and budget deficit figures since the early stages of the EMU. Nevertheless, the question remains: how should the EMU respond when countries experiencing fiscal strain cannot use domestic fiscal policy to countervail the recessionary effects of large asymmetric shocks?[22]

4.3 A Scheme of Fiscal Transfers: Symmetric Regions

In this section I use the estimated model to assess the welfare implications of a federal transfers scheme (FTS) that has both countries operating transfers across the border when sovereign spreads widen. Transfers from foreign to home are determined by the following simple rule

$$S_t = \kappa_s \left(\log \left(\delta_t \right) - \log \left(\overline{\delta} \right) \right) \tag{44}$$

An equivalent expression defines the transfers to be made the opposite way.[23] Importantly, the parameter governing the magnitude of the transfers, κ_s, is equal for both countries. As all variables in the model, including S_t and $S_t^\star$, are defined in *per capita* units, an equal κ_s implies an equal *per capita* burden for home and foreign households. Transfers are collected by the government and are made between governments.[24] Hence, the expressions for the government budget in both countries and for the net foreign assets have to be adjusted accordingly. The FTS proposed here addresses directly the problem of fiscal strain due to sovereign spreads. As there is no direct transfers to households or firms, the feedback to the real economy will be through taxation and public spending. Importantly, the FTS will also feed-back to the real economy through its potential effects on the pass-through of sovereign spread shocks.

To contextualize my results, I start by considering a model where both regions have symmetric governments and are both subject to sovereign spread shocks. Crucially, I consider the case when both regions have equal sizes and *per capita* GDP. In Table 6, the parameter values used for the region labelled Periphery correspond to those estimated for Portugal, whereas the estimates for

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[22]The model presented in the previous section, although providing an accurate illustration of how fiscal policy can run into indeterminacy, it is not especially gifted to analyse optimal government spending. On the one hand, government spending is not productive nor utility enhancing in the model. On the other hand, automatic stabilizers, such as unemployment benefits, are absent. That is partly the reason why pro-cyclical public expenditure might be welfare improving for some parametrization in Figure 4. Integrating these elements in the model is left for future research.

[23]By definition, transfers are only temporary, being equal to zero in the long-run.

[24]In this paper I assume δ_t is observable and, therefore, can be used to guide policy. In reality, however, sovereign spread shocks might be difficult to measure. Importantly, it might also be the case that optimal transfers do not respond to all swings in sovereign spreads as measured, for instance, by the differentials in government bond yields in the secondary market. It is also not clear that targeting a more *fundamental* measure, such as public debt to annual GDP, solves the problem. I leave these questions for future research.

the Eurozone are used for the region labelled Core. The FTS is defined by the value of κ_s that maximizes the aggregate welfare of the monetary union, that is, the sum of each region's welfare weighted by its population size. I follow Schmitt-Grohé and Uribe (2007) and express welfare gains in terms of certainty-equivalent consumption. First, I compute each country's welfare for a given set of allocations $\left\{c_t^k, l_t^k\right\}_{t=0}^{\infty}$, where k corresponds to a particular value of $\tau_s \in \mathbb{R}_0^+$. I then compare it to the case of no fiscal transfers, defining the welfare gain $\tilde{\lambda}$ as

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t u\left(\left(1+\tilde{\lambda}\right) c_t^0, l_t^0\right) \;\; = \;\; \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t^k, l_t^k\right) \tag{45}$$

For positive values of $\tilde{\lambda}$, there are gains from implementing the FTS. Welfare is computed up to a second order of approximation from the unconditional expected lifetime utility.

Table 6 reports the welfare gains from both regions engaging in the FTS. In the first column I report the baseline case where the two regions differ only in terms of the estimated parameters. The results show that the FTS is welfare improving for each region individually. This is an important finding because it states clearly the mutual benefits of both members entering the FTS. Interestingly, the Core is the region benefiting the most, with a 4% increase in permanent consumption. The difference in welfare gains between the two regions is largely explained by the difference in the set of estimated parameters.[25]

However, the distribution of welfare gains and their magnitude can vary easily depending on small asymmetries between the two regions, and in particular when the fiscal outlooks differ. For example, the second column shows that when public debt to GDP is twice as big in the Periphery as it is in the Core, welfare gains fall for the former, whereas they increase for the latter. Note that, up to the value of κ_s, the transfers are identical to the baseline scenario given that they only depend upon the sovereign spread shocks. Moreover, using the same $\kappa_s = 7.27$ as in the baseline, the Core still benefits more from entering the FTS with a Periphery with higher debt. Inspecting the reasons behind these results, I find that transfers do not do enough to counteract the magnifying effects of public debt on real fluctuations in the Periphery, whereas the additional gains to the Core stem from the feedback effects on the real exchange rate, as seen in Figure 1.

The third column reports the case when sovereign spreads respond to the fiscal outlook in the Periphery. For a given κ_s, setting $\Theta \neq 0$ increases the persistence of sovereign spread shocks. As a result, transfers between countries become asymmetric, with those incoming to the Periphery being more prolonged in time than those incoming to the Core. This, together with the fact that spread shocks have a greater impact on real activity when $\Theta \neq 0$, explain the substantial welfare gains of the FTS to the Periphery. On the contrary, the gains for the Core disappear, clearly driven by the disproportionate costs of outgoing transfers to the Periphery relative to the benefits of incoming transfers. If I assume instead that $\Theta^\star = \Theta$, the FTS becomes again welfare improving for both

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[25] The other factors behind the discrepancy between welfare gains are the risk premium on the interest rate on foreign bonds charged to home households and the asymmetry caused by the fact that the policy rate is the foreign nominal rate.

regions (results not shown in the table).

The next two columns inspect the consequences of fiscal policy in the Periphery. When taxes respond less to public debt, fiscal deficits and public debt fluctuate more. Hence, after a sovereign spread shock, as banks accommodate the increase in government debt, which in turn becomes less valuable, the pass-through is magnified. As transfers stabilize public debt, the welfare gains from the FTS for the Periphery increase. On the contrary, counter-cyclical government expenditures narrow the benefits in both regions. In the Periphery, the impact of incoming transfers in stimulating output is marginal when the government is already carrying counter-cyclical policy (even when considering their positive impact in stabilizing debt). On the other hand, the losses caused by outgoing transfers due to the FTS are further magnified by fiscal policy.[26]

Finally, the last column in Table 6 investigates the case when the volatility of sovereign spreads in the Core is reduced to 95% of that seen in the Periphery. The welfare effects are strikingly clear: the Core has no advantage in joining the FTS, whereas the Periphery has additional gains. The results are not surprising; but the fact that a relatively small drop in the volatility of spread shocks produces such an antagonistic result is symptomatic of the challenges posed to the implementation of a FTS between different regions. The discussion that follows is dominated by this difficulty in supporting a FTS that causes welfare losses for some of its participants.

4.4 A Scheme of Fiscal Transfers: Asymmetric Regions

Aggregate welfare is a good measure to assess the potential benefits of international fiscal transfers. However, it might be politically (and socially) impracticable to convince one country to participate in a FTS that reduces its own welfare. Therefore, rather than searching for the FTS that maximizes aggregate welfare, it is advisable to look at the welfare effects for each country individually. In this light, it turns out that modelling two countries with different sizes constitutes a challenge. In a nutshell, when the two countries differ in size, equal *per capita* transfers imply necessarily an asymmetric aggregate flow of transfers between countries. The greater is the discrepancy in relative sizes, the more (less) impact fiscal transfers have for welfare in the small (big) country.

To clarify the importance of relative sizes, I use again the model with symmetric regions Core and Periphery and run the following exercise: First, I consider only FTS for which the value of κ_s maximizes aggregate welfare. I then compute the minimum relative size of the Periphery, n, for which entering the FTS has no negative effects to the Core. Figure 3 illustrates this exercise. The minimum value I obtain is $n = 48.72\%$, which plainly shows how easy the support for a FTS can break down due to asymmetries between countries. As transfers are calculated in *per capita* terms, their aggregate levels change one-to-one with n. Although the *per capita* burden of engaging in a FTS with a smaller country diminish with n, the *per capita* benefits vanish more rapidly.

Conversely, one important aspect conveyed in the previous exercise concerns the potentially large gains small countries can secure from entering a FTS. In fact, if I were interested more broadly

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[26]Note that public spending in our model is not utility enhancing, as discussed in a previous note.

in FTS that generate a positive gain in aggregate welfare, despite reducing welfare in one region in particular, the minimum value of n sustaining a positive κ_s would be substantially lower. I therefore return to the model I have estimated and conduct another experiment. Suppose that to implement a FTS, all countries have to benefit from welfare gains derived from being part of a monetary union with fiscal transfers. That is, suppose first that entering the monetary union implies a gain of $\tilde{\alpha}$ in terms of lifetime consumption to all its members. A FTS can then be implemented as long as its welfare costs are smaller than $\tilde{\alpha}$. In other words, the alternative is not between implementing a FTS or not, but rather between a monetary union with a FTS and leaving the union altogether.

Welfare costs and benefits from entering a monetary union have been studied in the literature and I take a passive stance here by simply adopting existing estimates. On the negative side, the costs associated with entering a monetary union relate to the lack of synchronization between individual countries' business cycles. Among others, the costs arise from asymmetric shock to technology and fiscal policy, home bias in consumption, and incomplete financial markets. However, a growing literature is quantifying the extent to which trade and financial integration can off-set these losses. For instance, Lama and Rabanal (2014) show that a fall in trade costs, which they consider to be of a conservative magnitude, is responsible for a 1.2% increase in permanent consumption. However, if they include the business cycle costs of the common currency, they obtain a welfare loss. Auray et al. (2010) study the welfare effects of an increase in trade flows between member countries of around 10%. They show that trade integration can account for an increase of more than 7% in permanent consumption in an economy with incomplete financial markets, and that the benefits from trade could reach more than 10% of lifetime consumption if financial markets are complete. Also focusing on the level of financial markets integration, Lama and Rabanal (2014) run a rough experiment and assume that the EMU induces a sharp reduction in the volatility of private risk premium due an increase banks' risk pooling. Under this scenario, they calculate the welfare gains from entering the union to be higher than 2% of permanent consumption.

For the purpose of my experiment, I focus on two scenarios for which entering a monetary union brings welfare benefits to its members due to gains from trade. The more conservative scenario assumes a 1% increase in lifetime consumption, whereas the second scenario has a more optimistic conjecture of a 5% increase in permanent consumption. I make two more assumptions. First, I conjecture that welfare gains are identical across all member countries. Second, I suppose that the gains from trade are proportional to the size of each country entering the union. With these two assumptions, a country of size n is responsible for a permanent consumption increase of $(n/(1-n)) \times \tilde{\alpha}$ to all the remaining member countries of the union.

Table 7 shows the welfare effects of the FTS under the two scenarios. Under the assumption of a 1% gain derived from trade integration, Portugal could secure a 1.44% increase in lifetime consumption from the implementation of the FTS. In the optimistic scenario, the gain jumps to 7.8%. Table 7 also reports an approximation to the potential benefits bigger countries could secure from the FTS. Using the estimated parameters for Portugal, I recalibrate the size n of the home country and the ratio of *per capita* GDP to match Spain and Italy. This is a simple conjecture

since the parameter estimates are likely to differ across countries. Notwithstanding this caveat, the results show that for a fraction of the benefits derived from trade integration, welfare gains for the Periphery of the EMU are large.

The experiments reported in Table 7 serve to illustrate the magnitude of welfare changes involved with the implementation of the FTS. In particular, it shows that the smaller the recipient country is, the higher the potential gains it can obtain. In fact, even if the benefits from trade integration linked to the inclusion of a small country in the union were smaller than the conservative scenario, the positive impact on its welfare would still be substantial. The scheme has its limitations however. For instance, big countries like Germany, which represents less than 48% of the union, but significantly more than the 18% of Italy, would be unable to secure gains of the same magnitude as those reported in the table. Germany falls in a *grey area*: it is too big to benefit from sizeable welfare gains at the expense of the rest of the union, and too small to engage in a FTS that improves welfare everywhere as seen in Table 5.

As shown in Table 7, the welfare benefits for Portugal change modestly regardless of its domestic fiscal stance and policy. In Table 8, the value of κ_s is computed such that the Eurozone loses $(n/(1-n)) \times 1\%$ in permanent consumption. Clearly, the small size of Portugal explains the negligible variations in the values of κ_s. Notwithstanding that Tables 6 and 8 were built under different assumption, both sets of results are coherent. For instance, when $\Theta \neq 0$, κ_s falls so that the welfare losses for the Eurozone remain constant. On the other hand, welfare benefits are maximized when Portuguese fiscal policy is less strict, with taxes responding more weakly to public debt.

I have focused on the substantial welfare gains a federal transfer mechanism can generate. However, it is important to acknowledge that the implementation of the FTS requires some countries to forego a fraction of the initial gains obtained from entering the EMU. That is, the political support for the implementation of a transfers arrangement can not, by any means, be taken for granted. Yet, important considerations linked to spillover effects of sovereign spread shocks are, at least partially, absent from the model. In reality, the destabilizing effects of the European sovereign debt crisis were also felt in the Core of the EMU, where contagion was addressed seriously. For instance, in the model banks do not engage in international intermediation. As such, considerations regarding the systemic risk one country's banking sector poses to area-wide stability are mute. Dedola et al. (2013) show that country specific shocks affecting the domestic banking sector are transmitted to foreign banks when there is financial integration, thus requiring policy coordination to buffer shocks efficiently. Clearly, these channels have direct implications for the welfare of current net losers from the FTS. Including such considerations in the cost-benefit analysis of the FTS could induce wider support for a transfer scheme in these countries.

On the other hand, the push for the implementation of a Fiscal Union in Europe is faced with concerns over the risk of moral hazard and free riding.[27] Some steps to mitigate these fears have been alluded to in the 5 Presidents Report (Juncker et al., 2015), where the authors defend three

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[27] Although most times not made explicit, these concerns are nonetheless evident in, for instance, Juncker et al. (2015).

important prerequisites for the implementation of the Fiscal Union: (i) the economic convergence of the member states, which will increase the synchronization of business cycles, (ii) the enactment of fiscal rules that guarantee the sustainability of domestic fiscal accounts, which as a by-product will enable domestic fiscal policy to react to asymmetric shocks, and (iii) the guarantee that the interventions under the FTS have only a temporary nature.

Regarding the first point, as member states' business cycles become more synchronized, the lower are the costs of a single monetary policy with fixed exchange rates (see, for instance, Rose 2008). As such, and as discussed above, the higher the benefits from being part of the union, the easier it will be to grant support for the implementation of a FTS. Considering point (ii), I have rationalized how domestic fiscal policy is endogenously constrained by the fiscal outlook and how fiscal conditions can compromise the leeway needed for domestic policy to buffer spread shocks. One important dimension that remains to be addressed concerns how domestic policy should be conducted in an environment with transfers. As I have shown, the political support for a FTS between countries rests on how asymmetric fiscal conditions are. It is beyond the scope of this paper to draw on potential conditionalities involved with a FTS to enforce fiscal prudence. The model can, nevertheless, provide an accurate benchmark to think about the design of a Fiscal Union, and certainly is a good starting point for further research.[28] Finally, the FTS proposed in this paper satisfies point (iii) by construction.

4.5 Dynamics and Fiscal Policy

In this section, I compare the effects of domestic counter-cyclical policy, on the one hand, and of international fiscal transfers, on the other, to the transmission of sovereign spread shocks. I construct Figure 4 in the following way: I begin by assuming that Portugal and the Eurozone engage in a FTS defined by $\kappa_s = 0.05$. Secondly, I calculate the magnitude of the pass-through of sovereign shocks to the private risk premium under the FTS. I then compute the value of κ_g that, in the absence of the FTS, results in having an equal pass-through as the one calculated in the second step. In other words, I match the effects of sovereign spread shocks on the borrowing costs of private firms between the two policies.

As Figure 4 shows, both policies reduce the pass-through of sovereign spread shocks to private spreads. Although the fall in the price of government bonds is equal regardless of having any policy in place, the net worth of banks falls less in the presence of counter-cyclical policy and the

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[28]Two aspects are particularly relevant. One the one hand, time inconsistent behaviour can severely affect the implementation of inter-governmental transfers. This can be due to the impossibility to enforce structural reforms and fiscal prudence on a sovereign nation facing fiscal stress. If reforms and/or consolidation are not properly executed, the need for foreign transfers might persist, the positive spillovers from improving the fiscal stance might not materialize and the distribution of welfare gains from the FTS can skew easily. The same is true with respect to the *donating* country, which might be better-off not making a transfer when its fellow union member requires. On the other hand, but still related, alternative transfer rules to (44) might altogether improve the potential to implement a FTS. For instance, a mechanism that encompasses *automatic* reforms as well as transfers has the potential to maximize the positive externalities of risk-sharing at the same time as reducing the risks of moral hazard and free riding. These aspects, although extremely relevant, are left for future research.

FTS. This effect is due to the stimulus in aggregate demand generated by both policies, which feeds into an increasing demand for capital from private firms. Despite the fact that banks increase the risk premium in order to rebuild their net worth, the stimulus moderates the fall in the demand for credit and allows banks to reduce the pass-through. Consequently, the fall in investment is lessened as well as is the recession, which at the trough becomes nearly 1% milder.

Interestingly, the response of GDP differs between the two policies. Under counter-cyclical government expenditures the trough is more pronounced but the recovery is faster. With the FTS, the fall in GDP and its eventual recovery are more gradual. The same applies to employment, with the recovery under the FTS taking even longer than what would otherwise happen without any policy at place.

Clearly, the two policies are not equivalent. With counter-cyclical policy, the deficit grows further and stays higher for longer. With the FTS, the magnitude of the initial jump is very similar to the baseline scenario, as is its evolution towards the steady state. The similar dynamics of the deficit under the FTS and the baseline are due to the fact that, as GDP contracts less under the FTS, the increase in taxes needed to control public debt is also smaller. In effect, fiscal transfers substitute, at least partially, the need for domestic taxation.

In terms of aggregate demand, the FTS generates an indirect stimulus through the need for less taxation, whereas with counter-cyclical policy there is a reshuffle in domestic demand, with government expenditure leading the stimulus. Instead of crowding out other domestic sources of aggregate demand, the FTS appears to be a more efficient stimulus measure. One indicator supporting this claim is inflation, which reacts considerably less compared to the other two scenarios. This is due to the impact of fiscal transfers on the real exchange rate, which mitigates the need for a domestic devaluation and reduces the inefficiencies caused by price changes.

The differences in the operating mechanisms of counter-cyclical policy and the FTS are made patently clear when I make sovereign spreads elastic to the fiscal outlook. In Figure 5 I take the same values for κ_s and κ_g as before, but assume instead that $\Theta = 0.05$, that is, that sovereign spreads react to the ratio of public debt to GDP. In this scenario, sovereign spread shocks vanish relatively slower. Considering counter-cyclical policy, the spread banks charge to firms actually increases when compared to the baseline. Yet, employment and GDP still perform better when compared to the no policy scenario, with the demand effect lead by the government supporting real activity despite the negative impact on banks. The key for this apparently counter-intuitive result lies in the behaviour of asset prices. The price of government bonds falls more abruptly when the government runs an expansion, causing the net-worth of banks to contract more than in the absence of policy. The evolution in the price of government bonds explains why banks are unable to reduce the pass-through of sovereign spreads to the private sector. As before, the FTS outperforms domestic counter-cyclical policy and, most importantly, does not cause the perverse effects on the supply of credit to the economy.

Figure 4 presents, at least partially, the trade off of domestic counter-cyclical policy. For some parametrization of the model, counter-cyclical policy can be welfare improving, insofar as it

supports economic activity, reduces inflation and the miss-allocation of resources. However, the elasticity of sovereign spreads can invert these results and potentially cause a deeper recession. There are, however, important features missing in the model. On the one hand, public expenditures have no productive nor utility enhancing use. On the other hand, taxation is modelled in a very reduced form. A study of optimal domestic public policy in an environment with sovereign spreads and international transfers has to address these aspects. It is left for future research.

5   Conclusion

The recent sovereign debt crisis in Europe has tested the resilience of the most ambitious supra-national endeavour seen in the old continent. The viability of the common currency, and of European integration itself, has been openly threatened. The central question has concerned the type and extent of the response the monetary union should give to asymmetric shocks to its member countries. Related to this is yet the question of what level of solidarity can be reasonably expected between members. The answers so far have been in the direction of more integration and discipline, with the Banking Union and the Fiscal Compact being just some examples. Looking ahead, however, the completion of a fully fledged monetary union requires some form of fiscal arrangement at the federal level as well. After all, it was the inability of domestic fiscal policy to tackle sovereign spread shocks in the countries most affected by the crisis that sparked the severe tensions seen within the EMU.

In this paper, I set up and estimate a model capable of providing a consistent narrative of the crisis. The model features financial frictions due to leverage constraints on banks which link the availability of credit to productive firms to the value of bank's net worth. Domestic banks are also the suppliers of credit to the government, therefore being exposed to sovereign credit risk. I illustrate the mechanisms at work during a sovereign spread shock and compare its dynamic effects to the case of Portugal in 2011. I show that the ratio of public debt to GDP and the elasticity of sovereign spreads to the fiscal outlook can substantially magnify the pass-through of sovereign spreads to private borrowers. I also show that counter-cyclical policy is not feasible when sovereign spreads react sharply to a deterioration in public finances and the debt burden is at the levels seen in the periphery of the Eurozone during the crisis.

I contribute to the debate about a future fiscal capacity at the EMU level. I propose a simple fiscal transfer scheme between member countries triggered when sovereign spreads widen. The scheme acts at the root of the transmission mechanism of spread shocks by alleviating the fiscal strain on the government. At the same time, it provides a stimulus to real activity and reduces the impact of sovereign spreads on private lending rates. The fiscal arrangement I propose improves welfare when countries have symmetric structures, and in particular when the relative size of their economies and the profile of their fiscal stances is almost identical. However, asymmetries across countries induce welfare losses for some members. As a result, the proposed transfers scheme can easily lose political support for its implementation. Nevertheless, I demonstrate through a simple exercise that the welfare gains for a small country, like those at the core of the recent crisis, can

be large. Importantly, I show that these gains can be sustained through a scheme under which the costs for the remaining members of the union is significantly smaller than the benefits they secure by sharing the common currency.

This paper provides a realistic set up where asymmetric shocks to a currency union are addressed via a supra-national scheme of fiscal transfers. It shows the large potential gains derived from a simple, reduced form scheme and highlights the fragilities regarding its implementation. Further research needs to investigate the mechanisms by which these fragilities can be reduced. Namely it should explore the spillover consequences of localized asymmetric shocks and understand the role of policy coordination and enforceability at the national level.

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Tables and Figures

Table 1: Calibrated parameters

Parameter		Value
Discount factor	β	0.99
Elasticity of substitution Home and Foreign goods	γ	1.00
Capital share on production	α	0.36
Steady state depreciation rate	$\overline{\sigma}$	0.025
Elasticity of capital utilization	$\imath$	1.71
Elasticity of substitution across types of goods	μ_p	11
Elasticity of substitution across types of labour	μ_w	6
Private firms' risk premium	$\overline{r}_x - \overline{r}_h$	0.01
Steady state leverage ratio	$\overline{\phi}$	4
Fraction of divertable assets	ι	0.35
Start-up funds of new banks	ϵ	0.0038
Banker survival probability	λ_f	0.975
Steady state sovereign spread	$\overline{\underline{\delta}}$	0.002
Home's population share	n	0.03
Foreign to Home per capita GDP	$\overline{gdp}^{\star}/\overline{gdp}$	1.7
Degree of home bias in Home	ω	0.7
Degree of home bias in Foreign	$\omega^{\star}$	0.9945
Steady state Government Expenditure to GDP	$\tilde{g}$	0.2
Steady state labour supply	$\overline{l}$	0.33
Weight on labour disutility	ζ	18.86
Steady state Government Debt to GDP	$\tilde{d}_g$	0.6
Sovereign spread elasticity	Θ	0
Fiscal response to public debt	κ_τ	0.15
Government Expenditure response to GDP	κ_g	0
Fiscal transfer scheme	κ_s	0
Share of consumption taxes in revenue	κ_c	0.4

Table 2: Estimation: model parameters

parameter		pdf	prior mean	s.d.	spec. 1	posterior spec. 2	spec. 3
Habit persistence	ϱ	gamma	0.50	0.10	0.51	0.52	0.76
					(0.39 , 0.63)	(0.40 , 0.63)	(0.69 , 0.84)
Habit persistence	$\varrho^\star$	gamma	0.50	0.10	0.54	0.55	0.86
					(0.39 , 0.67)	(0.40 , 0.70)	(0.80 , 0.91)
Inv. elast. of labour supply	φ	gamma	1.00	0.25	0.82	0.81	0.80
					(0.46 , 1.15)	(0.47 , 1.16)	(0.46 , 1.11)
Inv. elast. of labour supply	$\varphi^\star$	gamma	1.00	0.25	1.02	0.99	1.39
					(0.64 , 1.42)	(0.60 , 1.38)	(0.96 , 1.81)
Investment adjust. costs	ψ	gamma	2.00	1.00	3.45	3.20	4.59
					(2.11 , 4.79)	(1.89 , 4.56)	(3.22 , 5.92)
Investment adjust. costs	$\psi^\star$	gamma	2.00	1.00	2.57	2.57	10.64
					(1.11 , 4.05)	(1.14 , 3.92)	(7.51 , 13.68)
Price stickiness	λ_p	beta	0.75	0.05	0.78	0.78	0.76
					(0.73 , 0.83)	(0.73 , 0.83)	(0.70 , 0.83)
Price stickiness	$\lambda_{p^\star}$	beta	0.75	0.05	0.71	0.71	0.81
					(0.63 , 0.79)	(0.63 , 0.78)	(0.78 , 0.85)
Indexation to past inflation	ϑ	beta	0.20	0.10	0.10	0.10	0.08
					(0.02 , 0.18)	(0.02 , 0.17)	(0.01 , 0.15)
Indexation to past inflation	$\vartheta^\star$	beta	0.20	0.10	0.12	0.12	0.02
					(0.02 , 0.21)	(0.02 , 0.20)	(0.01 , 0.03)
Wage stickiness	λ_w	beta	0.75	0.05	0.69	0.69	0.75
					(0.63 , 0.75)	(0.64 , 0.78)	(0.69 , 0.78)
Wage stickiness	$\lambda_{w^\star}$	beta	0.75	0.05	0.82	0.81	0.54
					(0.76 , 0.89)	(0.76 , 0.87)	(0.49 , 0.60)
Interest rate smoothing	ρ_i	beta	0.75	0.10	0.83	0.83	0.95
					(0.80 , 0.86)	(0.80 , 0.86)	(0.94 , 0.96)
Taylor rule inflation	ρ_π	normal	1.70	0.20	1.69	1.69	1.69
					(1.44 , 1.93)	(1.44 , 1.92)	(1.40 , 1.98)
Taylor rule GDP growth	ρ_y	normal	0.20	0.10	0.52	0.51	0.22
					(0.40 , 0.64)	(0.39 , 0.63)	(0.06 , 0.38)
Cost of foreign position	Γ	inv. gamma	0.001	0.005	0.0008	0.0008	0.0008
					(0.0002 , 0.001)	(0.0003 , 0.001)	(0.0003 , 0.001)

Parameters with $\star$ are for the Euro Area, the remaining are for Portugal. Note that there is a common Taylor rule for both regions. The table reports the posterior mean estimates and the 90% credible set.

Table 3: Estimation: persistence parameters

parameter		pdf	prior mean	s.d.	posterior spec. 1	posterior spec. 2	posterior spec. 3
Intratemporal preferences	ρ_l	beta	0.75	0.10	0.34	0.34	0.39
					(0.23 , 0.47)	(0.22 , 0.46)	(0.26 , 0.53)
Intratemporal preferences	$\rho_{l\star}$	beta	0.75	0.10	0.66	0.68	0.95
					(0.49 , 0.83)	(0.54 , 0.82)	(0.89 , 0.99)
Intertemporal preferences	ρ_c	beta	0.75	0.10	0.89	0.89	0.90
					(0.83 , 0.96)	(0.83 , 0.96)	(0.82 , 0.98)
Intertemporal preferences	$\rho_{c\star}$	beta	0.75	0.10	0.85	0.85	0.54
					(0.79 , 0.93)	(0.77 , 0.93)	(0.37 , 0.70)
Stationary technology	ρ_s	beta	0.75	0.10	0.73	0.72	0.97
					(0.56 , 0.90)	(0.56 , 0.90)	(0.96 , 0.99)
Stationary technology	$\rho_{s\star}$	beta	0.75	0.10	0.66	0.67	0.82
					(0.46 , 0.86)	(0.47 , 0.86)	(0.73 , 0.91)
Investment technology	ρ_z	beta	0.75	0.10	0.44	0.44	0.74
					(0.30 , 0.59)	(0.29 , 0.58)	(0.65 , 0.84)
Investment technology	$\rho_{z\star}$	beta	0.75	0.10	0.64	0.64	0.75
					(0.53 , 0.75)	(0.54 , 0.74)	(0.62 , 0.89)
Cost-push	ρ_{λ_p}	beta	0.75	0.10	0.72	0.72	0.74
					(0.57 , 0.87)	(0.58 , 0.86)	(0.58 , 0.90)
Cost-push	$\rho_{\lambda_{p\star}}$	beta	0.75	0.10	0.69	0.69	0.72
					(0.50 , 0.87)	(0.52 , 0.87)	(0.57 , 0.89)
Government expenditure	ρ_g	beta	0.75	0.10	0.94	0.79	0.94
					(0.91 , 0.97)	(0.70 , 0.87)	(0.91 , 0.98)
Government expenditure	$\rho_{g\star}$	beta	0.75	0.10	0.94	0.92	0.90
					(0.90 , 0.98)	(0.88 , 0.96)	(0.85 , 0.95)
Sovereign risk premium	ρ_δ	beta	0.75	0.10	0.92	0.92	0.93
					(0.89 , 0.96)	(0.89 , 0.96)	(0.90 , 0.97)
Measurement error (h)	ρ_e	beta	0.75	0.10	0.84	-	-
					(0.77 , 0.90)		
Measurement error (f)	$\rho_{e\star}$	beta	0.75	0.10	0.90	-	-
					(0.86 , 0.95)		

Parameters with $\star$ are for the Euro Area, the remaining are for Portugal. Note that there is a common Taylor rule for both regions. The table reports the posterior mean estimates and the 90% credible set.

Table 4: Estimation: standard deviations

parameter		pdf	prior mean	s.d.	posterior spec. 1	posterior spec. 2	posterior spec. 3
Intratemporal preferences	σ_l	gamma	0.200	0.150	0.470 (0.248 , 0.677)	0.465 (0.258 , 0.667)	0.676 (0.382 , 0.962)
Intratemporal preferences	$\sigma_{l^\star}$	gamma	0.200	0.150	0.304 (0.066 , 0.714)	0.242 (0.081 , 0.420)	0.048 (0.033 , 0.066)
Intertemporal preferences	σ_c	gamma	0.010	0.0075	0.022 (0.016 , 0.027)	0.022 (0.016 , 0.028)	0.051 (0.037 , 0.065)
Intertemporal preferences	$\sigma_{c^\star}$	gamma	0.010	0.0075	0.013 (0.009 , 0.017)	0.013 (0.009 , 0.018)	0.035 (0.023 , 0.047)
Stationary technology	σ_s	gamma	0.020	0.015	0.020 (0.001 , 0.039)	0.020 (0.001 , 0.039)	0.064 (0.043 , 0.086)
Stationary technology	$\sigma_{s^\star}$	gamma	0.020	0.015	0.010 (0.001 , 0.017)	0.009 (0.002 , 0.016)	0.172 (0.128 , 0.215)
Investment technology	σ_z	gamma	0.050	0.045	0.146 (0.093 , 0.200)	0.134 (0.082 , 0.187)	0.127 (0.094 , 0.160)
Investment technology	$\sigma_{z^\star}$	gamma	0.050	0.045	0.041 (0.025 , 0.059)	0.041 (0.025 , 0.057)	0.059 (0.025 , 0.094)
Cost-push	σ_{λ_p}	gamma	0.020	0.015	0.052 (0.012 , 0.085)	0.052 (0.015 , 0.085)	0.015 (0.001 , 0.029)
Cost-push	$\sigma_{\lambda_{p^\star}}$	gamma	0.020	0.015	0.008 (0.001 , 0.016)	0.007 (0.001 , 0.014)	0.013 (0.001 , 0.025)
Government expenditure	σ_g	gamma	0.010	0.0075	0.013 (0.011 , 0.014)	0.053 (0.046 , 0.059)	0.013 (0.011 , 0.015)
Government expenditure	$\sigma_{g^\star}$	gamma	0.010	0.0075	0.008 (0.007 , 0.010)	0.023 (0.020 , 0.026)	0.024 (0.020 , 0.027)
Monetary shock	σ_i	gamma	0.001	0.0005	0.001 (0.001 , 0.001)	0.001 (0.001 , 0.001)	0.002 (0.002 , 0.003)
Sovereign risk premium	σ_δ	gamma	0.020	0.010	0.016 (0.014 , 0.019)	0.017 (0.014 , 0.019)	0.016 (0.014 , 0.018)
Trend technology	σ_u	gamma	0.020	0.010	0.008 (0.006 , 0.011)	0.008 (0.006 , 0.010)	0.02 (0.015 , 0.025)
Measurement error (h)	σ_e	gamma	0.005	0.0015	0.008 (0.007 , 0.009)	-	-
Measurement error (f)	$\sigma_{e^\star}$	gamma	0.005	0.0015	0.004 (0.003 , 0.005)	-	-
marginal likelihood (Laplace)					3678.76	3214.72	2817.20
marginal likelihood (Harmonic mean)					3681.30	3216.74	2819.07
average acceptance rate					0.29	0.32	0.34

Parameters with $\star$ are for the Euro Area, the remaining are for Portugal. Note that there is a common Taylor rule for both regions. The table reports the posterior mean estimates and the 90% credible set.

Table 5: Variance Decomposition

	data	model	Pref.	Tech.	Inv.	Gov.	C.P.	Mon.	Def.	Abroad	M.E.
Δgdp	1.03	1.16	19.2	17.2	45.1	2.2	1.4	9.7	1.0	3.5	0.7
$\Delta gdp^\star$	0.68	1.05	6.5	35.4	38.1	2.0	7.1	10.5	0.0	0.0	0.6
Δc	1.14	1.09	84.2	9.0	0.7	0.1	0.2	2.4	0.0	3.3	0.0
$\Delta c^\star$	0.55	0.60	45.9	27.8	15.7	1.2	2.2	7.0	0.0	0.0	0.2
Δz	4.44	4.03	2.4	3.1	83.8	0.0	1.1	4.1	2.1	3.2	0.0
$\Delta z^\star$	2.31	2.81	2.6	22.5	62.8	0.1	5.6	6.5	0.0	0.0	0.0
Δg	1.24	1.01	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
$\Delta g^\star$	0.84	0.76	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
Δw	1.37	0.68	72.2	21.3	1.3	0.0	3.1	0.2	0.0	1.9	0.0
$\Delta w^\star$	0.29	0.37	15.5	51.4	12.2	0.2	17.8	2.8	0.0	0.0	0.1
$\Delta \pi$	0.44	0.40	18.6	24.5	5.1	0.2	3.6	13.9	0.2	33.8	0.1
$\Delta \pi^\star$	0.29	0.34	9.7	20.8	35.3	0.7	16.8	16.4	0.0	0.0	0.2
i_b	0.60	0.58	0.0	4.4	0.0	0.0	0.0	1.5	60.6	33.3	0.1
$i^\star$	0.43	0.36	8.9	12.6	70.6	1.4	1.9	4.3	0.0	0.1	0.3

Standard deviations are in percent. Standard deviations implied by the model and the uncon-
ditional variance decomposition are performed at the posterior mean estimates of the model's
parameters. Shocks are aggregated as explained in the main text.

Table 6: Two Equal-sized Regions

| d_g	0.6	1.2	0.6	0.6	0.6	0.6
Θ	0	0	0.01	0	0	0
κ_t	0.2	0.2	0.2	0.15	0.2	0.2
κ_g	0	0	0	0	-0.05	0
$\sigma_\delta^\star$	σ_δ	σ_δ	σ_δ	σ_δ	σ_δ	$0.95 \times \sigma_\delta$
	welfare gains (% CE consumption)					
κ_s	7.27	7.88	8.99	7.58	4.04	7.27
Core	4.08	4.50	0.00	4.08	1.49	-3.95
Periphery	0.72	0.49	5.76	0.88	0.33	8.91

The table reports unconditional welfare gains measured as % of certainty equi-
valent consumption. The values of κ_s reported correspond to the maximizers
of aggregated welfare, assuming $n = 0.5$ and $gdp^\star/gdp = 1$. Unless otherwise
stated, $d_g^\star = 0.6$, $\Theta^\star = 0$, $\kappa_t^\star = 0.2$, $\kappa_g^\star = 0$.

Table 7: One Small Open Country in a Wider Monetary Union

|			
n	3%	12%	18%
$gdp^{\star}/gdp$	1.7	1.2	1
d_g	0.6	0.6	0.6
Θ	0	0	0
κ_t	0.2	0.2	0.2
κ_g	0	0	0
welfare gains (% CE consumption)			
trade gains of 1% CE consumption			
κ_s	0.006	0.018	0.023
Eurozone	-0.03	-0.14	-0.22
Periphery	1.44	1.05	0.86
trade gains of 5% CE consumption			
κ_s	0.032	0.091	0.115
Eurozone	-0.15	-0.68	-1.09
Periphery	7.80	5.38	4.44

The table reports unconditional welfare gains measured as % of certainty equivalent consumption. The values of κ_s are such that the welfare losses of the Eurozone are no bigger that the trade gains corresponding to the Periphery entering the union (assuming trade gains are equal across all union members).

Table 8: The Case of Portugal

n	3%	3%	3%	3%	3%
$gdp^{\star}/gdp$	1.7	1.7	1.7	1.7	1.7
d_g	0.6	1.2	0.6	0.6	0.6
Θ	0	0	0.01	0	0
κ_t	0.2	0.2	0.2	0.1	0.2
κ_g	0	0	0	0	-0.05
welfare gains (% CE consumption)					
κ_s	0.0064	0.0064	0.0060	0.0064	0.0064
Eurozone	-0.031	-0.031	-0.031	-0.031	-0.031
Portugal	1.515	1.521	1.521	1.535	1.575

The table reports unconditional welfare gains measured as % of certainty equivalent consumption. The values of κ_s are such that the welfare losses of the Eurozone are no bigger that the trade gains corresponding to Portugal entering the union.

Figure 1: Responses to a Sovereign Spread Shock
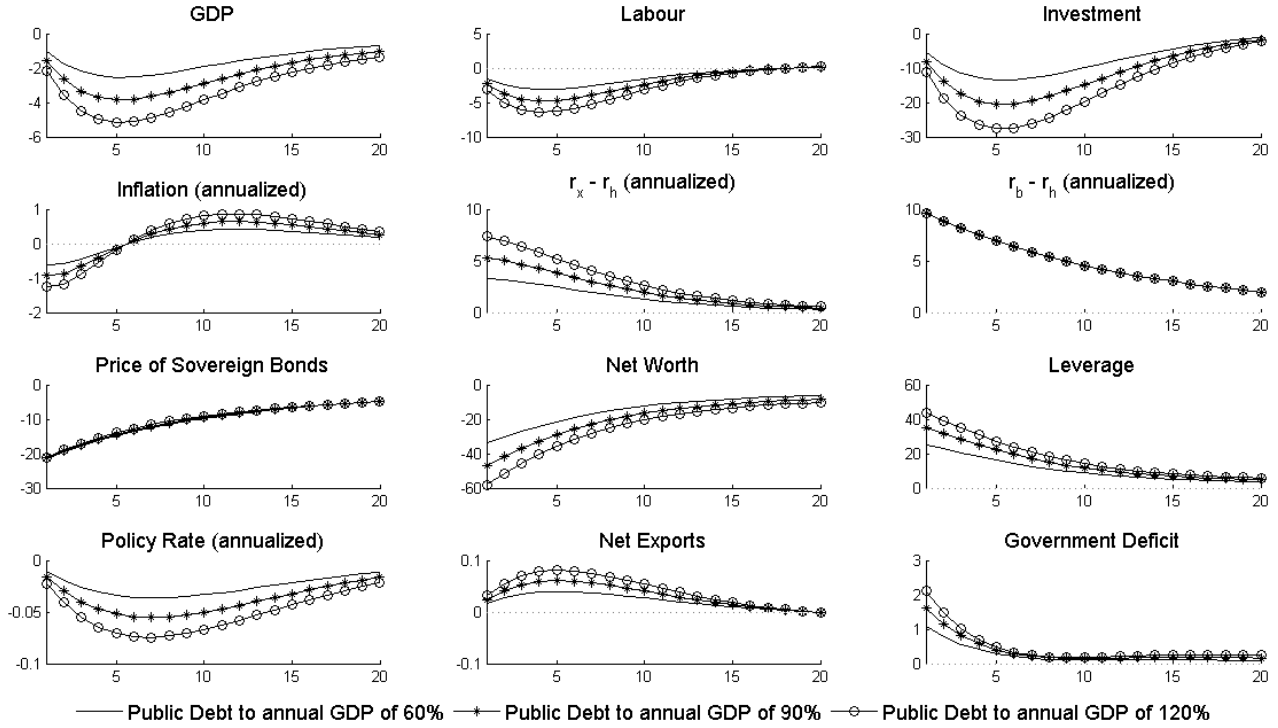
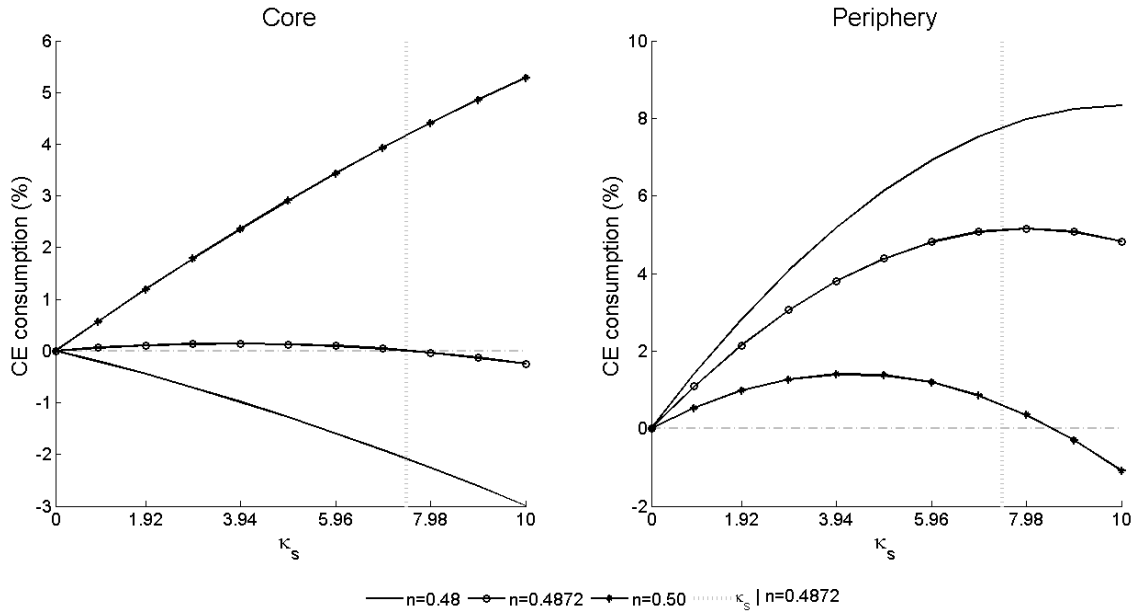
Impulse responses are expressed in terms of percent deviations from the steady state, except for the governmnet deficit and net exports, which are expressed in levels. Default values of $\kappa_t = 0.15$, $\kappa_g = 0$ and $\Theta = 0$.

Figure 2: Determinacy Regions
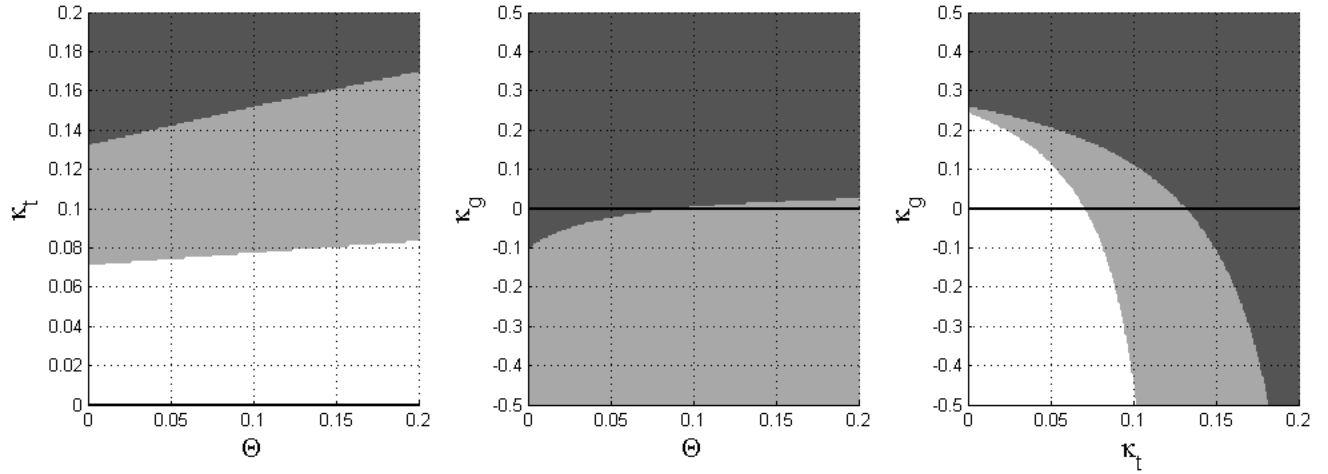
κ_t: elasticity of taxes to government debt to GDP, κ_g: responce of government expenditures to GDP and Θ: elasticity of sovereign spread to the fiscal outlook. Grey areas represent determinacy regions. Both areas represent determinacy when government debt to annual GDP equals 60%. For government debt to annual GDP of 120%, determinacy only occurs within the dark grey areas. Default values of $\kappa_t = 0.15$, $\kappa_g = 0$ and $\Theta = 0$.

Figure 3: Welfare in a (almost) Symmetric World*

*Estimated parameters and standard deviations differ across regions. Besides assuming $gdp^\star/gdp = 1$, the Core is assumed to have a government sector identical to the Periphery, including sovereign spread shocks.

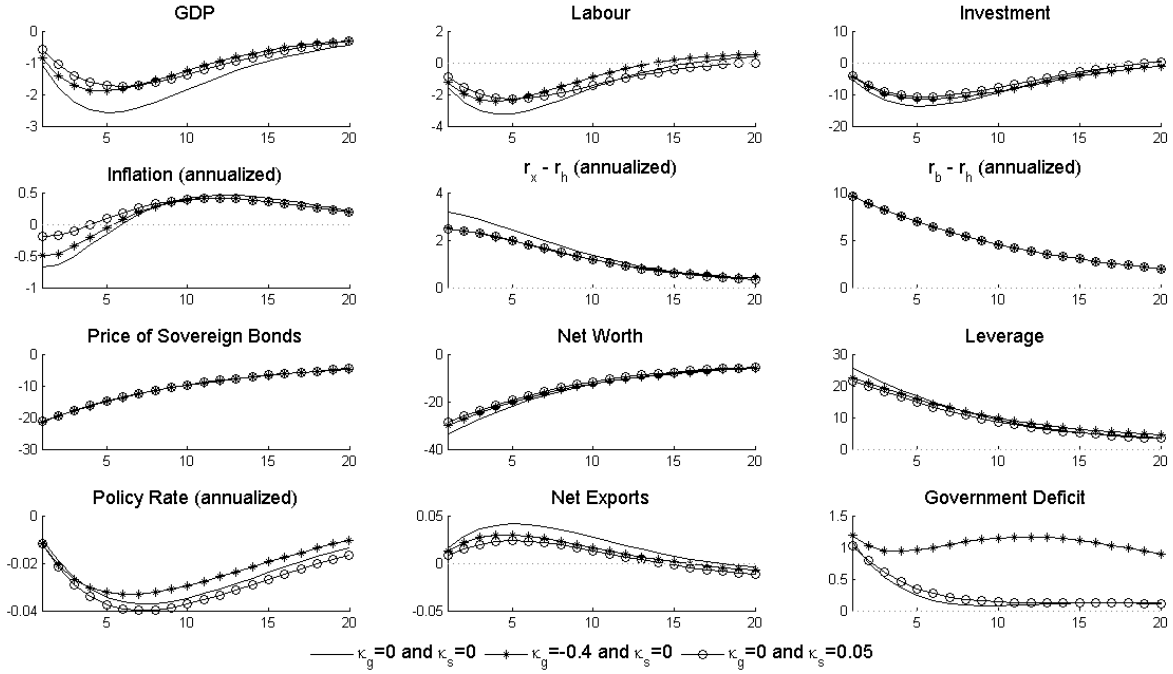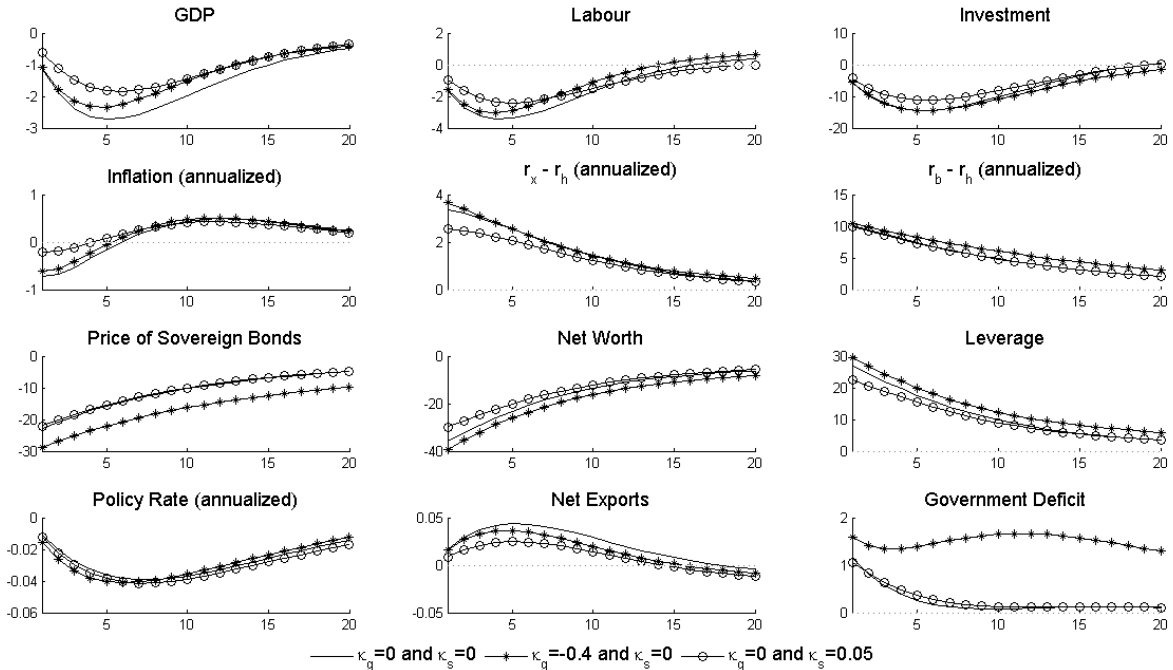Figure 4: Dynamic Impact of Fiscal Policy ($\Theta = 0$)

Figure 5: Dynamic Impact of Fiscal Policy ($\Theta = 0.05$)

Impulse responses are expressed in terms of percent deviations from the steady state, except for the governmnet deficit, which is expressed in levels. Default values of $\kappa_t = 0.2$ and public debt to annual GDP of 60%.