Is the sovereign risk channel effective under fiscal retrenchments? Evidence from the eurozone periphery

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Abstract
Sovereign and private sector default probabilities are introduced in a labor search monetary model to evaluate whether the consideration of a sovereign risk channel can affect the sign and size of output and unemployment fiscal multipliers, an hypothesis recently appeared in the literature. The model is estimated using data of EZ peripheral countries and simulated conditional to different policy measures. We show that i) in the short term, the risk channel can operate in a pro-cyclical direction, amplifying the contractionary effects of fiscal retrenchments; ii) the relation between government and credit interest rate spreads is weak, such that the risk channel is quantitatively ineffective, irrespective of the direction of change in the sovereign default probability.

Key Words: default risk, interest rates, fiscal policy, monetary policy, Bayesian estimation.

JEL Classification: E52, E62, E63, C11

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The authors are grateful to Efrem Castelnovo, Jordi Gali, Salvatore Nistico, Alessandro Piergallini, Morten O. Ravn, Kenneth D. West for useful comments. All errors our own.
Introduction

In the aftermath of the global financial crisis, a number of economies experienced unprecedented increases in sovereign debt. Such an evolution, which is still ongoing, has been particularly worrying in the periphery of the euro-zone (EZ), where markets questioned the sustainability of debt with increased borrowing costs, i.e. rising bond rates. Concerns about the risks of contagion (Guerrieri et al., 2012) led governments and European institutions to set-up coordinated fiscal consolidation measures targeted to gain confidence in solvency and control over strained public budgets².

The effectiveness of these fiscal arrangements, partly backed by the hypothesis of expansionary fiscal contractions (Giavazzi and Pagano, 1996; Alesina and Ardagna, 2010) receives a large interest in current macroeconomic research, even if it misses a widespread scientific consensus (Romer and Romer, 2010; Guajardo et al., 2014; Ramey, 2011).

The sovereign risk channel hypothesis, apparently consistent with the quite strong unconditional correlation between government bond and private sector spreads observed during the crisis (Harjes, 2011; Corsetti et al., 2013), has recently provided further support to the idea of expansionary austerity. The economic argument is that a front loaded fiscal retrenchment, by reducing the level of debt, can lead to a reduction in the sovereign default risk and thus in bond and lending rates to the private sector. The improved credit conditions stimulate a recovery, eventually reversing the negative effects of the fiscal contraction.

Figure 1 provides sample information about the key relations characterizing the risk channel hypothesis, i.e. the relation between sovereign debt and the 10 years government bond interest rate spread (mirroring the sovereign default probability), and that between the latter and the private sector lending rate spread.

Fig. 1. Risk channel hypothesis: sovereign debt and interest rate spreads - 1999q1-2014q3

Notes: The scatter plots in the left graph consider the relation between the sovereign debt to GDP ratio and the 10 years government debt interest rate spread, evaluated with respect to the ECB’s policy rate, for a selection of EZ’s peripheral countries. The scatter plots in the right graph relate the private lending rate spread (to non financial corporations) to the government debt interest rate spread.

²The Treaty on Stability, Coordination and Governance ("fiscal compact") establishes a set of policy measures that are - to a large extent - rooted in the automatic implementation of austerity plans in the case of structural deficits.
In a recent theoretical contribution, Corsetti et al. (2013) show that, by modeling the sovereign default risk as an increasing function of the debt level in a general equilibrium monetary model, and considering a spillover effect from government bond rates to the private sector’s credit conditions, a substantial reduction of the government expenditure fiscal multiplier can be observed. In extreme cases, i.e. for high levels of public debt and when the economy operates in a persisting liquidity-trap environment, the sign of the Keynesian multiplier can even be reversed, because the reduction of the nominal lending rate can be larger than the expected internal deflation. In these circumstances, expansionary fiscal contractions can materialize through reductions in the expected borrowing cost.

The consideration of a sovereign risk channel can thus overturn the key result of a recent of literature showing that, when the monetary authority is constrained by a binding zero-lower-bound (ZLB), fiscal consolidations - because of their deflationary implications - generate a rise in the real interest rate, reinforcing the effectiveness of the policy and leading to strong economic contractions (Christiano et al., 2011a; Eggertsson, 2011; Eggertsson and Krugman, 2012; Erceg and Lindé, 2014).

In this paper we develop an open economy monetary model to evaluate the empirical validity of the sovereign risk channel hypothesis and of the related result of the possible emergence of expansionary fiscal contractions for output and unemployment, with a special focus for the EZ periphery. Even if within the large body of literature on fiscal policy effectiveness, the extension of the analysis to the labor market allows to add evidence in the almost unsearched direction of the unemployment fiscal multipliers (Monacelli et al., 2010). The focus on the EZ’s peripheral countries is particularly suitable to test the risk channel hypothesis, given their heterogeneously high degree of indebtedness, the liquidity trap environment in which their economies operate, and the importance of the foregone and perspective fiscal compression to be implemented within the fiscal agreements.

We jointly consider some important extensions of the standard set-up of monetary models. Aside from the open economy-monetary union model structure (Adolfson et al., 2008; Flotho, 2015) and the labor market search and matching design (Gertler and Trigari, 2009), both functional to the scopes of the analysis, the design of the financial sector, in which we assume default probabilities on the side of both private and public borrowers, is key for the emergence of the sovereign risk channel.

On this latter respect, we formalize a relation between sovereign default probability and interest rate spreads in which i) both the debt and the net foreign asset (NFA) to GDP ratios are considered as arguments of the sovereign default probability function, and ii) a formal derivation of the private sector default probability is obtained by extending on the theoretical apparatus characterizing the credit channel of the monetary policy transmission (Bernanke and Gertler, 1995; Gertler and Karadi, 2011). The choice of considering the debt to GDP ratio in the place of its level (Corsetti et al., 2013), aside from encountering theoretical and empirical justifications in the literature (Yeyati and Panizza, 2011; Mendoza and Yue, 2012; Juessen et al., 2014), has the advantage to highlight the close link between the size of the fiscal multipliers and the sign of the sovereign risk channel effects. In fact, when the former are sufficiently high, the debt
to GDP ratio can increase following a fiscal contraction, leading to further deflationary pressure through increased bond and lending rate spreads. The consideration of the debt level would constrain the direction of change of the default probability to the one of the policy, a restriction which is not imposed when considering the debt to GDP ratio.

The model is estimated with Bayesian techniques on a large set of data for five major EZ peripheral countries, i.e. Greece, Ireland, Italy, Portugal and Spain (the PIIGS). Based on the estimated country-specific parameterizations, we first detail the transmission mechanism of fiscal consolidations on interest rate spreads, and then evaluate the output and unemployment multipliers of financially equivalent fiscal contractions affecting government consumption on the expenditure side, and labor and consumption taxes on the revenue side.

Provided that in a currency area framework the liquidity-trap environment, in which the ZLB binds, is not crucial for results (Flotho, 2015), policy simulations consider a normal times environment only. For a small country, the participation to a currency union is in fact akin to a liquidity trap situation.

Results show that i) conditional to fiscal retrenchments implemented with expenditure cuts, the relatively high size of the output multipliers implies that a temporary but persistent increase in the debt to GDP ratio is observed, such that the default risk channel tends to amplify the Keynesian effects of the fiscal contraction. The improvement in the NFA position is not sufficient to reverse the former effect; ii) conditional to labor tax increases, the risk channel might even operate in the predicted direction, but the size of its effects is so small that the short-term expansionary effects on output and employment do not materialize; iii) irrespective of the direction of change in the sovereign default probability, the default risk channel is only marginally effective, because the estimated relation between government and credit rate spreads is weak.

The paper is organized as follows. Section one describes the model, focusing in particular on the theoretical extensions implemented in the design of the financial sector. Section two provides the details of the estimation of the country-specific model parameters. Here we describe the data and their transformations, we address issues of empirical identification, the calibration and the elicitation of priors for the model parameters, and discuss the posterior estimates. Section three provides a discussion of simulation results, explaining the propagation mechanics in the constrained and unconstrained monetary policy environments. Section four concludes.

1 The model

We design a monetary model with a monopolistically competitive financial sector characterized by costly Rotemberg pricing and default probabilities on the side of both public and private borrowers, such that a sovereign default risk channel emerges. We jointly consider a number of further extensions to the standard set-up of monetary models. First, in order to allow for the evaluation of the effects of the policies on the NFA position, we consider a small open economy framework, in which the exogenous foreign sector (EZ and non EZ) is described by a structural vector auto-regressive system (SVAR). The peculiar feature this extension is that, given the focus on EZ countries, we detail the
elements of a currency union, in which the central bank targets area-wide variables. Second, in order to evaluate the effects of fiscal retrenchments on unemployment, we model the non Walrasian labor market according to a search and matching scheme with staggered Nash-wage bargaining (Gertler and Trigari, 2009) for the representation of the staggered Nash-wage bargaining between unions and firms. Third, we specify a simplified fiscal sector, considering standard exogenous fiscal instruments characterizing the expenditure and revenues sides of fiscal models in addition to unemployment benefits.

1.1 Financial sector and default risks

We consider non-zero default probabilities for both private and public sector borrowers, obtained by formalizing a cumulative distribution function relating the sovereign default probability to public debt and NFA-to-GDP ratios, and by relating the private sector default probability to the sovereign default probability. Default risk variations affect the bond interest rate spread through a no arbitrage condition between bank deposits and domestic bond holdings, and the lending rate spread through an optimality condition for credit institutions including the Loss Given Default (LGD) of the bank in the case of counterparty default.

1.1.1 Financial intermediaries and private default risk

In each period $t$ (a continuum of) monopolistically competitive banks receive deposits $D_t(i)$ from the households and supply loans $L_t(i)$ to banks in the retail sector at the nominal interest rate $R_l^t(i)$. Retail banks purchase differentiated loans from the monopolistically competitive banks and aggregate them in the single composite loan

$L_t = \left[ \int_0^1 L_t(i) \left( \chi_t^i - 1 \right) / \chi_t^i \right]^{\chi_t^i / (\chi_t^i - 1)},$

purchased by the intermediate good producer firms at the lending rate $R_l^t(i)$ for anticipated wage payments $W_t(i) n_t(i)$. The term $\chi_t^i = \chi_t^i u_{t,t}$ denotes the stochastic loan demand elasticity in the credit sector, whose stochastic component is assumed to follow the AR(1) stochastic process $u_{t,t} = u_{t,t-1} e^{s_{t,t}}$. Inter-temporal cost minimization implies that the optimal demand for loans is given by

$L_t(i) = \left( R_l^t(i) / R_t^i \right)^{-\chi_t^i} L_t.$

At the end of each period, the monopolistically competitive bank pays back the risk-free interest-augmented initial deposits $R_t D_t(i)$ and ownership profits to households, and maximizes its profit function period by period facing Rotemberg-type costs for adjusting the interest rate on loans, subject to the credit balance sheet constraint $D_{t+s}(i) = L_{t+s}(i) + Q_{t+s}(i)$, i.e.:

$$\max_{D_t(i),R_t^i} \sum_{s=0}^{\infty} \beta^s \left[ \prod_{t+s}^{\infty} \frac{P_t}{P_{t+s}} \right] \left[ 1 - p_t^{d,p} (1 - z^p f_t) \right] R_{t+s}^t(i) L_{t+s}(i) - R_{t+s} D_{t+s}(i)$$

$$- \frac{\kappa_b}{2} \left( \frac{R_{t+s}^l(i)}{R_{t+s-1}^l(i)} - 1 \right)^2 L_{t+s}(i)$$

4
where $Q_t(i) = \phi^a D_t(i)$ and $\phi^a$ denote the level and the ratio of bank reserves, respectively, and $\kappa_b$ is the lending rate adjustment cost parameter. The term $z^p$ is the share of the Gordon’s firm value $\Gamma \nu_t = [P^d_t Y_t - R^k_t K_t - W_t(i) n_t(i)] / [R^k_t - (\mu - 1)]$, determining the LGD of the bank in the case of counterparty default $1 - z^p \Gamma \nu_t$, where $P^d_t Y_t$ is the value of output $Y_t$ expressed in domestic prices $P^d_t$, and $R^k_t K_t$ denotes the return on installed capital $K_t$.

The co-movement between government bond and lending rates observed in recent data indicates that the market valuation of sovereign debt assets can affect the private sector credit conditions (Harjes, 2011). Private sector losses on government bond holdings, as well as losses in outputs and profits during a sovereign debt crisis, tend to increase the borrowing constraint. In order to formally capture this relation, we consider a private sector default probability $p_{t}^{d,p}$, described by the following cumulative density function (c.d.f.):

$$p_{t}^{d,p} = \frac{1 - \exp \left[ -\varphi^{s,p} \left( p_{t}^{d,g} \right)^{\phi^{s,p}} \right]}{1 - \exp \left\{ - \left[ \varphi^{s,p} + \left( 1 - p_{t}^{d,g} \right)^{\phi^{s,p}} \right] \right\}},$$

(1)

where $\varphi^{s,p}$ and $\phi^{s,p}$ are the scale and the shape parameters of the private sector default c.d.f., respectively, such that

$$p_{t}^{d,p} = \begin{cases} 1 & \text{if } p_{t}^{d,g} = 1 \\ 0 & \text{if } p_{t}^{d,g} = 0 \end{cases}.$$

Equation (1) defines the degree to which the default probability on sovereign debt $p_{t}^{d,g}$ spills-over the private sector. Given values for the scale and the shape parameters in (1), our formulation ensures a flexible representation of the relation between private and government borrowing spreads emerging in country-specific time series data. Note that, compared to the relation adopted in Corsetti et al. (2013), who assume a log-linear link between government and credit rate spreads, we explicitly model the underlying relation between the sovereign and the private sector default probabilities in the structure of the monopolistically competitive credit sector.

From the optimality condition of the bank, the following lending rate equation is obtained:

$$R_t^l(i) = \frac{1}{\left[ 1 - p_{t}^{d,p} (1 - z^p \Gamma \nu_t) \right]} \frac{1}{\lambda^l_t - 1} \left\{ \chi^l_t R_t - \kappa_b \left[ \left( \frac{R^l_t(i)}{R^l_{t-1}(i)} - 1 \right) \frac{R^l_t(i)}{R^l_{t-1}(i)} - \beta \frac{P_{t+1} \Lambda_{t+1}}{P_{t+1} \Lambda_t} \left( \frac{R^l_{t+1}(i)}{R^l_t(i)} - 1 \right) \frac{R^l_{t+1}(i) L_{t+1}(i)}{R^l_t(i) L_t(i)} \right] \right\}.$$

The expression above highlights that, differently from standard credit sector models, the risk free rate, the mark-up and the cost of adjusting the interest rate determine the lending rate along with the private sector firms default probability (or their survival rate) and the LGD.
1.1.2 The sovereign default risk

To simplify, we do not model the event of default as the result of a strategic decision (Eaton and Gersovitz, 1981; Arellano, 2008; Mendoza and Yue, 2012), but relate the sovereign default probability to two fundamental triggers addressed in the literature: i) the government debt to GDP ratio $B_t / Y_t$ and ii) the NFA position to GDP ratio $A_t / Y_t$.

The consideration of the debt to GDP ratio in the place of the debt level ensures consistency with the theoretical and empirical literature on sovereign default risk, addressing the former as a more appropriate measure of fiscal fragility, because of the relevance of economic growth for the ability of the government to service its debt (Yeyati and Panizza, 2011; Mendoza and Yue, 2012; Juessen et al., 2014).

The consideration of the NFA position as a trigger of the sovereign default risk is also common in the empirical literature (Edwards, 1986; Manasse and Roubini, 2009; De Grauwe and Ji, 2013). Default episodes are in fact often preceded by large imbalances in foreign indebtedness. A fiscal retrenchment, by improving the NFA position through reduced imports, is likely to mitigate the financial pressure of international lenders.

Formally, the sovereign default probability is defined by the following cumulative distribution function:

$$ p_{t}^{d,g} = \left\{ 1 - \exp \left[ -\varphi^{s,g} \left( \lambda_a B_t + \lambda_b A_t \right) \right] \right\}^{\varphi^{s,g}} $$

where $\lambda_a$ and $\lambda_b$ are elasticity parameters, such that $\partial p_{t}^{d,g} / \partial B_t > 0$, $\partial p_{t}^{d,g} / \partial A_t < 0$ and:

$$ p_{t}^{d,g} = \left\{ \begin{array}{ll}
1 & \text{if } B_t / Y_t = +\infty \land A_t / Y_t = +\infty \hfill \\
0 & \text{if } B_t / Y_t = A_t / Y_t = 0 \hfill 
\end{array} \right., $$

where $A_t^-$ is net foreign indebtedness.

From the optimality condition for deposits and domestic bond holdings the following no arbitrage condition holds:

$$ R_t = R_{t}^{g} \left[ \left( 1 - p_{t+1}^{d,g} \right) + z^g p_{t+1}^{d,g} \right], $$

where $z^g = \sigma_z \phi^i Y / \phi^{i*} Y^*$ is the recovery rate on government bonds in the case of sovereign debt default. The parameters $\phi^i$ and $\phi^{i*}$ denote the domestic and foreign contribution to a hypothetical international insurance institution (e.g. the IMF) and $\sigma_z$ is the efficiency parameter defining the relation between contribution and insurance coverage (e.g. the quota of SDRs to the IMF).

Given the positions above, considering the no arbitrage condition (3), and since $R_t^g = R_t q_t^b$, the interest rate spread on government bonds reads:

$$ q_t^b = \frac{1}{1 - (1 - z^g) p_{t+1}^{d,g}}, $$
Fig. 2. Default Risk and Bond Rate Spread

Notes: Sovereign default probabilities and interest rate spreads on government bonds are reported. The latter, defined with respect to the risk-free quarterly rate, consider a fiscal ceiling, reached when the service cost of public debt equals the value of output. The dark grey line is for Ireland, the dim grey for Greece, the silver for Spain, gray for Portugal and black for Italy. The fiscal ceiling binds before default occurs in all the EZ peripheral countries.

where the government bond premium $q_b^t$ emerges as a result of a non-zero probability $p_d^{d,g}$ of sovereign debt default.

Aside from the consideration of the NFA position, our specification of the sovereign default risk departs from the one adopted in Corsetti et al. (2013) in two main respects: first, we do not consider an exogenous fiscal limit, i.e. an upper bound for the debt to GDP ratio, on the grounds that such a limit is empirically unidentifiable for EZ countries (Juessen et al., 2014) and its inclusion is only of second order relevance for the scopes of our analysis; second, in line with the empirical literature, we consider the debt to GDP ratio in the place of the debt level, in order to take into account the crucial role of the GDP dynamics in the definition of the sovereign default risk addressed in the literature (Yeyati and Panizza, 2011; Mendoza and Yue, 2012).

The consideration of the debt to GDP ratio implies that the size and the sign of the default risk channel crucially depends on the size of the fiscal multipliers. When fiscal multipliers are large enough, fiscal contractions can lead to transitory but persistent increases in the debt to GDP ratio, activating a default risk channel operating in an opposite - pro-cyclical - direction than predicted.

Figure 2 depicts, for different levels of the debt to GDP ratio (defined with respect to quarterly output) and of the sensitivity parameter $\lambda_b$, the behavior of the default probability function and of the government bond spread $q_b^t$ (on quarterly rates) considering a parameterization which is broadly consistent with the data of the five economies in the analysis. The shape parameter $\phi^{d,g}$ is fixed to a value of 20, while the scale parameter $\psi^{d,g}$ is fixed such that, given an elasticity coefficient $\lambda_b = 0.5$, the observed intersections between the debt to GDP ratio and the government bond spread for each country belong to the default probability surface.

The government bond rate spread surface shows a country-specific upper limit defined
by a public debt service cost ceiling, which we assume reached for a bond rate level (and thus spread) for which the service cost equals the value of output. At this theoretical stage, the different ceilings depicted in Figure 2 depend exclusively on the country-specific steady state debt to GDP ratios, fixed to values observed in 2014q3.

In the next sections, the structure of the financial sector is appended to an open economy monetary model characterized by a search and matching labor market and a stylized fiscal sector.

1.2 Households

1.2.1 Optimizers

We consider a continuum of households indexed by \( j \in [0, 1] \), with a fraction \( \phi^h \) having limited access to capital markets (Galí et al., 2007). Ricardian households (superscript \( r \)) are assumed to maximize the lifetime utility function

\[
\max_{\tilde{C}_t, B_t^r, B^{sr}_t, K_t^r} \sum_{t=0}^{\infty} \beta^t \left[ \chi_t^c C_t^{r(1-\sigma_c)} - \chi_t^n \int_0^1 n_t(i) \, di \right],
\]

where \( C_t^r \) is a composite consumption index, \( \sigma_c \) is the consumption curvature parameter and \( 0 \leq n_t \leq 1 \) denotes the fraction of household members who are employed. The stochastic preference parameters \( \chi_t^c \) and \( \chi_t^n \) follow the autoregressive processes

\[
\chi_t^c = \chi^c u_{c_t} \text{ and } \chi_t^n = \chi^n \mu^{(1-\sigma_c)u_{n,t}},
\]

respectively. Each household purchases consumption and investment goods by means of after tax labor incomes and unemployment benefits, capital incomes and dividends. The budget constraint is thus given by:

\[
(1 + \tau_t^c) C_t^r + I_t^r + \frac{B_t^r}{P_t} + \frac{e_t B^{sr}_t}{P_t} + \frac{D_t^r}{P_t} = \left[ (1 - p_t^{d,g}) + z^g p_t^{d,g} \right] \frac{B_{t-1}^c}{P_t} + (1 - \tau_t^n) \int_0^1 [w_t(i) n_t(i) + \beta_t^s (1 - n_t(i))] \, di
\]

\[
+ \frac{R_{t-1} D_{t-1}^c}{P_t} + \frac{e_t B^{sr}_{t-1}}{P_t} + \frac{R_t^c}{P_t} K_{t-1}^r + \frac{\Pi_t^p \mu^t}{P_t},
\]

where \( I_t^r \) is private investment, \( A_t = e_t B^{sr}_{t+1}/P_t \) is the aggregate NFA position of the domestic economy, \( e_t \) is the nominal effective exchange rate and \( D_t^c/P_t \) denotes household’s deposits to financial intermediaries in real terms. \( B_t^c \) and \( B^{sr}_t \) are domestic and foreign bond holdings held by Ricardian households, respectively, \( P_t \) is the consumption price index, \( R_t^c/P_t \) is the real return on capital \( K_t^r \), and \( \delta \) is the capital depreciation rate. The ratio \( w_t(i) = W_t(i)/P_t \) is the real wage, and \( \Pi_t^p \mu^t/P_t \) defines real dividends, where \( \mu \) is the long-run trend growth of labor-augmenting productivity. Government

\[\text{The peculiar specification of the stochastic scaling factor of labor disutility } \chi_t \text{ is chosen to ensure balanced growth.}\]
unemployment benefits $b^u_t = b^l_t$ and the tax rates on consumption $\tau^c_t$ and labor income $\tau^l_t$ complete the budget constraint of the optimizing household.

The term $\Phi_t$ in (6) denotes the risk premium on foreign bond holdings in the modified uncovered interest parity (UIP) equation $E_t (e_{t+1}/e_t) = R^g_t/\Phi_t R^g_e$ (Adolfson et al., 2007), where:

$$\Phi_t = \exp[(R^g_e - R^g_t) - \phi_a A^e_t + \chi^a_t],$$

in which $A^e_t$ and $R^g_e$ denote the EZ’s net foreign assets (NFA) position and the interest rate on bonds, respectively related to the EZ’s domestic and foreign counterparts by $A^e_t = (A^e_t)^{1-\omega} (R^g_e)^\omega (R^g_{ez})^{1-\omega}$, where $A^e_t$, $R^g_e$, $R^g_{ez}$ are the corresponding figures in the rest of the EZ and $\omega$ is the country’s weight in the EZ. The parameter $\phi_a$ denotes the risk premium elasticity to the EZ’s NFA position and $\chi^a_t = \chi^a u_{uip,t}$ is the risk premium shock, which is assumed to follow the first order autoregressive stochastic process $u_{uip,t} = u_{uip,t-1} e^{\epsilon_{uip,t}}$.

The law of motion of capital is described by the following equation:

$$K^r_t = (1 - \delta) K^r_{t-1} + \chi^r_t \left[ 1 - S \left( \frac{I^r_t}{I^{r-1}_t} \right) \right] I^r_t,$$

where $S(I^r_t/I^{r-1}_t)$ defines the investment adjustment cost function, with curvature parameter $\psi^r$, and $\chi^r_t = \chi^r u_{inv,t}$ is an investment-specific shock, which is assumed to follow the autoregressive process $u_{inv,t} = u_{inv,t-1} e^{\epsilon_{inv,t}}$.

Aggregate demand for consumption and investment goods $X_t = (C_t, I_t)$, is obtained as a CES index of domestically produced and imported goods, such that:

$$X_t = \left[ (1 - \nu) \frac{1}{\eta} \left( X^d_t \right)^{\frac{\eta - 1}{\eta}} + \nu \frac{1}{\eta} \left( X^m_t \right)^{\frac{\eta - 1}{\eta}} \right]^{\frac{\eta}{\eta - 1}},$$

where, from households’ cost minimization, $X^d_t = (1 - \nu) \left[ P^d_t / P_t \right]^{-\eta} X_t$ and $X^m_t = \nu \left[ P^m_t / P_t \right]^{-\eta} X_t$ are the aggregate domestic and foreign produced goods, respectively, where $\nu$ denotes the import share parameter and $\eta$ is the elasticity of substitution between domestic and imported goods. $P^d_t$ and $P^m_t$ denote the price indexes of domestic and imported goods, respectively, such that:

$$P_t = \left[ (1 - \nu) (P^d_t)^{1-\eta} + \nu (P^m_t)^{1-\eta} \right]^{\frac{1}{1-\eta}}.$$

### 1.2.2 The rule-of-thumb household

We consider that a fraction of households is liquidity constrained, in order to allow for deviations from full Ricardian equivalence. Following Galí et al. (2007), we assume that constrained and unconstrained households have the same number of workers, $n_t = n^c_t = n_t^{nr}$. From the budget constraint of the hand-to-mouth household, the following consumption equation is obtained:

$$(1 + \tau^c_t)C^m_t = [(1 - \tau^n_t)w_t (i) n_t (i) + (1 - \tau^n_t)b^u_t (1 - n_t (i))],$$

where $w_t (i)$ and $b^u_t$ are the wages and job tenure at time $t$, respectively.
where it is evident that all their net income (from labor, government transfers and unemployment benefits) is spent in consumption goods.

1.3 Firms

1.3.1 Intermediate good sector

Each intermediate firm \((i)\) operates in a perfectly competitive environment combining capital and labor. The production technology is as follows:

\[ Y_i^t(i) = \chi_t^a [K_t(i)]^a [\mu^t n_t(i)]^{(1-a)}, \]

where \(\alpha\) is the output elasticity of capital and \(\chi_t^a = \chi^a u_{a,t}\), where \(u_{a,t} = u_{a,t-1} e^{a,t}\) is an AR(1) process defining the evolution of total factor productivity.

The optimizing firm chooses the capital stock by solving the following maximization problem:

\[
\max_{K_t(i)} P_i^j (i) Y_t(i) - R^k (i) K_t(i) \quad \text{s.t. (12)}
\]

where \(P_i^j(i)\) is the intermediate sector price index. Since the wage bill \(W_t(i) n_t(i)\) is anticipated by borrowing from financial intermediaries, the cost of one unit of labor is \(R_t^l(i) W_t(i)\), where

\[ R_t^l(i) = \left[ 1 - p_t^{dp}(i) \right] R_t^l(i) + d_t^{cp}(i) \]

denotes the effective interest rate and \(d_t^{cp}(i) = p_t^{dp}(i) R_t^l(i)\) is the cost of default per unit of borrowed cost of labor.

1.3.2 Final good sector: wholesalers and retailers in the domestic, import and export sectors

For expositional convenience, a joint description of the structure of the final good sector, composed of domestic, import and export wholesalers and retailers, is provided.

Domestic wholesale firms buy the homogeneous good \(Y_t^d\) from domestic intermediate good producers at the price \(P_t^d\), and differentiate the homogeneous product into \(Y_t^d(i)\) using a linear technology. Wholesalers sell their goods under monopolistic competition to domestic retailers, who use the differentiated goods \(Y_t^d(i)\) to produce the composite final good \(Y_t^d\).

Wholesale firms in the import sector buy the homogeneous good \(Y_t^*\) from foreign retailers at the foreign price \(P_t^*\), and obtain a differentiated good \(Y_t^m(i)\). Wholesale importing firms sell their goods under monopolistic competition to import retailers who use the differentiated goods \(Y_t^m(i)\) to produce the composite final good \(Y_t^m\).

Wholesale export firms buy the homogeneous good \(Y_t^d\) from domestic retailers at the price \(P_t^d\) and produce a differentiated good \(Y_t^x(i)\) using a linear technology. Wholesalers in the export sector sell their goods under monopolistic competition to export retailers, who use the differentiated goods \(Y_t^x(i)\) to produce the composite final good \(Y_t^x\).
We consider a variable demand elasticity in the three sectors, indexed by $k = (d, m, x)$, by assuming a flexible variety aggregator $G$ à la Kimball (1995), such that the domestic retailer’s demand function reads

$$\int_0^1 G \left( \frac{Y^k_t (i)}{Y^k_T}; \lambda^p_t \right) \, di = 1,$$

and the domestic retailers demand function for differentiated goods is:

$$Y^k_t (i) = Y^k_T G^{-1} \left[ \frac{P^k_t (i)}{P^k_T} \lambda^p_{p,t} \right],$$

where:

$$\lambda^p_{p,t} = \int_0^1 G' \left( \frac{Y^k_t (i)}{Y^k_T}; \lambda^p_t \right) \frac{Y^k_T (i)}{Y^k_T} \, di.$$

The optimization problem of wholesale firms that are allowed to re-optimize their prices reads:

$$\max_{P^k_t (i)} \mathbb{E}_t \sum_{j=0}^{\infty} (\beta \theta^k_p)^j \frac{\Lambda_{t+j} P_t}{\Lambda_t P_{t+j}} \left[ \tilde{P}^k_t (i) - MC^k_{t+j} \right] Y^k_{t+j} (i)$$

s.t. (13),

where $MC^d_t = P_t^d$, $MC^m_t = e_t P^s_t$ and $MC^x_t = P_t^d / e_t$ are the nominal marginal costs of domestic, import sector and export sector wholesalers, respectively. $(\beta \theta^k_p)^j \Lambda_{t+j} P_t / \Lambda_t P_{t+j}$ denotes the firm’s stochastic discount factor, where $\theta^k_p, k = (d, m, x)$, are the Calvo probabilities of price adjustment (Calvo, 1983) and $\chi^p_{p,k} = \chi^p_{p,k} u^m_{k,t}$, where $u^m_{k,t} = e^m_{k,t}$ are i.i.d. shocks defining the time-varying markups. Note that we do not take into account indexation mechanisms in order to allow an interpretation of the (observed) frequency of price changes in terms of (theoretical) price re-optimization.

1.4 The labor market

The matching process is described by a Cobb-Douglas matching technology $m_t = \sigma_m v^\sigma_t u^1-\sigma_t$, where $\sigma^n$ denotes the elasticity of matches to vacancies, $\sigma_m$ is the matching efficiency parameter, $v_t$ denotes the number of vacancies and $u_t = 1 - n_{t-1}$ the unemployment rate once the labor force stock has been normalized to one. Given the job filling rate $q_t = m_t / v_t$ and the job finding rate $s_t = m_t / u_t$, the labor market tightness can equivalently be defined as $\theta_t = v_t / u_t$ or $\theta_t = s_t / q_t$. Under the assumption of exogenous separation, the employment law of motion is described by the dynamic equation $n_t = (1 - \rho) n_{t-1} + m_t$, where $\rho$ is the separation rate.

1.4.1 Workers value functions

Let $H_t (w_t (i))$ be the worker’s value of being matched to a job evaluated at the wage $w_t (i)$ and $U_t$ be the value of being unemployed at time $t$. The value of the employ-
ment/unemployment states are the following:

\[ H_t(w_t(i)) = (1 - \tau_t^n)w_t(i) - \frac{\lambda^n}{\Lambda_t} + \beta E_t \frac{\lambda_{t+1}}{\Lambda_t} \left[(1 - \rho) \left[\theta_w H_{t+1}(w_t(i)) + (1 - \theta_w) H_{t+1}(w_{t+1}(i))\right] + \rho U_{t+1}\right] \] (14)

\[ U_t = (1 - \tau_t^n)b_t^n + \beta E_t \frac{\lambda_{t+1}}{\Lambda_t} \left[s_{t+1} \left(\theta_w H_{t+1}(w_t) + (1 - \theta_w) H_{t+1}(w_{t+1}^*)\right) + (1 - s_{t+1})U_{t+1}\right], \] (15)

where \( H_t(w_t) = \int_0^1 H_t(w_t(i)) m_t(i) / m_t \, di \) denotes the average value of employment, \( \theta_w \) is the Calvo parameter defining the probability of being unable to re-optimize the wage in \( t + 1 \), \( \Lambda_t \) is the Lagrange multiplier, \( p_t^d = P_t^d / P_t \) denotes the domestic relative price and \( w_{t+1}^* \) is the re-optimized wage. From equations (14) and (15) the net value of being employed, i.e. the worker surplus \( H_t(w_t(i)) - U_t \), is obtained.

### 1.4.2 Firms value functions

Let \( J_t(w_t(i)) \) be the asset value of a job evaluated at the wage \( w_t(i) \)

\[ J_t(w_t(i)) = \left(\zeta_t - R_t^w \frac{w_t(i)}{p_t^d}\right) + (1 - \rho) \beta \mu E_t \left\{ \frac{\lambda_{t+1}}{\Lambda_t} \left[\theta_w J_{t+1}(w_t(i)) + (1 - \theta_w) J_{t+1}(w_{t+1}(i))\right]\right\} \] (16)

where \( \zeta_t = (1 - \alpha) P_t^d Y_t / n_t \) denotes the marginal productivity of labor.

Given the value of a vacancy

\[ J_t^v = -\kappa + q_t \left[\theta_w J_t(w_{t-1}(i)) + (1 - \theta_w) J_t(w_{t+1}^*(i))\right] \] (17)

and imposing the free entry condition, \( J_t^v = 0 \), the vacancy posting condition is obtained

\[ \frac{\kappa}{q_t} = \theta_w J_t(w_{t-1}(i)) + (1 - \theta_w) J_t(w_{t+1}^*(i)). \] (18)

### 1.4.3 Nash wage bargaining

Given the worker’s surplus \( H_t(w_t(i)) - U_t \), the firm’s asset value of a job \( J_t(w_{t+1}^*(i)) \) and the union’s bargaining power \( \varsigma \), the Nash-bargaining solution is given by \( \varsigma (1 - \tau_t^n) J_t(w_{t+1}^*(i)) = (1 - \varsigma) [H_t(w_{t+1}^*(i)) - U_t] \). Plugging the value functions in the latter equation, the optimal real wage reads:
gradually, giving rise to interest rate smoothing where temporaneous rule considering EZ’s CPI inflation. The centralized monetary authority sets the nominal interest rate $1.5$ Monetary and fiscal policies

where $b^u_i + \frac{\lambda_t}{\lambda_t}$ and $\frac{1}{1 - \tau_{t+1}}\beta_t\mu_t \left\{ \frac{\Lambda_{t+1}}{\Lambda_t} \frac{\kappa}{\eta_{t+1}} \left[ 1 - \Xi_t(1 - \tau_{t+1}) \right] \right\} + \Theta_t E_t \sum_{j=1}^{\infty} \frac{\Lambda_{t+j}}{\Lambda_t} \Psi^j \left[ \frac{1}{\kappa} \left[ \gamma_{t+j} w^t_{t+1}(i) - w^t_i(i) - \frac{s_{t+1}}{1 - \rho}(w^t_{t+1}(i) - w_t(i)) \right] \right] + E_t \left[ \left( R_{t+1} - R_t \frac{w^t_{t+1}(i)}{P_{t+1}} - R_t \frac{w^t_i(i)}{P_t} \right) - \left( 1 - \Xi_{t+j} \right) \left( R_{t+1} \frac{w^t_{t+1}(i)}{P_{t+1}} - R_t \frac{w^t_i(i)}{P_t} \right) \right] \right\},

where $\gamma_{t+j} = (1 - \tau_{t+1})/(1 - \tau_t)$, $\Psi = (1 - \rho)\beta_t\mu_t$, $\Xi_t = (1 - \rho - s_t) / (1 - \rho)$, $\Theta_t \equiv 1/\left[ 1 - \zeta(1 - 1/p_t^d) \right]$, and $w_t(i) = [\theta_w w_{t-1}(i) + (1 - \theta_w) w^t_i(i)]$ is the average real wage.

1.5 Monetary and fiscal policies

The centralized monetary authority sets the nominal interest rate $R_t$ according to a contemporaneous rule considering EZ’s CPI inflation $\pi^c_t$, defined by $\pi^c_t = (\pi^c_t)^{\omega} (\pi^c_{t-1})^{1-\omega}$, where $\pi^c_{t-1}$ denotes CPI inflation in the rest of the EZ. The policy instrument is adjusted gradually, giving rise to interest rate smoothing

$$\frac{R_t}{R} = \left( \frac{R_{t-1}}{R} \right)^{\rho R} \left[ \frac{\pi^c_t}{\pi^c_{t-1}} \right]^{1-\rho R} e^{\chi^t},$$

where $\rho^R$ is the degree of autoregressive behavior in the interest rate adjustment, $\psi$ is the feedback coefficient to inflation $\pi_t$ and $\chi^t = \chi R u_{mp,t}$, where $u_{mp,t} = \epsilon_{mp,t}$ is an i.i.d. monetary policy shock.

By expressing government consumption, government transfers and unemployment benefits in terms of domestic goods, the government budget constraint in real terms reads:

$$G_t + (1 - \tau_t) b^g_t \int_0^1 \left( 1 - n_t(i) \right) di + \phi^t Y_t + \left[ (1 - p^d_t) + z^g p^d_t \right] \frac{B_{t-1}}{P_t} - \frac{B_t}{P_t R^g_t} - \phi^t C_t + \tau_t \int_0^1 w_t(i) n_t(i) di,$$

where $d^c_t = (1 - z^g) p^d_t$ is the unit cost of sovereign default, $G_t = G^\rho_{t-1} \epsilon_{g,t}$ is the stochastic process for government consumption expenditures.
1.6 Model closure

Given the presence of intertemporally optimizing households \(j \in [0, 1 - \phi^h]\) and of rule-of-thumb households \(j \in (1 - \phi^h, 1]\), aggregate consumption \(C_t\) is given by:

\[
C_t = \int_0^{1-\phi^h} C^r_t \, dj + \int_{1-\phi^h}^1 C_t^{ar} \, dj.
\]

Since only Ricardian households hold bonds and accumulate capital, the other Ricardian-specific variables are aggregated as follows:

\[
\Gamma_t = \int_0^{1-\phi^h} \Gamma^r_t \, dj
\]

for \(\Gamma_t = [I_t, K_t, B_t, B_t^{Gr}]'.

Market clearing in the foreign bond market and the final goods market requires that, at the equilibrium, the following two equations for NFA evolution and aggregate resources are satisfied:

\[
\frac{e_tB_t^{Gr}}{\Phi_tR_t^{Gr}q_t^{bw}} = e_tP_t^x (C_t^x + I_t^x) - e_tP_t^m (C_t^m + I_t^m) + e_tB_t^x
\]

and:

\[
C_t^d + C_t^x + I_t^d + I_t^x + G_t + \frac{\kappa_b}{2} \left( \frac{R_{t+s}^d (i)}{R_{t+s-1}^d (i)} - 1 \right) ^2 L_{t+s} (i) \leq Y_t - a \left( u_t^K \right) K_{t-1} - \kappa_t v_t,
\]

where \(C_t^x + I_t^x = [P_t^x / P_t^*]^{-\eta_*} Y_t^*\) are total exports, with \(\eta_*\) denoting the foreign demand elasticity parameter.

The stationary representation of the model is obtained by scaling the real variables with respect to the trending technology process.

The domestic economy model includes 16 shock processes, of which 10 are first order autoregressive and the remaining five are i.i.d..

1.7 The foreign economy

Foreign (rest of the world) output \(y_t^*\), inflation \(\pi_t^*\), short and long-term interest rates \(r_{s,t}^*\) and \(r_{b,t}^*\) are exogenous with respect to the variables of the domestic economy, and their evolution is described by a fourth-order SVAR, where contemporaneous correlations...
are defined by the structural error correlation matrix $B$. Formally:

$$A \begin{bmatrix} \pi_t^* \\ y_t^* \\ r_{s,t}^* \\ r_{b,t}^* \end{bmatrix} = B \begin{bmatrix} \varepsilon_t^{\pi^*} \\ \varepsilon_t^{y^*} \\ \varepsilon_t^{r_{s,t}^*} \\ \varepsilon_t^{r_{b,t}^*} \end{bmatrix}, \quad A_0 = I_4, \quad \varepsilon_t \sim N(0, I) \quad (22)$$

$$B = \begin{bmatrix} b_{11} & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 \\ b_{31} & b_{32} & b_{33} & 0 \\ b_{41} & b_{42} & b_{43} & b_{44} \end{bmatrix}, \quad BB' = \Omega.$$  

The assumptions on the matrix $B$ are consistent with the hypothesis that output and inflation do not respond contemporaneously to the other shocks in the system (Adolfson et al., 2008), and that the 10-years government bond rate is recursive with respect to the short-term interest rate.

2 Estimation

Even considering a large data-set, the rich parameterization of the model precludes the estimation of the entire parameter space, since a subset of this space remains empirically unidentifiable (Canova and Sala, 2009; Iskrev, 2010; Koop et al., 2011). For this reason, only the empirically identifiable parameters are estimated using the Bayesian method, whereas the remaining are fixed according to the available country-specific evidence and to conventional calibration values.

Because of the limited sample size, a Bayesian estimator is used also for the foreign variables SVAR, in this case considering a modified Minnesota priors specification approach (Banbura et al., 2010).

2.1 Data issues and measurement equations

We use a large set of domestic and foreign quarterly variables to estimate the country-specific models. For the domestic economies, 16 observables are considered: (log differences of) real per capita GDP$^4$ ($\Delta y_t^{obs}$), consumption ($\Delta c_t^{obs}$), investment ($\Delta i_t^{obs}$), imports ($\Delta m_t^{obs}$), exports ($\Delta x_t^{obs}$), the real wage ($\Delta w_t^{obs}$) and the public debt ($\Delta b_t^{obs}$); the unemployment rate ($u_t^{obs}$), the (quarterly) rates of change of the consumption ($\pi_t^{c,obs}$), import ($\pi_t^{m,obs}$), export ($\pi_t^{x,obs}$) and domestic sector ($\pi_t^{y,obs}$) price deflators; the nominal effective exchange rate ($e_t^{obs}$), the (quarterly) short-term interest rate, the 10-years government bond rate and the lending rate to non financial corporations ($r_t^{obs}$, $r_{b,t}^{obs}$ and $r_{l,t}^{obs}$, respectively). All real variables are referred to the base-year 2005.

In order to avoid stochastic singularity, at the estimation stage we add six measurement errors to the 10 structural shocks: an i.i.d. stochastic wedge $u_{cpi,t} = e^{cpi,t}$ affecting the CPI equation; the autoregressive processes $u_{m,t} = u_{m,t-1}^{\varepsilon_{m,t}}$ and $u_{x,t} = u_{x,t-1}^{\varepsilon_{x,t}}$.

$^4$Per capita variables are obtained considering the labor force as the normalizing variable.
entering the import and export equations, respectively; a first order autoregressive stochastic wedge \( u_{arc,t} = u_{arc,t-1} e^{e_{arc,t}} \) in the aggregate resources constraint; a first order autoregressive measurement error \( u_{rg,t} = u_{rg,t-1} e^{e_{rg,t}} \) entering the no arbitrage condition between government and risk free assets; an i.i.d. shock \( u_{b,t} = e^{e_{b,t}} \) entering the government budget constraint, which is needed in order to take into account measurement errors in the government bond equation.

Considering the variables for the foreign sector, the log difference of real output \((y_{t}^{*,obs})\) is obtained from the OECD area real output, and short and long-term interest rates \((r_{s,t}^{*,obs} \text{ and } r_{b,t}^{*,obs} \text{, respectively})\) are approximated by those for the US. The foreign price deflator \((\pi_{t}^{*,obs})\) is obtained from the real effective exchange rate definition equation using observed data on domestic inflation, the nominal and the real effective exchange rates. A total of 20 variables is thus considered in the country-specific estimates. All data are taken from official sources and cover the period 1999:1-2014:3

Before linking the observed variables to the theoretical counterparts, some of the latter are transformed in order to get full consistency with the statistical definitions. In particular, the transformations take into account that, differently from the statistical aggregates, consumption and investment in the theoretical model are composites of domestic and imported goods, and output also includes the hiring and the capital utilization rate costs. All data are demeaned prior to estimation, in order to get rid of the deviations from balanced growth observed in the data.

Formally, considering the vector of real per capita variables \(x_{t} = (y_{t}, c_{t}, i_{t}, m_{t}, x_{t}, w_{t}, y_{t}, b_{t})\), of inflation rates \(\pi_{t} = (\pi^{c}_{t}, \pi^{m}_{t}, \pi^{x}_{t}, \pi^{y}_{t}, \pi^{*}_{t})\), of risk free, bond and lending interest rates \(r_{t} = (r_{t}, r_{b,t}, r_{l,t}, r^{*}_{t}, r^{b}_{l,t})\), the 20 measurement equations linking the linearized model variables to the respective observables read as follows:

\[
\begin{bmatrix}
\Delta x_{t}^{obs} \\
u_{t}^{obs} \\
\pi_{t}^{obs} \\
r_{t}^{obs} \\
e_{t}^{obs}
\end{bmatrix} =
\begin{bmatrix}
x_{t} - x_{t-1} \\
u_{t} \\
\pi_{t} \\
r_{t} \\
e_{t} + \log e
\end{bmatrix}
\]

2.2 Priors

We impose 31 dogmatic priors on the 46-dimensional structural parameters space. Absent country-specific information, 12 structural parameters are fixed to common values across countries, while the remaining 19 are fixed considering country-specific evidence. Calibrated values are chosen taking into account both sample and extraneous evidence when informative for the theoretical parameters, and conventional literature values when such information is missing.

The remaining 15 parameters are estimated. The prior distributions are common across countries and are specified following the usual practice: the shape of the probabil-

\footnote{The choice of using a limited time span is made with the purpose of avoiding the potential estimation biases implied by the switch to the common currency in 1999 (2001 for Greece). A detailed description of data sources and manipulations is provided in the technical appendix.}
ity density functions is the gamma and the inverted gamma for parameters theoretically defined over the \( \mathbb{R}^+ \) range, the beta for parameters defined in a \([0, 1]\) range and the normal for priors on parameters theoretically defined over the \( \mathbb{R} \) range.

### 2.2.1 Financial sector and default risk probabilities

The priors for the parameters of the financial sector are specified by targeting the observed lending and government interest rate spreads.

Three parameters are fixed to common values across countries. The shape parameter for the government default probability function \( \phi^{s,g} \) is fixed to 20 in order to capture the recent observed nonlinear relation between fundamentals and government bond spreads; the shape parameter for the private default probability function \( \phi^{s,p} \) is fixed to 1, ensuring consistency with recent time series observations of a rather stable relation between the lending and the government bond rate, the latter with the observed average lending rate spread; the world contribution to the IMF parameter \( \phi^{i*} \) is fixed to 0.008 according to the observed total SDR (in USD) to world GDP ratio.

Other six parameters are fixed to country-specific values. The parameter denoting the contribution to the IMF \( \phi^i \) is set according to the SDR quota (in Euro) to GDP ratios; the international insurance efficiency parameter \( \sigma_z \) is fixed such that the debt repayment rate parameter \( z^g \) matches the sample SDR quota; the steady-state credit sector markup \( \chi^l_1 \) is fixed considering sample evidence on the Lerner index for the banking sector (Carbó et al., 2009; Weil, 2013); the share of the Gordon’s firm value \( z^p \) is chosen to match an average LGD of 0.61, based on Carty et al. (2000) analysis on senior secured and unsecured loan default events. Finally, the scale parameters of the government and private default probability functions, \( \varphi^{s,g} \) and \( \varphi^{s,p} \), respectively, are fixed in the following manner: concerning the former, given observations for the debt to GDP ratios, \( z^g \) and \( q^h \) (the latter probability evaluated by targeting the spread between the government bond rate and the short-term interest rate) and using equation (4), the parameter \( \varphi^{s,g} \) is unequivocally determined from (2), given the prior mean for the government default probability sensitivity parameter \( \lambda_b \), which is set to 0.5; concerning the private default scale parameter \( \varphi^{s,p} \), given the calibration values of the other parameters, country-specific prior values are chosen by targeting the observed lending rate interest rates and spreads.

The remaining three financial sector parameters are estimated. These are the default probability elasticity parameters \( \lambda_a \) and \( \lambda_b \), assumed to be normally distributed with prior mean 0.5 and s.d. 0.3, and the lending rate adjustment cost parameter \( \kappa_b \), which is assumed to be gamma-distributed with prior mean 3 and s.d. 1.5 (Gerali et al., 2010). Although these priors ensure an exact match between the steady state government bond and lending rate spreads and their sample counterparts, the very diffuse distributions reflect our imprecise prior opinions, and imply that the posterior estimates will be dominated by the conditional distribution.
2.2.2 Labor market

Given the lack of time series information for labor market variables (actually, only the real wage and the unemployment rate are available), six parameters are held fixed (five to country-specific values) and two are estimated. Concerning the former group, the matching elasticity parameter $\sigma^n$ is fixed to 0.5 (Petrongolo and Pissarides, 2001), the separation rate $\rho$ is fixed to the estimates provided by Hobijn and Sahin (2009), the unemployment benefit parameter $b^n$ is fixed according to OECD Tax and Benefit Systems (TBS) data on replacement rates, and the labor disutility scale parameter $\chi^n$ is fixed by targeting the sample information on the unemployment rate. The values of the matching efficiency parameter $\sigma_m$ and of the hiring cost parameter $\kappa$ are fixed by targeting a quarterly job filling rate $q$ of 0.7 (Jung and Kuester, 2015) and a hiring cost to wage ratio $\kappa v/m w$ of 0.15 (Silva and Toledo, 2009; Jung and Kuester, 2015). Concerning the estimated parameters, the union’s bargaining power parameter $\varsigma$ and the Calvo wage parameter $w$ are assumed to be beta-distributed with prior mean 0.5 and s.d. 0.1.

2.2.3 Other model parameters

Among the remaining model parameters, other 16 are held fixed, eight to common conventional values across countries, eight according to country-specific evidence. Considering the former group, the steady-state mark-up coefficients $\lambda^n_p$, $\lambda^m_p$ are fixed to 1.5 and $\lambda^n_c$, is fixed to 1; the Kimball endogenous demand elasticity parameters $\kappa^n_d$, $\kappa^m_d$ and $\kappa^v_d$ are fixed to 10 (Eichenbaum and Fisher, 2007; Smets and Wouters, 2007); the capital depreciation rate $\delta$ is fixed to 0.025; the risk premium elasticity parameter $\phi_a$ in the UIP is fixed to $10^{-2}$ (Schmitt-Grohé and Uribe, 2003).

Within the latter group, the trend growth parameter $\mu$ is fixed considering sample evidence on the per capita output dynamics; the discount factor $\beta$ is calibrated considering the country-specific trend growth and the average real interest rate; the output elasticity of capital $\alpha$ is fixed targeting the consumption and investment to output ratios; the country’s relative weight parameter $\omega$ and the home bias parameter $(1 - \nu)$ are fixed according to the ECB weights in the HICPI and the observed import shares; finally, the tax rates $\tau^n$ and $\tau^c$ are fixed according to the evidence on average tax rates (Eurostat, 2014) and the steady-state government consumption expenditure $g^p$ is fixed according to sample evidence on the expenditure to output ratio.

The seven exclusion restrictions for the identification of the foreign variables’ SVAR, i.e. the zero restriction for $b_{12}$, $b_{13}$, $b_{14}$, $b_{21}$, $b_{23}$, $b_{24}$ and $b_{34}$ add further seven dogmatic priors. Table 1 summarizes the common and country-specific dogmatic priors adopted in model estimation for the structural parameters only.

The remaining structural parameters of the model are estimated. Concerning preferences, the consumption curvature parameter $\sigma_c$ is assumed to be normally-distributed with a prior mean of 2 and a prior s.d. of 0.1, whereas the prior for the fraction of liquidity constrained households $\phi^h$ has mean 0.30 and s.d. 0.1; a weak gamma-distributed prior with mean 1.5 and s.d. 0.4 is adopted for the import and export Armington elasticities $\eta$ and $\eta^*$ (Adolfson et al., 2008).

Concerning real and nominal rigidities, the investment adjustment cost parameter
TABLE 1 - DOGMATIC PRIORS: STRUCTURAL PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Source</th>
<th>Greece</th>
<th>Ireland</th>
<th>Italy</th>
<th>Portugal</th>
<th>Spain</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi_i^{g}$</td>
<td>Gov. default sh.</td>
<td>Target: gvt bond rate spread</td>
<td>20.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\phi_i^{p}$</td>
<td>Priv. default sh.</td>
<td>Target: lending rate spread</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_i$</td>
<td>Foreign ins. contr.</td>
<td>Evidence: total SDR/GDP</td>
<td>0.008</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_j$</td>
<td>Dom. ins. contr.</td>
<td>Evidence: SDR quota/GDP</td>
<td>0.027, 0.022, 0.013, 0.023, 0.011</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\chi^\delta$</td>
<td>Contribution eff.</td>
<td>Target: $z^g = SDR$ quota</td>
<td>0.23, 0.62, 0.56, 0.34, 0.46</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda^\delta$</td>
<td>Credit demand elast.</td>
<td>Carbó et al. (2009), Weil (2013)</td>
<td>5.8, 8.1, 6, 6.3, 5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varphi^\delta$</td>
<td>Gordon's firm v. sh.</td>
<td>Target: $LGD = 0.61$</td>
<td>0.080, 0.068, 0.120, 0.110, 0.047</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varphi^{g,p}$</td>
<td>Sovereign default sc.</td>
<td>Target: gvt bond rate spread</td>
<td>0.46, 0.67, 0.57, 0.59, 0.80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varphi^{s,p}$</td>
<td>Private default sc.</td>
<td>Target: lending rate spread</td>
<td>0.23, 0.26, 0.25, 0.36, 0.98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma^\delta$</td>
<td>Matching elast.</td>
<td>Petrungolo and Pissarides (2001)</td>
<td>0.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho$</td>
<td>Separation rate</td>
<td>Hobijn-Sahin (2009)</td>
<td>0.028, 0.042, 0.021, 0.039, 0.061</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$b^u/w$</td>
<td>Unempl. benefit</td>
<td>OECD, TBS</td>
<td>0.30, 0.63, 0.67, 0.72, 0.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda^\delta d$</td>
<td>Labor disutility sc.</td>
<td>Target: $u$</td>
<td>0.30, 0.07, 0.41, 0.04, 0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma^\delta m$</td>
<td>Matching efficiency</td>
<td>Target: $q$, Jung-Kuester (2015)</td>
<td>0.54, 0.59, 0.39, 0.54, 0.49</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\kappa^\delta$</td>
<td>Hiring cost</td>
<td>Silva-Toledo (2009)</td>
<td>0.06, 0.08, 0.09, 0.08, 0.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda^\delta k$</td>
<td>M-up</td>
<td>Smets and Wouters (2007)</td>
<td>1.5, 1.0 for $k = x$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho^g$</td>
<td>Demand elast.</td>
<td>Smets and Wouters (2007)</td>
<td>10.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda^\delta$</td>
<td>Capital depr.</td>
<td>Conventional</td>
<td>0.025</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\phi_d^g$</td>
<td>Risk premium. elast.</td>
<td>Schnitt-Grolé and Uribe (2003)</td>
<td>$10^{-2}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\mu$</td>
<td>Growth rate</td>
<td>Evidence: p.c. output growth (%)</td>
<td>0.07, 0.47, 0.04, 0.14, 0.22</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta$</td>
<td>Discount factor</td>
<td>Evidence: real interest rate</td>
<td>0.991, 0.992, 0.994, 0.993, 0.996</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Output elast. of $K$</td>
<td>Target: Inv. and cons. to GDP</td>
<td>0.25, 0.30, 0.34, 0.26, 0.31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\omega$</td>
<td>Rel. wgt in EZ</td>
<td>ECB, HICP*</td>
<td>0.026, 0.014, 0.177, 0.021, 0.120</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\nu$</td>
<td>Import share</td>
<td>Evidence: import/output ratio</td>
<td>0.31, 0.74, 0.25, 0.35, 0.27</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau^c$</td>
<td>Cons. tax rate</td>
<td>Eurostat (2014)</td>
<td>0.16, 0.24, 0.18, 0.18, 0.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau^d$</td>
<td>Labor tax rate</td>
<td>Eurostat (2014)</td>
<td>0.33, 0.26, 0.42, 0.23, 0.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho^g$</td>
<td>Gov. cons/GDP</td>
<td>Evidence: Gov. cons/output share</td>
<td>0.20, 0.17, 0.19, 0.20, 0.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: The parameters related to 'great ratios' and other observable quantities related to steady state values are calibrated considering that the time unit is a quarter. The sector specific parameters are denoted by $k = d, m, x$.

* Harmonized Index of Consumer Prices

$\psi^i$ is assumed to be gamma-distributed around a prior mean of 5 with a prior s.d. of 1 (Christiano et al., 2011b), while for the Calvo parameters of the domestic, import and export sectors ($\theta_d^p$, $\theta_m^p$ and $\theta_x^p$, respectively) we assume a beta-distributed prior with mean 0.5 and s.d. 0.1.

Finally, concerning the monetary policy parameters, the interest rate smoothness coefficient $\rho^R$ is assumed to be beta-distributed with prior mean 0.75 and prior s.d. 0.1 and the inflation response parameter $\psi$ is assumed to be normally distributed with prior mean 1.5 and s.d. 0.1.

### 2.2.4 SVAR parameters

The elicitation of priors for the foreign variables’ SVAR is based on the partially modified Minnesota priors approach suggested by Banbura et al. (2010). Accordingly, priors are specified under the hypothesis of independent AR(1) processes (random walks for variables close to non-stationarity), with prior variabilities decreasing in the power of the lag order of the SVAR $i$ (net of an overall shrinkage parameter $\lambda$, calibrated according to the number of variables in the system) and scaled considering the variables’ error variance ratios $\sigma^2_{m}/\sigma^2_{r}$, the latter approximated by the estimated residuals of univariate autoregressive representations. Formally, the prior moments for the 73 coefficients of the fourth-order SVAR (22) are specified as follows:

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\[ E[(A_i, B)_{mn}] = \begin{cases} \vartheta & \text{for } i = 1, m = n, \\ 0 & \text{otherwise} \end{cases}, \quad V[(A_i, B)_{mn}] = \frac{\lambda^2}{\kappa^2 \sigma^2} \begin{cases} \sigma^2 & \text{for } m = n, \\ \frac{\sigma^2}{\kappa^2} & \text{otherwise} \end{cases}, \] (23)

where the values for the first-order autoregressive coefficients \( \vartheta \) are obtained from the estimates of independent AR(1) processes.

### 2.2.5 Stochastic component

Considering the stochastic component of the models, the prior opinions for the autoregressive coefficients of the 10 persistent shock processes (i.e., \( \rho_a, \rho_c, \rho_n, \rho_{inv}, \rho_{uip}, \rho_{rg}, \rho_m, \rho_x, \rho_{rl} \) and \( \rho_{arc} \)) are described by a weakly informative beta-distributed prior with mean 0.5 and s.d. 0.15. For the standard errors of the 19 innovations, we assume a prior mean of 0.01 with two degrees of freedom for all shocks, except those multiplying convolutions of parameters whose values are outside the \([10^{-1}, 10]\) range, that are scaled accordingly.

The prior opinions on the estimated structural parameters are summarized in the first column of the result Table 2.

### 2.3 Posterior mean estimates

Table 2 summarizes the priors and the posterior mean estimates for the structural parameters of the model\(^6\). The posterior means indicate reasonable estimates based on prior distributions and the available results in the literature, and add further cross-country structural heterogeneity to that implied by the country-specific dogmatic priors.

Concerning the financial sector parameters, the estimated elasticity of default risk to the debt ratio \( \lambda_b \) is above the prior in all countries, with a differentiated pattern ranging from 1.6 (Portugal) to 2.6 (Ireland). The default risk elasticity parameter to NFAs, \( \lambda_y \), is estimated to be lower, ranging between 0.5 (Ireland) and 1.3 (Spain). A very high degree of heterogeneity is estimated for the lending rate adjustment cost parameter \( \kappa^b \), ranging from 1.6 (Italy) to 8 (Greece).

The parameter defining the fraction of liquidity constrained households \( \phi^h \) is estimated to be between 0.24 (Italy) and 0.3 (Ireland), basically in line with the available EZ estimates in Forni et al. (2009).

The posterior mean estimates of the Calvo parameters in the domestic, import and export sectors, \( \theta^d, \theta^m \) and \( \theta^x \), respectively, are higher than the prior, indicating a flatter slope of the NKPCs than that implied by the joint consideration of the observed frequency of price changes and of the conventional calibration values for the mark-up (or demand elasticity) parameters. Results are less distant from the prior in the case of the frequency of wage non re-optimization \( \theta_w \).

The estimated Armington elasticities \( \eta, (\eta^*) \) are generally higher (lower) than the prior and denote a differentiated pattern across countries.

\(^6\)For expositional convenience, the estimates of the parameters defining the persistence and the size of the exogenous stochastic components are not reported in the main text and are summarized in tables B1 and B2 of the technical appendix, available upon request from the authors.
The union’s relative bargaining power parameter \( \zeta \), is estimated to be within the range of the conventional calibration values in the literature \((0.5 - 0.7)\).

### Table 2 - Prior Distributions and Posterior Mean Estimates

| Description                  | Prior distribution | Posterior mean | | | | | |
|------------------------------|--------------------|----------------|---|---|---|---|---|---|
| \( \lambda_b \) Def. risk el. to \( b_t/y_t \) | N (0.30) [1.59 - 1.90] [2.47 - 2.63] [1.69 - 1.85] [1.50 - 1.66] [1.58 - 1.71] | 1.75 [2.60] 1.82 [1.58] 1.64 | | | | | |
| \( \lambda_a \) Def. risk el. to \( a_t/y_t \) | N (0.30) [0.24 - 1.07] [0.14 - 0.95] [0.27 - 1.07] [0.61 - 1.31] [0.91 - 1.59] | 0.65 [0.53] 0.68 [0.96] 1.26 | | | | | |
| \( \kappa_b \) Lend. rate adj. cost | G (1.50) [4.98 - 10.9] [2.11 - 5.49] [0.39 - 2.76] [2.32 - 5.83] [3.34 - 7.63] | 8.01 [4.11] 1.60 [4.06] 5.52 | | | | | |
| \( \zeta \) Union barg. power | B (0.50) [0.49] [0.48] | 0.65 [0.65] [0.52] [0.66] | | | | | |
| \( \theta_w \) Calvo wage | N (0.10) [0.42 - 0.56] [0.39 - 0.55] [0.58 - 0.73] [0.46 - 0.68] [0.71 - 0.72] | 0.71 [0.69] 0.65 [0.59] 0.57 | | | | | |
| \( \sigma_c \) Consumption curv. | N (0.10) [0.63 - 0.79] [0.69 - 0.79] [0.59 - 0.72] [0.60 - 0.69] [0.49 - 0.64] | 1.65 [2.15] 2.35 [2.15] 2.10 | | | | | |
| \( \phi^h \) Fraction r.o.t. | B (0.10) [0.17 - 0.30] [0.22 - 0.37] [0.18 - 0.31] [0.18 - 0.33] [0.20 - 0.34] | 0.24 [0.30] 0.24 [0.25] 0.27 | | | | | |
| \( \eta \) El. subst. domestic | G (0.40) [0.60 - 1.06] [1.48 - 1.85] [1.78 - 2.35] [1.62 - 2.10] [1.94 - 2.32] | 0.83 [1.66] 2.08 [1.90] 2.12 | | | | | |
| \( \eta^* \) Elast. subst. foreign | G (0.40) [1.62 - 3.61] [0.51 - 1.09] [0.55 - 1.36] [0.34 - 0.84] [0.43 - 1.01] | 2.61 [0.80] 0.95 [0.58] 0.72 | | | | | |
| \( \psi^i \) Inv. adj. cost cur. | G (1.00) [2.68 - 5.06] [3.58 - 6.13] [4.81 - 8.11] [4.09 - 6.70] [5.75 - 9.03] | 3.86 [4.90] 6.50 [5.39] 7.38 | | | | | |
| \( \beta_d^d \) Calvo domestic | B (0.10) [0.79 - 0.91] [0.88 - 0.94] [0.74 - 0.84] [0.70 - 0.82] [0.73 - 0.82] | 0.86 [0.91] 0.79 [0.76] 0.77 | | | | | |
| \( \beta_{im} \) Calvo import | B (0.10) [0.48 - 0.60] [0.62 - 0.69] [0.68 - 0.78] [0.66 - 0.77] [0.66 - 0.75] | 0.54 [0.65] 0.73 [0.71] 0.70 | | | | | |
| \( \beta_e \) Calvo export | B (0.10) [0.84 - 0.94] [0.84 - 0.90] [0.82 - 0.89] [0.77 - 0.86] [0.77 - 0.85] | 0.89 [0.87] 0.86 [0.81] 0.81 | | | | | |
| \( \rho^R \) Int. rate smoothing | B (0.10) [0.84 - 0.90] [0.84 - 0.90] [0.81 - 0.86] [0.81 - 0.87] [0.82 - 0.87] | 0.87 [0.87] 0.84 [0.84] 0.85 | | | | | |
| \( \psi_1 \) Feed. coeff. inflation | N (0.20) [1.35 - 1.68] [1.36 - 1.67] [1.32 - 1.64] [1.32 - 1.64] [1.32 - 1.63] | 1.51 [1.53] 1.48 [1.48] 1.47 | | | | | |

Notes: N, B and G denote the Normal, the Beta and the Gamma distributions, respectively. Posterior mean estimates are obtained with 250000 M-H replications on two parallel chains.

Unsurprisingly, both the autoregressive component and the size of the monetary policy response are estimated to be homogeneous across countries, with the former indicating a quite high degree of inertial behavior and the latter being close to conventional calibration values.

### 3 Policy simulations: into the mechanics of the risk channel

In this section we provide a comparative analysis of the country-specific effects from the implementation of three financially equivalent contractionary fiscal policies: i) a reduction in government consumption; ii) an increase in the labor income tax rate; iii) an increase in the consumption tax rate. These policies are evaluated by simulating the model stochastically and considering the parameterization obtained at the country-specific posterior mean estimates. The different simulations are made comparable by
calibrating the size of each policy shock to a 1% of GDP and by homogenizing their persistence considering a one year average duration of the shock.

Note that, in order to improve the readability of results, the fiscal instruments are assumed to be fully exogenous.

The policy simulations are performed assuming a normal times environment, i.e. one in which the centralized monetary policy reacts to EZ inflation deviations from target according to the estimated Taylor rule feedback coefficients. We have verified that the consideration of a recessionary environment in which the economies are operating in a liquidity trap is not crucial for results, since we deal with a model in which the domestic economy is a small country in a currency union (Flotho, 2015). Provided that the central bank reacts to area-wide inflation, the internal price change triggered by the fiscal retrenchment is only marginally translated into counteracting monetary policy rate changes. From the perspective of the small economy implementing the fiscal contraction, the single currency situation thus approximates a ZLB environment, i.e. one in which a deflationary policy cannot be accommodated by the automatic response of the monetary authority. As a consequence, the price deflation is almost entirely translated into increased real interest rates that further depress internal demand and economic activity (Christiano et al., 2011a; Eggertsson, 2011; Eggertsson and Krugman, 2012).

Figure 3 reports the impulse responses of the public debt and the NFA position to output ratios to a 1% GDP fiscal retrenchment implemented with expenditure cuts, direct and indirect tax increases. Figure 4 provides the same information for the government debt and the private lending interest rate spreads. The debt and the NFA to GDP ratio responses depict their percent deviation from the steady state, and the responses of the spreads are expressed in annualized basis points deviations from the respective steady state values.

The output and unemployment fiscal multipliers of the three alternative measures are summarized in Table 3, where output monetary multipliers and percent variations in unemployment levels are considered.

A reduction in the debt level is obtained in all countries, irrespective of the instrument through which the fiscal contraction is implemented. The endogenous response in tax revenues (mainly due to reduced labor incomes) and in government expenditure (due to the change in unemployment benefit payments) does not reverse the positive effects on the government budget.

The net foreign asset response is always positive, basically reflecting the improvement in the trade balance, due to the decrease in imports and the slight increase in exports, triggered by the contraction in the domestic demand and the internal deflation.

However, since the multipliers of the specific fiscal instruments are different, the debt and the NFA to GDP ratio responses denote a heterogeneous pattern across fiscal measures. In the next subsections we detail the results and the transmission mechanics considering each fiscal instrument separately.

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7Results for the ZLB simulations can be obtained upon request from the authors.
Fig. 3. Response of fundamentals to a 1% GDP fiscal contraction

Notes: Impulse responses (in quarters) of the bond to output ratio \( (B_t/Y_t) \) and the net foreign asset \( (A_t/Y_t) \) to a one percent GDP fiscal contraction, obtained at the country specific posterior mean estimate.
IRF of $r_b - r$ to $G$ shock

IRF of $r_l - r$ to $G$ shock

IRF of $r_b - r$ to $\tau_n$ shock

IRF of $r_l - r$ to $\tau_n$ shock

IRF of $r_b - r$ to $\tau_c$ shock

IRF of $r_l - r$ to $\tau_c$ shock

Fig. 4. Response government and lending interest rate spreads a 1% GDP fiscal contraction

Notes: Impulse responses (in quarters) of the government interest rate spread ($r^G_{t+1} - r_t$) and of the lending interest rate spread ($r^l_{t+1} - r_t$) to a one percent GDP fiscal contraction, obtained at the country specific posterior mean estimate. Government and lending interest rate spreads are expressed in annualized basis points.

| TABLE 3 - PEAK OUTPUT AND UNEMPLOYMENT MULTIPLIERS (quarter) |
|-------------------|----------------|---------|--------|---------|---------|---------|
| Instrument        | Multiplier     | Greece  | Ireland| Italy  | Portugal| Spain   |
| Gov. consumption  | Output         | 1.09 (1) | 1.03 (1) | 1.09 (1) | 1.03 (1) | 1.04 (1) |
|                   | Unemployment   | 1.01 (2) | 0.83 (2) | 0.82 (2) | 0.75 (2) | 0.71 (2) |
| Labor income tax  | Output         | 0.20 (1) | 0.12 (1) | 0.20 (1) | 0.20 (1) | 0.24 (1) |
|                   | Unemployment   | 0.22 (2) | 0.12 (2) | 0.18 (2) | 0.16 (2) | 0.21 (2) |
| Consumption tax   | Output         | 0.50 (2) | 0.23 (1) | 0.46 (1) | 0.42 (1) | 0.50 (1) |
|                   | Unemployment   | 0.49 (2) | 0.21 (2) | 0.41 (2) | 0.33 (2) | 0.38 (1) |

Notes: The value of the monetary fiscal multiplier is reported. The unemployment variation is scaled in order to provide the percent change in the unemployment rate.
3.1 Government expenditure cuts

Considering the government expenditure cut, the resulting output contraction is more than proportional than the debt contraction, such that the debt to GDP ratio temporarily increases in all the peripheral EZ countries. A moderate variability of the response across countries is observed, basically reflecting the low sensitivity of the expenditure multiplier to the heterogeneity in the estimated country-specific parameterization. The main reason for this result is that government purchases affect output mainly directly, inducing only second-round effects on price and wage dynamics. As evidenced in Table 3, the peak output response to a 1% GDP government expenditure cut is negative and reached on impact, and denotes a monetary multiplier around unity in all countries. These results are broadly consistent with the available European estimates (Coenen and Straub, 2005; Forni et al., 2009). Employment also falls following the output contraction, with the unemployment rate reaching a maximum short term increase between 0.7% (Spain) and 1.1% (Greece). Given the relative homogeneity in the output response, these differences are to be attributed to the different labor market structures.

Unsurprisingly, the NFA to GDP ratio also increases following the expenditure cut, with differences in the response mainly reflecting the heterogeneity in the trade elasticity and in the domestic, import and export Calvo coefficient estimates.

As a result of the contrasting influence of the two fundamental ratios on default risk, the short-term response of the government bond spread is positive in all countries, reaching a peak value on impact ranging from more than 40 basis points (Greece) to 15 basis points (Spain), partly reflecting the size of the debt to GDP ratios. This signals that, given the estimated elasticities, the improved NFA positions are not enough to offset the pressure on sovereign default risk related to the increase in the debt to GDP ratios. The relatively high estimate for the elasticity of the default probability to foreign debt in Spain explains the smaller increase in the government bond rate spread.

As a result of the increase in the sovereign debt default probability, the lending rate spread temporarily increases in all countries, even if by a smaller amount than the government bond rate spread. A moderate reduction of the private borrowing cost is observed only after eight quarters, once also the sovereign debt interest rate spread is back in the negative terrain. The size of the short term increase in the lending rate spread, estimated to range between 7 basis points (Greece) and 12 basis points (Italy), reflects the different estimates for the lending rate adjustment cost parameter in the different countries. In the longer term (five years), the lending rate spread reduction ranges from 3 basis points (Ireland) and 21 basis points (Spain), mainly reflecting the different sovereign default elasticity to NFA.

Such a moderate size of the interest rate spread pass-through is confirmed by the simulation of recursive bivariate VAR models including the government debt and the lending rate spreads, whose results are reported in Figure 5.

The overall picture is that, conditional to a negative government consumption shock, the short-term effect of the default risk channel contrasts that predicted by Corsetti et al. (2013). The increase in the interest rate spreads amplifies the contractionary pressure directly stimulated by the fiscal retrenchment. However, consistent with time series evidence on government and private lending interest rates, the size of the increase
in the firm borrowing cost is quite small, such that the output and unemployment fiscal multipliers are only marginally affected. These are in fact basically aligned with those emerging when the default risk transmission dynamics is shut down, i.e. by setting $\lambda_b$ and $\lambda_a$ to zero.

### 3.2 Labor income tax shock

Results are quite different when considering the contractionary direct tax shock. Even if negative and persistent effects on real output and employment continue to be observed for all countries (Table 3), the peak multipliers are much smaller\(^8\) than those emerging under a fiscal retrenchment implemented with expenditure cuts. The peak output contraction ranges from 0.12 (Ireland) and 0.24 (Spain), while the peak increase in the unemployment rate ranges from 0.12\% (Ireland) and 0.22\% (Greece). The temporary nature of the shock implies a fractional transmission on domestic expenditure and production, with changes in the saving rate of the liquidity unconstrained households absorbing a large part of the reduction in net incomes.

A further factor responsible for the small size of the output multipliers is the currency area setting. A direct tax increase, by reducing after tax incomes, leads to both decreased demand in the fraction of liquidity constrained households and to decreased labor supply, the latter inducing a counteracting inflationary pressure in wages. This effect dampens the internal deflation and, akin to a liquidity trap situation, the expected real interest rate increase that would obtain because of the price deflation and the rather fixed policy rate. As noted by Eggertsson (2011), such effect leads to a contraction of the labor tax multiplier.

\(^8\)This result is basically in line with the abundant SVAR-based empirical literature on fiscal multipliers since the seminal analysis of Blanchard and Perotti (2002).
Because of the small multipliers, the decrease in the debt level tends to dominate the output contraction and a reduction of the debt to GDP ratio is observed even in the short run (on impact for Ireland). The internal demand contraction and the resulting deflation lead to an improvement in the trade balance, thus in the NFA to GDP ratio. The latter is however smaller than that obtainable with an expenditure cut, mainly because of the weaker output contraction.

Furthermore, the responses of the two ratios, as well as the general macroeconomic response, are more heterogeneous across countries, because of the different model structures. In the case of a labor tax rate increase, the conditional model dynamics has in fact a closer link with the model parameterization, since the transmission of the shock on output is indirect, as it mainly operates through the labor market adjustment, the link between current and expected incomes and expenditure (i.e. the fraction of spenders/savers), and the foreign sector variables’ responses. The finding of a particularly low fiscal multiplier for Ireland is mainly explained by its high degree of openness (the sample import to output ratio is 0.75), such that a high fraction of the reduction in expenditure is "exported" through reduced imports.

The heterogeneous but generally favorable conditional dynamics of the default risk triggers are translated into lower public and private borrowing costs even in the short term. However, the reduction in interest rate spreads is relatively small. At the five years horizon, the expected reduction in the lending rate spread is between 6 basis points (Ireland) and 33 basis points (Spain), even in this case with differences mainly explained by the size of the sovereign default probability elasticity to the NFA.

Contrary to the case of a fiscal retrenchment operated through expenditure cuts, the labor tax rate increase is thus able to stimulate a short term reduction in the public and private borrowing costs. Given the minimal reduction in borrowing costs, the relevance of the risk channel for the macroeconomic dynamics and for the size of the fiscal multipliers is confirmed to be only marginal.

3.3 Consumption tax shock

A fiscal retrenchment implemented with an increase in the indirect tax rate operates through the resulting reduction in private expenditure for domestic and foreign goods. The transmission mechanics on output and employment is thus more direct than in the case of a labor tax increase. As a result, the fiscal multipliers are higher, explaining the temporary increase in the debt to GDP ratio. The peak output multipliers range from 0.23 (Ireland) and 0.5 (Greece and Spain), while the unemployment variation lies between 0.21 (Ireland) and 0.49 (Greece). Differences are mainly explained by the degree of openness of the country economies, defining the fraction of the "exported" contraction in private expenditure and production.

The reduction in imports largely explains the improvement in the NFA, in which the positive variation in exports plays only a marginal role, since the inflationary pressure triggered by the increase in the indirect taxation tends to outweigh the internal deflation resulting from the output drop.

The persistent improvement in the NFA positions is - in the short term - always
outweighed by the worsening of the debt ratio. Consequently, the fiscal contraction leads to a temporary increase in the default probabilities and in the public and private borrowing costs. Even in this case, irrespective of the sign of the interest rate change, the relevance of the risk channel effect is only of second order.

### 3.4 The size of the default probability elasticity to fundamentals

Overall, according to our analysis, there is no clear evidence of the operation of a risk channel, especially in the short term. The estimated fiscal multipliers are in fact basically aligned with those obtainable from equally parameterized country models in which the risk channel effects are eliminated.

For these reasons, the recent surge in government bond and lending rate premia in the EZ peripheral countries should be mainly attributed to factors that are only loosely related to macroeconomic fundamentals.

The basic reason is that the transmission mechanisms traducing variations in public and foreign debt into sovereign and private default risk and spreads is weak.

An approximation of the elasticity of the spreads to a temporary increase in sovereign and foreign indebtedness can be obtained, given the country-specific posterior mean estimates, by solving equations (2), (4) and (1) alone, such that the effects of model dynamics are pinned down. Table 4 summarizes the overall elasticity of the public and private spreads to fundamentals. To emphasize the highly nonlinear relation between fundamentals and spreads, the table also reports the increases in spreads that would obtain if the steady state debt to GDP ratio is augmented by 20 percentage points.

#### TABLE 4 - ELASTICITY OF SPREADS TO MACROECONOMIC FUNDAMENTALS - %

<table>
<thead>
<tr>
<th>Elasticity</th>
<th>Greece</th>
<th>Ireland</th>
<th>Italy</th>
<th>Portugal</th>
<th>Spain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debt to GDP ratios at current values</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Gov borrowing cost spread to debt/GDP</td>
<td>9.87</td>
<td>5.33</td>
<td>4.74</td>
<td>11.0</td>
<td>4.60</td>
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<td>Priv borrowing cost spread to debt/GDP</td>
<td>1.57</td>
<td>1.89</td>
<td>2.76</td>
<td>3.78</td>
<td>2.89</td>
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<tr>
<td>Gov borrowing cost spread to NFA/GDP</td>
<td>3.68</td>
<td>1.10</td>
<td>1.78</td>
<td>6.72</td>
<td>3.52</td>
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<tr>
<td>Priv borrowing cost spread to NFA/GDP</td>
<td>0.59</td>
<td>0.39</td>
<td>1.04</td>
<td>2.31</td>
<td>2.21</td>
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<table>
<thead>
<tr>
<th>Debt to GDP ratios increased by 20%</th>
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<td>Gov borrowing cost spread to debt/GDP</td>
<td>20.0</td>
<td>17.1</td>
<td>13.4</td>
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<td>18.5</td>
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<td>6.19</td>
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<td>Gov borrowing cost spread to NFA/GDP</td>
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<td>3.53</td>
<td>5.03</td>
<td>10.3</td>
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<tr>
<td>Priv borrowing cost spread to NFA/GDP</td>
<td>1.22</td>
<td>1.27</td>
<td>3.00</td>
<td>3.63</td>
<td>9.37</td>
</tr>
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</table>

Notes: The elasticities are evaluated at the posterior mean estimates and are reported in percent values.

A given elasticity indicates the fraction of the increase in the public debt ratio and in foreign indebtedness which is translated into increased quarterly interest rate spreads. The debt ratio plays a bigger role than the NFA ratio in determining the interest rate spreads, because their sensitivity to fundamentals mostly depend on the steady-state debt to GDP ratios (fixed to end 2014q3 values) and on the estimated sensitivity parameters \( \lambda_b \) and \( \lambda_a \). The differences in the overall elasticities mostly reflect the differences in these parameters.

Table 4 clearly shows that, because of the nonlinearity of the default probability relations, higher values of the steady state debt ratios imply more than proportional
increases in the elasticities. At the current values of the sovereign debt ratio, the size of the lending rate spread elasticity is however quite small, ruling out a substantial operation of the risk channel.

As long as the private sector lending rates provide a reliable approximation of the actual credit conditions, these results point to a very limited effectiveness of the risk channel. Of course, this conclusion does not consider that the lending rate is only one of the many aspects defining the private sector access to financial resources, that variations in fundamentals might be perceived as permanent, and that the use of more recent time series might change the estimated elasticities. Notwithstanding these cautions, we believe our estimates to be more reliable than those based on cross-country evidence on CDS spreads and debt ratios (Corsetti et al., 2013). The use of this information to parameterize a key relation of a time series model can be misleading, since a correlation potentially emerging from the cross-sectional information, thus from idiosyncratic factors, is applied to a single economy model structure.

4 Conclusions

We develop, estimate and simulate a model characterized by government bond and lending rate spreads originating in the sovereign default risk. The consideration of an endogenous default risk channel introduces interesting elements for the conduct of fiscal policy in highly indebted economies. In principle, for increasing levels of debt and for small sized fiscal multipliers, a fiscal retrenchment can even be expansionary, given the potential reduction in the domestic and foreign debt positions. The improvement in fundamentals can trigger a reduction in sovereign and private default risks and thus of the interest rate spreads and borrowing costs.

Our analysis, developed at the country-level for a selection of peripheral EZ economies, shows that, contrary to this theoretical prediction and to some conclusions in the recent literature, the default risk channel is not effective.

Conditional to fiscal retrenchments implemented with expenditure cuts, the risk channel operates in the opposite direction than predicted, because temporary but persistent increases in the debt to GDP ratio are observed, such that in the short to medium run the sovereign and private default probabilities (thus interest rates) tend to increase in all the economies being considered. The improvement in the NFA position to GDP ratio is not sufficient to stimulate a significant reduction in default probabilities and spreads, i.e. to an extent that the former effects can be reversed.

Conditional to fiscal retrenchments implemented on the side of labor tax revenues, a reduction in sovereign default risk and bond rates can be observed, but the degree to which the sovereign risk is estimated to spill over private sector risk is so weak that a reduction in the lending rate spread is never observed. As a result, the sign of the Keynesian tax multiplier is not reversed.
References


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