Technical appendix to: The fiscal mix in the euro-area crisis – dimensions and a model-based assessment of effects

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Abstract

This appendix collects details on the construction of the data, the model, and the calibration.

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1 Derivation of the fiscal instruments

1.1 The real-time fiscal instruments database

The European Commission and Eurostat has recently improved the supply of data on the evolution of fiscal policy in the euro area and in the European Union. As part of the AMECO database, the European Commission includes data on the discretionary revenue and spending measures adopted by the EU countries since 2010. This data complement some useful existing data. In particular, in the context of the Taxation Trends report, Eurostat publishes a whole series of data on effective and implicit tax rates on labour, consumption and capital income, the latter decomposed in the business and non-business component (currently available until 2012). These data are then complemented by data on the evolution of statutory rates on labour, consumption and corporate taxes.

Despite these improvements, none of the existing databases present a comprehensive overview of real-time expectations of the evolution of effective tax rates and GDP shares of spending. To fill this gap and to facilitate the work of practitioners in this area, this paper is accompanied by a database (currently covering the 2006-2016 period) describing the evolution of the six fiscal instruments used in this paper (effective tax rates on labour, consumption and capital income, GDP shares of government consumption, public investment and public transfers). The database covers the euro area as a whole, the core and periphery aggregates and each individual euro area country.

The main contribution of our database is the inclusion of real-time projections of these instruments as implied by the European Commission Autumn and Spring projections, starting from the Autumn 2007 vintage and until the 2016 Spring one. Our database elaborates the (publicly available) data on past AMECO forecast vintages and makes them promptly available to researchers. In particular, the methodology chosen for the derivation of the effective tax rates allows us to have both historical and projected data for each forecast vintage. As also noted in the paper, the database allows the analysis of the combination of both policy and non-policy factors, using data that can be readily used for DSGE model simulations.

Our paper does not use the available data to a full extent, as the analysis in the paper relies only on ex-post data. Using our database, future research could further expand on the effects of real-time fiscal expectations, and the role they played in determining the economic evolution during the financial and sovereign crisis.

1.2 Labor tax rate

In a first step, we compute the average tax rate on household income defined as follows:

$$\tau^h_{t+s|t} = \frac{\mathrm{DTH}_{t+s|t}}{\mathrm{GDI}_{t+s|t} + \mathrm{THC}_{t+s|t}}. \tag{1}$$

where DTH are direct taxes paid by households, GDI is gross disposable income of households (B6g in ESA2010, UVGH in the AMECO database) and THC are direct taxes on income and wealth paid by the household sector (Current taxes on income and wealth, D5 for S1M in ESA2010, UTYH in the AMECO database). In a second step, we use our calculated average tax rate on household income to derive the average tax on labor income:

$$\tau^l_{t+s|t} = \frac{\tau^h_{t+s|t}\left[\mathrm{WGS}_{t+s|t} + \mathrm{OHH}_{t+s|t}/2\right] + \mathrm{SSC}_{t+s|t}}{\mathrm{COE}_{t+s|t} + \mathrm{OHH}_{t+s|t}/2}. \tag{2}$$

where WGS is total gross wages and salary received by households (D11 of S1M in ESA2010, UWSH in the AMECO database), OHH is the gross operating surplus of the household sector (B2g+B3g of S1M in ESA2010, UOGH in AMECO), SSC are net social security contributions received by the general government (D61r in ESA2010, UTSG in AMECO), COE is total economy compensation of employees (UWCD in AMECO). Unfortunately, in absence of data on how the operating surplus of the household sector splits between labour compensation of self-employed and other types of income, we need to follow Leeper et al. (2010) and assume that half of the operating surplus is labour income. [1]

[1] Gross operating surplus of the household sector is a residual item in the calculation of households' income. Most of it refers to the profits and labor income generated by self-employed individuals and unincorporated firms. Its importance is quite relevant, since it accounts for slightly more than 20% of total pre-tax income of households and about 40% of total economy operating surplus.

1.3 Taxes on capital income

Taxes on capital income are paid by two sectors: the household sector (for the component of its gross operating surplus that is not attributed to labour income of self-employed) and by the financial and non-financial corporations. Accordingly, and in line with the assumption on households' operating surplus made in equation (2), we assume that the remaining half of OHH is related to profits of self-employed. The average effective tax rate on capital income is then defined as follows:

$$\tau^k_{t+s|t} = \frac{\tau^h_{t+s|t}\,(\mathrm{OHH}_{t+s|t}/2 + \mathrm{NPH}) + \mathrm{DTE}_{t+s|t} + \mathrm{DTCG}}{\mathrm{OHH}_{t+s|t}/2 + \mathrm{OSS}_{t+s|t} + \mathrm{NPE}}. \tag{3}$$

Where where DTE are direct taxes paid by corporations (D5 for S11+S12 in ESA2010, UTYC in AMECO), NPH and NPE is the net property income (which is the sum of interest income and other capital income) of, respectively, households and total economy, $DTCG$ is the capital tax, which in the euro area is mostly generated by inheritance and gift taxation, and OSS is the gross operating surplus of corporations (B2g for S11+S12 in ESA2010, UOGC in AMECO).

1.4 Consumption taxes

The average tax rate on consumption is defined as:

$$\tau^c_{t+s|t} = \frac{\mathrm{TIN}_{t+s|t}}{\mathrm{PCE}_{t+s|t} + \mathrm{INC}_{t+s|t} + \mathrm{GIN}_{t+s|t}}. \tag{4}$$

The numerator (TIN) is total indirect taxes (including VAT, taxes on imports, excise and energy taxes, D2R in ESA2010 and UTVG in AMECO). The denominator is the sum of PCE, private final consumption expenditure at current prices (UCPH in AMECO), other current expenditure INC (UUOG in AMECO) and gross fixed capital formation GIN (P51 in ESA2010 and UIGG0 in AMECO) of the general government. In line with the methodology used by the EC in the computation of the implicit tax rate on consumption, the amount of indirect taxes received by the government is not deducted from the tax base. Because of this, and given also the inclusion of all indirect taxes, the resulting rate can be substantially higher than the statutory VAT rate.

1.5 Government consumption

Government consumption in our database aligns with the national account definition:

$$G_{t+s|t} = \text{COE}^g_{t+s|t} + \text{INC}_{t+s|t} + \text{STM}_{t+s|t} + \text{CFC}_{t+s|t} + \text{TPS}_{t+s|t} + \text{NOS}_{t+s|t} - \text{SAL}_{t+s|t}. \quad (5)$$

where COE^g refers to compensation of employees, INC refers to intermediate consumption, CFC is consumption of fixed capital, STM refers to social transfers in kind, TPS is the difference between taxes paid on production and subsidies received by the government sector, NOS is the net operating surplus of the government and SAL are government's sales (all relative to the general government). The government consumption-to GDP ratio is calculated dividing each forecasted value by the value of nominal potential GDP relative to the same period. Real government consumption is total final consumption expenditure of general government at constant prices (OCTG in AMECO), deflated by its own price level (PCTG).

1.6 Social transfers

Social transfers correspond to the aggregate "Social transfers other than in kind", (UYTGH in the AMECO database, D62p in the ESA2010 classification). This aggregate includes expenditure on pensions, non-funded social security benefits (like family, disability or education benefits) and unemployment benefits. This aggregate can be also defined in terms of the objective of spending. As specified in the Eurostat website, social transfers other than in kind are

> transfers to households, in cash or in kind, intended to relieve them from financial burden of a number of risks or needs (by convention: sickness, invalidity, disability, occupational accident or disease, old age, survivors, maternity, family, promotion of employment, unemployment, housing, education and general neediness), made through collective schemes, or outside such schemes by government units.

2 The model

The model is an extended version of Corsetti et al. (2014). Where there is overlap, the exposition below follows closely their exposition. It describes a monetary union that is comprised of two countries: HOME and FOREIGN. The countries differ in terms of size and fiscal policy settings. A fraction $\theta \in (0, 1)$ of households reside in HOME, a fraction $1 - \theta$ in FOREIGN. Consumers in HOME and FOREIGN have preferences for bundles of differentiated goods produced in HOME or FOREIGN. Consumption baskets exhibit home bias. Investment has the same structure. Goods are produced by firms in HOME and FOREIGN, using HOME and FOREIGN labor, respectively. Labor is not mobile internationally. Prices of individual goods are rigid, so that output is demand-determined. Nominal wages are rigid as well, being subject to quadratic adjustment costs.

As regards notation, where applicable, and unless noted otherwise, HOME and FOREIGN variables are expressed per capita of the HOME and FOREIGN population, respectively. FOREIGN-country variables are indexed by an asterisk.

2.1 Households

Following Gali et al. (2007) and others, the model features Ricardian households and non-Ricardian households. Ricardian households participate in asset markets whereas non-Ricardian households do not. We assume that all firms in the area-wide economy are owned by the Ricardian households. For simplicity, firms cannot be traded. Government bonds are held by domestic households only. Since the portfolio choice is not the central focus of the current paper, we consider these assumptions permissible. Denote by γ_{liq} the share of non-Ricardian households and by $1 - \gamma_{\text{liq}}$ the share of Ricardian households (superscript "liq" indicates that non-Ricardian households are liquidity-constrained, a term that we will use interchangeably). We assume that the share of non-Ricardian households in HOME is the same as in FOREIGN.

Households seek to maximize life-time utility

$$E_0 \sum_{t=0}^{\infty} e_t \beta^t \left[\xi_t^\tau \frac{(c_t^\tau - h_c c_{t-1}^\tau)^{1-1/\sigma^\tau}}{1-1/\sigma^\tau} - \psi^\tau A_t^{1-1/\sigma^s} \frac{(h_t^\tau)^{1+\nu}}{1+\nu} \right]$$

where parameter $\beta \in (0,1)$, and e_t is a unit-mean demand preference shock. Note that expectations are formed both about aggregate shocks and the future type τ. Households are indexed by their type and their country of residence, so that $\tau_t \in \{(H,\text{liq}),(F,\text{liq}),(H,b),(H,s),(F,b),(F,s)\}$, where the types will be described below. c_t^τ denotes consumption. h_t^τ denotes hours worked by the household. Parameter h_c $(0 < h_c < 1)$ indexes external habit persistence. $\sigma_\tau > 0$ is the intertemporal elasticity of substitution. Disutility of work is indexed by parameter $\psi^\tau > 0$ and trend productivity growth A_t. The latter ensures that the economy is consistent with balanced growth. Above, we suppress that household consumption and hours depend on the individual household i.

Let $c_{H,t}$ and $c_{F,t}$ be bundles of, respectively, HOME-produced and FOREIGN-produced differentiated intermediate goods, bundled according to the CES technologies

$$c_{H,t} = \left[\left(\frac{1}{\theta}\right)^{\frac{1}{\mu}} \int_0^\theta c_{H,t}(j)^{\frac{\mu-1}{\mu}} dj \right]^{\frac{\mu}{\mu-1}}, \qquad c_{F,t} = \left[\left(\frac{1}{1-\theta}\right)^{\frac{1}{\mu}} \int_\theta^1 c_{F,t}(j)^{\frac{\mu-1}{\mu}} dj \right]^{\frac{\mu}{\mu-1}}.$$

Here $\mu > 1$ marks the elasticity of substitution between goods within countries. Strictly speaking, instead of μ above, we should write μ_t, since we allow for markup shocks. We opt for not being more precise here for expositional parsimony.

The composite good c_t^τ is assumed to be a CES-bundle of the HOME bundle of goods and the FOREIGN bundle, with

$$c_t^\tau = \left[(\varpi)^{\frac{1}{\phi}} {c_{H,t}^\tau}^{\frac{\phi-1}{\phi}} + (1-\varpi)^{\frac{1}{\phi}} {c_{F,t}^\tau}^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}}, \quad \tau \in \{(H,b),(H,s)\}, \varpi \in (0,1), \phi > 0$$

There is home bias in private spending whenever parameter $\varpi > \theta$, which we will assume throughout. Parameter $\phi > 0$ provides a measure for the intratemporal elasticity of substitution across goods produced in different countries (the trade elasticity).[2]

Let $P_{H,t}(j)$ and $P_{F,t}(j)$ be the prices denoted in the common currency of differentiated domestic good j and foreign good j, respectively. We assume that the law of one price applies, so that net of VAT consumers in HOME and FOREIGN pay the same price for the same good j. The price indices for home and foreign good bundles are defined as $P_{H,t} = \left((1/\theta)\int_0^\theta P_{H,t}(j)^{1-\mu}dj\right)^{\frac{1}{1-\mu}}$ and $P_{F,t} = \left(1/(1-\theta)\int_\theta^1 P_{F,t}(j)^{1-\mu}dj\right)^{\frac{1}{1-\mu}}$. The price index for one unit of consumption spending, c_t^τ, (net of VAT) in HOME is given by[3]

$$P_t = \left[\varpi P_{H,t}^{1-\phi} + (1-\varpi)\, P_{F,t}^{1-\phi}\right]^{1/(1-\phi)}.$$

The terms of trade are defined as the relative price (both net of VAT) of HOME goods to FOREIGN goods

$$\tau_t = P_{H,t}/P_{F,t}.$$

Two features are worth noting here. First, changes in VAT are assumed to have a unitary pass-through to changes in final prices. What is assumed to be rigid are the prices net of VAT. Second, VAT is assessed according to where the goods are consumed, not where they are produced. Consumer prices including VAT (comparable to the euro area HICP), in HOME are given by[4]

$$P_t^c = (1+\tau_t^c)P_t.$$

[2] Similarly, for the FOREIGN households, the composite consumption good is given by

$$c_t^\tau = \left[(\varpi^*)^{\frac{1}{\phi}} c_{F,t}^{\tau\,\frac{\phi-1}{\phi}} + (1-\varpi^*)^{\frac{1}{\phi}} c_{H,t}^{\tau\,\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}, \quad \tau \in \{(H,b),(H,s)\}, \varpi^* \in (0,1).$$

If parameter $\varpi^* > (1-\theta)$, there is home bias in the FOREIGN country's consumption as well.

[3] The price index for one unit of spending in FOREIGN (net of VAT) is given by

$$P_t^* = \left[\varpi^* P_{F,t}^{1-\phi} + (1-\varpi^*)P_{H,t}^{1-\phi}\right]^{1/(1-\phi)}.$$

[4] and in FOREIGN by

$$P_t^{c*} = (1+\tau_t^{c*})P_t^*$$

2.2 Non-Ricardian households

Non-Ricardian households do not participate in asset markets. They consume all their income

$$c_t^{\text{liq}}(1+\tau_t^C) = \tau_t^{\text{transfer}} + e^{\text{liq}} w_t h_t^{\text{liq}}(1-\tau_t^L) - \frac{\phi_w}{2} A_t \left(\frac{w_t}{w_{t-1}} - g_A\right)^2$$

Above, τ_t^C is a value-added tax, τ_t^{transfer} are real lump-sum transfers from the government, τ_t^L is the labor tax rate, and w_t is the real wage rate per efficiency unit of labor. The non-Ricardian household's effective supply of labor is given by $e^{\text{liq}} h_t^{\text{liq}}$. The notation here anticipates that in equilibrium there will be just one economy-wide wage rate. Parameter $\phi_w > 0$ determines the Rotemberg-style wage adjustment costs. g_A is the trend growth rate of productivity. Non-Ricardian households sell a differentiated labor service to a competitive labor packer. The labor packer aggregates Non-Ricardian household's labor services into a homogenous labor service according to

$$l_t^{\text{liq}} = \left[\int_0^1 l_t(j)^{\frac{\eta-1}{\eta}} dj\right]^{\frac{\eta}{\eta-1}}, dj \quad \eta > 0.$$

Here $l_t(j)$ marks labor services of type j demanded by the packer. Letting w_t mark the price at which the packer sells the labor service, demand for labor services of type j is given by

$$l_t(j) = \left(\frac{w_t(j)}{w_t}\right)^{-\eta} l_t.$$

The households set the wage for their labor service j so as to maximize expected life-time utility subject to the budget constraint (and thus the wage adjustment costs). Imposing symmetry across liquidity-constrained households, the first-order condition for their wage setting can be expressed as

$$\begin{aligned}\phi_w A_t \tfrac{w_t}{w_{t-1}} \left(\tfrac{w_t}{w_{t-1}} - g_A\right) \quad &= \quad E_t \beta \tfrac{\lambda_{t+1}^{\text{liq}}}{\lambda_t^{\text{liq}}} \phi_w A_{t+1} \tfrac{w_{t+1}}{w_t} \left(\tfrac{w_{t+1}}{w_t} - g_A\right) \\ &\quad + \eta h_t^{\text{liq}} \left[e_t \psi^{\text{liq}} A_t^{1-1/\sigma^s} (h_t^{\text{liq}})^{\nu} / \lambda_t^{\text{liq}} - \tfrac{\eta-1}{\eta} w_t e^{\text{liq}} (1-\tau_t^L)\right]\end{aligned}$$

Here, $\lambda_t^{\text{liq}} := e_t \xi_t^{\text{liq}} (c_t^{\text{liq}} - h_c c_{t-1}^{\text{liq}})^{-1/\sigma^{\text{liq}}} / (1 + \tau_t^C)$ marks the marginal utility of income of a liquidity-constrained household.

2.3 Ricardian households

Ricardian households can substitute consumption intertemporally through saving and borrowing. As in Cúrdia and Woodford (2009), we assume that there are two types of Ricardian households. These are set apart by their preferences as regards intertemporal substitution. Ricardian households can be either borrowers (that is, have a preference for early consumption) or savers. This generates a role for financial intermediation. Borrowers are indexed by superscript b, saver households by superscript s. Among the Ricardian households, a fraction π_b are borrowers and a fraction $\pi_s = 1 - \pi_b$ are savers.

Following Cúrdia and Woodford (2009) savers can put their savings into domestic government bonds or make one-period risk-free deposits with a union-wide financial intermediary. Borrowers obtain funds from those financial intermediaries. As in Corsetti et al. (2014), their borrowing rates are subject to country-specific spreads. Intermediaries operate in a competitive market at the area-wide level. They fund themselves through deposits that pay the same return everywhere, regardless of the saver's country of residence. By contrast, the market for loans is fragmented and subject to country risk. In particular, the financial intermediaries' costs of lending to the resident of a particular member state rise with the costs of funding for the member state's sovereign. Thus, an increase in sovereign risk adversely affects private-sector borrowing conditions and depresses economic activity. These spillovers are at the heart of the "sovereign risk channel" explored in Corsetti et al. (2014).

In order to preserve tractability, we make an assumption that reduces the heterogeneity across households. Specifically, households of a particular type and country of residence are assumed to join large, representative families which pool the assets of their constituents of the respective type. Next, we assume that in each period a small, fixed share of households in HOME and FOREIGN are randomly selected to redraw not only their type (as in Cúrdia and Woodford 2009) but also their country of residence.[5]

[5] All households that are about to change type first pool their assets within their previous family. With

In each period, with probability $\delta \in (0, 1)$ a household is not selected to redraw its type. With probability $1 - \delta$ the household will redraw its type. If that is the case, with probability $1 - \pi$ the household does not redraw its country of residence, but only its borrower-saver type. Those households pool their resources and, with these, join the saver family with probability π_s and the borrower family with probability π_b. With probability $(1 - \delta)\pi$, the household not only redraws its preferences but also its location. In this case, the type changers pool resources not only with the type changers of their current country of residence but also with type changers of the other country. Type changers are assigned a country of residence as follows. θ is the probability of being assigned to HOME. $1 - \theta$ is the probability of being assigned to FOREIGN. Conditional on having been assigned to a country of residence, with probability π_b the type changer ends up with a borrower's preferences. With the opposite probability π_s, the household ends up being a saver.

For the Ricardian households, the type τ thus takes on one of the four realizations $\{(H, b), (H, s), (F, b), (F, s)\}$. Within each type, households' labor is differentiated. So, formally, a household is characterized by its type τ and household index $j \in [0, 1]$. For much of the exposition, however, we will suppress index j unless explicitly needed. In order to ensure balanced growth amid differences in intertemporal elasticities of substitution, we assume that $\xi_t^b = \xi^b A_t^{\frac{1}{\sigma_b} - \frac{1}{\sigma_s}}$. As a result, the marginal utilities of consumption of both savers and borrowers fall at the same rate as the economy grows. As before, we will assume identical preferences for borrowers and non-Ricardian households, so that $\xi_t^{\text{liq}} = \xi_t^b$. Further, we normalize $\xi_t^s = \xi^s$. As discussed above, we assume that there is complete pooling of assets within households of a particular location and type ("family"). Note that the assumed type-changing mechanism *partially* insures households across types, by making changes in wealth levels temporary. Nevertheless, changes in financial conditions will affect the consumption and labor supply decisions of different types τ differently.

We assume that Ricardian households who switch types inherit as the reference wage for the wage adjustment costs their new types' wage from last period. With this, the first-order

their share of these assets, they then join a family that corresponds to their newly-drawn type and country of residence. Clearly, these modeling assumptions imply that there is some limited cross-country risk sharing, irrespective of inter-euro-area fiscal transfers.

condition for wage setting for a Ricardian borrower household in HOME is given by

$$\begin{aligned}\phi_w A_t \tfrac{w_t}{w_{t-1}}\left(\tfrac{w_t}{w_{t-1}} - g_A\right) \quad = \quad & E_t \delta\beta \tfrac{\lambda^b_{t+1}}{\lambda^b_t}\phi_w A_{t+1}\tfrac{w_{t+1}}{w_t}\left(\tfrac{w_{t+1}}{w_t} - g_A\right) \\ & + \eta h^b_t \left[e_t \psi^b A_t^{1-1/\sigma^s}(h^b_t)^\nu/\lambda^b_t - \tfrac{\eta-1}{\eta} w_t e^b (1-\tau^L_t)\right]\end{aligned}$$

Here, $\lambda^b_t := e_t\xi^b_t(c^b_t - h_c c^b_{t-1})^{-1/\sigma^b}/(1+\tau^C_t)$ marks the marginal utility of income of a HOME borrower household. The wage equation for the saver results from replacing superscripts b with superscripts s.

From now on, we shall assume that liquidity-constrained households have the same preferences as the borrower households. We furthermore normalize the borrower's and liquidity-constrained household's efficiency of labor to unity. Households supply labor only in the country where they reside. Effective labor supply in the HOME economy, thus, is given by

$$h_t = (1-\gamma_{\text{liq}})(\pi_b h_{b,t} + \pi_s h_{s,t} e^s) + \gamma_{\text{liq}} h_{\text{liq},t}.$$

Stock of debt and deposits

Saving and borrowing are intermediated through perfectly competitive union-wide financial intermediaries. Throughout the paper, we assume that these intermediaries do not default. At the beginning of the period, and before type changes have played out, the combined wealth (denoted in nominal terms and per capita of the domestic population) of HOME households who are savers is given by

$$S^p_{t-1}(1+i^d_{t-1}) + (1-\vartheta_t)B^g_{t-1}(1+i^g_{t-1}) + T^c_t.$$

S^p_{t-1} denotes HOME households' deposits at financial intermediaries at the end of the previous period. The deposits earn the deposit rate i^d_{t-1}. Savers may also hold their domestic government's debt $B^g_{t-1} \geq 0$. We depart from CW by assuming that, for the individual household, government debt is not risk-free: In any given period, the government may honor its debt obligations, in which case $\vartheta_t = 0$; or it may partially default, in which case $\vartheta_t = \vartheta_{\text{def}}$, with $\vartheta_{\text{def}} \in (0,1)$ indicating the size of the haircut. i^g_{t-1} is the notional interest rate on government debt.

The *risk* of default affects the portfolio decisions of savers, and thus the wedge between the risk-free rate, i_t^d, and the interest rate on government debt, i_t^g. This interest rate wedge, as discussed below, plays a crucial role, affecting the allocation even prior to an actual sovereign default. To focus on the sovereign risk channel, we abstract from the possible *ex-post* consequences of an *actual* default through appropriate assumptions. Specifically, we assume transfers T_t^c that, in case of a sovereign default, compensate savers for the losses associated with the default (see Schabert and van Wijnbergen (2008) for a similar setup). These transfers do not affect investment decisions, as they are not proportional to the bond holdings of an individual saver. Formally, we set

$$T_t^c = \vartheta_t B_{t-1}^g (1 + i_{t-1}^g).$$

Analogous to the case of savers, at the beginning of the period, before type changes have played out, the combined debt of HOME households who are borrowers is given by $B_{t-1}^p(1 + i_{t-1}^b)$. where B_{t-1}^p denotes nominal private debt and i_{t-1}^b denotes the HOME borrowing rate. The beginning-of-period wealth of FOREIGN households is defined analogously. It bears noting that savers in HOME and FOREIGN receive the same rate of interest i_t^d on their deposits. As further specified below, we assume that this rate is the central bank's policy rate. By contrast, the rates of interest that borrowers in each of the two countries are charged may diverge.

The combined wealth of HOME saver households at the end of the period, i.e., after type changes have taken place, is given by:

$$\begin{aligned}
S_t^p + B_t^g \quad = \quad & \delta \left[S_{t-1}^p (1 + i_{t-1}^d) + B_{t-1}^g (1 + i_{t-1}^g) \right] \\
& + \pi_s (1-\delta)(1-\pi) \left[S_{t-1}^p (1 + i_{t-1}^d) + B_{t-1}^g (1 + i_{t-1}^g) - B_{t-1}^p (1 + i_{t-1}^b) \right] \\
& + \pi_s (1-\delta)\pi \quad \left[\theta(\, S_{t-1}^p (1 + i_{t-1}^d) + B_{t-1}^g (1 + i_{t-1}^g) - B_{t-1}^p (1 + i_{t-1}^b) \,) \right. \\
& \qquad \left. + \quad (1-\theta)(\, S_{t-1}^{p*} (1 + i_{t-1}^d) + B_{t-1}^{g*} (1 + i_{t-1}^{g*}) - B_{t-1}^{p*} (1 + i_{t-1}^{b*}) \,) \right] \\
& - \pi_s (1 - \gamma_{\text{liq}}) X_t^s .
\end{aligned}$$

Here the first row are the assets of households that stay savers. The second row pertains to the net assets of households who redraw their type but not the location. The third to fourth row are the net assets of households who pool internationally before redrawing both their type and their country of residence. X_t^s in the final row are the expenditures of a saver household net of their interest income:

$$\begin{aligned} X_t^s &= P_t c_t^s (1+\tau_t^c) - w_t e^s P_t h_t^s (1-\tau_t^l) - T_t^g \\ &\quad + \phi_w / 2\phi_w A_t (w_t / w_{t-1} - g_A)^2 \\ &\quad - D_{P,t}^f / (1-\gamma_{\text{liq}}) - D_t^{int} / (1-\gamma_{\text{liq}}). \end{aligned}$$

Above, $D_{P,t}^f$ is the cashflow generated by intermediate-goods producers and capital-goods firms in both HOME and FOREIGN. Since firms are held only be the Ricardian households, their revenues are only distributed to this share of the population. D_t^{int} are profits arising at the financial intermediaries. The intermediaries are assumed to be owned by HOME and FOREIGN households in proportion to their respective population size. Last, T_t^g are lump-sum transfers from the HOME government. τ_t^l, τ_t^p and τ_t^c are the labor, profit and consumption tax rates in HOME, respectively.

The combined end-of-period debt of HOME borrower households (per capita of the HOME population) is given by

$$\begin{aligned} B_t^p &= \delta B_{t-1}^p (1+i_{t-1}^b) \\ &\quad - \pi_b (1-\delta)(1-\pi) \left[S_{t-1}^p (1+i_{t-1}^d) + B_{t-1}^g (1+i_{t-1}^g) - B_{t-1}^p (1+i_{t-1}^b) \right] \\ &\quad - \pi_b (1-\delta)\pi \quad \left[\theta (S_{t-1}^p (1+i_{t-1}^d) + B_{t-1}^g (1+i_{t-1}^g) - B_{t-1}^p (1+i_{t-1}^b)) \right. \\ &\qquad\qquad + \quad \left. (1-\theta) (S_{t-1}^{p*} (1+i_{t-1}^d) + B_{t-1}^{g*} (1+i_{t-1}^{g*}) - B_{t-1}^{p*} (1+i_{t-1}^{b*})) \right] \\ &\quad + \pi_b (1-\gamma_{\text{liq}}) X_t^b. \end{aligned}$$

Net expenditures for the borrower, X_t^b, are defined analogously to those for the saver. The FOREIGN savings and debt levels follow laws of motion that are defined analogously to those for the HOME households.

Intertemporal consumption decisions

Turning to the intertemporal consumption decisions, note that, as a result of the family and pooling assumptions, all households of a specific type have a common marginal utility of real income, λ_t^τ. In HOME, the optimal choices regarding borrowing from and lending to intermediaries, as well as to the government, are governed by the following Euler equations:

$$\begin{aligned}
\lambda_t^s &= \beta(1+i_t^d)E_t\Big[\delta\lambda_{t+1}^s/\Pi_{t+1} + (1-\delta)(1-\pi+\pi\theta)\lambda_{t+1}/\Pi_{t+1} + (1-\delta)\pi(1-\theta)\lambda_{t+1}^*/\Pi_{t+1}^*\Big]. \\
\lambda_t^s &= \beta(1+i_t^g)E_t\Big[(1-\vartheta_{t+1})\Big(\delta\lambda_{t+1}^s/\Pi_{t+1} + (1-\delta)(1-\pi+\pi\theta)\lambda_{t+1}/\Pi_{t+1} \\
&\qquad +(1-\delta)\pi(1-\theta)\lambda_{t+1}^*/\Pi_{t+1}^*\Big)\Big]. \\
\lambda_t^b &= \beta(1+i_t^b)E_t\Big[\delta\lambda_{t+1}^b/\Pi_{t+1} + (1-\delta)(1-\pi+\pi\theta)\lambda_{t+1}/\Pi_{t+1} + (1-\delta)\pi(1-\theta)\lambda_{t+1}^*/\Pi_{t+1}^*\Big].
\end{aligned}$$

Above, $\lambda_t := \pi_b\lambda_t^b + \pi_s\lambda_t^s$ is the average marginal utility of consumption in HOME. λ_t^* is the same but for the FOREIGN terms. The consumption Euler equations have the same structure for the FOREIGN households.

Aggregate consumption in HOME is given by

$$c_t = (1-\gamma_{\text{liq}})(\pi_b c_{b,t} + \pi_s c_{s,t}) + \gamma_{\text{liq}} c_{\text{liq},t}$$

2.4 Firms

There are four sets of firms: financial intermediaries, capital producers, producers of intermediate goods, and final goods firms. All firms in the economy are held, in proportion to their population weights, by the currency-area's Ricardian households. Firms are not traded. We have to make an assumption as regards how the firms discount the future. We shall assume that the firms discount the future using the average marginal utility of their owners. Note that these are the ones to which the profits accrue. We assume that the firms, thus, value their actions using discount factor $Q_{t,t+1}$, where

$$Q_{t,t+1} = \beta\frac{\lambda_{t+1}^{\text{EA}}}{\lambda_t^{\text{EA}}}, \text{ where } \lambda_t^{\text{EA}} = \theta\lambda_t + (1-\theta)\lambda_t^*\frac{P_t}{P_t^*},$$

and correspondingly for the FOREIGN firms.

2.4.1 Financial intermediaries

Savers and borrowers have access to area-wide perfectly competitive intermediaries. The intermediaries accept risk-free deposits, paying the interest rate i_t^d. This is the same interest rate that the intermediaries would need to pay in order to refinance themselves at the central bank. Borrowing conditions, instead, depend on the jurisdiction in which the borrower resides. As in Cúrdia and Woodford (2009), we assume that in each period a fraction of loans χ_t and χ_t^* cannot be recovered in HOME and FOREIGN, respectively (due to, say, fraud).
Using ω_t as the spread between lending and deposit rates in HOME, we have

$$1 + \omega_t := \frac{1 + i_t^b}{1 + i_t^d}.$$

Choosing the amount of lending, B_t^p and B_t^{p*}, to maximize profits, the first-order conditions for loan origination yield

$$\omega_t = \chi_t \quad \text{and} \quad \omega_t^* = \chi_t^*.$$

Following Corsetti et al. (2014), we assume that χ_t and χ_t^* depend on sovereign risk in each country. This assumption is meant to capture the adverse effect of looming sovereign default risk on private-sector financial intermediation.[6] Specifically, we assume that in HOME

$$\chi_t = \chi_\psi[(1 + i_t^g)/(1 + i_t^d)]^{\alpha_\psi} - 1,$$

where parameter $\chi_\psi > 0$ is used to scale the private spread in the steady state, and $\alpha_\psi \geq 0$ measures the strength of the spillover from the (log) sovereign risk premium to the (log) private risk premium. In FOREIGN we have

$$\chi_t^* = \chi_\psi^*[(1 + i_t^{g*})/(1 + i_t^d)]^{\alpha_\psi^*} - 1.$$

The spreads in HOME and FOREIGN may thus differ. In the following, we will assume

[6] See Bocola (2016) for a more detailed analysis of how sovereign risks spread to banks' balance sheet

that the parameters that govern the spread (χ_ψ, α_ψ and $\chi^*_\psi, \alpha^*_\psi$) are the same in HOME and FOREIGN, respectively. Spreads can differ nevertheless if the yields on sovereign bonds in HOME and FOREIGN differ. Intermediaries are assumed to collect the largest quantity of deposits that can be repaid with the proceeds of the loans they originate, that is,

$$(1 + i^d_t)(\theta S^p_t + (1 - \theta)S^{p*}_t) = (1 + i^b_t)\theta B^p_t + (1 + i^{b*}_t)(1 - \theta)B^{p*}_t.$$

Finally, while the intermediaries in equilibrium do not make profits, we have to take into account the transfers from intermediaries to households implied by loans that are not recovered by the intermediaries. Therefore, in accounting for the value of the intermediary to the households, $D^{int}_t = \omega_t\theta B^p_t + \omega^*_t(1 - \theta)B^{p*}_t$.

Default

While *actual* default *ex post* is neutral in the sense described above, the *ex ante probability* of default is crucial for the pricing of government debt (i^g_t) and for real activity.[7] In the current paper, we follow Corsetti et al. (2013) and Corsetti et al. (2014) in operationalizing sovereign default by appealing to the notion of a fiscal limit in a manner similar to Bi (2012). Whenever the debt level rises above the fiscal limit, default will occur. The fiscal limit is determined stochastically, capturing the uncertainty that surrounds the political process in the context of sovereign default. Specifically, we assume that in each period the limit will be drawn from a generalized beta distribution with parameters α_{b^g}, β_{b^g}, and $\bar{b}^{\,\mathrm{g,max}}$. As a result, the *ex ante* probability of default, p_t, at a certain level of sovereign indebtedness, b^g_t, will be given by the cumulative distribution function of the beta distribution as follows:

$$p_t = F_{\mathrm{beta}}\left(\frac{b^g_t}{4y_H}\frac{1}{\bar{b}^{\,\mathrm{g,max}}}; \alpha_{b^g}, \beta_{b^g}\right).$$

[7]This implication of our setup is in line with evidence reported by Yeyati and Panizza (2011). Investigating output growth across a large number of episodes of sovereign default, they find that the output costs of default materialize in the run-up to defaults rather than at the time when the default actually takes place.

Note that $\bar{b}^{\mathrm{g,max}}$ denotes the upper end of the support for the debt-to-GDP ratio. Regarding the haircut this implies

$$\vartheta_t = \begin{cases} \vartheta_{\mathrm{def}} & \text{with probability } p_t, \\ 0 & \text{with probability } 1 - p_t. \end{cases}$$

The same holds for the FOREIGN government.

2.4.2 Capital producers

We turn to the capital producers. Productive capital is specific to the country for which it was built. We assume that the production of investment goods for HOME or FOREIGN uses the same composition of intermediate inputs as the production of consumption goods for HOME and FOREIGN consumers, respectively. Here the exposition is for HOME. The equations of FOREIGN are analogous.

The capital-goods producers in HOME generate nominal cashflow, $D_{k,t}$ in period t, where

$$D_{k,t} = P_t k^p_{t-1} \left(u_t r_{k,t}(1 - \tau_{k,t}) + (\delta_K + \phi_1(u_t - 1) + \phi_2/2 * (u_t - 1)^2)\tau_{k,t} \right) - P_t i^p_t$$

The first term are the revenues generated by renting out capital, net of capital taxes.[8] The second term reflects that there is a depreciation allowance that takes into account the actual depreciation of capital. The final term are the expenditures for investment. The capital stock in HOME, k_t, accumulates according to

$$k^p_t = \left(1 - (\delta_k + \phi_1(u_t - 1) + \frac{1}{2}\phi_2(u_t - 1)^2) \right) k^p_{t-1} + \zeta_t \left(1 - \frac{\kappa}{2} \left(\frac{i^p_t}{i^p_{t-1}} - g_A \right)^2 \right) i^p_t.$$

Parameters $\phi_1, \phi_2 > 0$ parameterize that depreciation of physical capital accelerates with capacity utilization, u_t. Parameter $\kappa > 0$ parameterizes the investment adjustment costs. Parameter ζ_t marks a unit-mean shock to the marginal efficiency of investment. The lower

[8] Note that capital taxes are assumed to be applied according to the country of origin, rather than by country of residence of the owner. In practice, home bias in portfolios means that most capital is held domestically. Capital taxes in HOME will, therefore, primarily distort investment in HOME. It is this effect that we wish to capture.

ζ, the higher the cost of turning output into capital goods.

Assuming that capital producers can deduct the actual depreciation from capital taxes, the first-order condition for utilization is

$$r_{k,t}(1-\tau_t^K)+(\phi_1+\phi_2(u_t-1))\tau_{k,t}=(\phi_1+\phi_2(u_t-1))E_tQ_{t,t+1}q_{k,t+1},$$

where $q_{k,t+1}$ is the shadow value of capital.

The first-order condition for investment is

$$1=E_tQ_{t,t+1}q_{k,t+1}\zeta_t\left[1-\frac{\kappa}{2}\left(\frac{i_t^p}{i_{t-1}^p}-g_A\right)^2-\kappa\left(\frac{i_t^p}{i_{t-1}^p}-g_A\right)\frac{i_t^p}{i_{t-1}^p}\right]+E_tQ_{t,t+1}q_{I,t+1}.$$

The envelope condition for capital gives

$$q_{k,t}=r_{k,t}u_t(1-\tau_t^K)+(\delta_K+\phi_1(u_t-1)+\phi_2/2(u_t-1)^2)\tau_t^K+E_tQ_{t,t+1}(1-(\delta_K+\phi_1(u_t-1)+\phi_2/2(u_t-1)^2))q_{k,t+1}.$$

The envelope condition for investment gives

$$q_{I,t}=E_tQ_{t,t+1}\zeta_t\kappa(i_t^p/i_{t-1}^p-g_A)\frac{i_t^{p2}}{i_{t-1}^{p\;2}}q_{k,t+1}.$$

2.4.3 Intermediate goods

In each of the two countries, there is a continuum of intermediate goods firms. HOME firms are indexed by $j\in[0,\theta)$, FOREIGN firms by $j\in[\theta,1)$. In order to operate, firms have to expend a fixed amount of production to funding fixed operating costs ΞA_t. As before, here we focus the exposition on the producers in HOME. Each of these produce a differentiated good using the production function

$$y_{H,t}(j)=z_tk_t(j)^\alpha(A_tl_t(j))^{1-\alpha},\ 0<\alpha<1$$

where z_t marks the country-specific temporary productivity level, whereas A_t marks trend productivity with

$$\log A_t=g_A+\log A_{t-1}+\epsilon_t^A.$$

$k_t(j)$ marks the capital stock that the firms rents in a competitive market. $l_t(j)$ marks the labor input rented from the competitive labor packers. In addition, the firm is subject to a fixed cost of production ΞA_t, to be satisfied using HOME goods.

Cost-minimization combined with market clearing for capital goods implies that

$$r_{k,t} = mc_t \alpha z_t (u_t k_{t-1})^{\alpha-1} (A_t l_t)^{1-\alpha}$$

With marginal costs given by

$$mc_t = \frac{w_t^{1-\alpha} r_{k,t}^{\alpha} \frac{1}{1-\alpha}^{1-\alpha} \frac{1}{\alpha}^{\alpha}}{z_t A_t^{1-\alpha}}$$

In each period only a fraction $(1-\alpha_C)$ of intermediate goods firms are able to reoptimize their prices. Firms that do not reoptimize adjust their price by $\Pi^{\iota}\Pi_{H,t-1}^{1-\iota}$. With $\iota \in [0,1]$ firms thus partially index prices to past inflation rates. Those firms that can reset their price in period t maximize expected discounted profits. This gives rise to the standard non-linear variant of the New Keynesian Phillips curve.[9] The law of motion for prices of the HOME-produced basket ($\Pi_{H,t} := P_{H,t}/P_{H,t-1}$) is given by

$$1 - \alpha_C \left(\frac{\Pi^{\iota}\Pi_{H,t-1}^{1-\iota}}{\Pi_{H,t}} \right)^{1-\mu} = (1-\alpha_C) \left(\frac{P_{H,t}^{opt}}{P_{H,t}} \right)^{1-\mu}.$$

For future reference, it is also useful to define price dispersion of HOME goods as $\Delta_{H,t} := \frac{1}{\theta}\int_0^{\theta} \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\mu} dj$, which evolves according to

$$\Delta_{H,t} = \alpha_C \Delta_{H,t-1} \left(\frac{\Pi_{H,t}}{\Pi} \right)^{\mu} + (1-\alpha_C) \left(\frac{P_{H,t}^{opt}}{P_{H,t}} \right)^{-\mu}.$$

[9] Namely, the resulting first-order condition for a generic firm that adjusts its price, $P_{H,t}^{opt}$, is given implicitly by $F_t = K_t$, with these auxiliary terms being given by

$$K_t = (1-\tau_t^p)\frac{\mu}{\mu-1} mc_t y_t \left(\frac{P_{H,t}^{\text{opt}}}{P_{H,t}}\right)^{-\mu} + \alpha_C \beta E_t \frac{\lambda_{t+1}^{\text{EA}}}{\lambda_t^{\text{EA}}} \left(\frac{P_{H,t}^{\text{opt}}\Pi^{\iota}\Pi_{H,t}^{1-\iota}}{P_{H,t+1}^{\text{opt}}}\right)^{-\mu} K_{t+1}$$

$$F_t = (1-\tau_t^p) y_t \left(\frac{P_{H,t}^{\text{opt}}}{P_{H,t}}\right)^{1-\mu} \left(\frac{P_{H,t}}{P_t}\right) + \alpha_C \beta E_t \frac{\lambda_{t+1}^{\text{EA}}}{\lambda_t^{\text{EA}}} \left(\frac{P_{H,t}^{\text{opt}}\Pi^{\iota}\Pi_{H,t}^{1-\iota}}{P_{H,t+1}^{\text{opt}}}\right)^{1-\mu} F_{t+1}$$

Analogous expressions apply to the corresponding FOREIGN terms. Finally, nominal profits distributed to households by these firms are (in per capita terms) given by $D^f_{H,t} = \frac{1}{\theta}\left[\int_0^\theta P_{H,t}(j)y_{H,t}(j) - P_t w_t h_t(j) - A_t \Xi P_{H,t} dj\right]$; or, in equilibrium, $D^f_{H,t} = P_{H,t}\, y_{H,t} - P_t w_t h_t - A_t \Xi P_{H,t}$. Here $y_{H,t} = \left[(1/\theta) \int_0^\theta y_{H,t}(j)^{\frac{\mu-1}{\mu}}\, dj\right]^{\frac{\mu}{\mu-1}}$ denotes the per capita production of the bundle of differentiated goods produced in the HOME country.

2.5 Government

In each block of the currency union, the respective government finances a stream of government consumption expenditures, g_t, of government investment, i^g_t, and of government transfers, T^g_t, through taxes on consumption, labor income, corporate taxes and capital taxes. Any residual will be filled by issuing or settling government debt. Taking into account the transfers in case of default (see Section 2.3), nominal HOME government debt (per capita of the HOME population) evolves according to:

$$
\begin{aligned}
B^g_t \quad = \quad & B^g_{t-1}(1 + i^g_{t-1}) \\
& + P_{H,t} g_t + P_t i^g_t + T^g_t \\
& - k^g_{t-1} u_t r_{k,t} \\
& - k^p_{t-1} \tau_{k,t} \left(u_t r^k_t - (\delta_K + \phi_1 (u_t - 1) + \phi_2 / 2 * (u_t - 1)^2) \right) \\
& - (P_t c_t \tau^c_t + P_t w_t h_t \tau^l_t + P_t D^f_{H,t} \tau^p_t).
\end{aligned}
$$

The first row is the debt with interest inherited from last period. The second row are the government's expenditure items. Namely, the government expends resources for government consumption, for government investment and for lump-sum transfers. The row reflects that government consumption expenditures are assumed to fall on the domestic goods only (the HOME government purchases only the HOME-type goods), whereas government investment has the same mix as the private-sector's investment activity. The next row has the government's revenues. The government generates revenue from renting out its capital stock to the private sector. It also (fourth row) generates revenues from taxes levied on private-sector capital income net of the depreciation allowance. Last, the government generates revenue from consumption taxes, labor taxes, and corporate taxes (last row). In our data, we will not be able to finely delineate corporate taxes and capital taxes. We will, therefore, in the following assume that they are equal, namely, $\tau_t^p = \tau_t^k$.

A key contribution of the current paper as opposed to earlier studies on the effects of the euro-area fiscal mix, for example in 't Veld (2013), is the disaggregation of fiscal measures instrument by instrument. Our model being a rational expectations model, not only the current level of these instruments matters but so do expectations as regards future fiscal policy. The governments in HOME and FOREIGN decide on the setting of their respective fiscal instruments. In the current paper, we will not model the optimal choice of these instruments. Rather, and following the literature, we will specify fiscal rules that govern the value of each of these instruments. The rules and their parametrisation are described in the main text.

2.5.1 Monetary policy

Turning to monetary policy, we assume throughout that the central bank follows a Taylor-type interest rate rule for the aggregate economy that also seeks to insulate aggregate economic activity from fluctuations in risk spreads if feasible, that is unless the central bank becomes constrained by the zero lower bound. The area-wide interest rate is set according to:

$$\begin{aligned}\log(1+i_t^d) \quad = \quad & \rho_R \log(1+i_{t-1}^d) + (1-\rho_R)\log(1+i^d) \\ & + \phi_\Pi \left[\theta \log(\Pi_t/\Pi) + (1-\theta)\log(\Pi_t^*/\Pi)\right] \\ & - \phi_\omega \left[\theta \log((1+\omega_t)/(1+\omega)) + (1-\theta)\log((1+\omega_t^*)/(1+\omega))\right]. \\ & + \phi_y \left[\theta \log(y_{H,t}/y_H) + (1-\theta)\log(y_{F,t}^*/y_F)\right].\end{aligned}$$

Here, $\phi_\Pi > 1$, $\phi_\omega > 0$, and $\phi_y \geq 0$.[10] The measure of potential output that we use for each of the countries is trend output.

[10] We will assume below that the central bank, if possible, will set ϕ_ω so as to neutralize the effect that the spreads ω_t and ω_t^* have on aggregate activity. For the closed economy, Cúrdia and Woodford (2009) show that optimal policy in the presence of credit frictions involves such an adjustment of policy rates in response to interest rate spreads.

2.6 Market clearing

Goods-market clearing in HOME and FOREIGN, respectively, requires[11]

$$\begin{aligned} \theta y_{H,t} \quad = \quad & \theta(c_{H,t} + i_{H,t}) + (1-\theta)(c^*_{H,t} + i^*_{H,t}) + \theta g_t \\ & +\theta \cdot \tfrac{\phi_w}{2} A_t \cdot (w_t / w_{t-1} - g_A)^2 \\ & +\theta \cdot \Xi \cdot A_t \end{aligned}$$

and

$$\begin{aligned} (1-\theta) y_{F,t} \quad = \quad & \theta(c_{F,t} + i_{F,t}) + (1-\theta)(c^*_{F,t} + i^*_{F,t}) + (1-\theta) g^*_t \\ & +(1-\theta) \cdot \tfrac{\phi_w}{2} A_t \cdot (w^*_t / w^*_{t-1} - g_A)^2 \\ & +(1-\theta) \cdot \Xi \cdot A_t \end{aligned}$$

the last two terms in these equations being, respectively, the wage adjustment costs and the fixed production costs in HOME and FOREIGN.[12]

The supply of HOME and FOREIGN output, in respective per capita terms, is given by

$$y_{H,t} \Delta_{H,t} = z_t (u_t k_{t-1})^{\alpha} \cdot (A_t h_t)^{1-\alpha}.$$

and

$$y_{F,t} \Delta_{F,t} = z^*_t (u^*_t k^*_{t-1})^{\alpha} \cdot (A_t h^*_t)^{1-\alpha}.$$

The total stock of capital in each of the economies is given by

$$k_t = k^g_t + k^p_t.$$

and

$$k^*_t = k^{g*}_t + k^{p*}_t.$$

[11] This already takes into account goods-market clearing at the level of each individual good.

[12] Again, one could introduce the intermediation costs in the clearing conditions.

2.7 Calibration

In a first step, we calibrate the steady state of the model economy to euro-area averages. Where there is overlap, we follow the calibration strategy of Corsetti et al. (2014). In the following, HOME refers to peripheral countries and FOREIGN to the rest of the euro area. In terms of structural parameters we assume that both regions are isomorphic, except for fiscal policies and size: HOME accounts for the GDP weight of Ireland, Greece, Spain, Italy and Portugal within the euro area. A time period in the model is one quarter. There are four blocks of parameters that need to be calibrated: fiscal parameters, household-level parameters, technology parameters, financial parameters, and shocks.

We start with the fiscal block. The strategy that we have is as follows, our baseline will contain symmetric fiscal rules for the core and the periphery. The only difference between countries then is in the state that characterizes their economies.

We assume a steady-state value of the consumption tax rate of 21 percent, of the labor tax rate of 39 percent, and the capital tax rate of 13.5 percent. All of these values are in line with the euro-area pre-crisis average. As regards the steady-state government debt to GDP level, we assume that government debt in both the core and the periphery converge to a level that amounts to 60 percent of annual GDP. Government consumption is assumed to settle at a level of 20 percent of GDP, government investment at a level of 3.5 percent of GDP. These values, along with the other calibration choices discussed below imply that transfers make up 18 percent of steady-state GDP. We do not calibrate the steady-state level of government transfers. Rather, we let this level be determined residually. Reassuringly, the level of government transfers thus implied at about 16 percent of GDP is consistent with the pre-crisis euro-area average.

We parameterize the fiscal rules according to the estimates that Coenen et al. (2013) obtain for the euro area as a whole- with one exception: the capital tax rule. Monetary policy is parameterized so as to exhibit interest rate persistence. Furthermore, we assume that monetary policy aims to absorb the effect of rising spreads on economic activity, so long as it can. The response parameters to inflation and the output gap take standard values.

Next, we turn to the calibration of the household-level parameters. Here, too, we opt for

Table 1: Fiscal and monetary parameters

	value	description	country	target
Long-run targets for distortionary taxes				
$\tau^{c\text{targ}}$	0.21	Consumption tax	H, F	pre-crisis EA avg
$\tau^{L\text{targ}}$	0.39	Labor tax	H, F	pre-crisis EA avg
$\tau^{K\text{targ}}$	0.135	Capital tax	H, F	pre-crisis EA avg
Long-run targets for debt and spending				
$b_y^{g\text{targ}}$	0.60	Gov't debt to annual GDP target	H, F	Maastricht treaty
g/y^{targ}	0.20	Gov't consumption/GDP	H, F	pre-crisis EA avg
i^g/y^{targ}	0.035	Gov't investment/GDP	H, F	pre-crisis EA avg
Adjustment parameters: taxes				
ρ_{τ^c}	0.91	persistence	H, F	Coenen et al. (2013)
$\theta_{\tau^c,B}$	0	response to debt	H, F	"
$\theta_{\tau^c,Y}$	0	response to output gap	H, F	"
ρ_{τ^L}	0.75	persistence	H, F	Coenen et al. (2013)
$\theta_{\tau^L,B}$	0.02	response to debt	H, F	"
$\theta_{\tau^L,Y}$	-0.01	response to output gap	H, F	"
ρ_{τ^K}	0.97	persistence	H, F	about Forni et al. (2009)
$\theta_{\tau^K,B}$	0.003	response to debt	H, F	"
$\theta_{\tau^K,Y}$	-0.003	response to output gap	H, F	"
Adjustment parameters: expenditures				
Government consumption				
ρ_g	0.77	persistence	H, F	Coenen et al. (2013)
$\theta_{G,B}$	-0.02	response to debt	H, F	"
$\theta_{G,Y}$	0.06	response to output gap	H, F	"
Government investment				
ρ_{i^g}	0.70	persistence	H, F	Coenen et al. (2013)
$\theta_{i^g,B}$	-0.18	response to debt	H, F	"
$\theta_{i^g,Y}$	0.55	response to output gap	H, F	"
Transfers				
ρ_{T^g}	0.70	persistence	H, F	Coenen et al. (2013)
$\theta_{T^g,B}$	-0.14	response to debt	H, F	"
$\theta_{T^g,Y}$	0.1	response to output gap	H, F	"
Monetary policy				
ρ_R	0.85	interest rate persistence	EA	standard value
ϕ_Π	1.5	response to inflation	EA	"
ϕ_ω	0.5	response to spread	EA	seek to absorb effect of spread on economic activity in normal times.
ϕ_y	0.5/8	response to output gap	EA	half of Taylor 93
$\overline{\Pi}$	1.005	inflation target	EA	two percent inflation per annum

Notes: Fiscal parameters of the baseline calibration.

symmetry whenever possible. A third of the population of the area as a whole resides in the periphery, so that $\theta = 1/3$. We model fifty percent of the population as savers. The remaining fifty percent split half into non-Ricardian (that is, liquidity-constrained) households and Ricardian borrower-type households. That is, we set $\gamma_{\text{liq}} = 0.25$, $\pi_b = 1/3$, and $\pi_s = 2/3$. The former is close to standard estimates in the literature. We assume that households are selected for type switches rarely, and even more rarely so for international switches, setting $\delta = 0.95$ (selected for new type draw once every 5 years), and π=0.2. These choices imply that an international type switch occurs once every 25 years. We target a real rate of interest

Table 2: Household-level parameters

	value	description	country	target
Types				
θ	1/3	population periphery	H	population share
γ_{liq}	0.25	share of liquidity-constrained hh	H, F	standard value
π_b	1/3	share of borrowers Ricardian hhs	H, F	share of savers of 50 percent
δ	0.95	prob. not selected for type switch	H, F	Selected once every 5 years
π	0.20	prob. of redrawing location	H, F	international pooling is rare
Preferences				
β	0.9976	Time-discount factor	H, F	Real return of 1.5 percent p.a.
ξ^s	0.0517	scaling param. util. of cons. saver	H, F	Target: hh debt 60% of GDP
ξ^b	0.1724	scaling param. util.y of cons. borrower	H, F	Target: hh debt 60% of GDP
ξ^{liq}	0.0416	scal. param. util. cons. liq-constr. hh	H, F	scaling constant: $h^{\text{liq}} = 1$
σ^b	1/1.4	intertemp. elast. subst. borrower	H, F	Smets and Wouters (2003)
σ^s	1/1.4	intertemp. elast. subst. saver	H, F	Smets and Wouters (2003)
ψ^s	0.2096	scaling param. disutil. of work saver	H, F	hours worked $h^s = 1$
ψ^b	0.1188	scaling param. disutil. work borrower	H, F	hours worked $h^b = 1$
h_c	.6	external consumption habits	H, F	Smets and Wouters (2003)
ν	2.5	inverse of Frisch elasticity	H, F	”
ϕ	0.85	trade elasticity	H, F	typical macro, Corsetti et al. (2008).
Work				
e^s	2	efficiency units of work savers	H, F	savers earn twice as much per hour.

Notes: Parameters on the household side for the baseline calibration.

of 1.5 percent, which (along with the other assumptions on preferences and growth) gives us parameter $\beta = 0.9976$. The scaling parameters for the utilities of labor are determined by. We target equal interest sensitivity of borrowers and savers in the baseline, setting the intertemporal elasticity of substitution to the common low values in the literature $\sigma = 1/1.4$. The scaling parameters for the disutility of work are derived from our assumption that all households have the same labor supply in steady state. Consumption habits are set to a moderate value of $h_c = 0.6$, in line with the estimates in the literature. We assume a rather low labor supply elasticity at the hours margin. Similarly, we set a parameter for the trade elasticity at a value of $\phi = .85$, reflecting the low short-run estimates for trade elasticities in the macro literature. Last, we assume that $e^s = 2$, so that saver households are twice as effective at work as borrowers or liquidity-constrained households.

In terms of the technology parameters, we parameterize the production function in a standard way. The parameters for the adjustment costs of investment and the costs of utilization are chosen so as to make the model replicate the magnitude of the investment and utilization responses in VAR studies. Similarly, we set the wage adjustment cost parameter to $\phi_w = 828$, which is roughly consistent with a Calvo wage rigidity of 4 quarters. Wages and prices are

Table 3: Technology parameters, financial parameters, and shocks

	value	description	country	target
α	1/3	capital-elasticity of production	H, F	standard
δ_K	0.015	depreciation rate of capital	H, F	6 percent per annum
κ	1	indexes investment adjustment cost	H, F	inv. response to mon. shock
α_C	0.925	price stickiness	H, F	flatter Phillips curve.
μ	11	elast. of demand diff. goods	H, F	standard value
Ξ	0.00	fixed costs of production	H, F	baseline.
ι	0.8	inflation indexation to past inflation	H, F	some inflation persistence
ϕ_1	0.0218	first-order term slope utilization costs	H, F	target of unitary utilization
ϕ_2	0.04	quadratic term utilization costs	H, F	utiliz. response to mon. shock
Wages				
η	11	demand elasticity hours	H, F	wage markup of 10 percent
ϕ_w	828	param governing wage adj. costs	H, F	slope as Calvo model 0.75
Financial parameters				
α_{b^g}	3.70	parameterization of sov. spread	H, F	Corsetti et al. (2014)
β_{b^g}	0.53	"	H, F	"
$\overline{b}^{g,\max}$	2.56	"	H, F	"
ϑ_{def}	0.55	haircut given default	H, F	"
α_ψ	0.55	spillover sov. spread to priv. spread	H,F	"
ξ_ψ	1.0057	scaling parameter spread	H, F	spread of 2.5 percent p.a.
Shocks				
ρ_z	0.85	persistence technology shock	H, F	Smets and Wouters (2003)
ρ_e	0.85	persistence demand pref. shock	H, F	"
ρ_ζ	0.86	persistence investment shock	H, F	" (5% bound)
ρ_μ	0.9	persistence markup shock	H, F	Smets and Wouters (2007)

Notes: Fiscal parameters of the baseline calibration.

assumed to be sticky for about five quarters each, standard values. We allow for a moderate indexation of producer price inflation to past inflation rates, so as to mimic the persistence of inflation. The parameterization of the sovereign risk channel follows Corsetti et al. (2014). We will solve the model through sequences of perfect-foresight simulations without future shocks. Therefore, all that we need to specify here is the persistence of shocks. In setting the baseline for assessing the role of the fiscal mix in the euro area in recent years, we will choose values for the permanent productivity shock, A_t, for the two country-specific TFP shocks, z_t and z_t^*, for the marginal efficiency of investment shocks, ζ_t and ζ_t^*, for the markup shocks μ_t and μ_t^*, and for the demand-preference shocks, e_t and e_t^*. For parsimony, we will assume that all the latter have persistence 0.9.

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