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Macroeconomic stabilisation properties of a euro area unemployment insurance scheme

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Abstract

In this paper we use a medium-scale DSGE model to quantitatively assess the macroeconomic stabilisation properties of a supranational unemployment insurance scheme. The model is calibrated to the euro area's core and periphery and features a rich fiscal sector, sovereign risk premia and labour market frictions. Adopting both simple policy rules and optimal policies, our simulations point to enhanced business cycle synchronisation and inter-regional consumption smoothing. Depending on the exact specification, the results suggest a reduction in the volatility of consumption by up to 49% at the region-level, while the cross-regional correlation of unemployment and inflation increases by up to 52% and 27%, respectively, compared to the decentralised setting. The higher degree of inter-regional risk-sharing comes at the cost of sizable fiscal transfers. Limiting such transfers via claw-back mechanisms implies a much weaker degree of stabilisation across countries.
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Non-technical summary

Unlike other monetary unions, the euro area is lacking a central budgetary instrument for macroeconomic stabilisation purposes. Following the European sovereign debt crisis, a broad consensus has emerged that a stronger fiscal dimension is needed to complete the architecture of Economic and Monetary Union (EMU). The publication of the Four Presidents' Report (see Van Rompuy et al., 2012) and later the Five Presidents' Report (see Juncker et al., 2015) have fuelled the related debate on the creation of a euro area fiscal capacity to enhance the EMU's resilience to economic shocks. Enhanced risk-sharing in the euro area is advocated also on the back of empirical evidence that suggests a more limited absorption of country-specific shocks in the euro area compared to the United States due, among other factors, also to the lack of a federal budget. European Unemployment Insurance (EUI) has been at the core of the debate on the creation of a euro area fiscal instrument.

This paper analyses the macroeconomic stabilisation effects of a euro area unemployment insurance using a medium-scale open-economy New Keynesian dynamic stochastic general equilibrium (DSGE) model. We build on the currency union model of Stähler and Thomas (2012) which we extend along the following dimensions. First, we add a contribution-based supranational unemployment insurance system at the union level that complements the national insurance systems. Our focus lies on inter-regional rather than intertemporal smoothing of economic shocks, as we abstract from the issuance of supranational debt. Second, similar to real-world social security systems – such as for example the US federal-state unemployment insurance system – we incorporate features to limit persistent transfers between regions, such as experience rating and claw-back mechanisms. Third, we introduce sovereign risk premia as in Corsetti et al. (2013), which allow us to analyse the implications of cross-country heterogeneity regarding the size of public debt.

Calibrating the model to the core and periphery of the euro area, our results suggest that a meaningful stabilisation of business cycle volatility can be achieved by the introduction of a EUI scheme. The stabilisation effects depend in particular on the specific design of the insurance scheme, the degree of cross-country correlation of shocks, and the fiscal space available at the national level. In our baseline calibration, we find that the volatility of GDP, consumption, unemployment, and inflation at the region-level can be reduced by up to 20%, 49% 21%, and 12% respectively. Moreover, the cross-regional correlation of unemployment and inflation increases by up to 52% and 27%, respectively, compared to the decentralised setting. The higher degree of inter-regional risk-sharing however comes at the cost of sizable fiscal transfers. Limiting such transfers via claw-back mechanisms implies a much weaker degree of stabilisation across countries.

Generally, the effectiveness of a EUI system to provide business-cycle stabilisation is lower the higher is the correlation of shocks between regions, as our analysis abstracts from the issuance of supranational debt. From a macroeconomic stabilisation point of view, the desirability of a EUI system therefore also depends on the presence of fiscal constraints at the level of the national fiscal authorities. The presence of non-linear cost of debt in our analysis introduces such constraints. By alleviating the national budget constraints in the presence of regional economic shocks, the EUI generates fiscal space at the national level which can be used to avoid pro-cyclical cuts in spending or increases in taxes.

1 Introduction

Unlike other monetary unions, the euro area is lacking a central budgetary instrument for macroeconomic stabilisation purposes. Following the European sovereign debt crisis, a broad consensus has emerged that a stronger fiscal dimension is needed to complete the architecture of Economic and Monetary Union (EMU). The publication of the Four Presidents' Report (see Van Rompuy et al., 2012) and later the Five Presidents' Report (see Juncker et al., 2015) have fuelled the related debate on the creation of a euro area fiscal capacity to enhance the EMU's resilience to economic shocks. Enhanced risk-sharing in the euro area is advocated also on the back of empirical evidence that suggests a more limited absorption of country-specific shocks in the euro area compared to the United States due, among other factors, also to the lack of a federal budget (see, e.g., European Central Bank, 2018). In this context, Farhi and Werning (2017) make the case for state-contingent fiscal transfers in order to take account of demand externalities within the currency union.

European Unemployment Insurance (EUI) has been at the core of the debate on the creation of a euro area fiscal instrument. Beblavý and Lenaerts (2017) present the main findings of a comprehensive research study on the feasibility of EUI. In this context, several options were analysed in terms of design, legal and institutional implications as well as economic impact. The European Commission in its roadmap for deepening Europe's Economic and Monetary Union (see European Commission, 2017) proposed a scheme to protect public investment in downturns, to be triggered by significant increases in unemployment compared to longer-term trends. Arnold et al. (2018) argue in favor of a central macroeconomic stabilisation fund that provides transfers to countries in economic bad times based on a pre-funded rainy day fund. Bénassy-Quéré et al., 2018) also put forward a rainy-day fund solution to insure against large shocks to unemployment. All of these proposals have in common that the underlying trigger is related to regional unemployment, i.e. activation of the scheme relates to cross-country unemployment differentials. Moreover, the proposals typically comprise safeguard mechanisms to avoid excessive cross-country redistribution which may fuel moral hazard. European Unemployment Insurance has again been put on the policy agenda by European Commission President Von der Leyen in her political guidelines for the 2019-24 European political cycle.

This paper analyses the macroeconomic stabilisation effects of a euro area fiscal capacity using a medium-scale open-economy New Keynesian dynamic stochastic general equilibrium (DSGE) model. The analysis focuses on the concept of a European unemployment insurance (EUI) that is considered to complement national unemployment insurance systems, in order to provide additional assistance to countries hit by adverse employment shocks. We build on the basic modelling structure of Stähler and Thomas (2012), i.e. a monetary union with search and matching frictions in labour markets, sticky price and wage setting, and incomplete asset markets. The framework also provides a rich fiscal sector characterised by several revenue and spending instruments and the issuance of domestic public debt. We extend the framework along the following dimensions. First, we add a contribution-based supranational unemployment insurance system at the union level that complements the national insurance systems. Our focus lies on inter-regional rather than intertemporal smoothing of economic shocks, as we abstract from the issuance of supranational debt. Second, similar to real-world social security systems – such as for example the US federal-state unemployment insurance system – we incorporate features to limit persistent transfers between regions, such as experience rating and claw-back mechanisms. Third, we introduce sovereign risk premia as in Corsetti et al. (2013), which allow us to analyse the implications of cross-country heterogeneity regarding the size of public debt.

We study various different settings for the EUI including optimal policy and various simple rules that can take into account cross-regional differences in the state of the business cycle and the amount of transfers a region received in the past. Calibrating the model to the core and periphery of the euro area, our results suggest that a meaningful stabilisation of business cycle volatility can be achieved by the introduction of a EUI scheme. The stabilisation effects depend in particular on the specific design of the insurance scheme, the degree of cross-country correlation of shocks, and the fiscal space available at the national level. In case of our baseline calibration, we find that the volatility of GDP, consumption, unemployment, and inflation at the region-level can be reduced by up to 20%, 49% 21%, and 12% respectively. As we exclude the option to finance the EUI intertemporally, the stabilisation at the aggregate level is smaller. The volatility of euro area output and consumption decrease by about 4% each. We obtain this result under a EUI scheme chosen optimally by a Ramsey-policy planner that aims to maximize utility of all agents in both regions.

We rule out the presence of permanent transfers *ex ante* by including an experience rating for regions. This implies that countries that would need to rely more heavily on a cross-national insurance system, e.g. due to higher structural unemployment in the past, would also need to make higher contributions. However, *ex post*, i.e. after the realisation of new shocks, permanent transfers are possible. These can be addressed by a claw-back mechanism that imposes temporarily higher contributions on countries that obtained more transfers from the EUI system in the past. We find that under optimal policy, non-negligible permanent transfers are ex post likely to occur, but the introduction of claw-back mechanisms can be effective in avoiding permanent distributional effects. This comes, however, at the cost of reduced stabilisation gains of such a policy scheme.

Generally, the effectiveness of a EUI system to provide business-cycle stabilisation is lower the higher is the correlation of shocks between regions, as the agency responsible for the EUI is not assumed to have a debt capacity. Moreover, we find that from a macroeconomic stabilisation point of view, the desirability of such a system depends decisively on the fiscal space of the national fiscal authorities. In case the latter are not restricted in issuing additional national debt, e.g. by risk premia that increase with the debt level, the value added of an additional supranational transfer system is limited, as national authorities can issue additional debt to cushion the negative impact of adverse shocks. In the case of limited fiscal space due our assumption of non-linear cost of public debt, support by the EUI frees fiscal space at the national level which can be used by national governments to avoid pro-cyclical spending cuts or increase in taxes taxes.

Although the policy debate about different designs for a fiscal capacity for the euro area has been vivid in the recent past, little formal analysis that is also suited for policy analysis is available at this stage. Our paper aims to contribute to this field. Closely related to our analysis, Moyen et al. (2019) analyse an optimal unemployment insurance scheme for the EMU in a two-region DSGE-model with frictional unemployment. They show the existence of a trade-off between cross-country risk sharing and an efficient labour market allocation due to the effect of unemployment insurance on replacement rates and households' work incentives. Compared to this work, our paper employs a larger medium-scale DSGE model, where we compare the macroeconomic stabilisation effects of different design schemes for a EUI. We also explicitly analyse the issue of permanent cross-regional transfers due to a EUI and we study ways to limit the occurance of such transfers.

The remainder of this paper is structured as follows. Section 2 provides a review of the related literature. An overview of the main features of the model is presented in Section 3, while the model calibration to the euro area's core and periphery is explained in Section 4. Section 5) discusses the main results and sensitivity analysis. Section 6 concludes.

2 Related literature

Already the early literature on optimal currency areas (Mundell, 1961, McKinnon, 1963 and Kenen, 1969) emphasises the role of fiscal transfers as a means to absorb asymmetric shocks. In the absence of the exchange rate mechanism, fiscal transfers are deemed necessary to stabilise regional economic shocks when monetary policy is geared to union-wide developments. The new open economy macroeconomics literature analyses the optimal conduct of monetary and fiscal policies in currency unions with explicit microfoundations (see, e.g., Beetsma and Jensen, 2005, Galí and Monacelli, 2008, Ferrero, 2009, Hjortsoe, 2016, and Kaufmann, 2019). Analysing optimal policy, these studies typically find a clear-cut separation of tasks between national fiscal policy makers and the central monetary authority. The former address idiosyncratic output shocks and inter-regional inflation differentials, while the latter ensures price stability at the level of the monetary union.

Evers (2015) uses a similar modelling framework to analyse different setups of fiscal federalism within a monetary union. He concludes that compared to a decentralised setup, a central fiscal authority tends to enhance cross-regional consumption smoothing and risk-sharing while a system of inter-regional fiscal equalization transfers is associated with relative welfare losses. This finding also links to the literature on the fiscal-federal design in currency unions and moral hazard (see, e.g., Persson and Tabellini, 1996). More recently, Farhi and Werning (2017) show that – without coordination – private insurance against idiosyncratic shocks tends to be inefficiently low in the presence of demand externalities within the currency union, even if financial markets are complete. The paper therefore emphasises a complementary role for public risk-sharing via state-contingent inter-regional transfers.

The empirical literature on risk-sharing in monetary unions focusses on the quantification of different channels of inter-regional consumption smoothing. The pioneering work by Asdrubali et al. (1996) on the US suggests that interstate variation in GDP is largely smoothed via cross-border holdings of financial assets and credit. The US federal budget complements these private channels of risk-sharing via social security related transfers to households and, to a lesser extent, transfers to state governments. The empirical risk-sharing model is also applied to other federations (see, e.g. Burriel et al., 2020) as well as the euro area (see, e.g., European Central Bank, 2018). Compared to the US, the euro area typically reveals a more limited degree of risk-sharing via financial and credit markets while public risk-sharing hardly occurs, given the lack of a federal budget with a stabilisation role. The latter finding is often put forward as an argument for the creation of a central fiscal capacity for macroeconomic stabilisation purposes (see, e.g., Juncker et al., 2015, Arnold et al., 2018 and Bénassy-Quéré et al., 2018).

European Unemployment Insurance has been at the core of the debate on the creation of a euro area fiscal instrument. A number of contributions assess the properties of different variants of an EUI scheme based on counterfactual simulation analyis (see, e.g., Beblavý and Lenaerts, 2017). The schemes analysed typically differ according to a number of key features, notably genuine schemes that pay directly to the unemployed versus equivalent schemes that provide transfers to the national fiscal authorities. Other features include the coverage of the scheme, the economic trigger as well as safeguards to avoid moral hazard and permanent transfers, such as experience rated contributions and claw-back mechanisms. Koester and Sondermann (2018) analyse the effects of differently designed EUI schemes for euro area countries between 2002 and 2014, coming to the conclusion that the degree of stabilisation in general would have been relatively contained given the importance of aggregate shocks during that period, especially if incorporating features that safeguard against moral hazard.

Another strand of the literature analyses the effects of EUI based on microeconometric simulations. Dolls et al., 2018 assess the risk-sharing properties of an unemployment insurance scheme for the euro area for the period 2000-2013. Based on their simulations, income volatility related to unemployment could have been reduced by around 10%, suggesting an important cross-regional stabilisation effect. Contingent benefits to reduce cross-country redistribution would have, however, limited the insurance effect.

Finally, EUI has been analysed in DSGE-models. In a two-country business cycle model with incomplete financial markets and frictional labour markets, Moyen et al. (2019) show that optimal risk-sharing via a supranational unemployment insurance increases the counter-cyclicality of replacement rates compared to the decentralised setting. Simulation results based on a calibration to the euro area's core and periphery suggest significant distributional effects via the unemployment insurance system. Ábrahám et al. (2019) study design options for a

EUI in a multi-country general equilibrium model with labour market frictions. The paper focuses on heterogeneous labour market institutions at the national level and implications for the setting up of a European system. Assuming a low replacement rate to maintain incentives to work as well as country-specific payroll taxes to eliminate cross-country persistent transfers, the analysis shows only small welfare gains from insuring against country-specific shocks via the federal unemployment insurance.

3 The model

Our model is based on a New Keynesian DSGE model for fiscal policy simulations ("FiMod") by Stähler and Thomas (2012). This model features a two-region monetary union, where the total population size of the union is normalised to unity with a share ω living in the home region and the share $1 - \omega$ living in the foreign region.

The model includes a rich fiscal block and a granularly-modelled labour market with search and matching frictions. This setting makes it particularly suitable for the analysis of a supranational unemployment insurance scheme. The model features sticky price and wage setting, incomplete asset markets, and two types of households: intertemporally-optimizing and liquidity-restricted consumers.

We follow the exposition of Stähler and Thomas (2012) closely both in terms of model ingredients and in notation. As such, quantity variables are expressed in per capita terms throughout the paper unless stated differently. We depart from the FiMod mainly in the following aspects. We assume a utility function that features complementarity between private and public consumption, we incorporate risky government debt, and the existence of a supranational fiscal authority. For brevity, we do not describe the model at the same level of detail as Stähler and Thomas (2012) and refer the reader instead to their original paper and the online appendix. A graphical representation of the standard model is given in Figure 5 in Appendix A. The following exposition of the model is given from the perspective of the home region, while the foreign region is modelled analogously.

3.1 Households

As in Stähler and Thomas (2012), we assume that each region in the monetary union is populated with two types of households of total mass one in the spirit of Galí et al. (2007). "Ricardian" households, indexed by o (standing for intertemporally "optimising"), comprise a share $(1 - \mu)$. They have access to financial markets and can, hence, smooth their consumption intertemporally. The remaining share μ of households, indexed by r (standing for liquidity-"restricted"), is not able to either safe nor borrow on financial markets. These "hand-to-mouth" households consume their disposable income each period in full. Both household types $i \in \{o, r\}$ have a continuum of members with a total mass of one and maximise the utility function

$$\mathbb{U}_0(i) = \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \frac{\left[\widetilde{c}_t^i - h \cdot \widetilde{c}_{t-1}^i\right]^{1-\sigma_c} - 1}{1-\sigma_c} \right\}, \tag{1}$$

where $\mathbb{E}_0$ is an expectations operator conditional on information in period 0, β the discount factor, σ_c the coefficient of relative risk aversion, and h measures the degree of habit persistence in the consumption of $\widetilde{c}_t^i$. The latter is a CES-aggregator of private and public consumption following

$$\widetilde{c}_t^i = \left[\psi_g^{1/\nu_g} \left(c_t^i\right)^{\frac{\nu_g - 1}{\nu_g}} + (1-\psi_g)^{1/\nu_g} \left(C_t^g\right)^{\frac{\nu_g - 1}{\nu_g}}\right]^{\frac{\nu_g}{\nu_g - 1}}, \tag{2}$$

where ψ_g is a preference share parameter, while $\nu_g > 0$ denotes the elasticity of substitution between private (c_t^i) and public (C_t^g) consumption goods. When $\nu_g \to 0$, the two types of goods are perfect complements, when $\nu_g \to \infty$ they are perfect substitutes, while the function becomes Cobb-Douglas in case of $\nu_g \to 1$. The households take the level of public consumption as given and it does not (directly) enter their budget constraint. We follow Coenen et al. (2013) in this specification to introduce government consumption to the utility function in a non-separable way.[1]

The private consumption basket of a type i household, c_t^i, is defined as a composite index over domestically- and foreign-produced tradable consumption goods according to

$$c_t^i = \left(\frac{c_{At}^i}{\omega + \psi}\right)^{\omega+\psi} \left(\frac{c_{Bt}^i}{1-\omega-\psi}\right)^{1-\omega-\psi}, \tag{3}$$

where c_{At}^i and c_{Bt}^i denote goods produced in region A (home) and B (foreign), respectively. The degree of home bias of consumption is determined by the parameter ψ. The corresponding producer price indices (PPI) are P_{At} and P_{Bt}, while it can be shown that the consumer price index (CPI) reads

$$P_t = P_{At}^{\omega+\psi} P_{Bt}^{1-\omega-\psi}. \tag{4}$$

CPI inflation is given by

$$\pi_t \equiv \frac{P_t}{P_{t-1}} = \pi_{At} \frac{p_{Bt}}{p_{Bt-1}}^{1-\omega-\psi}, \tag{5}$$

with $\pi_{At} \equiv P_{At}/P_{At-1}$ being PPI inflation in region A and $p_{Bt} \equiv P_{Bt}/P_{At}$ the terms of trade.

Besides consuming today, Ricardian households can save in internationally traded private bonds, in risky government bonds of their respective national government, and in physical capital. They receive labour income from working in the private and the public sector and

[1] These authors find a strong complementarity between public and private consumption when estimating their model. Similar to the presence of hand-to-mouth households, this feature supports, ceteris paribus, a positive correlation between private and public consumption.

unemployment benefits in case they are unemployed. Their budget constraint reads

$$\begin{aligned}(1+\tau_t^c)\,c_t^o + I_t^o + \frac{B_t^o + D_t^o}{P_t} + \frac{T_t}{1-\mu} &= \frac{\Pi_t}{P_t} + \left(\left(1-\tau_t^k\right) r_t^k - \frac{\rho^{RP}}{1-\vartheta_t} + \tau_t^k \delta^k\right) k_{t-1}^o \\ &+ \frac{R_{t-1} B_{t-1}^o}{P_t}(1-\vartheta_t) + \frac{D_t^S}{1-\mu} + \frac{R_{t-1}^{ecb} e^{-\psi_d (d_{t-1}-d)/Y_{t-1}} D_{t-1}^o}{P_t} + \frac{Sub_t}{1-\mu} \\ &+ (1-\tau_t^w)\left(w_t^p n_t^{p,o} + w_t^g n_t^{g,o}\right) + \left(1 - n_t^{p,o} - n_t^{g,o}\right)\kappa^U. \qquad (6)\end{aligned}$$

The labour income is determined by real wages in the private (p) and the public (g) sector, w_t^p and w_t^g, and the number of households employed in both sectors, $n_t^{p,o}$ and $n_t^{g,o}$. The wage income is subject to the labour income tax τ_t^w. Households without labour receive unemployment benefits κ^U. T_t and Sub_t denote lump-sum taxes and subsidies, respectively. The Ricardian households own the firms and receive nominal per capita profits Π_t. Their consumption purchases c_t^o are subject to a value-added tax τ_t^c.

Households in both regions can trade in an international bond D_t^o that yields the safe union-wide interest rate R_t^{ecb} plus a risk premium $e^{-\psi_d(d_{t-1}-d)/Y_{t-1}}$ that increases with the region's real net foreign asset position $d_t = D_t/P_{At}$ relative to its steady state d with D_t being the home's nominal net foreign asset position, Y_t output, and ψ_d a parameter.

We model risky government debt holdings B_t^o as in Corsetti et al. (2013), where governments can partially default on their bonds each period. The return on government bonds R_t is therefore discounted with an ex-ante expected haircut rate of ϑ_t. D_t^s denotes a lump-sum transfer to households that compensates the bondholders in case of a sovereign default. This setup leads to a risk premium between the risk-free rate and the government bond yield of[2]

$$RP_t \equiv \frac{R_{t-1}}{R_{t-1}^{ECB}} = \frac{1}{1-\vartheta_t}. \qquad (7)$$

Investments in physical capital, k_t^o, are denoted I_t^o. Capital is rented out to firms at the real rental rate r_t^k and it depreciates at the rate δ^k. Capital income net of depreciations is taxed at the rate τ_t^k. As in Corsetti et al. (2013) and Attinasi et al. (2017), we assume that there can be partial pass-through $\rho^{RP} \in [0,1]$ of the risk premium on sovereign bonds to private sector borrowing rates. This aims to capture the observed co-movement of private sector yields with the risk premium on debt issued by their respective sovereign. Private physical capital evolves according to

$$k_t^o = \left(1-\delta^k\right) k_{t-1}^o + \left[1 - S(I_t^o/I_{t-1}^o)\right] I_t^o, \qquad (8)$$

where $S(I_t^o/I_{t-1}^o) = (\kappa_I/2)\left(I_t^o/I_{t-1}^o - 1\right)^2$ is an investment adjustment cost function.

[2]For related setups, see Cantore et al. (2019) as well as Schabert and van Wijnbergen (2014).

Maximizing (1) subject to (6) and (8) yields the following first-order conditions:

$$\lambda_t^o = \frac{\left[\widetilde{c}_t^o - h \cdot \widetilde{c}_{t-1}^o\right]^{-\sigma_c} - \beta \cdot h \cdot E_t\left\{\left[\widetilde{c}_{t+1}^o - h \cdot \widetilde{c}_t^o\right]^{-\sigma_c}\right\}}{1+\tau_t^c}\left(\frac{\psi_g \widetilde{c}_t^o}{c_t^o}\right)^{1/\nu_g}, \quad (9)$$

$$\lambda_t^o = \beta R_t^{ecb} e^{-\psi_d(d_t-d)/Y_t} E_t\left\{\frac{\lambda_{t+1}^o}{\pi_{t+1}}\right\}\epsilon_t^d, \quad (10)$$

$$\lambda_t^o = \beta E_t\left\{\frac{\lambda_{t+1}^o}{\pi_{t+1}} R_t\left(1-\vartheta_{t+1}\right)\right\}, \quad (11)$$

$$Q_t = \beta E_t\left\{\frac{\lambda_{t+1}^o}{\lambda_t^o}\left[(1-\delta^k)Q_{t+1} + (1-\tau_{t+1}^k) r_{t+1}^k - \rho^{RP}\frac{\vartheta_t}{1-\vartheta_t} + \tau_{t+1}^k \delta^k\right]\right\}, \quad (12)$$

$$1 = Q_t\left[1 - S(I_t^o/I_{t-1}^o) - I_t^o S'(I_t^o/I_{t-1}^o)\right] + \beta E_t\left\{\frac{\lambda_{t+1}^o}{\lambda_t^o} Q_{t+1}\left(\frac{I_{t+1}^o}{I_t^o}\right)^2 S'(I_{t+1}^o/I_t^o)\right\}, \quad (13)$$

where λ_t^o and $Q_t\lambda_t^o$ are the Lagrange multiplier on equations (6) and (8), respectively. ϵ_t^d is a non-structural risk premium shock as in Smets and Wouters (2007), which is one of the few shocks that are able to generate a positive co-movement between, inter alia, consumption and investment over the business cycle.[3]

Hand-to-mouth households cannot engage actively in financial markets and consume the proceedings of their disposable income each period. Their budget constraint reads

$$(1+\tau_t^c)\, c_t^r = (1-\tau_t^w)\left(w_t^p n_t^{p,r} + w_t^g n_t^{g,r}\right) + \left(1 - n_t^{p,r} - n_t^{g,r}\right)\kappa^U + \frac{Sub_t}{\mu}. \quad (14)$$

Marginal utility of the hand-to-mouth consumers is given by an equation equivalent to (9).

All household quantity variables can generally be aggregated to total per capita units by taking the weighted average over both household types, such that $X_t = (1-\mu)x_t^o + \mu x_t^r$ for a generic variable X_t.

3.2 Production

The setup of the supply side of the economy follows Stähler and Thomas (2012) one-to-one. In the home region, there is a mass ω of retail producers that bundle a variety of intermediate goods into final goods. They sell these final goods Y_t at the price P_{At} to both regions, where the law of one price is assumed to hold. Final goods producers operate under perfect competition.

The intermediate goods firms j produce intermediate goods with the Cobb-Douglas technology

$$y_t(j) = \left[k_{t-1}^g\right]^\eta \left[k_t(j)\right]^\alpha \left[l_t(j)\right]^{1-\alpha}, \quad (15)$$

[3] Fisher (2015) shows that ϵ_t^d can be interpreted as a structural shock to the demand for safe and liquid assets. Christiano et al. (2015), among others, find this shock to be particularly helpful in explaining macroeconomic dynamics after the great recession.

where $k_t(j)$ and $l_t(j)$ are the demand for capital and labour services from the household sector, while $\alpha \in [0, 1)$ denotes the capital input elasticity of production. k^g_{t-1} is the stock of public capital available in period t, which is provided by the public sector. The parameter $\eta \in [0, 1)$ determines how productivity-enhancing public capital is. The intermediate goods producers operate under monopolistic competition and are subject to sticky price friction á la Calvo (1983), for further details, we refer to Stähler and Thomas (2012).

3.3 Labour markets

The description of the labour market of the economy follows Stähler and Thomas (2012) one-to-one. Firms do not employ workers directly. Instead, there are labour agencies that hire workers and bundle their labour into a homogeneous labour service, which they offer to the intermediate goods firms.

The labour markets are characterised by search and matching frictions. Workers can be in one of three states: Either they either work in the private or the public sector or they are unemployed. The unemployment rate is given by

$$U_t = 1 - N^p_t - N^g_t, \tag{16}$$

where N^p_t and N^g_t denote per capita employment in the private and the public sector, respectively. The pool of searching workers at the beginning of each period, $\tilde{U}_t$, consists of the previously unemployed plus those workers, who loose their job at a constant separation probability. Both private firms and the government search in the same pool for workers. Matching is described by a standard Cobb-Douglas matching function as

$$M^f_t = \kappa^f_e \left(\tilde{U}_t\right)^{\phi^f} \left(v^f_t\right)^{1-\phi^f} \quad \forall f \in \{p, g\}, \tag{17}$$

where M^f_t is the number of new matches in period t, κ^f_e the matching-efficiency parameter, ϕ^f the matching elasticity, and v^f_t the number of vacancies in sector f.

The private sector firms decide about creating new jobs optimally by trading off the expected value of a filled vacancy for the firm against the cost of opening a vacancy plus an additional training cost upon matching. Firms additionally have to pay a social security contribution rate τ^{sc}_t.

To determine the wage level, firms and workers engage in Nash bargaining over the expected surplus of employed workers. Wage bargaining happens in a Calvo-type staggered fashion, where each period a randomly chosen fraction of firms cannot renegotiate wages.

Employment and wages in the public sector are set separately by the regional governments as will be described below. For further details on the setup of the labour market, we refer again to Stähler and Thomas (2012).

3.4 Regional fiscal authorities

The budget constraint of the regional fiscal authority reads

$$b_t + \frac{R_{t-1}}{\pi_t}(1-\vartheta_t)b_{t-1} + PD_t, \tag{18}$$

where $b_t \equiv B_t/P_t$ denotes the real CPI-deflated per capita end-of-period government debt. PD_t is the real per capita primary deficit given by per capita fiscal expenditures minus fiscal revenues and defined as

$$\begin{aligned} PD_t \quad = \quad & \left[\frac{G_t}{p_{Bt}^{1-\omega-\psi}} + \kappa^{U,A}U_t + D_t^S + Sub_t + T_t^{EU}\right] \\ & - \left[\left(\tau_t^{w,A} + \tau_t^{sc}\right)\left[w_t^p N_t^p + w_t^g N_t^g\right] + \tau_t^c C_t + \tau_t^k\left(r_t^k - \delta^k\right)k_{t-1} + T_t\right], \end{aligned} \tag{19}$$

where $\kappa^{U,A}$ are unemployment benefits paid by the national fiscal authority to the domestic households. $\tau_t^{w,A}$ is the labour income tax levied by the authorities in region A. In case there exists a supranational fiscal capacity, T_t^{EU} denotes the per-capita lump-sum contributions from region A to the euro area authority, which will be discussed in more detail in the next section. G_t denotes the the per capita government spending in PPI terms, which is divided by $P_t/P_{At} = p_{Bt}^{1-\omega-\psi}$ to obtain a CPI-deflated term. G_t is in turn defined as

$$G_t = C_t^g + I_t^g + \left[\left(1+\tau_t^{sc}\right)w_t^g N_t^g\right] p_{Bt}^{1-\omega-\psi}, \tag{20}$$

where C_t^g and I_t^g denote public purchases of consumption and investment goods, respectively. All public purchases are exclusively on domestic goods, i.e. there is full home bias in consumption of the fiscal authority. The last part of government spending, $\left[\left(1+\tau_t^{sc}\right)w_t^g N_t^g\right] p_{Bt}^{1-\omega-\psi}$, is the public wage bill, gross of social security contributions.

The law of motion for the public capital stock is given by

$$k_t^g = \left(1-\delta^g\right)k_{t-1}^g + I_t^g, \tag{21}$$

assuming that public capital depreciates at the rate δ^g.

Following Corsetti et al. (2013), the lump-sum transfer that is paid to households in case of a sovereign default, D_t^S, is set in such a way that a default does not affect the actual debt level, i.e.

$$D_t^S = \vartheta_t \frac{b_{t-1}R_{t-1}}{\pi_t}. \tag{22}$$

This is necessary, as a lower post-default debt level would be anticipated by agents and could lead to even smaller risk premia on government debt ex ante. The size of the ex-ante expected haircut rate ϑ_t is given by the exogenously given actual haircut rate in case of a default ϑ^{def}

times the default probability p_t^S:

$$\vartheta_t = p_t^S \vartheta^{def} + \left(1 - p_t^S\right) 0 = p_t^S \vartheta^{def}. \tag{23}$$

To describe the default probability, we proceed as in Cantore et al. (2019) and Bi and Traum (2014). This approach can be implemented easily using perturbation methods. In this setting, default occurs when last period's debt-over-GDP, $\Gamma_{t-1} = b_{t-1}/Y_{t-1}^{tot}$ is higher than a stochastic fiscal limit, $\tilde{\Gamma}_t$, also expressed in terms of debt-to-GDP.[4] Each period this fiscal limit is drawn from a distribution, whose cumulative density function is given by the logistical function

$$p_t^S = P\left(\Gamma_{t-1} \geq \tilde{\Gamma}_t\right) = \frac{\exp\left(\eta_1 + \eta_2 \Gamma_{t-1}\right)}{1 + \exp\left(\eta_1 + \eta_2 \Gamma_{t-1}\right)}, \tag{24}$$

where η_1 and η_2 are two parameters that determine the shape of the distribution. p_t^S can then be interpreted as the default probability of the government.

The evolution of the various tax and spending instruments is modelled by simple rules. In total, the regional government has access to five tax and five spending instruments. The rules for τ_t^c, $\tau_t^{w,A}$, τ_t^{sc}, T_t, C_t^g, I_t^g, and N_t^g take the form

$$\frac{X_t}{X} = \left(\frac{X_{t-1}}{X}\right)^{\rho_x} \left(\frac{b_t}{b}\right)^{\xi_{b,x}} \left(\frac{Y_t^{tot}}{Y^{tot}}\right)^{\xi_{y,x}}, \tag{25}$$

where variables without a time subscript denote steady state values. These instruments are described by an autoregressive process with the coefficient ρ_x and they depend on government debt and GDP, all relative to their respective steady state values. The parameters $\xi_{b,x}$ and $\xi_{y,x}$ denote the elasticities of the instrument relative to steady state deviations of debt and GDP, respectively. τ_t^k and w_t^g are assumed to be constant over the business cycle.

Subsidies are assumed to consist of two components such that

$$Sub_t = Sub_t^A + Sub_t^{EU}, \tag{26}$$

where $Sub_t^{w,A}$ follows a fiscal rule as in (25), while $Sub_t^{EU} = -\omega^{EU} T_t^{EU}$, which implies that a share ω^{EU} of transfers the national fiscal authority receives from the supranational level is directly forwarded to the household sector.[5]

In the absence of a euro area fiscal capacity, it holds that $\tau_t^w = \tau_t^{w,A}$, $\kappa^U = \kappa^{U,A}$, and $T_t^{EU} = 0 \, \forall t$. Otherwise, their evolution is described in Section 3.6.2.

[4] The model counterpart of GDP, denoted by Y_t^{tot}, will be defined below.

[5] Farhi and Werning (2017) make a similar asssumption of (partial) direct pass-through of cross-regional transfers to the household sector.

3.5 Foreign region and international linkages

The foreign region, whose variables and parameters are indicated by an asterisk (*), is modelled analogously to the home region. We therefore provide only a limited set of equations that is needed to understand the international linkages between regions. In particular, the consumption basket of foreign households reads

$$c_t^{i*} = \left(\frac{c_{At}^{i*}}{\omega - \psi^*} \right)^{\omega - \psi^*} \left(\frac{c_{Bt}^{i*}}{1 - \omega + \psi^*} \right)^{1-\omega+\psi^*}, \tag{27}$$

where c_{At}^{i*} and c_{Bt}^{i*} denote the consumption of foreign households of goods produced in region A (home) and B (foreign), respectively. ψ^* is a parameter that governs the degree of home bias in consumption of households in the foreign region. The foreign consumer price index is given by

$$P_t^* = P_{At}^{\omega-\psi^*} P_{Bt}^{1-\omega+\psi^*}. \tag{28}$$

The current account from the perspective of region A links the two economies and is given by

$$d_t = \frac{R_{t-1}^{ecb} e^{-\psi_d (d_{t-1} - d)/Y_{t-1}}}{\pi_{At}} d_{t-1} + p_{Bt}^{1-\omega-\psi} Tr_t + \frac{1-\omega}{\omega} \left(C_{At}^* + I_{At}^* \right) - p_{Bt} \left(C_{Bt} + I_{Bt} \right), \tag{29}$$

where $(1-\omega)\left(C_{At}^* + I_{At}^*\right)/\omega$ are real per capita exports and $p_{Bt}\left(C_{Bt} + I_{Bt}\right)$ are real per capita imports. A fiscal transfer Tr_t in favour of region A, which will be defined in Section 3.6.2, is ceteris paribus related with a deficit in the trade balance, while paying a transfer to the other region requires a trade surplus.[6] The market clearing condition for the international bonds is given by

$$\omega d_t + (1-\omega) p_{Bt} d_t^* = 0. \tag{30}$$

The goods market clearing conditions show that per capita production is used for private and public consumption and investment in both regions,

$$Y_t = C_{At} + I_{At} + C_t^g + I_t^g + \frac{1-\omega}{\omega} \left(C_{At}^* + I_{At}^* \right) \tag{31}$$

$$Y_t^* = C_{Bt}^* + I_{Bt}^* + C_t^{g*} + I_t^{g*} + \frac{\omega}{1-\omega} \left(C_{Bt} + I_{Bt} \right). \tag{32}$$

Following Stähler and Thomas (2012) and consistent with national accounting rules, we define the GDP of each region as the sum of private- and public-sector production of goods and

[6] On this, see also Devereux and Smith (2007) as well as the literature on the classical transfer problem by Keynes (1929) and Ohlin (1929).

services. Real GDP per capita in then given by

$$Y_t^{tot} = Y_t + (1+\tau_t^{sc})\, w_t^g N_t^g p_{Bt}^{1-\omega-\psi} \tag{33}$$

$$Y_t^{tot*} = Y_t^* + (1+\tau_t^{sc*})\, w_t^{g*} N_t^{g*} p_{Bt}^{-(\omega-\psi^*)} \tag{34}$$

3.6 European authorities

3.6.1 Monetary policy

The interest rate is set by the European Central Bank for the monetary union according to a standard Taylor rule that responds to the harmonised index of consumer prices (HICP) and GDP deviations from their respective steady state values. The rule is given by

$$\frac{R_t^{ecb}}{R^{ecb}} = \left(\frac{R_{t-1}^{ecb}}{R^{ecb}}\right)^{\rho_R} \left\{ \left[\left(\frac{\pi_t^c}{\pi^c}\right)^{\omega} \left(\frac{\pi_t^{c*}}{\pi^{c*}}\right)^{1-\omega} \right]^{\varphi_\pi} \left[\left(\frac{Y_t^{tot}}{Y^{tot}}\right)^{\omega} \left(\frac{Y_t^{tot*}}{Y^{tot*}}\right)^{1-\omega} \right]^{\varphi_y} \right\}^{1-\rho_R}, \tag{35}$$

where the parameter ρ_R determines the persistence of the interest rate, while φ_π and φ_y give the responsiveness of the central bank to inflation and output deviations. $\pi_t^c \equiv \pi_t \left(1+\tau_t^c\right) / \left(1+\tau_{t-1}^c\right)$ denotes after-VAT CPI inflation in line with Eurostat's definition of the HICP that is given by the term in the first square bracket.

3.6.2 European unemployment insurance

The unemployment insurance system is in general defined in terms of the replacement rate

$$rr_t = \frac{\kappa^U}{(1-\tau_t^w)w_t}, \tag{36}$$

which is the share of household net labour income that is replaced by public benefits in case of unemployment. The European unemployment insurance scheme is modelled as follows. The scheme is managed by a supranational fiscal authority. We assume that the EUI partially substitutes for the national insurance systems. Specifically, we assume in line with available policy analysis (e.g. Beblavý and Lenaerts, 2017) that the European system covers the unemployment benefits needed for a given level of a long-run steady state replacement rate that is identical for all countries, rr_t^{EU}. In a next step, countries have the option to top up on this system with an additional term rr_t^A in case they want to be more generous. The total replacement rate can, thus, be defined as

$$rr_t = rr_t^{EU} + rr_t^A, \tag{37}$$

where

$$rr_t^{EU} = \frac{\kappa^{U,EU}}{(1-\tau_t^w)w_t} \quad \text{and} \quad rr_t^A = \frac{\kappa^{U,A}}{(1-\tau_t^w)w_t} \tag{38}$$

implicitly define the size of the European and the region-specific unemployment benefits $\kappa^{U,EU}$ and $\kappa^{U,A}$. Total unemployment benefits paid to households are accordingly given by

$$\kappa^{U} = \kappa^{U,EU} + \kappa^{U,A}. \tag{39}$$

Notably, unemployment benefits per capita are held constant at their steady state value, such that replacement rates may fluctuate over the business cycle. Besides, since net wages can differ across the countries of the union, the European unemployment benefits $\kappa^{U,EU}$ can have a different size in the two regions to ensure the same level of European steady state replacement rates in all member states.

We assume that the EUI is financed either via lump-sum contributions T_t^{EU} levied on the national fiscal authorities or via direct European social security contributions from workers, τ_t^{EU}. In the latter case, the total labour income taxation levied on households consists of a national and a European part:

$$\tau_t^{w} = \tau_t^{EU} + \tau_t^{w,A}. \tag{40}$$

The budget constraint of the EUI agency reads[7]

$$\begin{aligned} \kappa^{U,EU}\omega U_t + \kappa^{U,EU*} p_{Bt}^{\psi+\psi^*}(1-\omega)U_t^* \quad = \quad & \tau_t^{EU}\omega\left[w_t^p N_t^p + w_t^g N_t^g\right] \\ & + \tau_t^{EU*}(1-\omega)p_{Bt}^{\psi+\psi^*}\left[w_t^{p*}N_t^{p*} + w_t^{g*}N_t^{g*}\right], \end{aligned} \tag{41}$$

where $p_{Bt}^{\psi+\psi^*} = P_t^*/P_t$ denotes the real exchange rate between the two regions of the monetary union.

From the perspective of the home region, whenever the payments made to the EUI are smaller than the funds received, *implicit* transfers to the region can occur that are defined as

$$Tr_t \equiv \kappa^{U,EU} U_t - \tau_t^{EU}\left(w_t^p N_t^p + w_t^g N_t^g\right). \tag{42}$$

The regional contribution rates need to be set in order to fulfill the budget constraint (41) at any time, since we do not allow for an intertemporal European debt capacity in this setting. For both, the stabilization and the distributional effects of the EUI it is decisive how these regional contribution rates are set. The simplest case, where $\tau_t^{EU} = \tau_t^{EU*}\forall t$ such that (41) holds, would imply permanent transfers, also in steady state. In order to avoid permanent transfers between the regions *ex ante*, we introduce an *experience rating*. According to this, regions that experienced higher unemployment levels in the past need to contribute relatively more to the common European scheme, as also discussed by Beblavý and Lenaerts (2017).[8] In

[7] In the following exposition, we focus on the case where the EUI scheme is financed via τ_t^{EU}. The structure of the model is analogously in case the EUI is financed via T_t^{EU}. Additionally, the EUI could also be financed via debt issuance from the supranational agency. In this paper we abstract from this possibility.

[8] As an example, experience rating is used systematically in the United States to determine contributions of firms to the state-level unemployment insurance systems. This is done to force employers to internalise the social cost of laying off workers.

our model, this implies that we set the steady-state rates τ^{EU}, τ^{EU*} such that no transfers occur in steady state:

$$Tr = \kappa^{U,EU} U - \tau^{EU} \left(w^p N^p + w^g N^g \right) \stackrel{!}{=} 0 \tag{43}$$

$$Tr^* = \kappa^{U,EU*} U^* - \tau^{EU*} \left(w^{p*} N^{p*} + w^{g*} N^{g*} \right) \stackrel{!}{=} 0 \tag{44}$$

This implies that contribution rates of the regions will differ from one another depending on their past economic experiences, such as the steady-state unemployment rates or the productivity level.

3.6.3 Simple rules and optimal policy

In response to shocks the contribution rates need to be adjusted to balance the budget of the EUI agency. The simplest approach would be to set the regional contribution rates proportional to each other, such that

$$\tau_t^{EU} / \tau^{EU} = \tau_t^{EU*} / \tau^{EU*} \, \forall t. \tag{45}$$

We will refer to this setting in the following as the *proportional* financing setting of the EUI. A consequence of setting the European taxes as in (45), is that *ex post*, i.e. after realisation of shocks, permanent transfers are possible. Moreover, this setting can imply that taxes need to be raised in regions that are hit by large adverse idiosyncratic shocks. This could reduce the stabilisation properties of such a setting.

We therefore analyse the effects of the following flexible simple rule for the European contribution rates:

$$\widehat{\tau}_t^{EU} = \rho_\tau \widehat{\tau}_{t-1}^{EU} + \underbrace{\rho_{U*} \widehat{U}_t^* - \rho_U \widehat{U}_t}_{\text{business-cycle adjustment}} + \underbrace{\rho_{tt} \left(\widehat{\frac{TT_{t-1}}{Y_{t-1}^{tot}}} \right)}_{\text{claw-back}}, \tag{46}$$

where hats ($\widehat{\ }$) denote deviations from steady state values, ρ_τ, ρ_{U*}, ρ_U, ρ_{tt} are coefficients, and $TT_t = TT_{t-1} + Tr_t$ is the total amount of implicit transfers received by a region at time t. According to this rule, the contribution rate can be described as an autoregressive process with a potential adjustment to allow for business-cycle stabilisation, and a further adjustment to address ex post permanent transfers.

For the former, we assume that the contribution rate can be set depending on relative unemployment levels in both regions. This part ensures that regions that are currently affected by relatively stronger adverse shocks temporarily need to contribute less to the financing of the EUI scheme. This naturally implies temporarily higher transfers to this region. Using unemployment rates instead of GDP has advantages for a practical implementation of such a rule, as data on unemployment rates are available in real-time, while GDP data usually is only available with considerable lags.

With the last term in (46), we assume a clawback mechanism for the EUI scheme. This means that contribution rates become higher for regions that have received transfers in the past, in order to rule out permanent redistributions.[9] The contribution rate of the other region, $\widehat{\tau}_t^{EU*}$, is then set to clear the EUI budget (41).

As there does not exist any guidance from practical experiences or research on how to calibrate the parameters of the rule in (46), we derive a benchmark rule using a Ramsey optimal policy approach. This involves finding sequences for the relevant policy instruments that support the welfare-maximising competitive equilibrium of the economy. We restrict the analysis of optimal policy to the supranational fiscal authority. Monetary policy and all regional fiscal policies are determined rule-based as described in Sections 3.4 and 3.6.1.

The objective of the Ramsey planner is the weighted Utilitarian welfare function of the monetary union

$$\mathbb{W}_0 = \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\varpi \widetilde{u}_t^{\mu}(r) \widetilde{u}_t^{1-\mu}(o) + (1-\varpi)\, \widetilde{u}_t^{*,\mu^*}(r) \widetilde{u}_t^{*,1-\mu^*}(o) \right] \right\}, \tag{47}$$

where $\widetilde{u}_t(i)$ is the instant felicity function as defined by the fractional term in Equation (1) and ϖ is the weight that the Ramsey planner attaches to the utility of households in the periphery region. The dual solution to the optimal policy problem is found by maximising (47) subject to all relevant equilibrium conditions for both regions.

4 Calibration

We calibrate the home and the foreign region of the model as the core and periphery regions of the euro area.[10] The model is calibrated at quarterly frequency. For the general calibration strategy, we broadly rely on Stähler and Thomas (2012) and Attinasi et al. (2019), who calibrate a closely related version of the FiMod to the euro area core and periphery. Accordingly, we match the steady state values of several variables with their empirical counterparts in the data, in particular for the fiscal variables. For most of the structural parameters and the fiscal rule parameters we rely on estimates from the related literature. The shock processes are calibrated by means of a second moments matching exercise.

Table 1 gives an overview over a set of region-specific parameters and targeted steady state values that we take in large parts from Attinasi et al. (2019). Based on population data from Eurostat, we set the size of the periphery to $\omega = 0.40$.

We assume that GDP per capita is normalised to one in both regions, which implies region-specific long-run values for the productivity levels. PPI inflation in both regions and the terms of trade are set to unity also. Together with the assumption of an import share of 15 percent and long-run balanced trade, i.e. $d = 0$, we obtain an endogenous value for ψ, which determines the

[9] Such clawback settings are a regular component of unemployment insurance systems in the United States. For the European context, see Beblavý and Lenaerts (2017).

[10] The calibration of the core region is based on Austria, Belgium, Germany, Finland, France, Luxembourg, and the Netherlands, while the calibration of the periphery is based on Greece, Ireland, Italy, Portugal, and Spain.

Table 1: Calibration of region-specific parameters and steady state values

Parameter	Symbol	Periphery	Core
GDP per capita	Y^{tot}	1.00	1.00
Size of region	ω	0.40	0.60
"Hand-to-mouth" household share	μ	0.50	0.46
Unemployment rate	U	0.12	0.08
Public employment share	N^g	0.18	0.16
Replacement rate	rr	0.70	0.65
Vacancy filling rate (private)	q^p	0.70	0.70
Vacancy filling rate (public)	q^g	0.80	0.80
Market power	ϵ	4.00	6.00
Value-added tax rate	τ^c	0.20	0.18
Capital tax rate	τ^k	0.32	0.21
Labour income tax rate	τ^w	0.28	0.30
Social security contribution rate	τ^{sc}	0.25	0.17
Public consumption-to-GDP	C^g/Y^{tot}	0.12	0.11
Public investment-to-GDP	I^g/Y^{tot}	0.02	0.02
Public subsidies-to-GDP	Sub/Y^{tot}	0.19	0.18
Debt-to-GDP (annualised)	$b/(4Y^{tot})$	0.90	0.75

Notes: Symbols are given from the periphery (home) region perspective.

degree of home bias. The share of hand-to-mouth households is slightly larger in the periphery (0.50) than in the core (0.46) based on estimates by Le Blanc et al. (2015). Market power of intermediate goods producers (ϵ) is higher in the periphery than in the core as in Kaufmann (2019).

Table 1 also gives region-specific steady state values for several labour market and fiscal variables. As described by Attinasi et al. (2019), these values are based on data from the European System of Accounts (ESA), the European Commission, and the OECD. An exception are the region-specific replacement rates that we calculate based on the replacement rates of European countries given in Claeys et al. (2014), which are based on the EU's Mutual Information System on Social Protection (MISSOC). As a result, we assume a replacement rate of 0.70 for the periphery and 0.65 for the core. In the setting with a European unemployment insurance, we assume that unemployment benefits that imply a common replacement rate of $rr^{EU} = 0.50$ for both regions is provided by the European capacity, while the residual shares remain to be financed by the regional fiscal authorities.

For the calibration of fiscal rules for the national fiscal authorities, we rely whenever possible on the posterior mode values from a Bayesian estimation by Coenen et al. (2013) of an extended version of the New Area Wide Model (NAWM) (Christoffel et al., 2008). The chosen coefficient values for all fiscal variables that follow the rule in (25) are given in Table 2. As the NAWM does not allow to estimate region-specific fiscal rules, we assume identical coefficients for both regions.

Table 2: Calibration of fiscal rules

Instrument	Symbol	Autocorr.	$\rho_{b,x}$	$\rho_{y,x}$
VAT rate	τ_t^c	0.81	0.10	-0.20
Regional labour income tax rate	$\tau_t^{w,A}$	0.81	0.04	-0.01
Social security contribution rate	τ_t^{sc}	0.69	0.01	-0.03
Lump-sum tax	T_t	0.68	0.07	0.21
Public consumption	C_t^g	0.77	-0.02	0.06
Public investment	I_t^g	0.70	-0.18	0.55
Regional subsidies	Sub_t^A	0.72	-0.14	0.10
Public employment	n_t^g	0.77	-0.02	0.06

Source: Own calculations and assumptions and Coenen, Straub, Trabandt (2013, *JEDC*)

The model by Coenen et al. (2013) does not feature public employment and their rule for the VAT does not include feedback coefficients for output and public debt. We set the coefficients for public employment to the same values as for government consumption. The autoregressive coefficient of the VAT is set to the same value as the regional labour income tax, while the feedback coefficients on debt and output are set to relatively higher values of 0.10 and -0.20, respectively.

The debt feedback coefficients of all tax and expenditure instruments imply a stabilisation of the debt level. This is generally required for at least a subset of the instruments, in order to ensure stationarity of the model. All expenditure items and all tax instruments, except for the lump-sum tax, respond pro-cyclically to GDP. This limited degree of automatic stabilisation is in line with the experience of several euro area countries in the course and aftermath of the European sovereign debt crisis. The efficacy of cross-regional fiscal transfers increases with the pro-cyclicality of the fiscal instruments. We will therefore provide some sensitivity results of our findings with fiscal rules that imply a higher degree of automatic fiscal stabilisation at the regional level.

We set the share ω^{EU} of supranational transfers that are forwarded directly to the households, Sub_t^{EU}, to a value of 0.30 for our baseline results. We provide a sensitivity analysis of the results for different values of ω^{EU}.

Table 3 shows values of parameters that are set symmetrically in both regions of the monetary union. The Taylor rule coefficients for interest rate persistence, inflation and output sensitivity are set to 0.85, 1.5, and 0.125, respectively, which are standard values in the literature. The same holds true for the Calvo parameters determining the degree of price and wage stickiness that are set to 0.75 and 0.85.

The discount rate is set to $\beta = 0.995$, which implies an annual real interest rate of about 2 percent in steady state. This is slightly smaller than the value of 0.99 usually taken in the business cycle literature. This accounts for the decline in interest rate levels after the global financial and the European sovereign debt crisis. The risk aversion parameter reads $\sigma_c = 4$, which is the range of standard values chosen in the literature. For the habit persistence parameter h,

Table 3: Calibration of common parameters

Parameter	Symbol	Value
Monetary policy:		
Interest rate smoothing	ρ^R	0.85
Stance on inflation	φ_π	1.5
Stance on output	φ_y	0.125
Price and wage stickiness:		
Calvo parameter (prices)	θ_p	0.75
Calvo parameter (existing wages)	θ_w	0.85
Calvo parameter (new wages)	θ_w^n	0.85
Preferences:		
Discount rate	β	0.995
Risk aversion	σ_c	4
Habits in consumption	h	0.6
Utility weight on private consumption	ψ_g	0.85
Elasticity of substitution public-private consumption	ν_g	0.29
Bond market:		
International bond risk premium parameter	ψ_d	0.001
Fiscal limit distribution parameter 1	η_1	-7.204
Fiscal limit distribution parameter 2	η_2	1.201
Sovereign default haircut rate	ϑ^{def}	0.063
Sovereign risk premium pass-through	ρ^{RP}	0.6
Production:		
Private sector capital depreciation	δ^k	0.025
Public sector capital depreciation	δ^g	0.025
Private sector capital elasticity	α	0.33
Public sector capital elasticity	η	0.10
Investment adjustment cost	κ_I	10
Labour market:		
Matching elasticity (private sector)	ϕ^p	0.5
Matching elasticity (public sector)	ϕ^g	0.3
Separation rate (private sector)	s^p	0.04
Separation rate (public sector)	s^g	0.02
Training costs	κ_{tc}	0.55
Worker bargaining power	ξ	0.50

the utility weight of private consumption ψ_g, and the elasticity of subsitution between public and private consumption goods ν_g, we choose the posterior mode estimates by Coenen et al. (2013) of 0.6, 0.85, and 0.29, respectively.

Private and public sector depreciation rates are set to the standard value of 0.025. The private sector capital elasticity reads 0.33. For the public sector capital elasticity, we choose a value of 0.10 as in Leeper et al. (2010). The capital adjustment cost parameter is set to a value of 10, which is somewhat higher as in other studies, in order to limit excess volatility of private investment compared to the business-cycle second moments described below. The labour market parameters given in Table 3 are all set as in Stähler and Thomas (2012) or Attinasi et al. (2019).

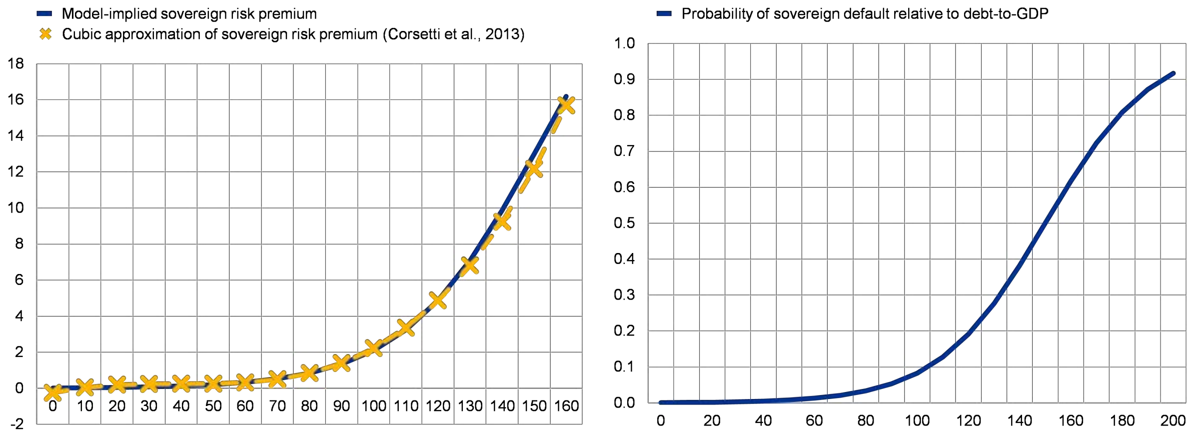

Figure 1: Sovereign risk premia and default probabilities relative to debt-to-GDP

Notes: LHS: Sovereign risk premia (eq. 7) (blue line) and cubically-fitted line of empirical risk premia (eq. 48) (yellow crossed line) in percentage points as a function of debt-to-GDP in percent. RHS: Probability of sovereign default p_t^s (eq. 24) as function of debt-to-GDP.

The risk premium parameter for the internatioanally traded private bond is set to a small value, $\psi_d = 0.001$, that does not distort model dynamics significantly, while still ensuring determinacy of the model as suggested by Schmitt-Grohé and Uribe (2003).

The size of the sovereign risk premia depends on the two parameters of the cumulative density function (24), η_1 and η_2, as well as on ϑ^{def}. For the calibration of these parameters, we proceed as follows. Attinasi et al. (2017) approximate the relation between general government debt-to-GDP and sovereign risk premia, as measured by 5-year sovereign CDS spreads in May 2011, for a broad cross-section of developed economies by the third-order polynomial

$$rp_t = -24.492 + 3.90941 \left(\frac{b_t}{Y_t^{tot}} \right) - 0.1014 \left(\frac{b_t}{Y_t^{tot}} \right)^2 + 0.00087 \left(\frac{b_t}{Y_t^{tot}} \right)^3 , \tag{48}$$

where rp_t denotes the cubically-fitted empirical sovereign risk premium. The underlying data for this estimation is taken from Corsetti et al. (2013). For given values of η_1, η_2, and ϑ^{def}, we obtain $p_t^s(b_t/Y_t^{tot})$ and $RP_t(b_t/Y_t^{tot})$ as functions of debt-to-GDP using (7) and (24). In a next step, we numerically search for parameter values that minimize the average distance between $RP_t(b_t/Y_t^{tot})$ in the model and (48). The left panel of Figure 1 shows that the model-implied risk premium as a function of debt-to-GDP matches the empirical risk premium from (48) closely. The right panel of Figure 1 depicts the probability of default p_t^s in the model as a function of debt-to-GDP.

For the pass-through of the sovereign risk premium to private sector interest rates, we follow Corsetti et al. (2013) by assuming $\rho^{RP} = 0.6$.

We assume that the development of the economy outside the steady state is driven by region-specific but correlated risk premium shocks that enter the household Euler equations for the private-sector bond as described in Section 3.1. These shocks follow a multivariate autoregressive process of order one, given by

$$\mathcal{E}_t^d = \varrho^d \mathcal{E}_{t-1}^d + \varepsilon_t^d, \tag{49}$$

where $\mathcal{E}_t^d = [\epsilon_t^d, \epsilon_t^{d*}]'$, ϱ^d is a [2x2] matrix of autocorrelation parameters and ε_t^d a multivariate white-noise error term with a $N(0, \Sigma^d)$-distribution. We set the own lag parameters in ϱ^d to 0.85, while the non-diagonal cross-variable parameters take on values of zero. The variance-covariance matrix

$$\Sigma^d = \begin{pmatrix} \sigma_d^2 & r^d \sigma_d \sigma_d^* \\ r^d \sigma_d \sigma_d^* & \sigma_d^{*2} \end{pmatrix} \tag{50}$$

allows for cross-regional correlation of the shocks by means of the parameter r^d. We calibrate the variances of the two shocks, σ_d^2 and σ_d^{*2}, to match the volatility of the quadratically-detrended GDP in core and periphery, respectively. As our analysis focusses on the effects of a supranational unemployment insurance scheme, we calibrate the parameter r^d to match the cross-correlation between the quadratically-detrended unemployment rates of both regions. For this calibration exercise, we use a version of the model without European fiscal capacity.

Table 4: Empirical and model-implied second moments

	Empirical moments		Model-implied moments	
Region:	Periphery	Core	Periphery	Core
Standard deviations:				
GDP (Y_t^{tot})	**3.30**	**1.68**	**3.21**	**1.48**
Consumption (C_t)	3.06	1.16	3.95	1.75
Investment (I_t)	10.56	5.11	12.57	6.34
Unemployment (U_t)	2.39	0.61	1.95	1.13
Correlations with GDP:				
$corr(C_t, Y_t^{tot})$	0.96	0.81	0.95	0.89
$corr(I_t, Y_t^{tot})$	0.98	0.91	0.55	0.40
$corr(U_t, Y_t^{tot})$	-0.99	-0.58	-0.79	-0.73
Unemployment cross-correlation:				
$corr(U_t, U_t^*)$	**0.20**		**0.22**	

Notes: Empirical moments calculated for quadratically-detrended data from 1996q1 to 2018q2. Data source is Eurostat. Targeted moments are given in bold font.

The parameter values resulting from this exercise read $\sigma_d^2 = 0.0075$, $\sigma_d^{*2} = 0.0045$, and $r^d = 0.2625$. Table 4 provides a comparison of empirical and model-implied second moments of several business-cycle variables. The three target moments are matched closely. Overall, the model matches also the non-targeted moments relatively well, given that we use only two correlated shocks. The empirical volatility of all variables and their correlation with the regional GDP is generally higher in the periphery than in the core. This pattern is also reflected in the model-implied results.

The volatility of consumption and investment is somewhat higher in the model than in the data. We use comparably high parameter values for risk aversion (σ_c) and the investment adjustment cost (κ_I) to address this characteristic of the model. The correlation between consumption and regional GDP is matched quite closely, while correlations with investment fall short of their empirical counterpart. The correlations between GDP and unemployment rates are in the right order of magnitude with the model-implied value for the periphery being slightly smaller than the empirical moment, while the model-implied value for the core is slightly larger.

Finally, we determine the weighting parameter $\overline{\omega}$ of the Ramsey planner and the coefficients of Rule (46) as follows.

The equilibrium allocation both in steady state and over the business cycle depends significantly on the weighting parameter $\overline{\omega}$. An approach frequently chosen in the related literature is to use the relative population weight ω. In our analysis, this yields a violation of the "experience rating" conditions (43) and (44) and, hence, permanent transfers in steady state. The reason for this violation is that the Ramsey planner's objective implies to equate marginal utility of agents in both regions of the economy. Since the supranational policies we are focussing on in this paper are considered as a stabilisation tool and are not meant to achieve general convergence in economic standards of living across regions, we do not use relative population shares as weights. Instead, for a given calibration we numerically solve for a value $\overline{\omega}$, such that (43) and (44) hold.

In a second step, we analyse the effects of the European fiscal capacity if implemented by means of "optimised" simple rules in the form of (46). We obtain benchmark values for the rule parameters ρ_τ, ρ_{U*}, ρ_U, and ρ_{tt} as follows. We simulate the model economy under optimal policy as described above for 10000 periods. We then run simple ordinary least squares regressions of (46) using this simulated data to obtain the rule coefficients. Adjusting these parameter values allows us to study various stabilisation and distributional consequences of different EUI settings relative to an optimal policy benchmark.

5 Results

5.1 Stabilising effects of the common unemployment insurance

Figure 2 compares impulse response functions (IRFs) of key variables in both regions with (dotted dashed lines) and without (solid lines) a European unemployment insurance scheme that is financed by regional governmental contributions. The response of the contributions

T_t^{EU} and T_t^{EU*} is derived from the optimal benchmark described in Section 3.6.3. The impulse analysed in the figure is a Smets and Wouters (2007) type demand shock to the periphery, implemented via a higher risk premium by means of ϵ_t^d in the household Euler equation, and a partially correlated weaker shock to the core, using the benchmark shock calibration values described in Section 4.

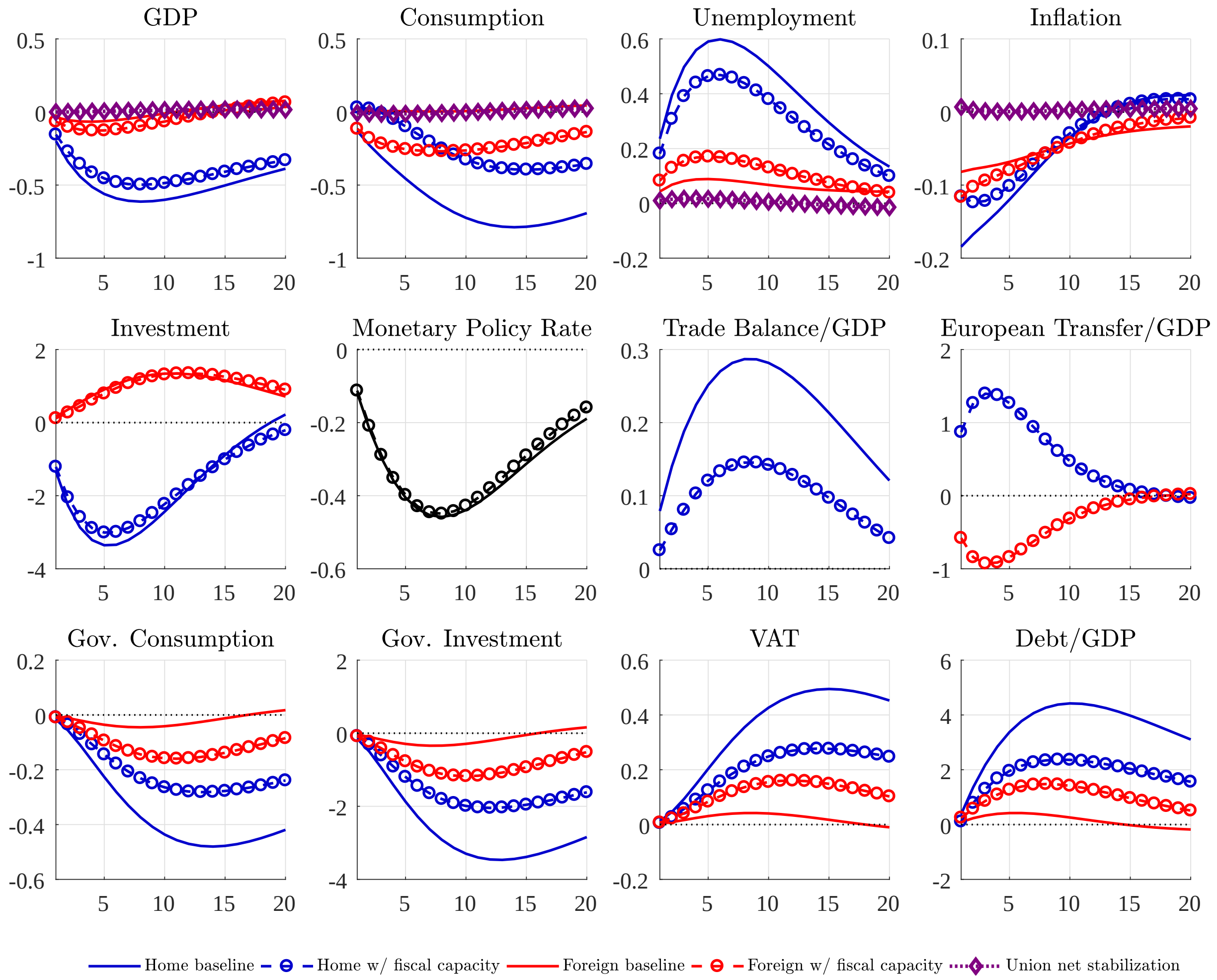

Figure 2: Impulse response functions with optimal European unemployment insurance

Notes: Benchmark calibration. EUI financed by regional government contributions T_t^{EU} and T_t^{EU*}. Solid (dotted dashed) lines show responses without (with) a common EUI scheme. Purple diamond lines show net stabilisation effects, calculated as difference between the responses with and without EUI, for the monetary union as a whole.

The response of GDP is shown in the first (upper-left) panel of the figure. The solid lines depict the IRFs when no supranational stabilisation mechanism is in place. In this case, the shock leads to a recession in both regions with a trough for GDP in the periphery of -0.61% (solid blue line) that occurs eight quarters after the initial impact. When an optimal European fiscal capacity policy is in place the recession trough is only -0.5% in the periphery (blue dotted dashed lines), indicating some degree of business cycle stabilisation by the supranational policy, which is about 20%. This stabilisation, however, comes at the cost of a somewhat stronger reduction of GDP in the core of the monetary union. Significant stabilisation effects for the periphery are also visible for other variables, such as consumption, unemployment, inflation, and investment, shown in Panels 2 to 5 of the figure. The Ramsey planner achieves the strongest stabilisation gains for consumption (about 51% for the periphery), in line with the objective function (47).

The optimal policy entails a redistribution that allows for a relatively higher consumption of households in the periphery and a relatively lower consumption in the core. Optimal policy is not able to achieve a significant degree of aggregate stabilisation for the monetary union as a whole, indicated by the purple dotted diamond lines. As a result, the response of the monetary policy rate is almost the same in both settings. Since the correlation of all macroeconomic variables, including inflation, increases, the common union-wide monetary policy becomes more efficient by means of the introduction of the fiscal capacity.

The optimal policy is implemented by means of significant fiscal transfers from the relatively less hit core to the European fiscal authority, which redistributes these resources to the regional fiscal authority of the periphery. Transfers to the periphery are almost one percent of GDP on impact before reaching a peak of 1.4% of GDP after three quarters (Panel 8). They remain positive for about four years. These regional fiscal transfers are transmitted to the wider economy through the joint financing of the additional unemployment expenditures in the periphery by both regions. The transfers received by the periphery are, however, larger than the amount needed to finance the additional unemployment benefits. These additional transfers generate fiscal space in the budget of the periphery's fiscal authority. This fiscal space is in turn transmitted to households and firms via the various tax and expenditure measures of the regional authorities.

An important implication of these transfers is that the debt-to-GDP ratio of the periphery increases by much less under the EUI. Instead of a peak increase of 4.4 percentage points, the debt ratio rises by only 2.4 percentage points (Panel 12). Peak debt levels in the core under this policy, yet, increase by 1.5 instead of only 0.4 percentage points. The relatively stronger increase of debt levels in the periphery vis-á-vis the core in presence of the EUI is optimal from an aggregate perspective due to the presence of the risk premia for sovereign debt. The latter depend positively on the debt level, which is assumed to be larger for the periphery in the calibration.

As described in the fiscal rules in Section 3.4, all fiscal income and expenditure items respond pro-cyclically to the business cycle and fiscal policy needs to be tightened in response to higher debt levels. The relatively lower debt level in the periphery, hence, implies that government consumption and investment fall and the VAT increases by less than in the baseline case without the EUI (Panels 9 to 11). These changes in regional fiscal policy positively feed back into consumption and GDP in the periphery. The optimal policy also allows households in the periphery to reduce their relative imports of consumption goods by less, as indicated by the smaller appreciation of the trade balance over GDP shown in Panel 7. Besides, the persistence of the slump in the periphery is reduced since public investment is cut significantly less. The public sector capital stock is, accordingly, partially stabilised, which directly affects the potential output of the economy.

Table 5: Business-cycle moments under alternative settings for the European unemployment insurance

EUI Design:	Region	(I) prop.	(II) optimal	(III) optimised rule	(IV) w/o autocorr.	(V) w/ claw back
(A) Change of volatility (%):						
Output	H	-6.65	-20.11	-31.87	-38.27	-5.66
	F	-5.54	-14.61	-30.01	-28.71	-2.20
	EA	-1.10	-3.47	-3.53	-4.75	-1.61
Consumption	H	-6.65	-49.09	-37.99	-52.62	-16.55
	F	-6.28	-25.76	-36.27	-26.56	-7.12
	EA	-0.56	-3.78	-2.72	-3.91	-2.25
Unemployment	H	-2.70	-21.39	-15.05	-25.03	-12.08
	F	-1.08	-9.31	-8.93	-7.89	-5.18
	EA	0.48	-0.12	0.35	1.09	0.26
Inflation	H	0.38	-12.46	-4.29	-10.76	-8.07
	F	1.29	-0.53	-0.43	0.10	-0.51
	EA	1.47	-1.01	0.40	0.15	0.62
(B) Change of cross-regional correlation (pp):						
Unemployment		0.10	0.52	0.41	0.60	0.30
Inflation		0.07	0.27	0.15	0.25	0.24
(C) Elasticity of transfers over GDP to unemployment (%):						
Tr_t/Y_t^{tot}	U_t	0.10	2.85	0.90	2.96	0.94
	U_t^*	-0.11	-3.07	-1.03	-3.28	-0.99
(D) Half-life of transfer mean reversion (years):						
		10.29	3.84	22.10	6.43	4.30

Notes: Panels (A) and (B) compare changes of theoretical second moments in baseline scenario with different EUI scenarios. Panel (C) shows regression coefficients of unemployment in both regions on Home transfers over GDP based on 10000 periods of simulated data. Panel (D) shows mean reversion half-life of Home transfers estimated as AR(1)-process based on 10000 periods of simulated data. Column (I) based on Rule (45). Column (II) Ramsey-optimal policy. Columns (III)-(V) based on Rule (46) with following parameters. (III): $\rho_\tau = 0.92$, $\rho_{U*} = 0.26$, $\rho_U = -0.17$, and $\rho_{tt} = 0.0008$; (IV): $\rho_\tau = 0$, $\rho_{U*} = 3.61$, $\rho_U = -3.05$, and $\rho_{tt} = 0.0068$; (V): $\rho_\tau = 0$, $\rho_{U*} = 3.61$, $\rho_U = -3.05$, and $\rho_{tt} = 0.136$. Regions are periphery (H), core (F), and whole euro area (EA).

The findings of Figure 2 are generalised in an analysis of business cycle moments in Table 5. Panel (A) of the table compares the change in volatility of the key macro variables (GDP, consumption, unemployment, and inflation), in order to assess the degree of business cycle stabilisation that can be achieved under five different policy specifications of the EUI. Panel (B) shows the change of the cross-regional correlation of unemployment and inflation. The higher the correlation of the business cycle between the two regions, the more appropriate it is to have one single currency for the union as a whole.[11] Panels (C) and (D) of Table 5 provide further measures to analyse the size of the cross-regional transfers made as well as their persistence under the different policy settings. The last aspect gives an indication about the permanence of transfers paid.

We begin the description of the results for the proportional financing as defined by Rule (45), which are given in Column (I) of Table 5. This setting is the most straightforward way of financing the EUI scheme. It can lead to permanent transfers ex post though and it does not take into account the relative position of the two regions in the business cycle. Regions that are hit by an idiosyncratic shock may have to pay higher taxes or contributions, in order to finance the increased unemployment benefits from the EUI during a downturn.

In line with these considerations the stabilisation effects of the policy setting in Column (I) are relatively limited. The volatility of output and consumption in both regions decrease by about 6%, while aggregate stabilisation at the euro area level remains close to zero. The additional synchronisation of the business cycle is also small as shown in Panel (B). The correlations of unemployment and inflation increase by 10 and 7 percentage points, respectively.

The size of cross-regional transfers paid in response to a recession is also limited (Panel C). An increase of the unemployment rate in the periphery by one percentage point leads to transfers to the region of only 0.1 percent of GDP. In sum, this setting allows for a limited degree of stabilisation, implemented by relatively small transfers. A set of impulse response functions for this policy setting can be found in Figure 6 in Appendix B.

Column (II) shows results for the optimal policy setting, which also formed the basis for the analysis in Figure 2. In line with the observations from the impulse responses, this policy allows for a significant degree of business cycle stabilisation. Results in Panel (A) show that the reduction of output, consumption and unemployment volatility is almost always of a double-digit magnitude for both regions. For example, output and consumption volatility in the periphery can be reduced by 20% and 49%, respectively. At least in one of the regions, optimal policy also leads to a reduction of inflation volatility by about 12%. Euro area stabilisation is significantly smaller than stabilisation at the region level, but still output and consumption volatility are about 4% smaller at the aggregate level.

Under the optimal policy, we can also achieve a strong increase of cross-regional correlation of unemployment by 52 percentage points and of inflation by 27 percentage points. This implies that the common monetary policy of the euro area is much more able to achieve aggregate

[11] This refers back to the debate on optimal currency area criteria and the point made by first by Kenen (1969) that fiscal risk sharing is an important ingredient needed to compensate for the loss of flexible exchange rates of countries within a monetary union.

stabilisation efficiently, as cross-regional divergence is reduced.

The Ramsey planner makes this relatively high degree of stabilisation possible by channelling relatively high transfers between the two regions. In response to a one percent increase of periphery unemployment, the region obtains transfers of almost 3% of GDP. At the same time, the persistence of the transfers paid, which can be seen as a measure for how permanent transfers are, is relatively contained. The half-life time for a given transfer received by one region to be brought back to its steady state value of zero is 3.84 years.

The policy settings in columns (III) to (V) analyse how well the optimal policy result in Column (II) can be approximated by simple rules for the supranational financing instrument as defined by Equation (46) with optimised coefficients.

The results in Column (III) are based on a rule that features an autoregressive, a business cycle, and a clawback component, whose coefficients are obtained from a simple projection of the rule on simulated data that was obtained under the optimal policy setting in Column (II). It turns out that the autocorrelation of the regional contribution is relatively high with $\rho_\mathcal{T} = 0.92$, while the clawback mechanism is basically absent in the optimised rule ($\rho_{tt} = 0.0008$). The coefficients of the unemployment deviations in both regions have the expected signs as hypothesized in (46). The R^2 of the projection reads 0.91, indicating that this simple rule is a reasonable approximation of the Ramsey policy.

This policy rule is able to reduce business cycle volatility significantly in both regions in the same order of magnitude as the optimal policy. The reductions are more symmetric across the regions in this setting, though. The synchronisation of the business cycle as shown in Panel (B) is somewhat smaller now with an increase of unemployment and inflation correlation by 41 and 15 percentage points, respectively. The most visible differences between Columns (II) and (III) are in Panels (C) and (D). The elasticity of transfers over GDP to the unemployment rates is reduced considerably from about 3% in Column (II) to about 1% in Column (III). As a consequence of the high degree of persistence in the rule and the small clawback, it takes a long time for transfers to revert back to steady state. The half-life of mean reversion reads more than 22 years in this setting.

5.2 Persistence of transfers

To reduce the persistence of contributions and transfers made that is shown in Column (III), we re-estimate the projection of Rule (46) on the simulated data without the autocorrelation component by assuming that $\rho_\mathcal{T} = 0$. This yields significantly larger coefficients for the unemployment deviations ($\rho_{U^*} = 3.61$ and $\rho_U = -3.05$) and also the clawback ($\rho_{tt} = 0.0068$). The results of this exercise are shown in Column (IV). Despite a smaller R^2 of this projection of 0.66, this policy reproduces the optimal policy of Column (II) very closely. The stabilisation of output is stronger than under the optimal policy, while the volatility reduction of all other variables resembles the optimal policy values closely. The transfer elasticities to unemployment are back to values around 3% and the half-life of mean reversion is again down to 6.43 years.

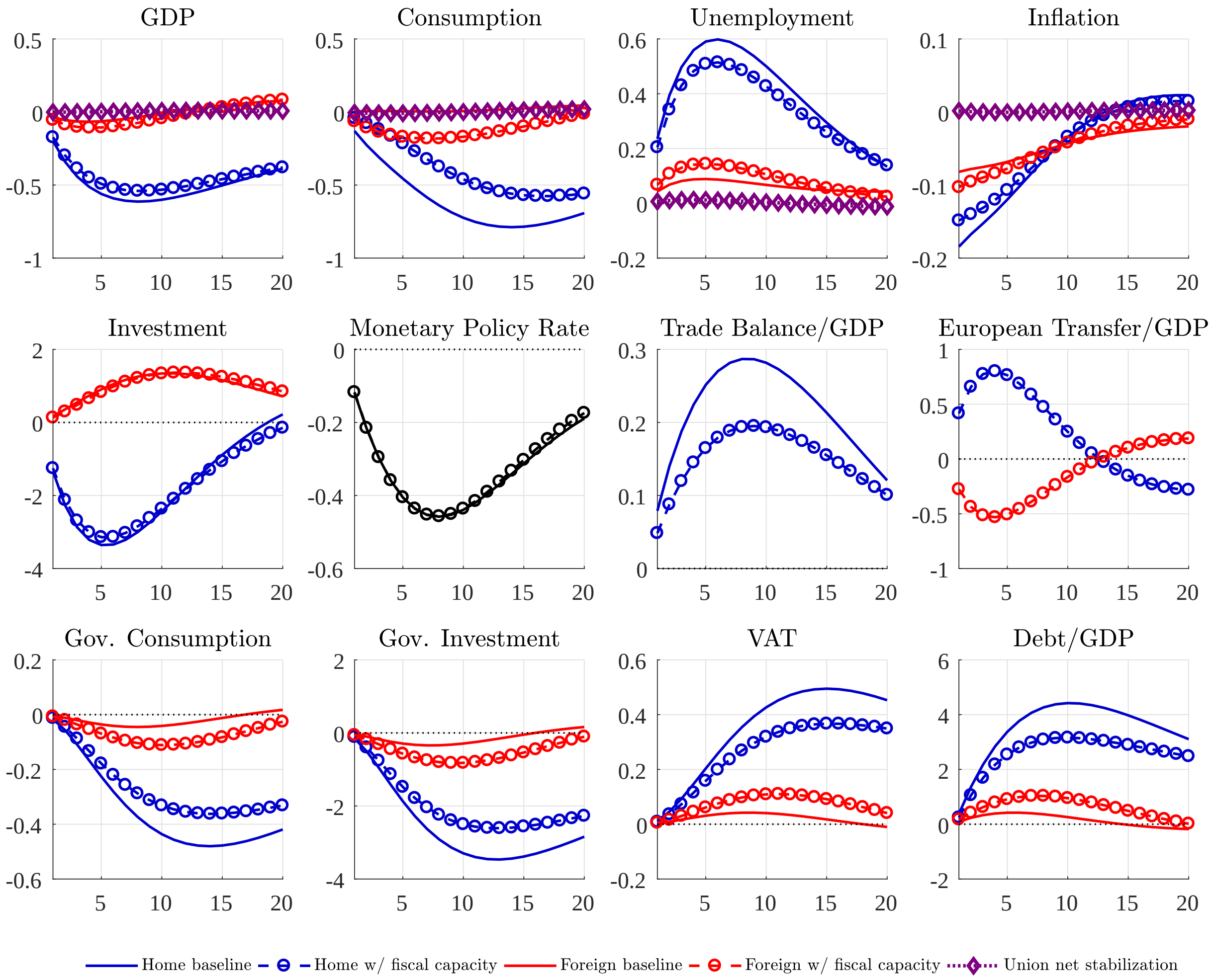

Figure 3: Impulse response functions with European unemployment insurance, optimized rule with clawback mechanism

Notes: Benchmark calibration. EUI financed by regional government contributions T_t^{EU} and T_t^{EU*}. Coefficients in optimized rule (46) read $\rho_\tau = 0$, $\rho_{U*} = 3.61$, $\rho_U = 3.05$, and $\rho_{tt} = 0.1360$. Solid (dotted dashed) lines show responses without (with) a common EUI scheme. Purple diamond lines show net stabilisation effects, calculated as difference between the responses with and without EUI, for the monetary union as a whole.

The impulse responses for this setting, which are shown in Figure 7 in Appendix B, also are very similar to those shown for optimal policy in Figure 2.

While the stabilisation properties of the policies shown in Column (IV) are quite significant, they also require high transfers which are put in place for an extented period of time. In order to avoid reducing incentives for policy makers at the regional level to postpone growth-fostering policies, it may be desirable to enforce a faster payback of transfers to the other region. The consequences of implementing a stronger clawback mechanism are shown in Column (V). To this end, we increase the respective rule coefficient by a factor of 20 to $\rho_{tt} = 0.136$.

As expected, this change in the policy setting reduces the stabilisation properties. For example, output and consumption volatility in the periphery are now reduced to 6% and 17%

compared to 38% and 53% in Column (IV). The transfer elasticity to the unemployment rates is again reduced to about 1%. The stronger clawback helps reducing the persistence of the transfers. Compared to Column (IV), the half-life of mean reversion is reduced by about one third to 4.3 years.

The faster payback of transfers is also visible from impulse responses for this policy setting, which are presented in Figure 3. In line with the results in Table 5, the stabilisation of macro variables is smaller than shown in Figure 2. At the same time, one can see that transfers under this setting change signs after 12 quarters. After these three years transfers revert and the regional fiscal authority of the periphery starts repaying transfers previously received.

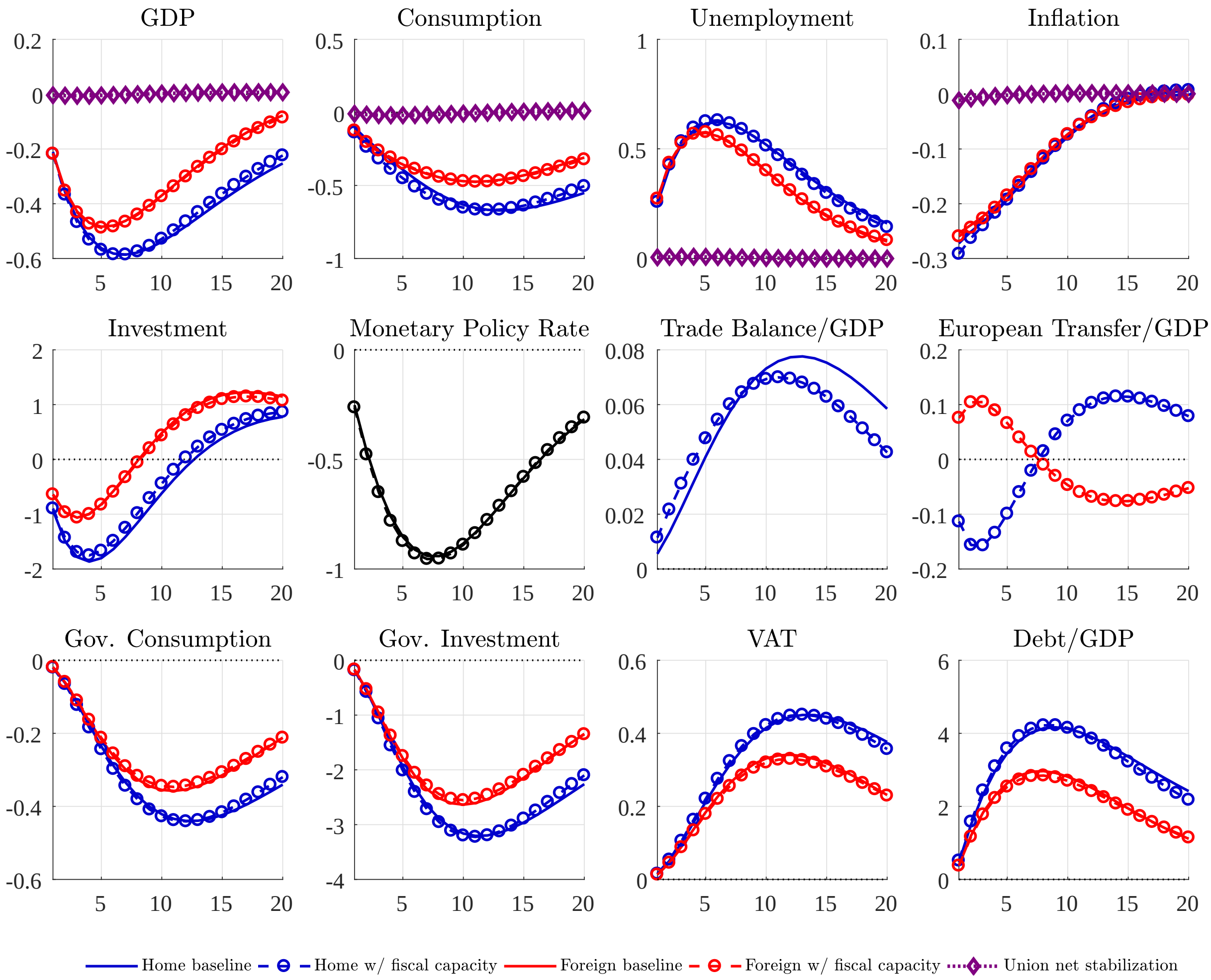

Figure 4: Impulse response functions with optimal European unemployment insurance, aggregate shock

Notes: Benchmark calibration. EUI financed by regional government contributions T_t^{EU} and T_t^{EU*}. Shock volatility in both regions set to value of periphery ($\sigma_d^2 = \sigma_d^{*2} = 0.0075$) with correlation of $r^d = 0.95$. Purple diamond lines show net stabilisation effects, calculated as difference between the responses with and without EUI, for the monetary union as a whole.

Table 6: Business-cycle moments under European unemployment insurance with aggregate shocks

EUI Design:	Region	(I) prop.	(II) optimal	(III) optimised rule	(IV) w/o autocorr.	(V) w/ claw back
(A) Change of volatility (%):						
Output	H	-2.88	-3.96	-8.40	-8.17	-2.45
	F	-0.50	-1.66	-3.97	-3.52	-0.06
	EA	-0.23	-0.11	-0.21	-0.19	-0.20
Consumption	H	-2.22	-7.97	-4.92	-5.30	-3.31
	F	-0.20	-1.60	-6.12	-5.57	-0.12
	EA	-0.07	-0.43	-0.14	-0.05	-0.03
Unemployment	H	-0.26	-0.90	-0.32	-0.22	-0.40
	F	0.60	-0.36	-0.71	-0.78	0.27
	EA	0.50	0.36	0.35	0.42	0.54
Inflation	H	1.77	1.47	2.35	3.01	2.41
	F	1.86	1.35	1.27	0.92	1.42
	EA	1.85	1.60	1.81	1.94	1.96
(B) Change of cross-regional correlation (pp):						
Unemployment		0.07	0.10	0.11	0.11	0.09
Inflation		0.06	0.07	0.07	0.07	0.07
(C) Elasticity of transfers over GDP to unemployment (%):						
Tr_t/Y_t^{tot}	U_t	0.10	1.68	0.93	1.75	0.76
	U_t^*	-0.11	-1.99	-1.15	-2.07	-0.85
(D) Half-life of transfer mean reversion (years):						
		8.33	3.53	14.11	4.63	3.23

Notes: Shock volatility in both regions set to value of periphery ($\sigma_d^2 = \sigma_d^{*2} = 0.0075$) with correlation of $r^d = 0.95$. Panels (A) and (B) compare changes of theoretical second moments in baseline scenario with different EUI scenarios. Panel (C) shows regression coefficients of unemployment in both regions on Home transfers over GDP based on 10000 periods of simulated data. Panel (D) shows mean reversion half-life of Home transfers estimated as AR(1)-process based on 10000 periods of simulated data. Column (I) based on Rule (45). Column (II) Ramsey-optimal policy. Columns (III)-(V) based on Rule (46) with following parameters. (III): $\rho_\tau = 0.87$, $\rho_{U*} = 0.39$, $\rho_U = -0.30$, and $\rho_{tt} = 0.0002$; (IV): $\rho_\tau = 0$, $\rho_{U*} = 2.07$, $\rho_U = -1.58$, and $\rho_{tt} = 0.0006$; (V): $\rho_\tau = 0$, $\rho_{U*} = 2.07$, $\rho_U = -1.58$, and $\rho_{tt} = 0.12$. Regions are periphery (H), core (F), and whole euro area (EA).

5.3 Sensitivity analysis

The setting of the EUI discussed in this paper does not foresee a debt capacity at the European level. This option is also excluded from several current euro area reform proposal because of the limited political appetite of such an instrument. The analysis so far shows that significant degrees of stabilisation can be achieved nevertheless. This conclusion, though, no longer applies in case of aggregate shocks that hit the two regions of the monetary union simultaneously. In Table 6 and Figure 4 we show IRFs and summary statistics for the case where both regions are hit by a symmetric shock with a standard deviation of $\sigma_d^2 = \sigma_d^{*2} = 0.0075$ and a correlation of 95% ($r^d = 0.95$).

Column (II) of Table 6 shows that even under an optimal policy response, output volatility is only reduced by 4% and 1.7% in the periphery and the core, respectively. The cross-regional correlation of unemployment and inflation increase by 10% and 7% only. These findings are confirmed in the IRFs of Figure 4, where almost no differences between the settings with and without EUI are visible. As both regions are hit by the shock simultaneously, the redistribution across regions remains limited. As the periphery is affected slightly more, the planner induces transfers from the core to the periphery of about 0.1% of GDP. Transfer payments revert, however, already after seven quarters after which the core is a net transfer recipient.

The underlying reason for the limited stabilisation is that in case of the aggregate shock, any redistribution would come at the cost of additional welfare losses in the transfer-paying region. In response to the aggregate shock, the monetary policy rate is reduced significantly more by almost 1% compared to a reduction of 0.45% in Figure 2. Despite this stronger monetary response, the central bank is not able to fully stabilise the shock to the economy. These results therefore support the notion that in response to an aggregate shock, deficit-financed fiscal spending could become necessary. This is even more relevant as long as the policy rates are close to their effective lower bound.

Table 7 provides a sensitivity analysis where the calibration of the fiscal sector of the model is perturbed. For convenience, Column (I) of the table reproduces the optimal policy baseline results from Table 5 against which we compare the following changes.

One aspect that we add to the model of Stähler and Thomas (2012) are sovereign risk premia. Column (II) shows how the main results change when this model component is switched off, which is achieved by setting $\vartheta^{def} = 0$. The results make clear that risk premia are a relevant model ingredient for driving the results. The stabilisation effect of the EUI scheme, as shown by the change in volatility in Panel (A), decrease considerably. The volatility of output, in fact, even increases under the EUI by about 10% in both regions.

The changes in the volatility of consumption, unemployment, and inflation are more pronounced for the periphery, while results for the core remain relatively similar. As the debt level of periphery is relatively higher, it is also located higher up in the exponential part of the risk premium function shown in Figure 1. In this environment, small changes of the debt level already affect the allocation of the economy via higher risk premia considerably.

The intuition for the important role of risk premia in the model is the following. Without risk premia it is relatively inexpensive for the regional fiscal authorities to increase debt levels, in order to alleviate a recession. This implies that the value-added of a central European fiscal capacity is also limited in this case. In turn, the presence of risk premia strengthens the

Table 7: Sensitivity analysis of business-cycle moments under European unemployment insurance

	Region	(I) baseline	(II) no risk premia	(III) no C^g in util.	(IV) less tax pro-cycl.
(A) Change of volatility (%):					
Output	H	-20.11	10.65	-10.94	-38.75
	F	-14.61	11.87	-8.85	-31.19
	EA	-3.47	0.15	-1.77	-8.58
Consumption	H	-49.09	-17.89	-40.73	-55.77
	F	-25.76	-26.89	-30.84	-25.13
	EA	-3.78	-0.69	-3.45	-5.56
Unemployment	H	-21.39	-4.19	-15.90	-29.20
	F	-9.31	-9.69	-11.17	-7.25
	EA	-0.12	-0.57	-0.57	0.76
Inflation	H	-12.46	0.25	-9.16	-15.85
	F	-0.53	-2.64	-2.09	2.17
	EA	-1.01	1.56	-0.80	-0.58
(B) Change of cross-regional correlation (pp):					
Unemployment		0.52	0.27	0.45	0.62
Inflation		0.27	0.18	0.25	0.28
(C) Elasticity of transfers over GDP to unemployment (%):					
Tr_t/Y_t^{tot}	U_t	2.85	0.76	1.85	4.11
	U_t^*	-3.07	-2.17	-2.47	-3.70
(D) Half-life of transfer mean reversion (years):					
		3.84	10.29	5.02	3.31

Notes: Panels (A) and (B) compare changes of theoretical second moments in baseline scenario with different EUI scenarios. Panel (C) shows regression coefficients of unemployment in both regions on Home transfers over GDP based on 10000 periods of simulated data. Panel (D) shows mean reversion half-life of Home transfers estimated as AR(1)-process based on 10000 periods of simulated data. All results are based on Ramsey-optimal policy. Column (I): baseline calibration results under optimal policy. Column (II): No risk premia ($\vartheta^{def} = 0$). Column (III): C^g not in utility function ($\psi_g = 1$). Column (IV): Less pro-cyclicality of the VAT ($\rho_{b,c} = 0.01$). Regions are periphery (H), core (F), and whole euro area (EA).

arguments for central risk sharing in the monetary union.

Another aspect of the FiMod by Stähler and Thomas (2012) that we add is the complementarity between private and public consumption in the utility of the household sector. We present results for the case where this ingredient is deactivated by setting $\psi_g = 1$ in Column (III). The table shows that also in this case there is still a reasonable degree of business cycle stabilisation, although smaller than in the baseline of Column (I). For example, output volatility in the periphery is reduced by about 11% compared to 20% in the baseline calibration.

The underlying reason for the smaller stabilisation effects lies in the pro-cyclicality of public consumption. Whenever C_t^g falls during a recession, private consumption falls as well due to the complementarity. Hence, the stronger the complementarity, the stronger is also the stabilising effect of the EUI as it reduces fluctuations in the fiscal spending and, therefore, also private consumption.

We further study the role of pro-cyclicality of the regional fiscal policy in Column (IV), where we reduce the responsiveness of the VAT to changes in the debt level to $\rho_{b,c} = 0.01$. This parameter change implies that the VAT rate increases by less when the public debt level goes up during a recession. This allows households to smooth their consumption to a larger extent and also helps stabilising output over the business cycle.

As a final robustness check for the findings presented in Sections 5.1 and 5.2, we show results for the case when the supranational fiscal authority is financed via a European labour income tax, τ_t^{EU}, which is directly levied on households, in Table 8 and in Figure 8 of Appendix B.

These results indicate that similar, though somewhat smaller, degrees of stabilisation can be achieved under this alternative financing instrument. The amount of transfers paid in response to changes in unemployment are smaller throughout all policy settings and the half-life of mean reversion is longer. This finding is related to the well-known optimal policy result that movements in distortionary labour taxes should be smoothed over time.[12] In this way, the policy distorts the households' and firms' first-order optimality conditions to a lesser extent.

6 Conclusions

We argue in this paper that the macroeconomic stabilisation effects of supranational unemployment insurance schemes can be significant. To show this, we use a medium-scale New Keynesian two-region open economy DSGE of a monetary union with a rich fiscal setting and frictional labour markets. We calibrate this model to the core and periphery regions of the euro area. We study various different design schemes of a EUI both based on optimal policy and on flexible simple rules. Depending on the exact specification, the results suggest a reduction in the volatility of consumption by up to 49% at the region-level, while the cross-regional correlation of unemployment and inflation increases by up to 52% and 27%, respectively, compared to the decentralised setting. The higher degree of inter-regional risk-sharing comes at the cost of sizable fiscal transfers. Limiting such transfers via claw-back mechanisms implies a much weaker degree of stabilisation across countries. Moreover, as long as the design of the EUI does not allow for a financing through a debt capacity, the stabilisation of aggregate shocks that hit the whole monetary union simultaneously is limited.

[12]See, for example, Lucas and Stokey (1983) and Werning (2007).

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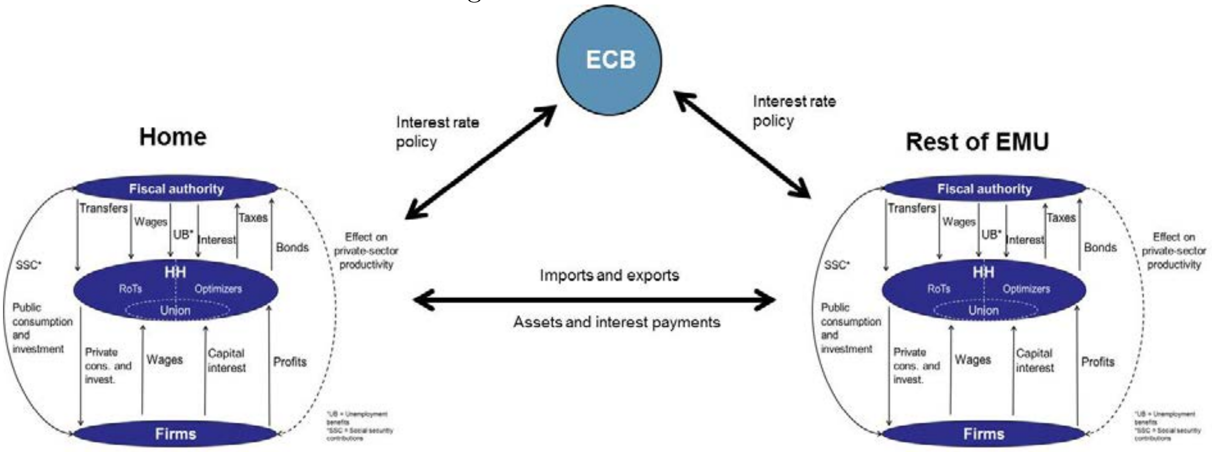
Appendix

A Further details on the model

Figure 5 shows a graphical representation of the standard FiMod by Stähler and Thomas (2012).

Figure 5: Model overview



B Additional results

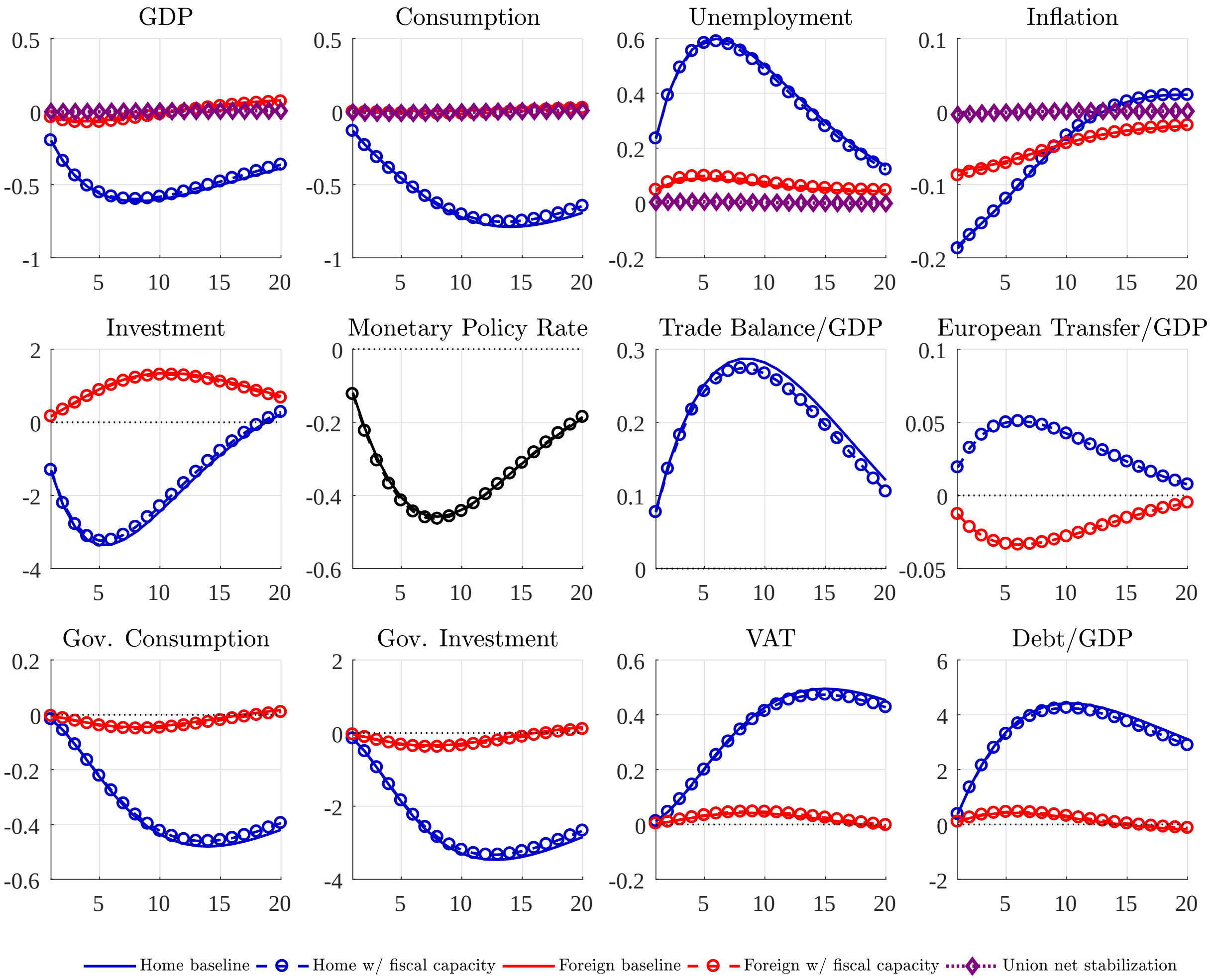


Figure 6: Impulse response functions with European unemployment insurance with symmetric financing

Notes: Benchmark calibration. EUI financed by proportional regional government contributions T_t^{EU} and T_t^{EU*} as in rule (45). Purple diamond lines show net stabilisation effects, calculated as difference between the responses with and without EUI, for the monetary union as a whole.

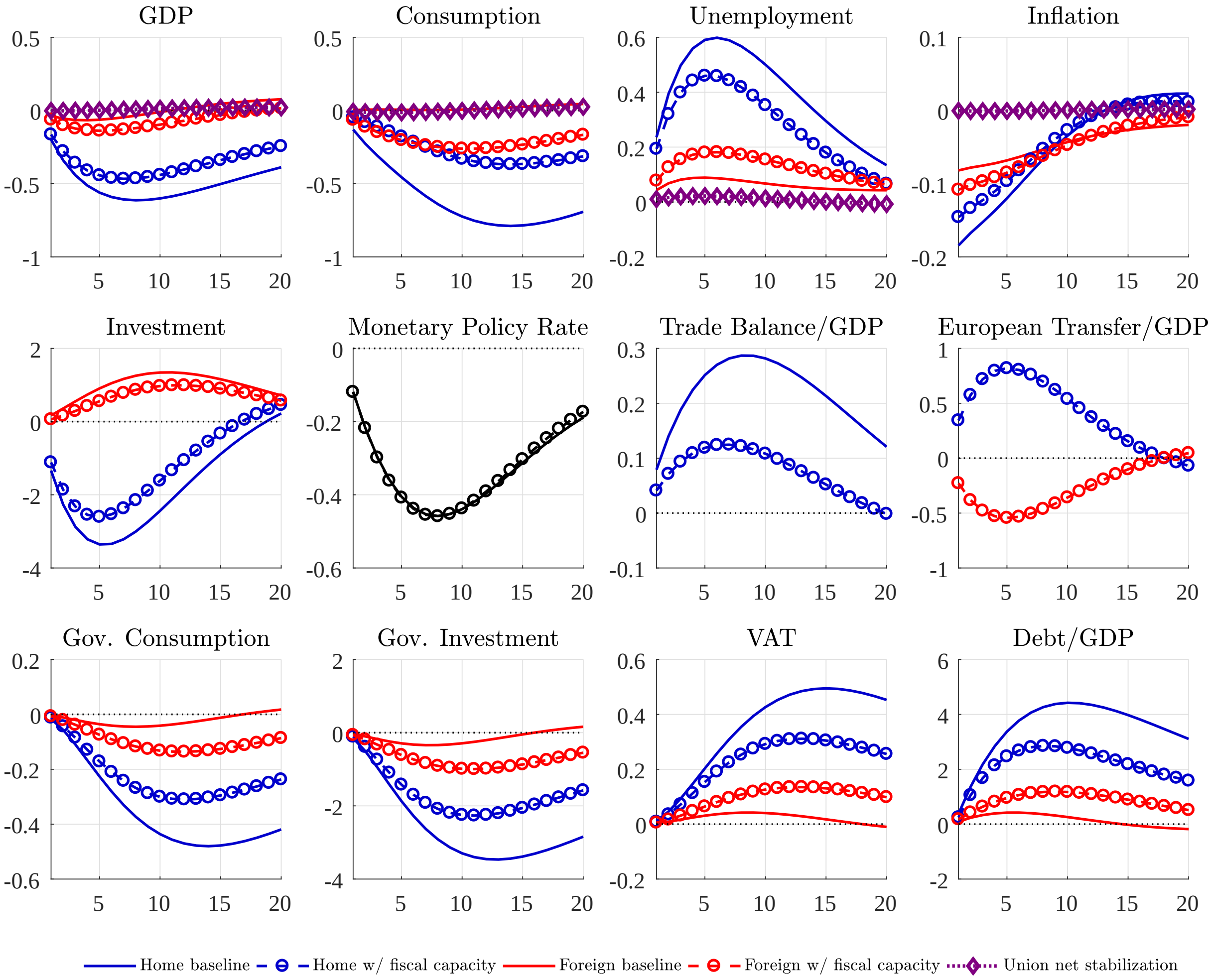


Figure 7: Impulse response functions with European unemployment insurance, optimized rule without autocorrelation coefficient

Notes: Benchmark calibration. EUI financed by regional government contributions T_t^{EU} and T_t^{EU*}. Coefficients in optimized rule (46) read $\rho_\tau = 0$, $\rho_{U*} = 3.61$, $\rho_U = 3.05$, and $\rho_{tt} = 0.0068$. Purple diamond lines show net stabilisation effects, calculated as difference between the responses with and without EUI, for the monetary union as a whole.

Table 8: Business-cycle moments under European unemployment insurance financed with labour income taxes

EUI Design:	Region	(I) prop.	(II) optimal	(III) optimised rule	(IV) w/o autocorr.	(V) w/ claw back
(A) Change of volatility (%):						
Output	H	-7.54	-25.67	-27.86	-13.79	-7.54
	F	-6.40	-20.92	-27.73	-13.31	-6.67
	EA	0.95	-1.34	-1.00	0.34	0.95
Consumption	H	-7.87	-33.36	-33.07	-15.34	-6.48
	F	-8.04	-36.54	-44.48	-20.66	-7.22
	EA	-0.27	-1.61	-1.59	-0.65	-0.26
Unemployment	H	-1.11	-11.22	-12.66	-6.73	-3.30
	F	0.23	-8.77	-7.05	-5.01	-2.62
	EA	3.52	3.11	3.41	3.36	3.38
Inflation	H	2.27	-0.16	-0.29	1.21	1.44
	F	2.66	0.94	1.46	1.40	1.76
	EA	3.38	2.71	3.26	3.38	3.39
(B) Change of cross-regional correlation (pp):						
Unemployment		0.15	0.43	0.43	0.31	0.22
Inflation		0.08	0.14	0.14	0.12	0.12
(C) Elasticity of transfers over GDP to unemployment (%):						
Tr_t/Y_t^{tot}	U_t	0.11	0.42	0.40	0.42	0.28
	U_t^*	-0.15	-0.66	-0.41	-0.68	-0.45
(D) Half-life of transfer mean reversion (years):						
		10.38	26.64	34.06	8.90	6.82

Notes: Panels (A) and (B) compare changes of theoretical second moments in baseline scenario with different EUI scenarios. Panel (C) shows regression coefficients of unemployment in both regions on Home transfers over GDP based on 10000 periods of simulated data. Panel (D) shows mean reversion half-life of Home transfers estimated as AR(1)-process based on 10000 periods of simulated data. Column (I) based on Rule (45). Column (II) Ramsey-optimal policy. Columns (III)-(V) based on Rule (46) with following parameters. (III): $\rho_\tau = 0.98$, $\rho_{U*} = 0.39$, $\rho_U = -0.22$, and $\rho_{tt} = 0.00$; (IV): $\rho_\tau = 0$, $\rho_{U*} = 1.61$, $\rho_U = -0.53$, and $\rho_{tt} = 0.0001$; (V): $\rho_\tau = 0$, $\rho_{U*} = 1.61$, $\rho_U = -0.53$, and $\rho_{tt} = 0.10$. Regions are periphery (H), core (F), and whole euro area (EA).

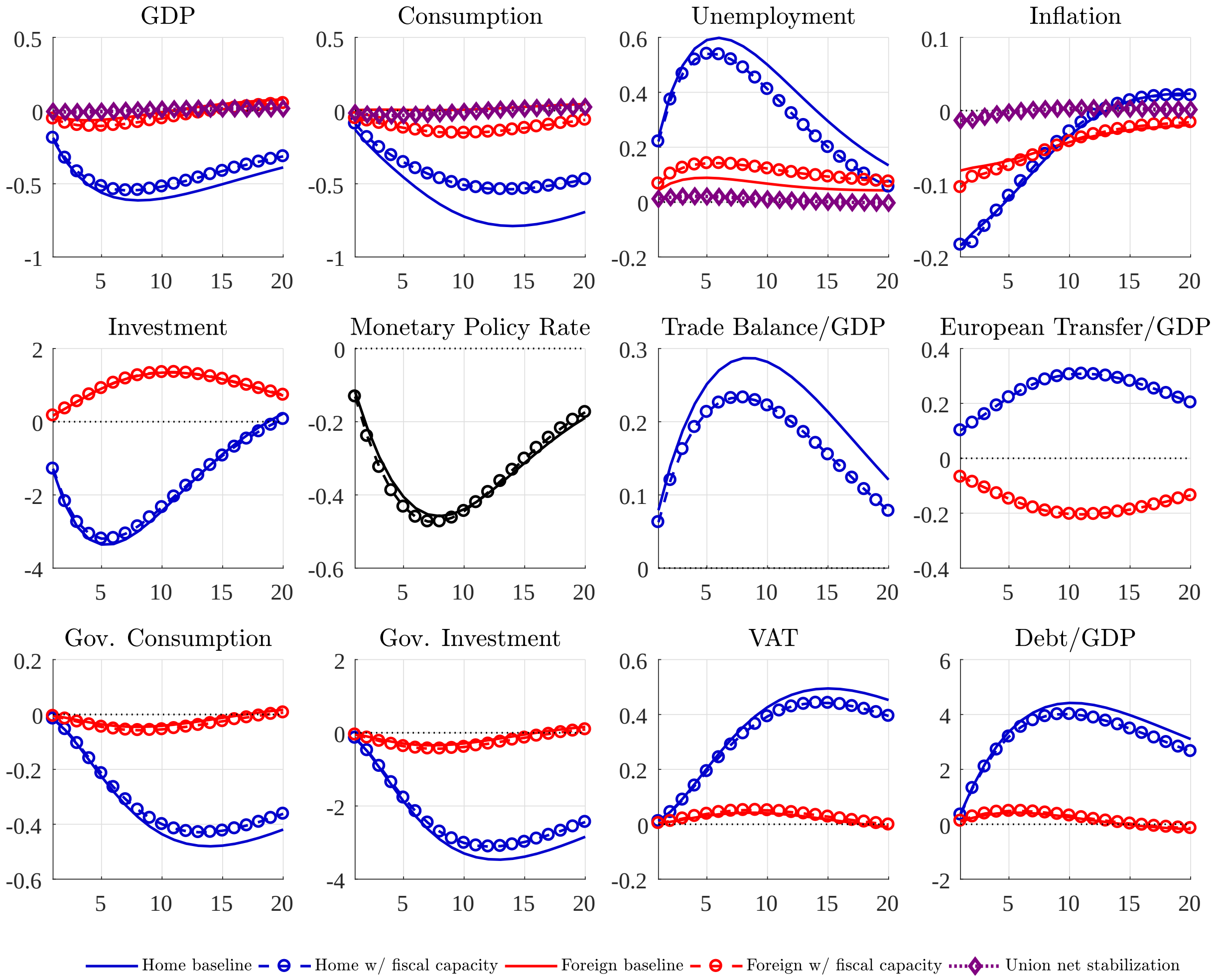


Figure 8: Impulse response functions with optimal European unemployment insurance, financed via labour income taxes

Notes: Benchmark calibration. EUI financed by European labour income taxes τ_t^{EU} and τ_t^{*EU}. Tax responses determined via optimal policy. Purple diamond lines show net stabilisation effects, calculated as difference between the responses with and without EUI, for the monetary union as a whole.

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