Synopsis of the Euro Area Financial Crisis *

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Abstract

The main objective of the paper is putting forward a structural narrative for the euro area financial crisis and its asymmetric consequences through the monetary union. In this respect, we conjecture three originating factors to the euro area financial fragmentation and discuss the role of specific financial frictions in transmitting and amplifying them: *i*) the cross-country rise in sovereign spreads, together with the strength of the sovereign-bank nexus, *ii*) the cross-country rise in corporate risk and non-performing loans together with banks risk-aversion and capital position, *iii*) the frontloading of bank deleveraging needs in a context of unprecedented regulatory overhaul. We develop global DSGE model featuring a sovereign-bank nexus, a granular set of relevant financial frictions. We calibrate it for 6 regions in order to reflect the financial heterogeneity across the largest countries of the euro area. The counterfactual scenarios show that the interplay between sovereign, banks and corporate solvency risks generated sizeable procyclicality in some jurisdictions of the euro area and severely impaired the transmission of the single monetary policy.

Keywords: DSGE models, banking, financial regulation, cross-country spillovers, bank lending rates.

JEL classification: E4, E5, F4.

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1 Introduction

The main objective of the paper is putting forward a structural narrative for the euro area financial crisis and its asymmetric consequences through the monetary union. In this respect, we conjecture three originating factors to the euro area financial fragmentation and discuss the role of specific financial frictions in transmitting and amplifying them: *i*) the cross-country rise in sovereign spreads, together with the strength of the sovereign-bank nexus, *ii*) the cross-country rise in corporate risk and non-performing loans together with banks risk-aversion and capital position, *iii*) the frontloading of bank deleveraging needs in a context of unprecedented regulatory overhaul. We develop global DSGE model featuring a sovereign-bank nexus, a granular set of relevant financial frictions. We calibrate it for 6 regions in order to reflect the financial heterogeneity across the largest countries of the euro area. The counterfactual scenarios show that the interplay between sovereign, banks and corporate solvency risks generated sizeable procyclicality in some jurisdictions of the euro area and severely impaired the transmission of the single monetary policy.

Three sets of empirical evidence are motivating the scenarios analysis at the core of the paper. First of all, the financial stress shouldered by intermediaries from 2010 to 2013 is related to sovereign debt tensions as illustrated by the rise in sovereign spreads in Italy and Spain notably (see Figure 1, top-left panel). The sovereign debt crisis contributed to the increase in bank-bond spreads for domestic banking jurisdictions (see Figure 1, top-right panel) and beyond, as some contagion to other banking sectors in countries less affected by the sovereign tensions became apparent (in France or Belgium notably). The resulting funding difficulties for banks impaired the ability of intermediaries to provide credit in many countries, with adverse implications for bank lending rates. Second, corporate risk surged in some jurisdictions and led to mounting non-performing assets in the banking system (see Figure 1, bottom-left and bottom-right panel). Increasing credit risk, deteriorating asset quality and bank risk aversion can also help to explain divergences in lending rates in an environment of weak economic growth. Third, euro area banks sizeably frontloaded over a three to four-year period a tightening of capital requirements related to the Basel III reform. While phased-in arrangement would have given almost 10 years for banks to adjust, the monitoring exercise conducted by the European Banking Authority shows that from mid-2011 to end-2014, euro area banks had increased their common equity tier 1 capital ratio (CET1) under the full implementation of the Basel III package, by around 5 p.p. (see Figure 2), thereby meeting market expectations well in advance of the initially planned horizon. Such a frontloading reinforced the deleveraging forces in some countries, already facing adverse financial market turbulence. Indeed, banks have in principle many ways to gradually comply with the new regulatory requirements while shielding their loan portfolio and lending practices to firms and households. However, an *ad hoc* question of the euro area bank lending survey (BLS) suggests that Italian or Spanish banks faced the regulatory and supervisory pressures by cutting on credit origination while in France and Germany the bulk of the adjustment came from capital increases (see Figure 3).

Against this background, first we develop a global dynamic stochastic general equilibrium (DSGE) model with a detailed banking system and a rich set of financial frictions. Second, based on this model we propose macro-financial scenarios which can give some meaningful synopsis of the various phases of the euro area (EA) financial crisis. The macroeconomic cost of financial fragmentation lies in the interplay between sovereign, banking and corporate credit risk. So the **first experiment** considers the transmission through credit channels, of the sovereign market tensions which are calibrated to reproduce the surge in sovereign spreads as observed from 2010 to 2013. This source of financial fragmentation is amplified by the observed contagion to bank funding conditions in jurisdictions less affected by the turbulence in sovereign segments. The macroeconomic multipliers are strong in countries under stress and spillovers within the euro area are sizeable. In itself, this counterfactual experiment would explain a large part of lending rate dispersion and poor economic performance in the euro area over the period. The **second experiment** focuses on the vicious circle that was activated through the crisis, from rising corporate default, lower bank asset quality and higher credit constraints. We simulate a cross-country increase in corporate risk to match available evidence on default frequency and non-performing loans within the euro area. These conditions propagate more forcefully through the intermediation chain of jurisdictions where banks are under-capitalised and risk-averse. The scenario adequately portrays another important source of financial fragmentation and shows to which extent such real-financial feedback loops could contribute to impair the monetary policy transmission channel in countries like Spain and Italy. The **final experiment** explores the potential for bank deleveraging process, on the back of unprecedented regulatory reform, to explain the pervasively high bank lending rates and the lacklustre credit dynamics in some countries, beyond the forces analysed in the previous two experiments. Even if our experiments could potentially overlap, not least as their quantitative calibration is not based on structural estimation, they do reflect independent forces at play during the crisis. A face value reading of the simulations, taken all together, would imply dramatic effects on lending rate dispersion, potentially beyond what was observed in reality both for stressed and non-stressed countries. This should not be seen as questioning the plausibility of our experiments but instead, it implicitly points to mitigating factors which partially shielded some jurisdictions. A crucial one has been non-standard monetary policy measures. Dealing with the joint role of fragmentation drivers and monetary policy actions is however beyond the scope of the present paper and is left for future research.

The specification of the domestic financial frictions in our model does bridge various strands of modelling literature which consider both supply and demand-side credit frictions, introduce risky banks and sovereign default (Bernanke et al. (1999), hereafter BGG, Christiano et al. (2010) and Kumhof et al. (2010) Gertler and Karadi (2011), Gerali et al. (2010), Darracq Pariès et al. (2011), Clerc et al. (2015),Benes and Kumhof (2011); Benes et al. (2014b,a)). On the last point, our modelling strategy is largely inspired by the seminal contribution of Corsetti et al. (2013) which put the emphasis on the credit channels of sovereign tensions.[1] We extend their work by introducing more granular financial and banking frictions, and by considering wider cross-country heterogeneity through a 6-region global model. The cross-country dimension of our analysis calls for a review of the direct financial spillovers within the monetary union. For the sake of clarity and given the sophistication in the design of domestic financial frictions, we only considered one type of international financing flows between domestic wholesale banks and retail foreign entities which can be interpreted as direct cross-border lending.[2] Finally, the model is calibrated which allows us to consider the state

[1] Corsetti et al. (2013) propose a New Keynesian model of a two-region monetary union that introduces a sovereign risk channel to credit spread in the private sector. In our model, the sovereign-bank nexus is dealt with in reduced-form manner, albeit with more structure than Corsetti et al. (2013): risky banks do not directly hold government debt but are exposed to sovereign default risk through their funding costs. van der Kwaak and van Wijnbergen (2014) introduce sovereign default risk in the model of Gertler and Karadi (2013) and analyse the link between sovereign solvency and financial fragility. A more microfounded treatment of sovereign bank interactions in the spirit of van der Kwaak and van Wijnbergen (2014) is left for future research.

[2] Guerrieri et al. (2012) study the international propagation of sovereign debt default in a different setup. They propose a two-block economy including core and periphery where capital constrained banks grant loans to firms and

of the economy before and during the crisis.

Overall, our model is a global DSGE including a reduced-form sovereign-bank nexus, risky banks acting in a monopolistic manner, financial frictions *à la* BGG and cross-border lending. It provides an original set of financial frictions together with wide cross-country heterogeneity. The real side of the economy is quite standard and as such close existing model like EAGLE (Gomes et al., 2012), the NAWM (Coenen et al., 2008), GEM (Laxton and Pesenti (2003) and Pesenti (2008)), GIMF (Kumhof et al., 2010) or QUEST (Ratto et al. (2009) and Kollmann et al. (2014)).

The remainder of this paper is organized as follows. Section 2 describes the model. Section 3 discusses the calibration strategy and the parameterizing of the model. Section 4 is devoted to the synopsis of the euro area financial crisis, through the lenses of three macro-financial scenarios. Section 5 summarizes and concludes.

2 The model

The next sections focus on the financial segments, which constitute the original part of the model. For the sake of clarity, we will present the associated decision problems in a closed economy setup, finally exposing the open economy dimension with cross-border lending. Beforehand, we start with a brief overview of the global economic environment (see also Figure 4 for the overall schematic representation). To save space we do not present households, firms, capital producers and government features (see Darracq Pariès et al. (2016)).

2.1 Global economic environment

Households are infinitely-lived agents and identified as Ricardian or non-Ricardian according to their access to financial markets. The former have access to financial markets while the latter do not. A fraction of Ricardian household's members are workers while the remaining is split into entrepreneurs and bankers. Furthermore, households supply differentiated labour services in monopolistically competitive markets where they act as setter of the nominal wage. It is assumed that wages are determined by staggered nominal contracts *à la* Calvo (Calvo (1983)). Ricardian households also gain utility from bank deposits over consumption due to the liquidity services bank debt provides them.

On the supply side, there are two types of firms, the intermediate and the final goods producing firms. The intermediate goods are consisting of internationally tradable and non-tradable goods for consumption and investment. The final-goods producing firms use all intermediate goods to produce the final goods which are non-traded and used for consumption and investment. Each firm in the intermediate goods sector sells its differentiated output under monopolistic competition. There is sluggish price adjustment due to staggered price contracts as *à la* Calvo.

Finally, the public authority includes the government and the central bank. Sovereign default may arise as a consequence of the government's inability to raise the funds necessary to honor its debt obligations. The monetary policy in each of the regions of the model (euro area and rest of the

invest in bonds issued by the domestic and the foreign government. Interestingly, they find sizeable spillover effects of default from Periphery to the Core through a drop in the volume of credit extended by the banking sector. In a more stylized manner Kollmann et al. (2011) and Kalemli-Ozcan et al. (2012) are also considering a two-country environment with a global banking sector. When a shock erodes the capitalisation of global banks, it reduces credit supply and depresses economic activity in both countries. In our case banks are local.

world) follows an interest rate rule of Taylor-type. In the case of the euro area, the equation holds for the single monetary authority.

Regarding the international dimension, cross-country spillovers can arise via two main channels: firstly, through cross border lending from domestic bankers to foreign retail lending branches and secondly through trade of intermediate consumption and investment. The different agents that interplay in our model and the respective sectors in the domestic or foreign economy where they operate on are illustrated in Figure 4 in a simplified schematic representation.

2.2 Financial intermediation

The banking sector collects deposit from Ricardian households and provides funds to the retail deposit banks. Wholesale banks take deposits from the retail deposit banks and give loans to the retail lending branches. In doing so, they face capital requirements which are sensitive to the riskiness of the loan contract. In particular, it is clear that by introducing capital requirements that are sensitive to the state of the economy, the inherent cyclicality in banks' lending behaviour is likely to be reinforced, as shown in Darracq Pariès et al. (2011). *Ceteris paribus*, a risk-sensitive capital requirements regime (i.e. the Basel II or Basel III capital adequacy framework; see BIS (2004)) is expected to have pro-cyclical effects. Wholesale banks provide lending to the retail lending banks which subsequently through loan officers provide loan contracts to entrepreneurs. The presence of nominal stickiness generates imperfect pass-through of market rates to bank deposit and lending rates. Credit contracts are proposed by loan officers to entrepreneurs with predetermined lending rates. The latter buy capital stock from the capital producers. Due to asymmetric information and costly state verification through monitoring costs, there are external financing premia which depend indirectly on the borrower's leverage.

Overall, default can occur in the model in three layers. Firstly, sovereign default materialises whenever the government debt-to-GDP reaches the fiscal limit. Secondly, banks may default when their return on asset is not sufficient to cover the repayments due to deposits. Lastly, entrepreneurs default when their income that can be seized by the lender falls short of the agreed repayment of the loan. Additionally, the same schematic representation provides an illustrative way to the impairments in the transmission mechanism of monetary policy by decomposing final lending rate into the chain of financing costs faced by the different agents and the associated financial shocks.

2.2.1 Banking sector

Every period, a fraction $(1 - f_I)$ of the representative I-type household's members are workers while a fraction $f_I e_I$ are entrepreneurs and the remaining mass $f_I(1 - e_I)$ are bankers. Bankers face a probability ζ_b of staying banker over next period and a probability $(1 - \zeta_b)$ of becoming a worker again. When a banker exits, accumulated earnings are transferred to the respective I-type household while newly entering bankers receive initial funds from households. Overall, households transfer a real amount $\Psi_{B,t}$ to the bankers for each period t. In our setting, bankers' decisions are identical so we will expose the decision problem for a representative banker.

The banking sector is owned by the I-type households and is segmented in various parts. First, bankers get financing in the money market and fund to the retail lending branches, facing a regulatory penalty which forces bankers to hoard a sufficient level of equity and benefiting from limited liability under a deposit insurance scheme. Second deposit branches collects savings from the I-type households and place them in the money markets. Third retail lending branches receive funding from the bankers and allocate it to the loan officers. In the retail segment, banks operate under monopolistic competition and face nominal rigidity in their interest rate setting. The final segment of the banking group is formed loan officers which provide loan contracts to entrepreneurs.

2.2.2 Retail deposit branches

The deposits offered to I-type households are a CES aggregation of the differentiated deposits provided by the retail deposit branches

$$D_t = \left[\int_0^1 D_t(j)^{\frac{1}{\mu_D^R}} \mathrm{d}j \right]^{\mu_D^R} \tag{1}$$

expressed in real terms. Retail deposits are imperfect substitute with elasticity of substitution $\frac{\mu_D^R}{\mu_D^R - 1} < -1$. The corresponding average interest rate offered on deposits is

$$R_{D,t} = \left[\int_0^1 R_{D,t}(j)^{\frac{1}{1-\mu_D^R}} \mathrm{d}j \right]^{1-\mu_D^R}. \tag{2}$$

Retail deposit branches are monopolistic competitors which collect deposit from savers and place them in the money market.[3] Deposit branches set interest rates on a staggered basis *à la* Calvo, facing each period a constant probability $1 - \xi_D^R$ of being able to re-optimize their nominal interest rate. When a retail deposit branch cannot re-optimize its interest rate, the interest rate is left at its previous period level

$$R_{D,t}(j) = R_{D,t-1}(j). \tag{3}$$

The retail deposit branch j chooses $\hat{R}_{D,t}(j)$ to maximize its intertemporal profit.

$$\mathbb{E}_t \left[\sum_{k=0}^{\infty} (\beta \xi_D^R)^k \, \frac{\Lambda_{I,t+k}}{\Lambda_{I,t}} \left(R_{BD,t+k} D_{t+k}(j) - \hat{R}_{t,D}(j) D_{t+k}(j) \right) \right] \tag{4}$$

where

$$D_{t+k}(j) = \left(\frac{\hat{R}_{D,t}(j)}{R_{D,t}} \right)^{-\frac{\mu_D^R}{\mu_D^R - 1}} \left(\frac{R_{D,t}}{R_{D,t+k}} \right)^{-\frac{\mu_D^R}{\mu_D^R - 1}} D_{t+k} \tag{5}$$

and $\Lambda_{I,t}$ is the marginal value of consumption for the Ricardian households.

A markup shock is introduced on the interest rate setting, by allowing μ_D^R to follow an AR(1) process with i.i.d. error term.

2.2.3 Bankers

Bankers operate in competitive markets providing loans to retail lending branches, $L_{BE,t}$. To finance their lending activity, bankers receive deposits, $D_{B,t}$, from the retail deposit branches, with a gross

[3] Notice that in an open economy setup with incomplete markets, deposit branches are charged by an extra risk premium depending on the country intra-EA net foreign position. The risk premium is required for the existence of a well-defined steady state and stationarity of the net foreign asset position. See for example Schmitt-Grohe and Uribe (2003) and Quint and Rabanal (2014).

interest rate $\widetilde{R}_{BD,t}$ and accumulate net worth, $NW_{B,t}$. Their balance identity reads

$$L_{BE,t} = D_{B,t} + NW_{B,t} \tag{6}$$

Bankers' assets are subject to idiosyncratic shocks, $\omega_{b,t}$, independent and identically distributed across time and across bankers. $\omega_{b,t}$ follows a lognormal CDF $F_b(\omega_{b,t})$, with mean 1 and variance $\sigma_{b,t}$. One may rationalise this source of microeconomic risks as a lack of diversification in loan exposures at the bank level or any other source heterogeneity which leads to a distribution of asset returns across the banking system.

The operating profit of a banker for the period $t+1$, OP^b_{t+1}, results from the gross interest received from the loans to the retail lending bank, the lump-sum share of profits (and losses) coming from retail deposit, $\Pi^R_{D,t}$, retail lending and loan officers activity, $\Pi^R_{B,t}$, pro-rated according to each banker's net worth, minus the gross interest paid on deposits

$$OP^b_{t+1}(\omega_{b,t+1}) \equiv \omega_{b,t+1} R_{BLE,t} L_{BE,t} - \widetilde{R}_{BD,t} D_{B,t} + \Pi^R_{D,t} + \Pi^R_{B,t+1}. \tag{7}$$

where $R_{BLE,t}$ is the banker's financing rate while $\widetilde{R}_{BD,t}$ captures the funding cost of the bankers specified as follows

$$\widetilde{R}_{BD,t} = \Psi_t R_{BD,t} \tag{8}$$

with

$$\Psi_t = \Lambda_{\Psi,t}\left(RP_{G,t} - 1\right) + 1 \tag{9}$$

being the funding cost spread related to sovereign risk. In a reduced-form manner, we set it as a linear function of the sovereign risk premium $RP_{G,t}$, with semi-elasticity $\Lambda_{\Psi,t}$.

Following Corsetti et al. (2013) we allow for sovereign default as a consequence of the government's inability to raise the funds necessary to honor its debt obligations. Subsequently sovereign risk premia respond to changes in the fiscal outlook of the country and the probability of sovereign default is closely and nonlinearly linked to the level of public debt. Overall this sovereign risk channel raises the cost of financial intermediation as described above. More specifically, sovereign default is operationalised with the notion of a fiscal limit in a manner similar to Corsetti et al. (2013) and Bi and Leeper (2010). Whenever the debt level rises above the fiscal limit, a default will occur. The fiscal limit is determined stochastically capturing the uncertainty that surrounds the political process in the context of sovereign default. Specifically, we assume that in each period the limit will be drawn from a normal distribution with parameters $B_Y^{\max}$ which is the maximum debt-to-GDP that a country can sustain and σ_{BY} the standard deviation of the probability distribution which captures the sensitivity of sovereign risk to debt-to-GDP. Beyond this limit the probability of default is certain. As a result, the *ex ante* probability of a default, $p_t^{\xi_G}$, at a certain level of sovereign indebtedness, $B_{Y,t+1}$, will be given by the normal cumulative distribution function $F_g(B_{Y,t+1})$, with mean $B_Y^{\max}$ and standard deviation σ_{B_Y}.

$$p_t^{\xi_G} \approx E_t\left\{F_g\left[\frac{B_{Y,t+1} - B_Y^{\max}}{\sigma_{B_Y}}\right]\right\} \tag{10}$$

where $B_Y^{\max}$ denotes the upper range of the support for the debt level in terms of the debt-to-GDP.

By assuming that the size of the haircut in case of a default is constant, the actual haircut in the economy is defined as

$$\begin{aligned}\xi_{G,t} &= \begin{cases} \xi_G^{\max}, & \text{with probability } p_t^{\xi_G} \\ 0, & \text{with probability } 1 - p_t^{\xi_G} \end{cases} \\ &= p_t^{\xi_G}\xi_G^{\max}\end{aligned} \tag{11}$$

Following the optimisation solution of the households problem, the sovereign risk premium can be defined as

$$RP_{G,t} = \frac{1}{1 - p_t^{\xi_G}\xi_G^{\max}} \tag{12}$$

We introduce two key assumptions in the decision problem of bankers: first, bankers enjoy *limited liability*, so their payoffs are always positive and second, regulators impose a *penalty* $\chi_b L_{BE,t}$ if the operating profit is less than a fraction ν_b of the risk weighted assets

$$rw_{e,t}\omega_{b,t+1}R_{BLE,t}L_{BE,t} \tag{13}$$

where $rw_{e,t}$ is the risk weight on corporate loans. Each banker takes the risk weight $rw_{e,t}$ as exogenous to their decisions.

In line with the Basel III capital adequacy framework, the risk weighted assets can be modelled as non-linear functions of the probability of default of the borrowers at a certain horizon.[4] Except if stated otherwise, we assume that the risk weight is constant and equal to 1. This assumption will be relaxed in the final sections of the paper.

Regarding limited liability, bankers default when their return on asset is not sufficient to cover the repayments due to deposits. This happens for draws of $\omega_{b,t+1}$ that fall below the threshold $\overline{\omega}_{b,t+1}$ given by

$$\overline{\omega}_{b,t+1} \equiv \frac{\widetilde{R}_{BD,t}D_{B,t} - \Pi^R_{D,t} - \Pi^R_{B,t+1}}{R_{BLE,t}L_{BE,t}}. \tag{17}$$

Bank leverage is denoted as $\kappa_{b,t} = \frac{L_{BE,t}}{NW_{B,t}}$ and the default cutoff point can be expressed as

[4] For more details on the Basel II formulas, see BIS (2004). For corporate exposures, the risk weights are given by

$$rw_{e,t} = \frac{\overline{LGD}_E}{\nu_b}\Phi\left[\left(1-\tau_t^E\right)^{-0.5}\Phi^{-1}\left(PD_t^E\right) + \left(\frac{\tau_t^E}{1-\tau_t^E}\right)^{0.5}\Phi^{-1}(0.999)\right] - \frac{\overline{LGD}_E}{\nu_b}PD_t^E \tag{14}$$

where PD_t^E and LGD_t^E refer to the one-year-ahead probability of default and loss-given-default on corporate exposures, respectively. Φ denotes the cumulative distribution function for a standard normal random variable. τ_t^E denotes the asset-value correlation which parameterizes cross-borrower dependencies and being a decreasing function of PD_t^E is equal to

$$\tau_t^E = 0.12\left[\frac{\left(1-\exp\left(-50PD_t^E\right)\right)}{\left(1-\exp\left(-50\right)\right)}\right] + 0.24\left[1 - \frac{\left(1-\exp\left(-50PD_t^E\right)\right)}{\left(1-\exp\left(-50\right)\right)}\right] \tag{15}$$

As we assume a fixed $\overline{LGD}_E$ (equal to 0.45), the only time-varying component in the risk weighting is the PD_t^E and the resulting risk curve has a concave nature. On the other hand, PD_t^E is related to entrepreneurs quarterly default probability according to

$$PD_t^E = \mathbb{E}_t\left\{\sum_{i=1}^{4}\left[\prod_{s=0}^{i-1}\left(1 - F_e\left(\overline{\omega}_{e,t+s}\right)\right)\right]F_e\left(\overline{\omega}_{e,t+i}\right)\right\} \tag{16}$$

$$\overline{\omega}_{b,t+1} \equiv \frac{\widetilde{R}_{BD,t}\left(\kappa_{b,t}-1\right)-\frac{\Pi^{R}_{D,t}}{NW_{B,t}}-\frac{\Pi^{R}_{B,t+1}}{NW_{B,t}}}{\kappa_{b,t}R_{BLE,t}} \tag{18}$$

When bankers default occurs, the deposit insurance agency serves the depositors and takes over the loan portfolio of the failed banker subject to resolution costs (μ_b), expressed as a fraction of the banker's assets.

Turning to the penalty, if the banker does not default, it will be paid for realisations of $\omega_{b,t+1}$ below a second threshold $\overline{\omega}^{\nu}_{b,t+1}$ given by

$$\overline{\omega}^{\nu}_{b,t+1} = \frac{\overline{\omega}_{b,t+1}}{1-\nu_b rw_{e,t+1}} > \overline{\omega}_{b,t+1} \tag{19}$$

where ν_b is the regulatory bank capital ratio. We assume that bankers are myopic and choose the volume of loans that maximizes the expected return on net worth one period ahead. Due to the assumption of limited liability, the period t objective of a banker is

$$\max_{\{\overline{\omega}^{\nu}_{b,t+1},\overline{\omega}_{b,t+1},\kappa_{b,t}\}} \mathbb{E}_t \left\{ \widetilde{E}\left[OP^{b}_{t+1}\left(\omega_{b,t+1}\right) \mid \omega_{b,t+1} \geq \overline{\omega}_{b,t+1}\right] - \widetilde{E}\left[\chi_b L_{BE,t} \mid \omega_{b,t+1} \leq \overline{\omega}^{\nu}_{b,t+1}\right] \right\} \tag{20}$$

where $\widetilde{E}$ is the conditional expectation operator for the cross-section distribution of idiosyncratic banker returns on private loans.

After some manipulations, this problem can be formulated as follows

$$\max_{\{\overline{\omega}^{\nu}_{b,t+1},\overline{\omega}_{b,t+1},\kappa_{b,t}\}} \mathbb{E}_t \left\{ R_{BLE,t}\kappa_{b,t}\left[1-\Gamma_b\left(\overline{\omega}_{b,t+1}\right)\right] - \chi_b\kappa_{b,t}\left(F\left(\overline{\omega}^{\nu}_{b,t+1}\right)-F\left(\overline{\omega}_{b,t+1}\right)\right)\right\} \tag{21}$$

subject to the balance sheet constraint (6) and the definition of cutoff idiosyncratic shocks (18) and (19) and where χ_b is the regulatory penalty, and $\Gamma_b(\overline{\omega})$ is defined as follows

$$\Gamma_b(\overline{\omega}) = (1-F_b\left(\overline{\omega}\right))\overline{\omega} + \int_0^{\overline{\omega}} \omega \mathrm{d}F_b\left(\omega\right) \tag{22}$$

The first order condition for the banker's decision problem, in the case of limited liability, after some manipulations, gives

$$R_{BLE,t}\left(1-\int_0^{\overline{\omega}_{b,t+1}} \omega \mathrm{d}F_b\left(\omega\right)\right) = \widetilde{R}_{BD,t}\left(1-F_b\left(\overline{\omega}_{b,t+1}\right)\right) \tag{23}$$
$$+\chi_b \left[\begin{array}{c} \left(F\left(\overline{\omega}^{\nu}_{b,t+1}\right)-F\left(\overline{\omega}_{b,t+1}\right)\right) \\ +\left(\mathrm{d}F_b\left(\overline{\omega}^{\nu}_{b,t+1}\right)/\left(1-\nu_b rw_{e,t+1}\right)-\mathrm{d}F_b\left(\overline{\omega}_{b,t+1}\right)\right)\left(\frac{\widetilde{R}_{BD,t}}{R_{BLE,t}}-\overline{\omega}_{b,t+1}\right) \end{array}\right]$$

In the absence of limited liability, the expected return on net worth would boil down to

$$\mathbb{E}_t\left[R_{BLE,t}\kappa_{b,t}\left(1-\overline{\omega}_{b,t+1}\right)-\chi_b\kappa_{b,t}F\left(\overline{\omega}^{\nu}_{b,t+1}\right)\right] \tag{24}$$

and the first order condition could be written as

$$R_{BLE,t} = \widetilde{R}_{BD,t} + \chi_b \left[F\left(\overline{\omega}^{\nu}_{b,t+1}\right) + \frac{\mathrm{d}F_b\left(\overline{\omega}^{\nu}_{b,t+1}\right)}{1-\nu_b rw_{e,t+1}} \left(\frac{\widetilde{R}_{BD,t}}{R_{BLE,t}} - \overline{\omega}_{b,t+1} \right) \right] \tag{25}$$

Finally, aggregating across bankers, a fraction ζ_b continues operating into the next period while the rest exits from the industry. The new bankers are endowed with starting net worth, proportional to the assets of the old bankers. Accordingly, the aggregate dynamics of bankers' net worth is given by

$$NW_{B,t} = \zeta_b \left\{ R_{BLE,t-1}\kappa_{b,t-1}\left[1-\Gamma_b\left(\overline{\omega}_{b,t}\right)\right] - \chi_b\left(F\left(\overline{\omega}^{\nu}_{b,t}\right) - F\left(\overline{\omega}_{b,t}\right)\right) \right\} \frac{NW_{B,t-1}}{\Pi_{C,t}} + \Psi_{B,t} \tag{26}$$

Several shocks are introduced in the banker's problem. The first one is a bank capital shock, rationalised as a temporary decline in the bankers survival probability $\zeta_{b,t}$, the second one is a permanent or temporary increase in regulatory requirement ν_b, and the last one is a temporary increase in the idiosyncratic risk on bankers asset return $\sigma_{b,t}$. All variables are assumed for this purpose to follow an AR(1) process with i.i.d. error term.

2.2.4 Retail lending branches

A continuum of retail lending branches indexed by j, provide differentiated loans to loan officers. The total financing needs of loan officers follow a CES aggregation of differentiated loans

$$L_{E,t} = \left[\int_0^1 L_{E,t}(j)^{\frac{1}{\mu^R_E}} \mathrm{d}j \right]^{\mu^R_E} \tag{27}$$

Differentiated loans are imperfect substitute with elasticity of substitution $\frac{\mu^R_E}{\mu^R_E - 1} > 1$. The corresponding average return on loan is

$$R_{LE,t} = \left[\int_0^1 R_{LE,t}(j)^{\frac{1}{1-\mu^R_E}} \mathrm{d}j \right]^{1-\mu^R_E}. \tag{28}$$

Retail lending branches are monopolistic competitors which levy funds from bankers and set gross nominal interest rates on a staggered basis *à la* Calvo, facing each period a constant probability $1 - \xi^R_E$ of being able to re-optimize. As for deposits, the indexation rule in case a retail lending branch cannot re-optimize its interest rate is given by

$$R_{LE,t}(j) = R_{LE,t-1}(j) \tag{29}$$

The retail lending branch j chooses $\hat{R}_{LE,t}(j)$ to maximize its intertemporal profit

$$\mathbb{E}_t \left[\sum_{k=0}^{\infty} \left(\beta\xi^R_E\right)^k \frac{\Lambda_{I,t+k}}{\Lambda_{I,t}} \left(\hat{R}_{LE,t}(j) L_{E,t+k}(j) - R_{BLE,t+k}(j) L_{E,t+k}(j) \right) \right] \tag{30}$$

where the demand from the loan officers is given by

$$L_{E,t+k}(j) = \left(\frac{\hat{R}_{LE,t}(j)}{R_{LE,t}} \right)^{-\frac{\mu^R_E}{\mu^R_E - 1}} \left(\frac{R_{LE,t}}{R_{LE,t+k}} \right)^{-\frac{\mu^R_E}{\mu^R_E - 1}} L_{LE,t+k} \tag{31}$$

The staggered lending rate setting acts in the model as maturity transformation in banking activity and leads to imperfect pass-through of market interest rates on bank lending rates. We add markup shocks to the staggered nominal interest rate setting, by allowing μ_E^R to follow an AR(1) process with i.i.d. error term.

2.2.5 Loan officers

Loan officers provide loan contracts to entrepreneurs. They operate in a perfectly competitive environment. They receive one-period loans from the retail lending branches which pay a gross nominal interest rate $R_{LE,t}$. The loan officers have no other source of funds so that the level of loan they provide to the entrepreneurs equals the level of financing they receive, $B_{E,t}$. Loan officers seek to maximise its discount intertemporal flow of income so that the first order condition of their decision problem gives

$$\mathbb{E}_t\left[\Xi_{t,t+1}^I\left(\frac{\widetilde{R}_{LE,t+1}-R_{LE,t}}{\Pi_{C,t+1}}\right)\right]=0 \tag{32}$$

We denoted $\widetilde{R}_{LE,t+1}$ the state-contingent returns on the loan portfolio, whereas $\Xi_{t,t+1}^I=\beta\frac{\Lambda_{I,t+1}}{\Lambda_{I,t}}$ is the period t stochastic discount factor of the I-type households for nominal income streams at period $t+1$.

2.2.6 Market clearing conditions

On the credit market, due to nominal rigidity in the setting of interest rate by retail banking branches, the following conditions holds

$$\begin{aligned} L_{BE,t} &= \Delta_{E,t}^R L_{E,t} && (33)\\ D_{B,i} &= \Delta_{D,t}^R D_t && (34) \end{aligned}$$

where $\Delta_{i,t}^R=\int_0^1\left(\frac{R_{i,t}(j)}{R_{i,t}}\right)^{-\frac{\mu_i^R}{\mu_i^R-1}}\mathrm{d}j$ for $i\in\{E,D\}$ are dispersion indexes among retail bank interest rates.

In equilibrium

$$\Pi_{D,t}^R=\left(R_{BD,t}-R_{D,t}\right)D_{B,t} \tag{35}$$

$$\Pi_{B,t+1}^R=\left(\widetilde{R}_{LE,t+1}-R_{BLE,t}\right)L_{BE,t}. \tag{36}$$

Finally, the financing needs of the deposit insurance agency, which are assumed to be amount to be recouped out of government spending are defined as follows

$$\Omega_{b,t}\equiv\left[\overline{\omega}_{b,t}-\Gamma_b\left(\overline{\omega}_{b,t}\right)+\mu_b\int_0^{\overline{\omega}_{b,t+1}}\omega\mathrm{d}F_b\left(\omega\right)\right]R_{BLE,t}L_{BE,t}. \tag{37}$$

where μ_b is the resolution cost of the bankrupt bank.

2.2.7 Entrepreneurs

Every period, a fraction $f_I e_I$ are entrepreneurs. Each entrepreneur faces a probability ζ_e of staying entrepreneurs over next period and a probability $(1-\zeta_e)$ of becoming a worker again. To keep the share of entrepreneurs constant, we assume that similar number of workers randomly becomes entrepreneur. When an entrepreneur exits, their accumulated earnings are transferred to the respective I-type household. At the same time, newly entering entrepreneurs receive initial funds from households. Overall, households transfer a real amount $\Psi_{E,t}$ to the entrepreneurs for each period t. Finally, as it will become clear later, entrepreneurs decisions for leverage and lending rate are independent from their net worth and therefore identical. Accordingly, we will expose the decision problem for a representative entrepreneur.

A segment of perfectly competitive capital producer firms, owned by the I-type households, produce the stock of fixed capital in the economy using tradable investment goods. At the end of the period t entrepreneurs buy the capital stock K_t from the capital producers at real price Q_t (expressed in terms of consumption goods). They transform it into an effective capital stock $u_{t+1}K_t$ by choosing the utilisation rate u_{t+1}. The adjustment of the capacity utilization rate entails some costs per unit of capital stock $\Gamma_u(u_{t+1})$. The effective capital stock can then be rented out to intermediate goods producers at a nominal rental rate of $r_{K,t+1}$. Finally, by the end of period $t+1$, entrepreneurs sell back the depreciated capital stock $(1-\delta)K_t$ to capital producer at price Q_{t+1}. The gross nominal rate of return on capital across from period t to $t+1$ is therefore given by

$$R_{KK,t+1} \equiv \frac{((1-\tau^K_{t+1})(r_{K,t+1}u_{t+1}-\Gamma_u(u_{t+1}))P_{I,t+1}+\tau^K_t\delta P_{I,t+1}+(1-\delta)Q_{t+1})}{Q_t\Pi_{C,t+1}} \tag{38}$$

where τ^K_t is tax rate to capital, $\Pi_{C,t+1}$ is CPI inflation and $P_{I,t+1}$ is the relative price of investment goods in terms of consumption goods.

Each entrepreneurs' return on capital is subject to multiplicative idiosyncratic shock $\omega_{e,t}$. These shocks are independent and identically distributed across time and across entrepreneurs. $\omega_{e,t}$ follows a lognormal CDF $F_e(\omega_{e,t})$, with mean 1 and variance $\sigma_{e,t}$. By the law of large number, the average across entrepreneurs (denoted with the operator $\widetilde{E}$) for expected return on capital is given by

$$\widetilde{E}\left[\mathbb{E}_t\left(\omega_{e,t+1}R_{KK,t+1}\right)\right] = \mathbb{E}_t\left(\int_0^\infty \omega_{e,t+1}\mathrm{d}F_{e,t}(\omega)\,R_{KK,t+1}\right) = \mathbb{E}_t\left(R_{KK,t+1}\right) \tag{39}$$

Entrepreneur's choice over capacity utilization is independent from the idiosyncratic shock and implies that $r_{K,t} = \Gamma'_u(u_t)$.

Entrepreneurs finance their purchase of capital stock with their net worth $NW_{E,t}$ and one-period loan $L_{E,t}$ from the commercial lending branches, where

$$Q_tK_t = NW_{E,t} + L_{E,t} \tag{40}$$

In the tradition of costly-state-verification frameworks, loan officers cannot observe the realisation of the idiosyncratic shock unless they pay a monitoring cost μ_e per unit of assets that can be transferred to the bank in case of default. We constrain the set of lending contracts available to entrepreneurs. They can only use debt contracts in which the lending rate $R_{LLE,t}$ is pre-determined at the previous time period. Default will occur when the entrepreneurial income that can be seized by the lender falls short of the agreed repayment of the loan. At period $t+1$, once aggregate shocks are realised, this will happen for draws of the idiosyncratic shock below a certain threshold $\overline{\omega}_{e,t}$, given by

$$\overline{\omega}_{e,t+1}\chi_e R_{KK,t+1}\kappa_{e,t} = \left(R_{LLE,t}+1\right)\left(\kappa_{e,t}-1\right) \tag{41}$$

where $R_{LLE,t}$ is the nominal lending rate determined at period t and $\kappa_{e,t}$ is the corporate leverage defined as

$$\kappa_{e,t} = \frac{Q_t K_t}{NW_{E,t}}. \tag{42}$$

χ_e represents the share entrepreneurs assets (gross of capital return) that banks can recover in case of default. When banks take over entrepreneur's assets, they have to pay the monitoring costs.

The *ex post* return to loan officers, denoted $\widetilde{R}_{LE,t}$, can then be expressed as

$$\widetilde{R}_{LE,t} = G(\overline{\omega}_{e,t})\chi_e R_{KK,t}\frac{\kappa_{e,t-1}}{\kappa_{e,t-1}-1} \tag{43}$$

where

$$G_e(\overline{\omega}) = (1-F_e\left(\overline{\omega}\right))\overline{\omega} + (1-\mu_e)\int_0^{\overline{\omega}} \omega \mathrm{d}F_e\left(\omega\right). \tag{44}$$

We assume that entrepreneurs are myopic and the end-of-period t contracting problem for entrepreneurs consists in maximising next period return on net worth for lending rate and leverage

$$\max_{\{R_{LLE,t},\kappa_{e,t}\}} \mathbb{E}_t\left[\left(1-\chi_e\Gamma_e(\overline{\omega}_{e,t+1})\right)R_{KK,t+1}\kappa_{e,t}\right] \tag{45}$$

subject to the participation of constraint of the lender (32), the equation (41) for the default threshold $\overline{\omega}_{e,t+1}$, and where

$$\Gamma_e(\overline{\omega}) = (1-F_e\left(\overline{\omega}\right))\overline{\omega} + \int_0^{\overline{\omega}} \omega \mathrm{d}F_e\left(\omega\right). \tag{46}$$

After some manipulations, the first order conditions for the lending rate and the leverage lead to

$$\mathbb{E}_t\left[\left(1-\chi_e\Gamma_e(\overline{\omega}_{e,t+1})\right)R_{KK,t+1}\kappa_{e,t}\right] = \frac{\mathbb{E}_t\left[\chi_e\Gamma_e'(\overline{\omega}_{e,t+1})\right]}{\mathbb{E}_t\left[\Xi^I_{t,t+1}G_e'(\overline{\omega}_{e,t+1})\right]}\mathbb{E}_t\left[\Xi^I_{t,t+1}\right]R_{LE,t} \tag{47}$$

where

$$\Gamma_e'(\overline{\omega}) = \left(1-F_e\left(\overline{\omega}\right)\right) \tag{48}$$

$$G_e'(\overline{\omega}) = \left(1-F_e\left(\overline{\omega}\right)\right) - \mu_e\overline{\omega}\mathrm{d}F_e\left(\overline{\omega}\right). \tag{49}$$

As anticipated at the beginning of the section, the solution of the problem shows that all entrepreneurs choose the same leverage and lending rate. Moreover, the features of the contracting problem imply that the *ex post* return to the lender $\widetilde{R}_{LE,t}$ will defer from the *ex ante* return $R_{LE,t-1}$.[5]

The loan contract introduced in this section is different from the one of Bernanke et al. (1999) in two respects: first, we impose that the contractual lending rate is predetermined and second, we assume limited seizability of entrepreneurs assets in case of default. In BGG, it is the return to the

[5] Log-linearising equation (47) and the participation constraint (32), one can show that innovations in the *ex post* return are notably driven by innovations in $R_{KK,t}$.

lender that is predetermined[6] while the contractual lending rate is state contingent. This implies that from period t to $t+1$, the realisation of aggregate shocks has no impact of lender's balance sheet. The assumption of predetermined contractual lending rate relaxes this property and allows for innovations on the lender's return. Besides, the restrictions imposed on the contracting problem imply that it is not optimal in the sense of Carlstrom et al. (2013a,b).

Finally, the dynamic of net worth is given by

$$NW_{E,t} = \zeta_e \left(1 - \chi_e \Gamma_e(\overline{\omega}_{e,t})\right) R_{KK,t} \kappa_{e,t-1} \frac{NW_{E,t-1}}{\Pi_{C,t}} + \Psi_{E,t}. \tag{50}$$

It is assumed that the standard deviation σ_e which measures the risk to bankruptcy, is time-varying and follow and AR(1) process with i.i.d error terms.

2.2.8 Cross-border banking

Following the closed economy exposition of the various financial segments, we now introduce the open economy dimension which allows for the possibility of cross-border lending between domestic bankers and foreign retail lenders. Given the stylised description of the banking system in the model, such flows can be interpreted both as cross-border lending whereby a domestic bank provides direct loan contract to a foreign non-financial corporation, or intrabank lending to an affiliate which in turn provides financing to foreign non-financial corporations. We will discuss this point in more detail in the section on the model calibration.

To simplify the notations, the open economy specifications will be exposed in a symmetric two-country setup under monetary union, denoting by H the domestic country and by F the foreign one. In the following, we derive the modified decision problems for retail lending branches and bankers in country H.

Each retail lending branch receives funding domestic as well as foreign bankers through a CES aggregation technology

$$L_{E,t} = \left[v_{LE}^{\frac{1}{\xi_{LE}}} \left(L_{E,t}^{H}\right)^{\frac{\xi_{LE}-1}{\xi_{LE}}} + (1 - v_{LE})^{\frac{1}{\xi_{LE}}} \left(RER_t L_{E,t}^{H \leftarrow F}\right)^{\frac{\xi_{LE}-1}{\xi_{LE}}} \right]^{\frac{\xi_{LE}}{\xi_{LE}-1}} \tag{51}$$

where $L_{E,t}^{H}$ and $L_{E,t}^{H \leftarrow F}$ are domestic and foreign currency loans, expressed in real terms, and RER_t is the bilateral CPI-based real exchange rate.

Cost minimisation implies that the composite gross funding cost for the retail lending branches $\widehat{R}_{BLE,t}$ is given by

$$\left(\widehat{R}_{BLE,t}\right)^{1-\xi_{LE}} = v_{LE} \left(R_{BLE,t}^{H}\right)^{1-\xi_{LE}} + (1 - v_{LE}) \left(R_{BLE,t}^{F}\right)^{1-\xi_{LE}}. \tag{52}$$

In this context, the demand for domestic and foreign lending is

$$L_{E,t}^{H} = v_{LE} \left(\frac{R_{BLE,t}^{H}}{\widehat{R}_{BLE,t}} \right)^{-\xi_{LE}} L_{E,t} \tag{53}$$

[6] If the lending rates offered by banks are not contingent on the *ex post* realization of aggregate uncertainty (i.e. pre-determined lending rates) shocks hitting the economy tend to have a more muted effect relative to the benchmark scenario. In this case, this reflects the less pronounced interactive effects between macroeconomic developments (e.g. the accelerator effects on borrower net worth) and the credit market. This mitigates somewhat the macroeconomic amplification implied by the existence of credit frictions observed in the benchmark case.

$$RER_t L_{E,t}^{H\leftarrow F} = (1 - \upsilon_{LE}) \left(\frac{R_{BLE,t}^{F}}{\widehat{R}_{BLE,t}} \right)^{-\xi_{LE}} L_{E,t}. \tag{54}$$

In this open economy context, the market clearing condition of bank loans is modified as follows

$$L_{BE,t} = \Delta_{E,t}^{R} L_{E,t}^{H} + \Delta_{E,t}^{R*} L_{E,t}^{F\leftarrow H} \tag{55}$$

where $\Delta_{E,t}^{R}$ and $\Delta_{E,t}^{R*}$ are dispersion indexes among retail bank interest rates in the home economy and the foreign one, respectively.

2.3 Monetary policy

Given the variety of interest rates in the model, the monetary policy implementation deserves some discussion. We assume that the central bank aims at steering the money market rate, i.e. the credit-risk free interest rate that applies to bank funding instruments, $R_{BD,t}$. The asset structure of the model economy could in principle have allowed for another operational target, like the risk-free private bond (i.e. the CAPM interest rate) or the household deposit rate. Our specification is probably more realistic and consistent with the approach followed by most recent papers which consider segmented banking models.

The monetary policy in each of the regions of the model (rest-of-the-world or the euro area) follows an interest rate rule, of Taylor-type, defined as follows

$$R_{BD,t} = \phi_R \left(R_{BD,t-1} \right) + (1 - \phi_R) \left[\left(\overline{R} \right) + \phi_\Pi \left(\Pi_{C,t} - \overline{\Pi} \right) \right] + \phi_Y \left(\Delta Y_t - 1 \right) \tag{56}$$

specified in terms of region-wide CPI inflation rate ($\Pi_{C,t}$ defined in deviation from the target $\overline{\Pi}$ and output growth ΔY_t). The intercept of the rule is the equilibrium interest rate $\overline{R}$.

3 Calibration

The calibration is summarised in annual terms in Tables 1 to 15 and is set according to empirical evidence or existing literature. As concerns the financial variables, we use data on loans and lending rates from the BSI and MIR statistics from the ECB. We also base the calibration on consolidated banking statistics for foreign exposures from BIS (2013), on the expected default probabilities from Moodys, and Basel II and III capital adequacy framework (see BIS (2004)). The calibration of financial block is broadly in line with existing literature, e.g. Jakab and Kumhof (2014), Benes and Kumhof (2011) and Cruces and Trebesch (2013).

3.1 Non-financial block

Table 1 shows the steady-state values of **main macro variables** in the model. Variables which are part of national accounts and represent the domestic demand and trade in the economies are reported as ratios to GDP. Table 2 reports the calibration of the **monetary and fiscal authorities**. Regarding the monetary policy rule, the interest rate reacts to its lagged value as well as to quarterly inflation and to the quarterly output growth. It is calibrated non-symmetrically across countries as we allow for higher interest rate inertia and interest rate sensitivity to inflation gap in the rest of the world rather than in the euro area, while the sensitivity of output growth in the rest of the world is lower than in the euro area. The inflation target is set to 2% per year on all regions.

Table 3 reports the calibration of the Ricardian and non-Ricardian **households**. The discount factor, β, is set symmetrically across countries to 0.995. This implies that the equilibrium gross annual real interest rate, $(1/\beta)^4$, is approximately equal to 1.02. The parameters for the intertemporal elasticity of substitution, σ, and the inverse of the Frisch elasticity of labour, ζ, are also calibrated symmetrically and equal to 1 and 2. The habit persistence parameter, κ, is calibrated symmetrically to 0.9. Wage implied elasticities of substitution, η_I and η_J, are calibrated symmetrically across the two types of households but country specific across regions. They imply higher wage markups in the euro area around 30% compared to the rest of the world which is around 16%. Calvo wage parameters, ξ_I and ξ_J, are calibrated as well symmetrically across the two types of households and equal to 0.75. The indexation parameters, χ_I and χ_J, are calibrated symmetric across the two types of households and across regions and equal to 0.65. As concerns only the Ricardian I-type households whose share $1-\omega$ is set to 0.75 in all region, their deposit preferences, ζ_{db}, are consistent with an overall annual deposit spread of 40%, since households are ready to accept lower returns on deposits due to utility gains from services provided. The elasticity of substitution for deposits, η_{db}, is calibrated symmetrically and equal to 1.25.

Table 4 reports the calibration of the **capital producers and firms** behaviour. With respect to the capital producers, the depreciation rate, δ, the investment adjustment cost parameter, γ_I, and the capital utilisation rate, γ_{u2}, are calibrated symmetrically across countries being equal to 2.5% (consistent with an annual depreciation rate of 10%), 6 and 7, respectively. In the intermediate goods sector, the bias towards capital is higher for tradable goods (α_T) than for nontradable goods (α_N). As for the final goods baskets, the degree of substitutability between domestic and imported tradables, μ_{TC}, is higher than that between tradables and nontradables, μ_C, consistent with existing literature (e.g. GEM or EAGLE). In particular, we set the elasticity of substitution between tradables and non-tradables to 0.5 while the elasticity between domestic and imported tradable goods to 3.5.[7] In most countries, the bias towards the tradable bundle is higher in the investment basket than in the consumption baskets. The weight of domestic tradable goods in the consumption and investment tradable baskets is different across countries, to be coherent with multilateral import-to-GDP ratios. Price markups in the two sectors are higher in the EA than in ROW. Specifically, the net price markup in the tradables sector ($\theta_T/(\theta_T-1)$) is around 20% in the euro area and around 15% in the rest of the world. The markup in the nontradable good's sector ($\theta_N/(\theta_N-1)$) is equal to 40% in the euro area and below 30% in ROW.[8] Calvo price parameters in the domestic tradables, ξ_H, and non-tradables, ξ_N, sectors are set to 0.90 ($1/(1-\xi_H)=10$ quarters) in the euro area, consistently with estimates by Christoffel et al. (2008) and Smets and Wouters (2003). Corresponding nominal rigidities outside the euro area are equal to 0.75, implying an average frequency of adjustment equal to 4 quarters, in line with Faruquee et al. (2007). Calvo price parameters in the export sector, χ_X, are equal to 0.75 in all the regions. The indexation parameters on prices, χ_H and χ_N, are both equal to 0.40.

[7] These numbers are broadly in line with related literature, see Imbs and Méjean (2009), Imbs and Méjean (2010) and Corbo and Osbat (2013) for details.

[8] The chosen values are consistent with estimates from Martins et al. (1996), suggesting that the degree of competition in the nontradable sector is lower than in the tradable sector. Also, these values are in line with other similar studies, such as Bayoumi et al. (2004), Faruquee et al. (2007) and Everaert and Schule (2008).

3.2 Financial block

The financial block of the model involves sovereign risk associated with fiscal developments of each country, the banking sector which is represented by bankers and retail banking branches and entrepreneurs. There are three different calibration strategies for assigning parameter values. The first one involves the direct setting of parameters in the financial block based on information from existing literature or historical data. If that is not possible, then the second strategy uses information on endogenous variables which can shed light on the target parameters.[9] Lastly, when dealing with the dynamic model, we try to specify sensitivities and degrees of adjustments through the usage of information on elasticies or pass-through parameters or multipliers available from econometric studies. Irrespective of the above techniques, we calibrate the above sectors both symmetrically across regions and asymmetrically. The symmetric one aims at facilitating the interpretation of the qualitative properties of the model and could for some aspects be rationalised as a pre-crisis calibration (notably regarding bankers or entrepreneurs calibration) or correspond to very long-term structural features of the steady state (notably regarding symmetric government debt-to-GDP ratio). The asymmetric calibration allows for cross-country heterogeneity which helps quantifying the role of country-specific financial frictions in domestic propagation and international spillovers.

Starting with **sovereign risk**, we calibrate the parameters of the cumulative probability function which links debt-to-GDP developments to the probability of default of the government. Although in Corsetti et al. (2013) the CDF is represented with a *beta* distribution, in our case due to computational limitations,[10] we try to proxy the *beta* with a *Normal* distribution, in the range debt-to-GDP around 40-160% that we consider more plausible to materialise for the countries we focus our analysis on. In this respect, the *Normal* distribution $F_g(B_Y)$ is characterised by two parameters, the mean B_Y^{mean} and the standard deviation σ_{B_Y}. We calibrate both parameters by mapping them with two endogenous variables of the model. The first being the average level of sovereign risk premium as observed from the five-year credit default swaps. The second is the sensitivity of the sovereign government bond spread to a 1% increase in the debt-to-GDP ratio. These elasticities are taken from available studies: Borgy et al. (2011) estimates the increase in five-year spreads of France, Italy and Spain against Germany following an expected increase in their debt-to-GDP ratio over the next year; the sensitivity for Germany is assumed to be similar to the US which is estimated in Laubach (2006).

The symmetric calibration of sovereign risk is shown in Table 5. Sovereign bond spreads are set at 0.8%, resulting in B_Y^{mean} equal to 119.5. The sovereign bond spread sensitivity to debt-to-GDP is set to 0.12%, a cross-country average following the above studies, implying that σ_{B_Y} is 20.4. Lastly, debt-to-GDP ratio is calibrated to be 67.5% which corresponds to the average value across time and countries in the pre-crisis period. The level of haircut, $\xi_G^{\max}$, in case of sovereign default, is calibrated symmetrically across countries to 0.37, which according to Cruces and Trebesch (2013) corresponds to the median haircut calculated from a sample of sovereign debt re-structuring between 1970 and 2010.

When allowing for cross-country heterogeneity, as reported in Table 6, we intend to capture country-specific features on the steady-state level of debt-to-GDP, on the probability of government

[9] We map an endogenous variable at the steady state with a parameter and adjust the later to match the target value for the former.

[10] The beta distribution is not available in Troll.

default and its sensitivity to changes in government indebtedness. Sovereign spreads for Germany and France are calibrated below average, at 0.32% and 0.4%, respectively, while in Spain and Italy there are higher, at 1.2% and 1.12%, respectively. Furthermore, the sensitivity of sovereign spreads to 1% increase in debt-to-GDP is also calibrated to be heterogeneous across countries and consistent with the studies above: at 0.035% for Germany, 0.07% for France, 0.17% for Spain and 0.23% for Italy. Concerning steady-state debt levels, Spain has the lowest while Italy the highest. The rest-of-the-euro-area region remains calibrated as in the symmetric case. As mentioned before, our asymmetries are taken from (Borgy et al., 2011). The loss given default parameter $\xi_G^{\max}$ in case of sovereign default remains the same across countries. The fiscal rules are also kept unchanged.

Table 7 shows the calibration of the **bankers** in the symmetric case. We set the bankers funding cost sensitivity to sovereign bond spread, Λ_Ψ, to 0.6. This value is consistent to the average empirical evidence across euro area countries on the pass-through of sovereign yield to lending rates (see for example Darracq Pariès et al. (2014) or Altavilla et al. (2014)). Furthermore, we calibrate the standard deviation of the idiosyncratic shock σ_b so that the annual percentage of banks violating the minimum capital adequacy ratio is approximately equal to 15%, corresponding to a 4% per quarter as in Benes and Kumhof (2011). The bank resolution cost, μ_b, is calibrated to 0.3. The minimum capital requirements, ν_b, is set to 8% while the steady-state capital ratio of bankers is set approximately to 12%. A symmetric capital buffer of around 4-4.5% is consistent with available empirical evidence over the pre-crisis period. Furthermore, we calibrate regulatory penalty, χ_b, such that in the steady state, the bank capital wedge which is the spread over and above the funding cost is equal to 0.6%. The continuation probability of bankers, ζ_b, clears the net worth accumulation equation for given spreads and capital ratio. This calibration leads to a negligible steady-state probability of bankers defaulting. In this context, the limited liability distortions become almost irrelevant in the symmetric case.

In the non-symmetric case, as shown in Table 8 we generate cross-country heterogeneity through a non-symmetric calibration of the level of NFC loan indebtedness of each country which results in non-symmetric bank leverage for each country. Furthermore, cross-country heterogeneity emerges from the non-symmetric calibration of sovereign risk, which impacts in a non-symmetric manner the funding cost of the banking sector. Although the rest of the calibration in the benchmark case remains the same as in the symmetric case, in section **??** we perform and show some sensitivity analysis around the above two cases where we allow for higher and asymmetric bank risk calibration and for limited liability to be active. The calibration of these exercises is not shown in the tables.

Table 9 shows the calibration of the **retail banking branches** in the symmetric case. The elasticity of substitution μ_D^R of the CES aggregation of differentiated deposits is parameterised to be 0.999, resulting in a negative deposit spread of 40%. Furthermore, the probability of not being able to re-optimise deposit rate, ξ_D^R, is set to 1%, resulting in almost perfect pass-through of market interest rate on to bank deposit rates. The elasticity of substitution μ_E^R of the CES aggregation of differentiated loans is calibrated as such so that the overall spread between the commercial lending rate is equal to 2.4%. Regarding staggered lending rate setting, the probability of not being able to re-optimise lending rates each quarter, ξ_E^R, is calibrated symmetrically at 40%. This value allows to reproduce the euro area wide average pass-through of short-term rate to composite bank lending rates (see notably the evidence provided by Darracq Pariès et al. (2014)).

When allowing for cross-country heterogeneity, as shown in Table 10, we assume that in Germany and France there is lower maturity transformation than in Spain and Italy. This is calibrated through higher probabilities of not re-optimising lending rates in Germany and France, up to 60% , and lower in Spain and Italy, down to 20%.

As shown in Table 11, we calibrate the standard deviation of the idiosyncratic shock in the **entrepreneurs** problem, σ_e, to match 2.8% of corporate default probability. This value is very close to the one used by Jakab and Kumhof (2014). The monitoring cost μ_e of the costly-state-verification set-up is set so that the commercial lending rates are 0.6% higher than the retail bank returns. The recovery ratio in case of default, χ_e, is calibrated to 100%. On this basis, the steady-state level of corporate leverage, κ_e, is symmetric across countries at around 1.6. The entrepreneurs debt-to-GDP ratio is however country-specific as it also depends on asymmetric features from the non-financial block. The level of private sector indebtedness in the steady state is broadly consistent with an interpretation of bank intermediation which would cover both firms and household borrowing. In this sense, the productive capital stock of the model should also account for commercial and residential housing stock. At the same time, the recovery ratio, χ_e, constitutes an additional degree of freedom to target lower levels of corporate indebtedness, everything else being equal. The continuation probability of bankers, ζ_e, clears the net worth accumulation equation for given spreads.

In the non-symmetric case, as indicated in Table 12, we intend to account for cross-country differences in steady-state probabilities of default, private sector indebtedness and external finance premium. This is done firstly by setting lower default probabilities for Germany and France but higher for Spain and Italy, in line with corresponding evidence from Moody's Expected Default Frequency.[11] Furthermore, we target steady-state values for entrepreneurs debt-to-GDP ratio to match historical data on country-specific indebtedness ratio for the non-financial private sector. The deep parameters that are adjusted are the monitoring cost, μ_e, and the volatility of idiosyncratic shocks, σ_e. The external finance premium and the entrepreneurs leverage are determined endogenously.

Finally, Table 13 shows the calibration of the **cross-border lending** matrix which allows for international financial linkages. The calibration of the matrix is based on consolidated banking statistics on foreign exposures from (BIS, 2013). Similarly to the calibration of the trade matrix, the quasi-shares of the CES function aggregating financing flows from euro area countries to domestic loan officers are calibrated to match the structure of cross-border loans as a share of total financing (endogenous in the model). In the symmetric case, it is assumed that there is no cross-border lending and therefore no direct financial spillovers arising from the banking sector. In the asymmetric case, we would like to focus on exposures among euro area countries, therefore ignore cross-border flows between the euro area and the rest of the world. The BIS data suggest that Germany, Italy and rest-of-euro area are the most exposed countries with loans granded by foreign banks accounting to around 35% of total private credit. The largest bilateral exposure is observed between Italy and France as around 19% of Italian corporate loans are granted by French banks. Financial bilateral spillovers among other euro area countries are also significant but to a lesser extent. For example, around 20% of German NFC loans are granded by Italian and rest-of-euro area banks. In addition, around 17% of Italian NFC loans are granted by French banks. Lastly, around 11% of rest-of-euro area NFC loans are intermediated also by French banks.

Tables 13 and 14 attempts to show an accounting decomposition of lending rates in order to

[11]The probabilities of default are calculated based on the Moodys Expected Default Frequency (EDF). The EDFs corresponds to the expected probability of default 1-year ahead.

identify the major source of risks in the determination of lending rates. The former table corresponds to the symmetric case, while the latter in the non-symmetric case. As shown in Tables 10 and 14, cross border lending has an impact on the determination of the final commercial lending rate, allowing for risk shifting within euro area countries. For example, we observe that in jurisdictions with higher risk (e.g. sovereign and banking) like Italy and Spain, the more open is the banking sector the more it helps in alleviating some of the factors that has an upward push in commercial lending rates. The vice versa is almost true. In jurisdictions with less riskiness, the more open the banking sector, the more the increase in commercial lending rates. In the symmetric case where we do not allow for cross border lending, this factor is zero.

In the dynamic setup of the model the AR(1) processes of the exogenous shocks have an autocorrelation parameter equal to 0.9-0.95 and the errors are i.i.d with zero mean and standard deviation equal to 1.

4 Synopsis of the financial crisis

The narrative of the euro area financial crisis that our model aims at disentangling, lies in the interplay of credit risk in the sovereign, banking and corporate sectors. The phases of the euro area crisis that we concentrate on, abstract from the first recession in 2008-2009 when the global demand and uncertainty constituted common contractionary factors for all euro area countries. Conversely, the subsequent years, from 2011 to 2013, witnessed successive episodes of financial stress whose emblematic symptoms could be portrayed by bank lending rate dispersion. The size of the model leaves any direct estimation strategy computationally challenging. Therefore, we do not intend in this paper to reach formal statistical inference on the most likely sources of financial fragmentation over this period. Instead, we develop three scenarios which illustrate the structural underpinnings of three salient features of the crisis: ***(i)* the macroeconomic spillovers of sovereign market tensions through risky banks, *(ii)* the adverse real-financial feedback loop from rising corporate default to weak banks and credit supply constraints, *(iii)* bank deleveraging process at times of unprecedented regulatory overhaul.** Those three dimensions are certainly not mutually exclusive but give some meaningful synopsis of the various phases of the euro area financial crisis.

To construct our counterfactual experiments we proceed in two steps. First, we derive suitable country-specific instruments to proxy the source of financial fragmentation under scrutiny (from sovereign tensions to corporate rate risk and bank deleveraging needs). Second, we consider amplification or dampening forces that could operate across the euro area economies. The benchmark model used in the scenarios allows for asymmetric calibration in sovereign risk, monopolistic lending rate setting, corporate risk and cross-border lending. The symmetric calibration of section **??** is also used to help disentangling the role of asymmetric shocks and non-financial block calibration in the cross-country features of the scenarios.[12]

We will also assume that monetary policy is temporarily constrained in responding to the financial disturbance. In doing so, we want to reflect the conditions in which the central bank rapidly exhausted its room of maneuver regarding its standard monetary policy instrument. Treating the

[12]This symmetry concerns both the steady-state features as well as the strength of the financial frictions which are intimately related in our micro-foundations and calibration strategy. To some extent, it could also be seen as a pre-crisis calibration, when the financial spreads across the monetary union appeared relatively close to each other.

lower bound on interest rate more explicitly is beyond the scope of the present paper. Similarly, we would not consider the role of non-standard monetary policy actions in mitigating the adverse consequences of the various scenarios. This evaluation is also left for further research. Nonetheless, the macroeconomic multipliers of financial factors that we illustrate thereafter are plausible assessment lines that central banks may consider *ex ante* when deciding and calibrating non-standard measures.

4.1 Euro area financial fragmentation and the sovereign debt crisis

The first scenario takes as its main driving force, the emergence of tensions in sovereign markets from 2010 to 2012. The surge in sovereign spreads for Italy and Spain due to re-appraisal of solvency risk as well as global uncertainty around the future of the euro area can be seen as the main originating factor for our experiment. Another dimension to consider is the financial contagion from domestic sovereign tensions to foreign banks. In particular, market-based funding costs increased significantly in countries less affected by the sovereign stress, like France or Belgium. Therefore, we will set exogenous shocks on government bond yield risk premium in Spain, Italy and the rest-of-euro area, and supplement this with a funding shock on bankers in France. Germany and the rest-of-the-world are not hit by any specific disturbance. For the sake of isolating the credit channels of the euro area sovereign debt tensions, we nonetheless ignore two important aspects of the economic narrative: first, we do not account for a global uncertainty shock and its fallouts on global growth, which undoubtedly accompanied the euro area crisis. Second, the fiscal rules in the stressed countries are left unchanged even if the deteriorating fiscal positions would otherwise call for additional fiscal consolidation as governments unconvincingly attempt to address markets' concern about the sustainability of the public finances.

The magnitude of the sovereign shocks, $\xi_{G,t}^{max}$, is guided such that the increases in sovereign bond yields simulated with the symmetric calibration, are qualitatively similar to the observed developments during the 2010-2012 period. In reality, the rise in sovereign spreads is driven by series of risk factors, like "risk-free" term premium, fundamental solvency risk, liquidity premium, global uncertainty and what has been labelled "redenomination risk" (see De Santis (2015)). Such premia can be considered exogenous in our model and proxied by $\xi_{G,t}^{max}$ shocks, with the exception of fundamental solvency risk. Consequently, the counterfactual experiment could have been calibrated *ex ante* on the basis of the changes in sovereign spreads that cannot be attributed to fundamental solvency risk. The regression analysis of De Santis (2015) may provide a basis to do so and would imply smaller shocks. At the same time, since we do not directly account in the scenario for the observed increase in public indebtedness and solvency risk, this strategy would understate the contribution of the sovereign-bank feedback loop over the period.

Figure 5 first shows the outcome of higher government spreads for three years in Italy, Spain and rest of euro area, based on the symmetric calibration of the model. The sovereign yield shocks propagate through the intermediation chain of the vulnerable countries, ultimately driving up commercial lending rates by approximately 150 bps in Spain, 125 bps in Italy and 100 bps in the rest-of-euro area. The tightening of credit supply conditions is particularly adverse in Italy and Spain, with around 10% decline in investment, around 2% output loss and 6% credit contraction. For Germany and France, the financial conditions remain broadly unchanged (also given that in the symmetric calibration cross-border lending is absent) and the adverse effects on economic activity come from trade and exchange rate channels. Overall, the disinflationary pressures peak at -0.2 p.p. for all euro area countries. The homogenous responses on the nominal side contrasts with the asymmetric impact on economic activity: as noticed in the analysis of financial wedge shocks transmission, this can be explained by the "cost channel" of financial tensions which raises up the output sacrifice ratio of disinflation in the countries most affected by sovereign tensions.

Figure 6 repeats the same scenario, adding contagion to French banks and using the benchmark asymmetric calibration. The *ex ante* funding shock on bankers in France is calibrated at 40% of the sovereign shock in Italy, in line with the high frequency dynamic correlation measured over the crisis period 2010-2012. The benchmark calibration implies stronger transmission of the sovereign shocks on the cost-of-financing chain in Italy and Spain and now, commercial lending rates in France also move up by almost 100 bps. Through cross-border lending, financing conditions in Germany tighten, albeit marginally. Turning to the real-side, investment falls significantly more than in the symmetric calibration and the output loss reaches around 3% in Italy and Spain and 1.5% in France while Germany is not significantly affected.

4.2 Real-financial amplification through weak bank balance sheets

Protracted periods of weak economic conditions and continued uncertainty regarding the duration of the sovereign debt crisis have weighed on the profitability and the financial buffers of non-financial corporations. Successive recessionary episodes left the corporate sectors in part of the euro area with fragile balance sheet conditions, impaired debt-servicing capacity and higher probability of default. As a result, banks would tend to charge higher lending rates and tighten credit conditions for borrowers. The pro-cyclical behaviour of financial intermediaries may also be aggravated by weak bank capital position, excessive risk concentration or mounting legacy assets. In these conditions, lenders can be expected to recoup more than the expected losses due to rising default rates, building up capital buffers, de-risking their asset composition and even outright deleveraging.

Our second scenario imports such a rationale and portrays real-financial feedback loops by considering the propagation of corporate credit risk shocks through risk-averse bankers which respond to increasing expected losses on their loan portfolio by hoarding more capital. This mechanism is introduced in the model through risk-sensitive capital requirements: bankers extrapolate the unexpected increase in corporate default probability into higher regulatory risk weights for corporate exposures. This assumption shares some similarities with the model of bank credit supply exposed in Adrian et al. (2012) and Adrian and Shin (2014), where intermediaries adjust their leverage through the cycle and crisis time, in order to stabilise their value-at-risk (VaR). In our model, we account for this pattern through the risk-weights formulae of the Basel Committee for Banking Supervision, which actually proxy a VaR constraint from the credit risk model of Vasicek (2002). As shown in the description of bankers decision problem of section 2.2.3, risk weights are a non-linear functions of regulatory probability of default, the later being some "through the cycle" average of borrowers default risk (see equations (14) to (16)): $rw_{e,t} = g\left(PD_t^E\right)$ with $PD_t^E = \mathbb{E}_t\left\{h\left(..., F_e\left(\overline{\omega}_{e,t+i}\right), ...\right)\right\}$. The tightness of the additional "VaR constraint" will therefore depend on the link between PD_t^E and the shorter term actual default probabilites of entrepreneurs $F_e\left(\overline{\omega}_{e,t+i}\right)$. To illustrate the mechanism, we postulate the following relation

$$PD_t^E = \alpha_{PD}\left\{F_e\left(\overline{\omega}_{e,t}\right)\right\}^{annual} + \left(1-\alpha_{PD}\right)\mathbb{E}_t PD_{t+1}^E \qquad (57)$$

setting α_{PD} equal to 0.05. Accordingly, the regulatory probability of default will respond to the corporate risk shocks of the scenario, reflecting the medium-term average of expected default probabilities of entrepreneurs.

The exogenous disturbances for this scenario are the standard deviations of idiosyncratic shocks, $\sigma_{e,t}$, affecting entrepreneurs return on capital. The scenario is calibrated so that the simulated credit risk compensation in lending rate setting under the symmetric calibration, reaches the level of expected losses and capital charges observed from the mechanical lending rate decomposition of Figure **??** for Spain, Italy and France. Over a two-year horizon, commercial lending rates gradually increase to 150 bps in Spain, 100 bps in Italy and 50 bps in France, following a sequence of unexpected corporate risk shocks.

Figure 7 reports on the scenario outcome under the symmetric calibration, assuming that risk-weights are not responding to the temporary rise in corporate default risk. We focus the description of the scenario on peak effects. The repeated upside surprises on corporate default probabilities trigger loan losses for bankers due to pre-determined lending rates in loan contracts offered to entrepreneurs. In turn, bankers decrease their financing rate, by around 30-40 bps depending on the country. The tightening in cost of financing conditions leads to investment cutbacks of approximately 13% in Spain, 8% in Italy and 3% France. The corresponding output losses amount to 2% in Spain, 1% in Italy and 0.6% in France while the associated credit contractions are roughly four times bigger. The trade spillovers to Germany and the rest-of-euro area bring economic activity are quite limited. Overall, annual inflation falls by 0.2 p.p. below baseline across euro area countries. Similarly to the previous sovereign tension scenario, the disinflation pressures are quite homogenous across countries despite the asymmetric corporate risk shocks: this is partly explained by the "cost channel" of financial frictions in stressed countries which the lack of monetary policy accommodation reinforces the disinflationary dynamics in the other countries.

Figure 8 reproduces the scenario of Figure 7 using the benchmark asymmetric calibration. Riskier sovereign and corporate sectors in Italy and Spain, and to a lesser extent in France, significantly amplify the real-financial propagation of corporate risk shocks. Commercial lending rates now rise up to 150 bps in Spain and 125 bps in Italy. The transmission of corporate vulnerabilities to sovereign risk is particularly pronounced in Italy and to a lesser extent Spain, leading to stronger and pervasive fragmentation in bankers funding rate through the sovereign-bank nexus. For Italy the decline in capital expenditures and economic activity is then twice stronger than in the symmetric case (with 2% instead of 1% output losses).

In Figure 9, the same scenario is conducted but now banks in Italy and Spain adjust their risk weights along with the rise in entrepreneurs default probabilities. This creates an additional accelerator mechanism, this time on the supply side of credit markets. Commercial lending rates now rise up to almost 250 bps in Spain and 200 bps in Italy. The more stringent regulatory requirements in Spain and Italy constrain bankers in those jurisdictions to reduce their leverage and increase their loan-deposit margins, which is noticeable in the stronger adjustment of bankers refinancing rates, as compared to the constant risk-weight simulations. Overall, the decline in investment is more pronounced in Spain and in Italy. We set for these simulations quite low response of regulatory default probability to actual ones, and it did generate significant amplification. Higher and more protracted pick-up in risk-weights would trigger dramatic deleveraging patterns and credit supply constraints.

4.3 Bank deleveraging process and regulatory pressures

The third scenario explores the potential for bank deleveraging needs, on the back of unprecedented regulatory reform, to explain the pervasively high bank lending rates and the lacklustre credit dynamics in some countries, beyond the forces analysed in the previous two experiments. In principle, the new regulatory requirements for banks initiated since 2010 would constitute a common shock across euro area countries. Its phase-in arrangements would ensure that the transitory costs are contained and its credible implementation would allow the long-term benefits to even materialise earlier. Our model has potentially a lot to say about both macroeconomic costs and benefits of regulatory changes: higher capital requirements lead to a temporary tightening of loan supply conditions which is gradually compensated by lower bank default probability, the mitigation of risk-shifting behaviour and lower fiscal cost of deposit insurance. A fully-fledged analysis along those lines is not the focus of the present paper and as such, would have limited relevance for the assessment of euro area financial fragmentation. Indeed, euro area banks have met the new regulatory requirements much ahead of the envisaged timeline, against the backdrop of adverse financial market conditions. Such a frontloading of bank balance sheet adjustment is the main subject of this section.

Transitory costs and long-term benefits of higher regulatory requirements: some illustrative simulations

Beforehand, we nonetheless expose the trade-offs between transitory costs versus potential long-term benefits of regulatory changes within our modelling framework. Certainly, the long-term macroeconomic benefits of tighter regulatory requirements are stronger when banks are risky and weakly capitalised and when phase-in arrangements cover an extended period of time. In order to illustrate this, as in Clerc et al. (2015), we first postulate the following relation on the funding cost of bankers

$$\widetilde{R}_{BD,t} = \Psi_{1,t}\Psi_{2,t}R_{BD,t} \tag{58}$$

with

$$\Psi_{1,t} = \Lambda_{\Psi_{1},t}\left(RP_{G,t} - 1\right) + 1 \tag{59}$$

being the funding cost spread related to sovereign risk, as described in section 2.2.3, while $\Psi_{2,t}$ captures the cost depositors incur in case of bank default. The later is defined as

$$\Psi_{2,t} = \frac{1}{1 - \Lambda_{\Psi_{2},t}\Gamma_b\left(\overline{\omega}_{b,t+1}\right)} \tag{60}$$

with $\Lambda_{\Psi_{2},t}$ being the semi-elasticity to bank default probability. This cost should not be thought as being related to any loss on deposits since the presence of the deposit insurance agency guarantees that its financing needs are fully recouped out of government spending. It should rather be thought as a transaction cost associated with bank restructuring in the case of default.

On the one hand, this assumption provides a channel for higher capital requirements, and thereby lower probability of bank default, to ease in the long-run the financing conditions of bankers. An additional steady-state macroeconomic benefits stems from the lower fiscal cost of deposit insurance, $\Omega_{b,t}$ from equation (37), which is assumed to be recouped out of public spending. On the other hand, higher capital requirements have a detrimental effect on steady-state lending conditions through the bank capital channel and the regulatory penalty.

In order to evaluate these trade-offs both in the steady state and through the transitional dynamics, the model is calibrated symmetrically across countries with high bank risk, and significant risk-shifting distortions within the banking system. Similarly to the calibration strategy explained in section 3.2, bankers in each country have now an annual probability of default of 2%, a capital buffer of 3 p.p. and a financing rate spread of 0.6% (in annual terms). We also vary the depositor cost of bank default $\Lambda_{\Psi_2,t}$, from 0.1 to 0.2.

The first exercise focuses on *steady-state comparative statics*. We illustrate the sensitivity of the steady-state allocation to higher capital requirements, for different assumptions on the depositor cost of bank capital or the fiscal cost of deposit insurance. Figure 10 shows the steady-state level of euro area GDP and lending rate spreads for various levels of ν_b, starting from 8% to 15%. Results are expressed in deviation from the initial steady state (with ν_b at 8%). The blue and green lines correspond to the simulations with $\Lambda_{\Psi_2,t} = 0.1$ and $\Lambda_{\Psi_2,t} = 0.2$ respectively, assuming that the fiscal cost of deposit insurance is constant. The red line keeps $\Lambda_{\Psi_2,t} = 0.2$ and let the fiscal cost of deposit insurance decline with lower bank probability of default. As anticipated, output and intermediation spread tend to display hump-shaped patterns, which are all the more pronounced as the depositor and fiscal costs channels of bank default are active. Capital requirements is costly for banks and as the increase in capital requirements becomes larger, this effect dominates. For milder regulatory tightening however, the benefits from safer banks outweigh the costs, by deterring incentives for risk-shifting, and lowering the costs for depositors and governments. Quantitatively, with high depositor cost of bank default and endogenous fiscal cost of deposit insurance, the steady-state output improves and lending rate spread compresses till capital requirements reach around 10-11% (see red lines in Figure 10). Keeping the fiscal cost of deposit insurance constant limits the output gains but leaves the narrowing of spreads unchanged. Dampening the depositor cost channel dramatically mutes the scope for net benefits, with output declining below and spreads ending up above the initial steady state for capital requirements higher then 10% (see blue line in Figure 10).

We turn now to *the transitional dynamics*. We consider a scenario of 25% more stringent capital requirements (i.e. from 8% to 10%) phased-in over 5 years. In addition, the regulatory reform is announced 5 years before it gradually enters into play and we assume that it is fully anticipated by economic agents. The scenario is then run for two calibrations of the model. The first one corresponds to the high bank risk calibration as in Figure 10, with high depositor cost of bank default and endogenous fiscal cost. In this case, the 2 p.p. increase in capital ratio almost maximises the long-term output benefits. The second one is the symmetric calibration of section 3.2 which ignores the economic benefits channels given the very low probability of bank defaults in the steady state. The two simulations will therefore give polar illustrations for the transition to meaningful long-term benefits in the former case, and to mild long-term cost in the later case. Figure 11 displays the euro area output and lending rate spread responses for both calibrations, in percentage deviations from the initial steady state. With the high bank risk calibration (red line), the macroeconomic allocation is broadly unchanged over the anticipation period. When the capital requirements start increasing, the lending rate spread tightens somewhat for two years before gradually decreasing towards its long-term level at 0.25% below the initial steady state. This generates a mild temporary contraction in output, peaking at less than 0.2 p.p., 3 years after the new requirements are phased-in. Thereafter, the macroeconomic benefits gradually materialise amounting to 0.9 p.p. of output in the long run. By contrast, with the symmetric calibration (blue line), the output transitional costs appear sooner, also through the announcement period as banks and firms start deleveraging in anticipation of future tightening of capital requirements. Output then reaches its new steady-state level already after 10 years. Lending rate spreads temporarily overshoot their long-term increase in the first 3 years of the implementation period, peaking at 0.35%, and narrow somewhat afterwards to end at around 0.25% above the initial steady state after 15 years.

Overall, this section has shown that, within the confines of our theoretical framework, higher regulatory requirements can lead to sizeable long-term net benefits and mild transitional costs when *i*) banks engaged in excessive risk-taking and are weakly capitalised, and *ii*) the new requirements are credibly announced and gradually phased-in. It is also worth noticing that the macroeconomic costs measured under the symmetric calibration, both for the short-to-medium term and in the long-run, are quite close to the main DSGE-based evaluation of the FSB-BCBS Macroeconomic Assessment Group and the long-term economic impact studies from the BCBS (see BIS (2010b) and BIS (2010a)). However the preceding simulations showed that our model can go beyond the costs and quantify the sources of macroeconomic benefits related to the lower riskiness of banking system. More quantitative analysis in this respect is left for future research.

Bank deleveraging and frontloading of regulatory adjustments

Conditions prevailing through the euro area financial crisis were certainly not conducive to the relatively benign evaluation of the regulatory reform illustrated previously. Instead, some euro area jurisdictions faced strong deleveraging pressures against adverse financial market developments. In this context, banks frontloaded the needed adjustments as an attempt to bring back market confidence. To some extent, the financial turbulences made the regulatory changes pro-cyclical, adding deleveraging pressures at times of weak economic fundamentals, tight lending conditions, disruptions in funding markets and low bank profitability.

The previous two scenarios, on sovereign tensions and corporate losses, precisely put banks in Italy and Spain, and to a lesser extent France, in a challenging position to strengthen their capital base, due to funding strains and loan losses. To recall, with the benchmark model calibration, the combination of both scenarios would imply a peak bank capital shortfall for these countries between 0.4 p.p. and 0.8 p.p. of total assets over the first 5 years of the simulations. At the same time, the peak decline in loans over the same horizon reaches 7% in Italy and Spain, and 4% in France, while GDP falls below baseline by 5% and 3.5% respectively.

Against the backdrop of unfolding sovereign and corporate risk scenarios, the frontloadling of capital requirements would be consistent, notably for banking jurisdictions already struggling to consolidate their balance sheets against such adverse headwinds. The evidence presented in section **??** on stylised facts also suggest that while most of euro area banks met the new requirements much ahead of the envisaged final implementation, the shedding of assets and the more adverse spillovers to the macroeconomy, would have been most acute in Italy and Spain.

This notwithstanding, we start by simulating for all euro area countries a symmetric higher capital requirements, by 4 percent in a period of 3 to 4 years. Figures 12 reports the outcome of the scenario, under the benchmark calibration of the model. As in the symmetric calibration used before, we ignore here the economic benefits channels from depositor cost of bank default and endogenous fiscal cost of the deposit insurance scheme, also given the very low probability of bank defaults in the steady state. Higher capital requirements will lead to an immediate increase in bank risk of exhausting its capital buffer. Bankers are therefore pushing up their financing rate in order to boost net interest income and retained earnings. Cross-country heterogeneity already appears at this stage with higher rate in Italy, mainly due to the stronger sensitivity of sovereign spreads, and thereby bankers funding cost, to deteriorating fiscal position. Subsequently, the higher capital requirements impact entrepreneurs as commercial lending rates increase with even more cross-country dispersion. Asymmetric nominal rigidities in lending rate setting together with different degree of corporate riskiness drive the stronger increase observed for Italy and Spain, compared with France and Germany: commercial lending rates peak at 50 bps in Italy, 40 bps in Spain and around 35 bps in France, Germany and rest-of-euro area. before returning to a new higher equilibrium. The overall capital ratio of banks gradually increase, by almost three percentage points after 5 years. Given the 4 p.p. higher capital requirements, it implies a compression of the long-run capital buffer: by consolidating their capital base and raising their net interest rate margin (even in the steady state as shown in Figure 11, blue line), bankers can cushion part of the tighter requirements through lower excess capital.

Turning to broader economic conditions, investment expenditures are significantly cut back, declining by 7% at the peak for Italy, around 6% for Germany, 5% for Spain and France, and a bit less for rest-of-the euro area. This cross-country heterogeneity extends to output responses, with peak effects ranging from around 1.2% in Germany and Italy to less than 1% in France and rest-of-the euro area.

As discussed before, such a frontloading of capital requirements which affects adversely euro area countries in a symmetric manner may not be fully plausible, as some jurisdictions had much easier access to capital markets and might have coped with the new regulatory framework in ways that shielded their core retail exposures. In order get a sense of an asymmetric distribution of bank deleveraging needs across the monetary union, we reproduced the previous scenario only considering the frontloading of capital requirements in Spain and Italy. The corresponding simulations are displayed in Figure 13. Now, the deterioration of economic situation in Spain and Italy is slightly stronger, with output declining by more than 1.5% and investment by almost 10%. The degradation is explained by a less favourable evolution of real interest rates compared to previous case (higher nominal interest rates – only part of the EA is affected – are not fully compensated by higher inflation). All in all, the interest rate channel dominate here clearly the trade channel which brings positive gains from the countries which did not adjust. This also contributes to more pronounced increase in commercial lending rates in Italy notably. All in all, for the non-affected euro area countries, output is hardly responding.

4.4 Holistic perspective on the financial scenarios in the presence of the lower bound on interest rate

One salient feature of the crisis, which has not been explicitly discussed yet, is the lower bound on interest rate (ZLB) faced by the monetary authority. The severity of the financial crisis has exhausted the room of manoeuvre of standard monetary policy easing. Actually, the ZLB constraint has prevented the central bank from being as accommodative as necessary, according to available estimates of the Taylor rule for the euro area. Certainly, non-standard monetary policy actions have complemented the cuts in policy rates and in some cases, have been directly targeted to address financial fragmentation and impairments in the transmission channel of monetary policy. Modelling non-standard measures and assessing their effectiveness is beyond the scope of the present paper.

Instead, we focus here on the propagation of financial tensions in the presence of the lower bound of interest rate.

For the sake of illustration, we consider the macroeconomic impact of the combined three crisis scenarios and evaluate the amplification that the ZLB may generate in this context. The literature has long emphasized the large impact on macroeconomic multipliers that restriction on monetary policy rates could have (see for example Gomes et al. (2015)). Therefore, we complement our scenario analysis by adding a ZLB constraint to the model (where $\underline{R}$ is the lower bound). This is implemented in the following way

$$R_{BD,t} = max\left(\underline{R}, R^*_{BD,t}\right) \tag{61}$$

$$R^*_{BD,t} = \phi_R\left(R^*_{BD,t-1}\right) + (1-\phi_R)\left[\left(\overline{R}\right) + \phi_\Pi\left(\Pi_{C,t} - \overline{\Pi}\right)\right] + \phi_Y\left(\Delta Y_t - 1\right). \tag{62}$$

This specification enables the length of time for which the ZLB is binding to become endogenously determined.

Considering the shocks of the scenarios exposed in the previous sections, two sets of simulations are conducted, with and without ZLB. Let us consider first the cumulative impact of the financial crisis without the ZLB, as shown in Figure 14. The overall scenario clearly implies much more severe consequences for Italy and Spain where GDP declines by around -6% while for other euro area countries output losses range between -1% in Germany and -3% in France. The same hierarchy across countries applies to investment which drops in cumulated terms by -35% in Italy and -30% in Spain. On the nominal side, inflation moderates by -0.7/-0.8 p.p. The rise in government debt to GDP ratio is particularly pronounced in Italy (6 p.p.) and to a lower extent in Spain (2 p.p.). As a consequence, sovereign risk premia increase in these countries and spillover to banks funding costs. Overall commercial lending rates surge in the most affected countries with a peak of 300 bps in Italy and Spain and around 100 bps for France. Altogether, the various financial scenarios lead to a significant loosening of the single monetary policy stance, despite the uneven cross-country distribution of the financial stress. In line with the Taylor rule, the policy rate is cut by around 150 bps over the first three years of the simulation.

Now, we assume that the short-term interest can not decline by more than 110 bps, which broadly corresponds to the fall in the EONIA observed from 2011 to 2015. Figure 16 presents the corresponding results and Figure 15 show them in deviation from the no-ZLB case. Once hit by the set of shocks needed to mimic the financial crisis, the model generates a ZLB period of around four years, starting 6 quarters after the beginning of the scenario. Restricting the monetary policy rate during the crisis hurts significantly the euro area as a whole and more specifically Italy with peak effects reached the fourth year of the simulation for all countries (when the gap between the notional interest rate and the lower bound is the largest, by around 30 bps). This translates into extra losses of output ranging from -1 p.p. in Italy to -0.7 p.p. in REA. Investment follows more or less the same pattern although in a more pronounced way with almost -4 p.p. for Italy and between -2 p.p. and -1 p.p. for the other countries. It is also during the fourth year that inflation decreases the more and the sovereign debt ratio increases the more: up to 2 p.p. for Italy. The more unsecured economic environment brought by the crisis and exacerbated by the ZLB ultimately incites banks to increase their lending rates: from 30 bps for France and Germany to 75 bps for Italy (and around 40 bps for Spain and REA).

5 Conclusion

In this paper we provide some stylised synopsis of the various phases of the euro area financial crisis from 2010 to 2013 that we resume to three macro-financial scenarios to interpret the structural underpinnings of lending rate fragmentation and its macroeconomic spillovers. The first experiment considers the transmission through credit channels of the sovereign market tensions which are calibrated to reproduce the surge in sovereign spreads, amplified by the observed contagion to bank funding conditions in jurisdictions less affected by the turbulence in sovereign segments. The second experiment focuses on the vicious circle that was activated through the crisis, from rising corporate default, lower bank asset quality and higher credit constraints. It is calibrated based on a cross-country increase in corporate risk to match available evidence on default frequency and non-performing loans within the euro area. The final experiment explores the potential for bank deleveraging process on the back of unprecedented regulatory reform.

The macroeconomic multipliers of those scenario are strong in countries under stress and spillovers within the euro area are sizeable. In itself, the sovereign stress scenario would go a long way in explaining lending rate dispersion and poor economic performance in parts of the euro area over the period. These conditions propagate more forcefully through the intermediation chain of jurisdictions where banks are under-capitalised and risk-averse. The second scenario adequately portrays another important source of financial fragmentation and shows to which extent such real-financial feedback loops could contribute to impair the monetary policy transmission channel in a lasting manner, as vulnerable corporations operate with risk-averse and weakly capitalised banks. The last experiment argues that the frontloading of new capital requirements triggered a bank deleveraging process which adversely constrained the provision of credit in some jurisdictions. This would partly explain the pervasively high bank lending rates in some jurisdictions, beyond the forces analysed in the previous two experiments.

Even if our experiments could potentially overlap, not least as their quantitative calibration is not based on structural estimations, they do reflect independent forces at play during the crisis. A face value reading of the simulations, taken all together, would imply dramatic effects on lending rate dispersion, potentially beyond what was observed in reality both for stressed and non-stressed countries. This should not be seen as questioning the plausibility of our experiments but instead, it implicitly points to mitigating factors which partially shielded some jurisdictions. A crucial one has been non-standard monetary policy measures. Dealing with the joint role of fragmentation drivers and monetary policy actions is promising avenue for future research.

Moreover, our model can go beyond the quantification of the costs of the euro area financial crisis and shed light on the macroeconomic benefits related to lower riskiness of banking system on the back of regulatory reforms, and the role for macro-prudential policies in a global general equilibrium set-up. This analysis will be considered in future research.

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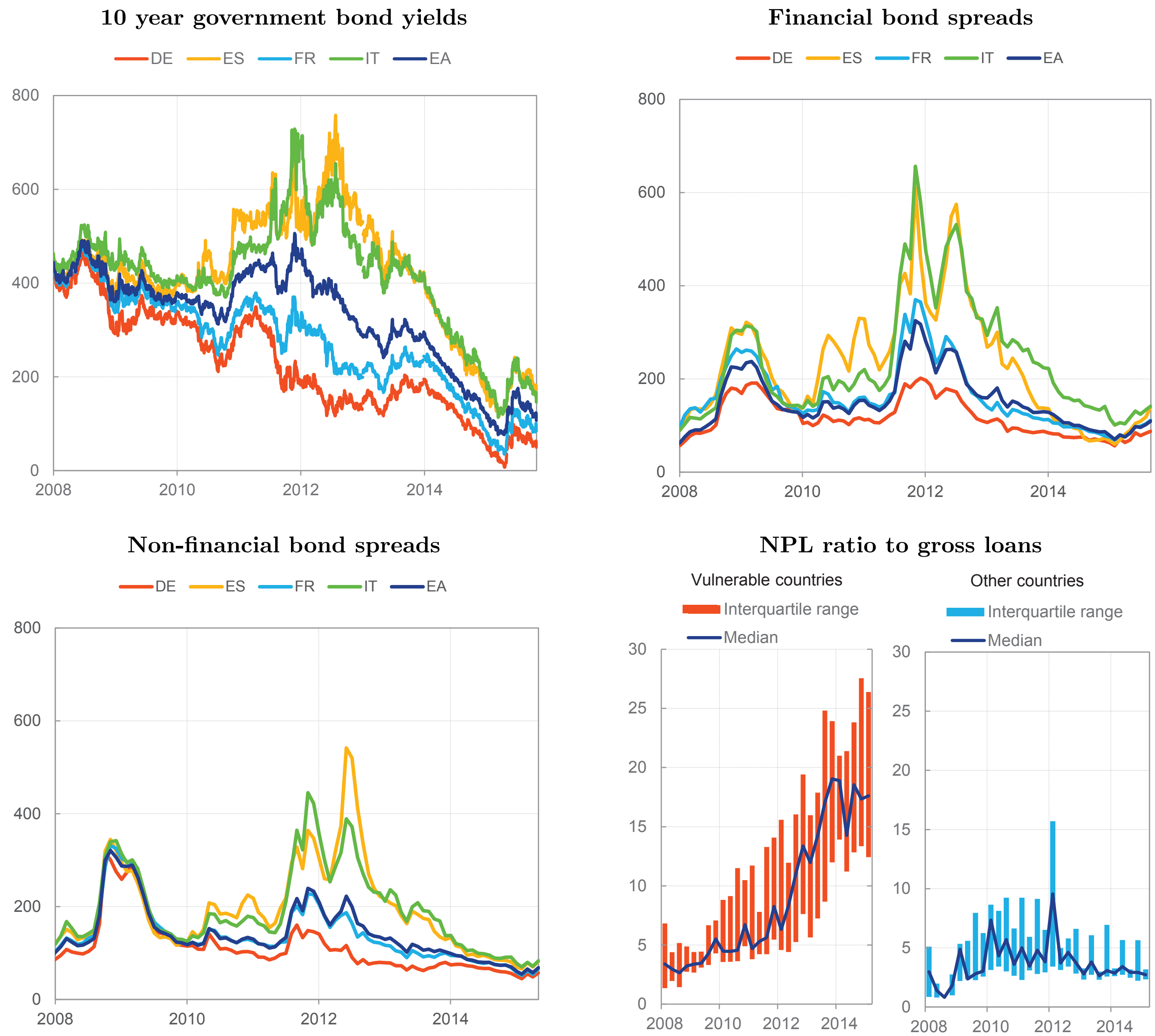
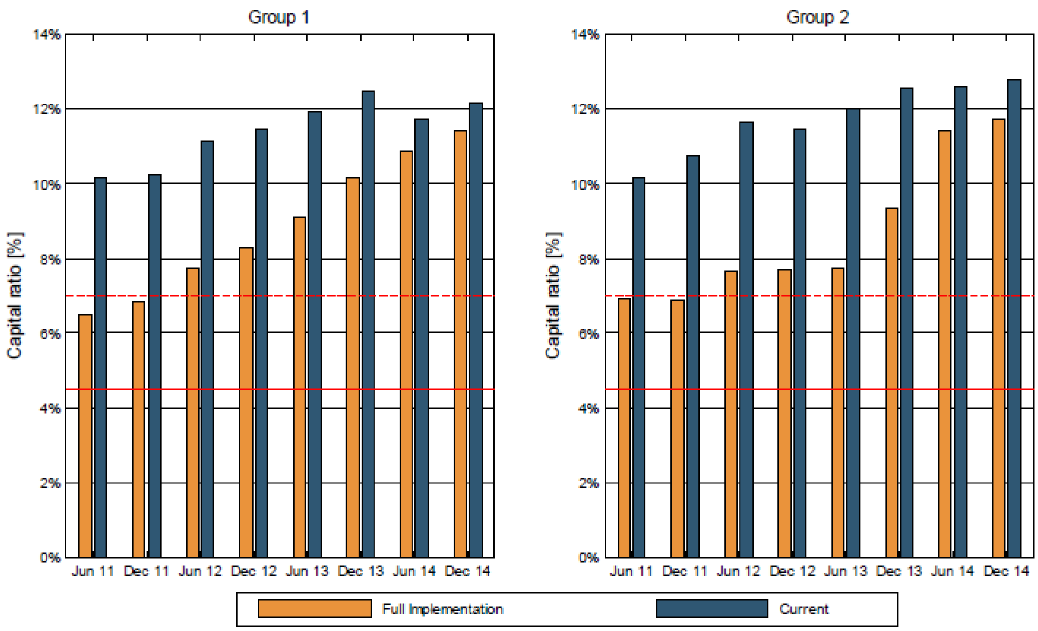
Figure 1: Evidence of financial stress since 2008



Sources: ECB, ECB calculations, Merrill Lynch and SNL Financial.
Notes: **Top-left panel**: 10-year Government Benchmark bond yield for euro area is GDP weighted. Latest observation: 23rd October 2015. **Top-right and bottom-left panels**: Maturity matched bond spreads. Indicators by country of risk excluding bonds which embed options such as asset-backed, callable, putable, floating rate, perpetual or sinking funds. **Bottom-right panel**: LHS - based on an unbalanced sample of up to 52 euro area banks which report at a quarterly frequency. RHS - based on a balanced sample of 12 euro area banks that have already reported the ratio of impaired loans to risk-weighted assets for 2015 Q1. Latest observation: 20145 Q1.

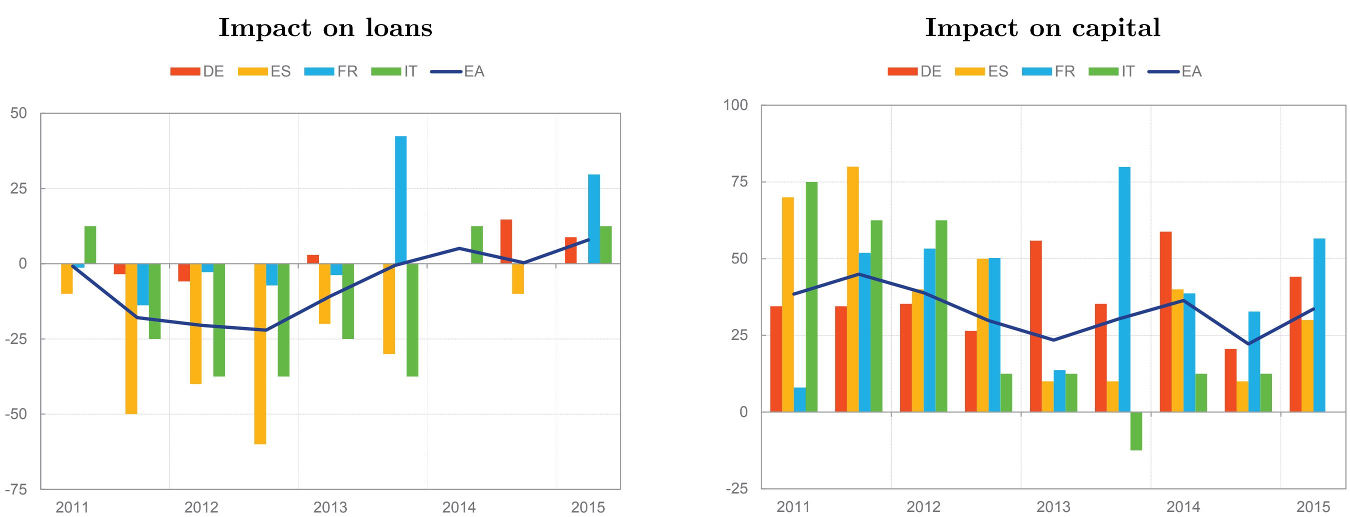
Figure 2: Evolution of CET1 ratios over time



Source: EBA (2015)

Notes: Group 1 banks are defined as banks with Tier 1 capital in excess of EUR 3 billion which are internationally active. All other banks are classified in Group 2. Comparison between capital ratios under the current level of implementation with the capital ratios that banks would exhibit where the set of rules in the CRD IV package fully implemented at the reference date.

Figure 3: Impact of regulatory or supervisory actions (net percentages)



Source: ECB (Bank Lending Survey).

Notes: Net percentages are defined as the difference between the sum of the percentages for *increase considerably* and *increase somewhat* and the sum of the percentages for *decreased somewhat* and *decreased considerably*.

Figure 4: Schematic representation of the model with cross border lending

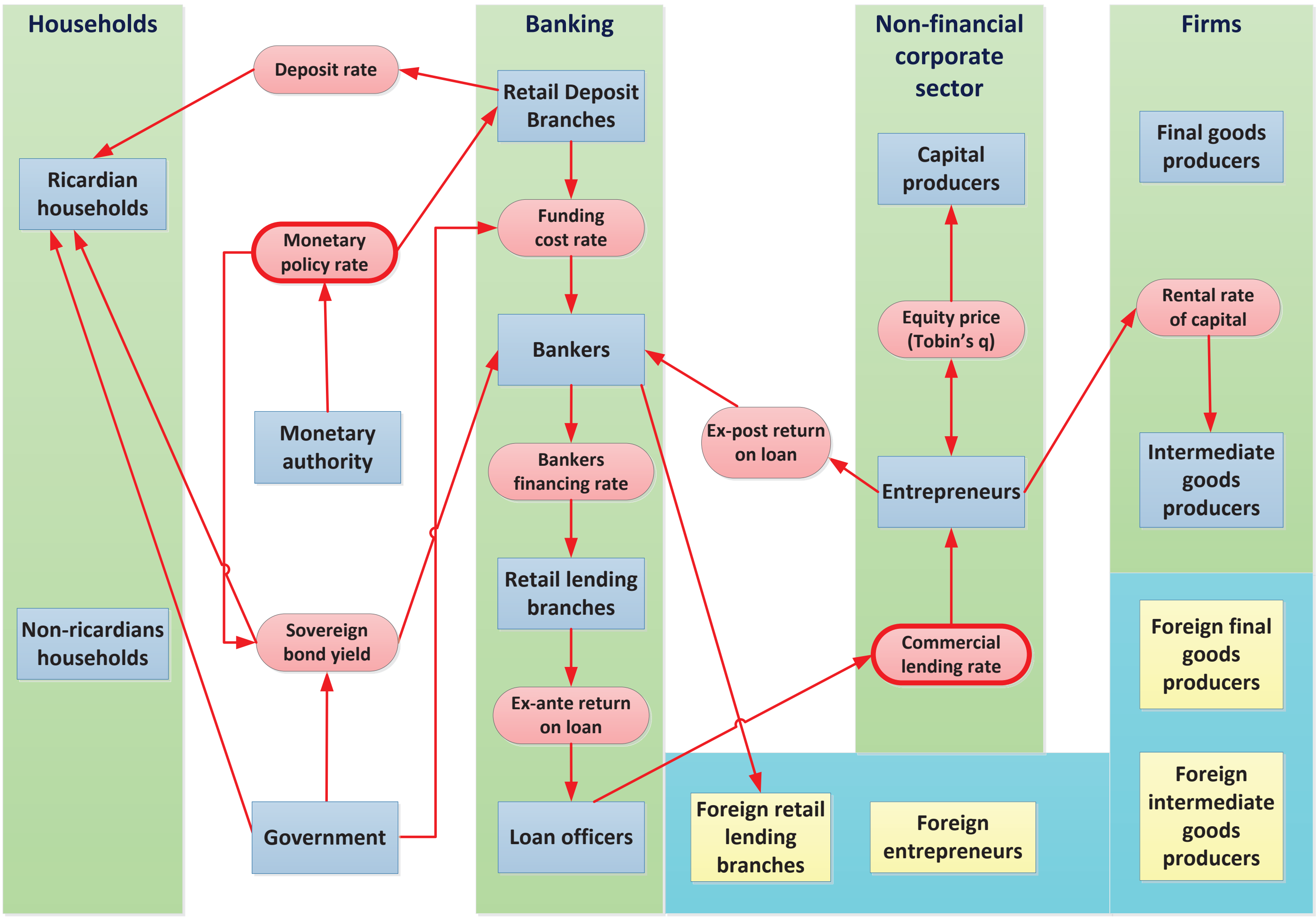


Table 1: Main macro variables

Variable		DE	FR	SP	IT	REA	ROW
Domestic demand (ratio to GDP)							
Private consuption	C/Y	0.626	0.568	0.554	0.600	0.580	0.602
Private investment	I/Y	0.210	0.220	0.250	0.210	0.210	0.220
Public consumption	G/Y	0.164	0.212	0.196	0.190	0.210	0.178
Trade (ratio to GDP)							
Total imports	M/Y	0.371	0.272	0.306	0.265	0.492	0.050
Imports of consumption goods	M_C/Y	0.253	0.196	0.225	0.198	0.351	0.032
Imported from DE		–	0.015	0.010	0.015	0.061	0.152
FR		0.026	–	0.015	0.016	0.037	0.102
SP		0.027	0.030	–	0.014	0.032	0.122
IT		0.025	0.020	0.010	–	0.034	0.110
REA		0.065	0.031	0.016	0.017	–	0.222
ROW		0.010	0.005	0.002	0.004	0.011	–
Imports of investment goods	M_I/Y	0.118	0.077	0.081	0.067	0.141	0.018
Imported from DE		–	0.013	0.002	0.005	0.020	0.078
FR		0.016	–	0.003	0.006	0.011	0.040
SP		0.013	0.010	–	0.009	0.010	0.039
IT		0.013	0.006	0.002	–	0.011	0.036
REA		0.029	0.008	0.004	0.006	–	0.094
ROW		0.008	0.003	0.001	0.002	0.005	–
Share of world GDP		0.060	0.040	0.015	0.033	0.044	0.808

Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world. In annualised terms.

Table 2: Monetary and fiscal authorities

Parameter		DE	FR	SP	IT	REA	ROW
Monetary authority							
Annual inflation target (percent)	$\overline{\Pi}^4 - 1$	2.000	2.000	2.000	2.000	2.000	2.000
Interest rate inertia	ϕ_R	0.750	0.750	0.750	0.750	0.750	0.820
Interest rate sensitivity to inflation gap	ϕ_Π	1.500	1.500	1.500	1.500	1.500	1.830
Interest rate sensitivity to output growth	ϕ_Y	0.150	0.150	0.150	0.150	0.150	0.060
Fiscal authority							
Consumption tax rate	τ^C	0.178	0.196	0.169	0.203	0.201	0.101
Divident tax rate	τ^D	0.066	0.128	0.079	0.128	0.115	0.102
Capital income tax rate	τ^K	0.372	0.352	0.331	0.321	0.286	0.398
Labor income tax rate	τ^N	0.174	0.102	0.109	0.150	0.127	0.127
Rate of social security contr. by firms	τ^{W_f}	0.168	0.303	0.233	0.246	0.174	0.094
Rate of social security contr. by hhs	τ^{W_h}	0.174	0.095	0.059	0.070	0.120	0.073
Lump-sum taxes sens. to debt-to-GDP ratio	ϕ_{B_Y}	0.500	0.500	0.500	0.500	0.500	0.500

Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world. In annualised terms.

Table 3: Households

Parameter		DE	FR	SP	IT	REA	ROW
Preferences I & J-type							
Discount factor	β	0.995	0.995	0.995	0.995	0.995	0.995
Intertemporal elasticity of substitution	σ	1.000	1.000	1.000	1.000	1.000	1.000
Inverse of the Frisch elasticity of labour	ζ	2.000	2.000	2.000	2.000	2.000	2.000
Habit persistence	κ	0.900	0.900	0.900	0.900	0.900	0.900
Share of J-type households	ω	0.250	0.250	0.250	0.250	0.250	0.250
Preferences I-type							
Deposit to consumption preferences	ζ_{db}	0.004	0.005	0.006	0.004	0.004	0.005
Elasticity of substitution for deposits	η_{db}	1.250	1.250	1.250	1.250	1.250	1.250
Transaction costs							
Transaction cost function param. I & J-type	γ_{vi1}	0.029	0.029	0.029	0.029	0.029	0.029
Transaction cost function param. I & J-type	γ_{vi2}	0.154	0.154	0.154	0.154	0.154	0.154
Internationally traded bonds transaction cost I-type	γ_{B^*}	0.010	0.010	0.010	0.010	0.010	0.200
Wage mark-ups							
Household I-type	$\eta_I/(\eta_I-1)$	1.303	1.303	1.303	1.303	1.303	1.159
Household J-type	$\eta_J/(\eta_J-1)$	1.303	1.303	1.303	1.303	1.303	1.159
Wage implied elasticities of substitution							
Household I-type	η_I	4.300	4.300	4.300	4.300	4.300	7.300
Household J-type	η_J	4.300	4.300	4.300	4.300	4.300	7.300
Wage calvo parameters							
Household I-type	ξ_I	0.750	0.750	0.750	0.750	0.750	0.750
Household J-type	ξ_J	0.750	0.750	0.750	0.750	0.750	0.750
Wage degree of indexation							
Household I-type	χ_I	0.650	0.650	0.650	0.650	0.650	0.650
Household J-type	χ_J	0.650	0.650	0.650	0.650	0.650	0.650

Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world; I-type = Ricardian households; J-type = Non-Ricardian households. In annualised terms.

Table 4: Capital producers and firms

Parameter		DE	FR	SP	IT	REA	ROW
Capital producers							
Depreciation rate (percent)	δ	10.00	10.00	10.00	10.00	10.00	10.00
Investment adjustment cost parameter	γ_I	6.000	6.000	6.000	6.000	6.000	6.000
Capital utilization rate	γ_{u2}	7.000	7.000	7.000	7.000	7.000	7.000
Intermediate-good firms							
Bias towards capital, tradable goods	α_T	0.400	0.400	0.450	0.400	0.400	0.400
Bias towards capital, nontradable goods	α_N	0.388	0.415	0.463	0.365	0.333	0.434
Share of nontradables		0.414	0.527	0.517	0.543	0.407	0.649
Final consumption-good firms							
Subst. btw. domestic and imported trad. cons. goods	μ_{TC}	3.500	3.500	3.500	3.500	3.500	3.500
Bias towards domestic trad. cons. goods	υ_{TC}	0.645	0.548	0.111	0.527	0.235	0.707
Substitution btw. trad. and nontrad. cons. goods	μ_C	0.500	0.500	0.500	0.500	0.500	0.500
Bias towards trad. cons. goods	υ_C	0.737	0.624	0.560	0.596	0.789	0.390
Final investment-good firms							
Subst. btw. domestic and imported trad. inv. goods	μ_{TI}	3.500	3.500	3.500	3.500	3.500	3.500
Bias towards domestic trad. inv. goods	υ_{TI}	0.386	0.516	0.168	0.575	0.132	0.628
Substitution btw. trad. and nontrad. inv. goods	μ_I	0.500	0.500	0.500	0.500	0.500	0.500
Bias towards trad. inv. goods	υ_I	0.746	0.622	0.564	0.641	0.790	0.485
Price markups							
Tradables	$\theta_T/(\theta_T-1)$	1.213	1.213	1.213	1.213	1.213	1.150
Nontradables	$\theta_N/(\theta_N-1)$	1.400	1.400	1.400	1.400	1.400	1.279
Implied elasticities of substitution							
Tradables	θ_T	5.700	5.700	5.700	5.700	5.700	7.670
Nontradables	θ_N	3.500	3.500	3.500	3.500	3.500	4.580
Adjustment costs							
Imports of consumption goods	γ_{M^C}	2.000	2.000	2.000	2.000	2.000	2.000
Imports of investment goods	γ_{M^I}	1.000	1.000	1.000	1.000	1.000	1.000
Calvo parameters							
Prices - domestic tradables	ξ_H	0.900	0.900	0.900	0.900	0.900	0.900
Prices - domestic nontradables	ξ_N	0.900	0.900	0.900	0.900	0.900	0.900
Prices - exports	ξ_X	0.750	0.750	0.750	0.750	0.750	0.750
Degree of indexation							
Prices - domestic tradables	χ_H	0.400	0.400	0.400	0.400	0.400	0.400
Prices - domestic nontradables	χ_N	0.400	0.400	0.400	0.400	0.400	0.400
Prices - exports	χ_X	0.500	0.500	0.500	0.500	0.500	0.500
Degree of indexation							
Substitution btw. consumption good imports	μ_{MC}	3.500	3.500	3.500	3.500	3.500	3.500
Substitution btw. investment good imports	μ_{MI}	3.500	3.500	3.500	3.500	3.500	3.500

Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world. In annualised terms.

Table 5: Sovereign risk (symmetric)

Parameter		DE	FR	SP	IT	REA	ROW
Government debt-to-annual GDP ratio (percent)	$\overline{B_Y}$	67.5	67.5	67.5	67.5	67.5	67.5
Mean of distribution	B_Y^{mean}	119.5	119.5	119.5	119.5	119.5	119.5
Std. dev. of prob. of default distribution	σ_{B_Y}	20.40	20.40	20.40	20.40	20.40	20.40
Loss given default (percent)	ξ_G	37.00	37.00	37.00	37.00	37.00	37.00
Variable							
Sov. bond spread sens. to debt-to-GDP (percent)	$\Lambda_{B_{GY}}$	0.120	0.120	0.120	0.120	0.120	0.120
Sovereign bond spread (percent)	$4(R_G/R_{BD}-1)$	0.800	0.800	0.800	0.800	0.800	0.800

Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world. In annualised terms.

Table 6: Sovereign risk (cross-country heterogeneity)

Parameter		DE	FR	SP	IT	REA	ROW
Government debt-to-annual GDP ratio (percent)	$\overline{B_Y}$	63.7	61.8	49.3	106.5	61.8	60.3
Mean of distribution	B_Y^{mean}	149.9	114.5	98.7	142.1	113.8	199.8
Std. dev. of prob. of default distribution	σ_{B_Y}	30.20	18.98	20.55	14.65	20.40	54.73
Loss given default (percent)	ξ_G	37.00	37.00	37.00	37.00	37.00	37.00
Variable							
Sov. bond spread sens. to debt-to-GDP (percent)	$\Lambda_{B_{GY}}$	0.035	0.070	0.170	0.230	0.120	0.043
Sovereign bond spread (percent)	$4(R_G/R_{BD}-1)$	0.320	0.400	1.200	1.120	0.800	0.800

Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world. In annualised terms.

Table 7: Bankers (symmetric)

Parameter		DE	FR	SP	IT	REA	ROW
Sensitivity of funding cost to sov. spread	Λ_ψ	0.600	0.600	0.600	0.600	0.600	0.600
St.dev. of idiosyncratic shock	σ_b	0.028	0.028	0.028	0.028	0.028	0.028
Bank resolution cost	μ_b	0.300	0.300	0.300	0.300	0.300	0.300
Regulatory bank capital ratio (percent)	ν_b	8.000	8.000	8.000	8.000	8.000	8.000
Bank capital ratio (percent)		12.00	12.00	12.00	12.00	12.00	12.00
Regulatory penalty	χ_b	0.003	0.003	0.003	0.003	0.003	0.003
Continuation probability of bankers	ζ_b	0.962	0.962	0.962	0.962	0.962	0.962
Variable							
Prob. of violating regulatory req. (percent)	$1-(1-F(\overline{\omega}_b^\nu))^4$	15.07	15.07	15.07	15.07	15.07	15.07
Prob. of default (percent)	$1-(1-F(\overline{\omega}_b))^4$	0.000	0.000	0.000	0.000	0.000	0.000
Bank NFC loans to GDP (percent)	$L_{BE}/(4Y)$	82.3	86.2	98.0	82.3	82.3	86.2
Bank leverage	κ_b	8.335	8.335	8.335	8.335	8.335	8.335
Funding cost spread (percent)	$4(\Psi-1)$	0.480	0.480	0.480	0.480	0.480	0.480
Bank capital wedge (percent)	$4(R_{BLE}/\widetilde{R}_{BD}-1)$	0.600	0.600	0.600	0.600	0.600	0.600

Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world. In annualised terms.

Table 8: Bankers (cross-country heterogeneity)

Parameter		DE	FR	SP	IT	REA	ROW
Sensitivity of funding cost to sov. spread	Λ_ψ	0.600	0.600	0.600	0.600	0.600	0.600
St.dev. of idiosyncratic shock	σ_b	0.028	0.028	0.027	0.027	0.028	0.028
Bank resolution cost	μ_b	0.300	0.300	0.300	0.300	0.300	0.300
Regulatory bank capital ratio (percent)	ν_b	8.000	8.000	8.000	8.000	8.000	8.000
Bank capital ratio (percent)		11.93	11.97	12.02	12.00	11.99	12.00
Regulatory penalty	χ_b	0.003	0.003	0.003	0.003	0.003	0.003
Continuation probability of bankers	ζ_b	0.952	0.956	0.967	0.965	0.961	0.962
Variable							
Prob. of violating regulatory req. (percent)	$1-(1-F(\overline{\omega}_b^\nu))^4$	15.07	15.07	15.07	15.07	15.07	15.07
Prob. of default (percent)	$1-(1-F(\overline{\omega}_b))^4$	0.000	0.000	0.000	0.000	0.000	0.000
Bank NFC loans to GDP (percent)	$L_{BE}/(4Y)$	80.0	100.0	120.0	100.0	77.1	80.4
Bank leverage	κ_b	8.382	8.353	8.317	8.334	8.339	8.331
Funding cost spread (percent)	$4(\Psi-1)$	0.192	0.240	0.720	0.672	0.480	0.480
Bank capital wedge (percent)	$4(R_{BLE}/\widetilde{R}_{BD}-1)$	0.600	0.600	0.600	0.600	0.600	0.600

Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world. In annualised terms.

Table 9: Retail banking branches (symmetric)

Parameter		DE	FR	SP	IT	REA	ROW
Retail deposit branches							
Elasticity of substitution of dif. deposits	μ_D^R	0.999	0.999	0.999	0.999	0.999	0.999
Prob. of not re-opt. deposit rates (percent)	ξ_D^R	1.000	1.000	1.000	1.000	1.000	1.000
Retail lending branch							
Elasticity of substitution of dif. loans	μ_E^R	1.002	1.002	1.002	1.002	1.002	1.002
Prob. of not re-opt. lending rates (percent)	ξ_E^R	40.00	40.00	40.00	40.00	40.00	40.00
Variable							
Retail deposit branches							
Deposit spread (percent)	$4(R_D/R_{BD}-1)$	-0.396	-0.396	-0.396	-0.396	-0.396	-0.396
Retail lending branch							
Cross border impact (percent)	$4(\widehat{R}_{BLE}/R_{BLE}-1)$	0.000	0.000	0.000	0.000	0.000	0.000
Monopolistic wedge (percent)	$4(R_{LE}/\widehat{R}_{BLE}-1)$	0.715	0.715	0.715	0.715	0.715	0.715

Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world. In annualised terms.

Table 10: Retail banking branches (cross-country heterogeneity)

Parameter		DE	FR	SP	IT	REA	ROW
Retail deposit branches							
Elasticity of substitution of dif. deposits	μ_D^R	0.999	0.999	0.999	0.999	0.999	0.999
Prob. of not re-opt. deposit rates (percent)	ξ_D^R	1.000	1.000	1.000	1.000	1.000	1.000
Retail lending branch							
Elasticity of substitution of dif. loans	μ_E^R	1.003	1.003	1.001	1.001	1.002	1.002
Prob. of not re-opt. lending rates (percent)	ξ_E^R	60.00	60.00	20.00	20.00	40.00	40.00
Variable							
Retail deposit branches							
Deposit spread (percent)	$4(R_D/R_{BD}-1)$	-0.396	-0.396	-0.396	-0.396	-0.396	-0.396
Retail lending branch							
Cross border impact (percent)	$4(\widehat{R}_{BLE}/R_{BLE}-1)$	0.095	0.022	-0.014	-0.108	-0.028	0.000
Monopolistic wedge (percent)	$4(R_{LE}/\widehat{R}_{BLE}-1)$	1.174	1.018	0.368	0.581	0.710	0.690

Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world. In annualised terms.

Table 11: Entrepreneurs (symmetric)

Parameter		DE	FR	SP	IT	REA	ROW
St.dev. of idiosyncratic shock	σ_e	0.357	0.357	0.357	0.357	0.357	0.357
Monitoring cost	μ_e	0.122	0.122	0.122	0.122	0.122	0.122
Continuation probability of entrepreneurs	ζ_e	0.984	0.984	0.984	0.984	0.984	0.984
Recovery ratio in case of default (percent)	χ_e	100.0	100.0	100.0	100.0	100.0	100.0
Variable							
Prob. of default (percent)	$1-(1-F(\overline{\omega}_e))^4$	2.771	2.771	2.771	2.771	2.771	2.771
Leverage	κ_e	1.644	1.644	1.644	1.644	1.644	1.644
Indebtedness to annual GDP (percent)	$L_E/(4Y)$	82.3	86.2	98.0	82.3	82.3	86.2
External financing premium (percent)	$4(R_{KK})/R_{LE}-1)$	1.760	1.760	1.760	1.760	1.760	1.760
Credit risk compensation (percent)	$4(1+R_{LLE})/R_{LE}-1)$	0.600	0.600	0.600	0.600	0.600	0.600
Total commercial lending spread (percent)	$4(1+R_{LLE})/R_{BD}-1)$	2.400	2.400	2.400	2.400	2.400	2.400

Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world. In annualised terms.

Table 12: Entrepreneurs (cross-country heterogeneity)

Parameter		DE	FR	SP	IT	REA	ROW
St.dev. of idiosyncratic shock	σ_e	0.262	0.383	0.368	0.277	0.389	0.381
Monitoring cost	μ_e	0.221	0.166	0.100	0.083	0.126	0.125
Continuation probability of entrepreneurs	ζ_e	0.982	0.984	0.984	0.983	0.984	0.984
Recovery ratio in case of default (percent)	χ_e	100.0	100.0	100.0	100.0	100.0	100.0
Variable							
Prob. of default (percent)	$1-(1-F(\overline{\omega}_e))^4$	1.195	1.985	3.552	3.940	2.771	2.771
Leverage	κ_e	1.894	1.532	1.645	2.025	1.556	1.576
Indebtedness to annual GDP (percent)	$L_E/(4Y)$	99.1	76.4	98.1	106.3	75.0	80.4
External financing premium (percent)	$4(R_{KK})/R_{LE}-1)$	1.760	1.760	1.760	1.760	1.760	1.760
Credit risk compensation (percent)	$4(1+R_{LLE})/R_{LE}-1)$	0.334	0.515	0.720	0.651	0.633	0.625
Total commercial lending spread (percent)	$4(1+R_{LLE})/R_{BD}-1)$	2.400	2.400	2.400	2.400	2.400	2.400

Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world. In annualised terms.

Table 13: Cross border lending

Variable	DE	FR	SP	IT	REA	ROW
Share of NFC loans in percent granted by:						
DE banks	69.91	7.48	1.03	4.03	8.00	0.00
FR banks	7.22	84.70	1.22	16.77	11.16	0.00
SP banks	2.29	1.48	96.72	1.27	4.70	0.00
IT banks	10.67	1.77	0.13	68.89	5.64	0.00
REA banks	9.91	4.57	0.90	9.04	70.50	0.00
ROW banks	0.01	0.00	0.00	0.00	0.00	100.00

Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world.

Table 14: Lending rate decomposition (symmetric)

Variable (in percent)		DE	FR	SP	IT	REA	ROW
Deposit spread[a]	$4(R_D/R_{BD}-1)$	-0.40	-0.40	-0.40	-0.40	-0.40	-0.40
Sovereign bond spread[b]	$4(R_G/R_{BD}-1)$	0.80	0.80	0.80	0.80	0.80	0.80
Funding cost spread[c]	$4(\Psi-1)$	0.48	0.48	0.48	0.48	0.48	0.48
Bank capital wedge[d]	$4(R_{BLE}/\widetilde{R}_{BD}-1)$	0.60	0.60	0.60	0.60	0.60	0.60
Cross border impact[e]	$4(\widehat{R}_{BLE}/R_{BLE}-1)$	0.00	0.00	0.00	0.00	0.00	0.00
Monopolistic wedge[f]	$4(R_{LE}/\widehat{R}_{BLE}-1)$	0.71	0.71	0.71	0.71	0.71	0.71
External financing premium[g]	$4(R_{KK})/R_{LE}-1)$	1.76	1.76	1.76	1.76	1.76	1.76
Credit risk compensation[h]	$4(1+R_{LLE})/R_{LE}-1)$	0.60	0.60	0.60	0.60	0.60	0.60
Commercial lending spread$^{i\approx c+d+e+f+h}$	$4(1+R_{LLE})/R_{BD}-1)$	2.40	2.40	2.40	2.40	2.40	2.40

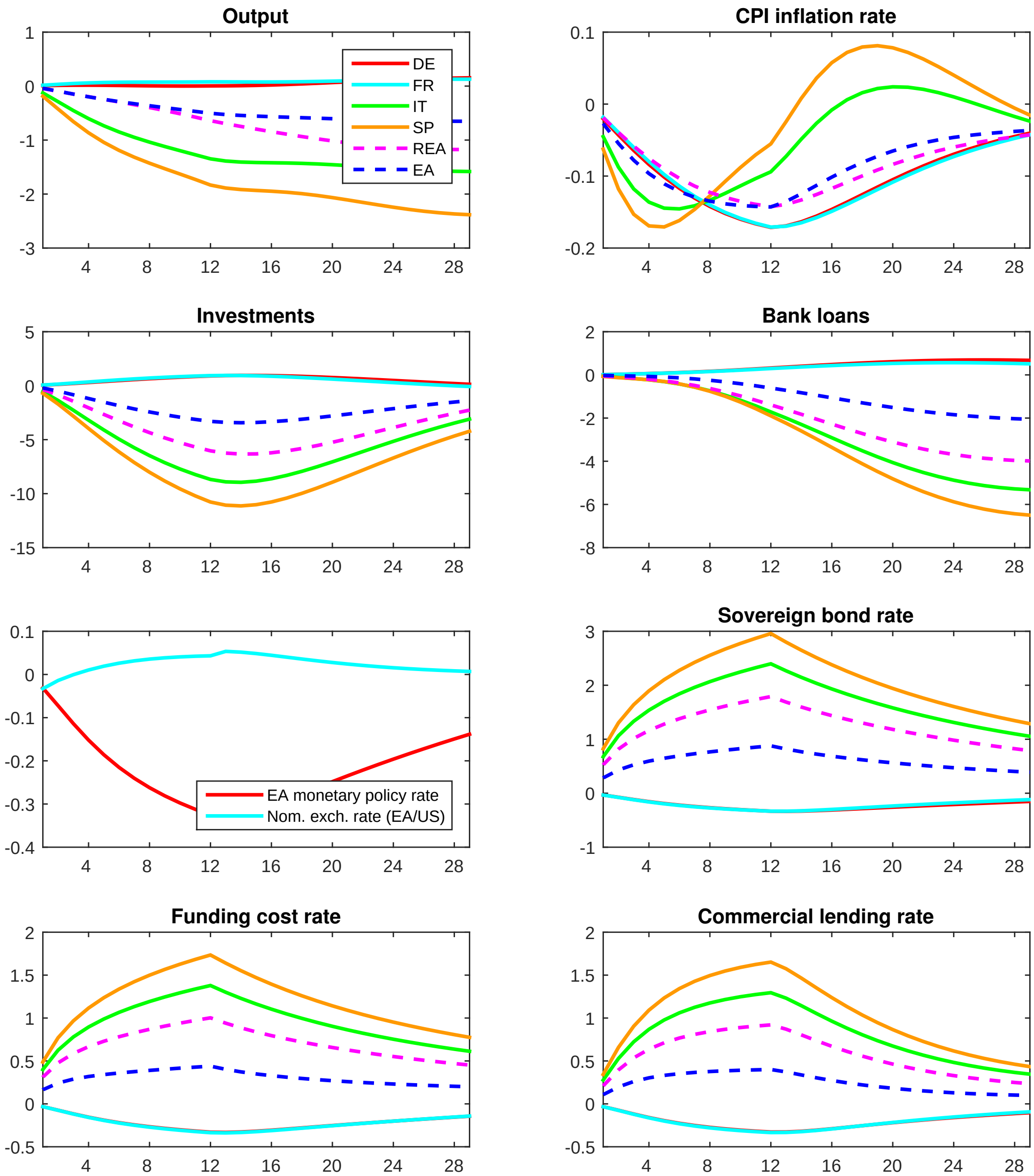
Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world. In annualised terms.

Table 15: Lending rate decomposition (cross-country heterogeneity)

Variable (in percent)		DE	FR	SP	IT	REA	ROW
Deposit spread[a]	$4(R_D/R_{BD}-1)$	-0.40	-0.40	-0.40	-0.40	-0.40	-0.40
Sovereign bond spread[b]	$4(R_G/R_{BD}-1)$	0.32	0.40	1.20	1.12	0.80	0.80
Funding cost spread[c]	$4(\Psi-1)$	0.19	0.24	0.72	0.67	0.48	0.48
Bank capital wedge[d]	$4(R_{BLE}/\widetilde{R}_{BD}-1)$	0.60	0.60	0.60	0.60	0.60	0.60
Cross border impact[e]	$4(\widehat{R}_{BLE}/R_{BLE}-1)$	0.10	0.02	-0.01	-0.11	-0.03	0.00
Monopolistic wedge[f]	$4(R_{LE}/\widehat{R}_{BLE}-1)$	1.17	1.02	0.37	0.58	0.71	0.69
External financing premium[g]	$4(R_{KK})/R_{LE}-1)$	1.76	1.76	1.76	1.76	1.76	1.76
Credit risk compensation[h]	$4(1+R_{LLE})/R_{LE}-1)$	0.33	0.51	0.72	0.65	0.63	0.62
Commercial lending spread$^{i \approx c+d+e+f+h}$	$4(1+R_{LLE})/R_{BD}-1)$	2.40	2.40	2.40	2.40	2.40	2.40

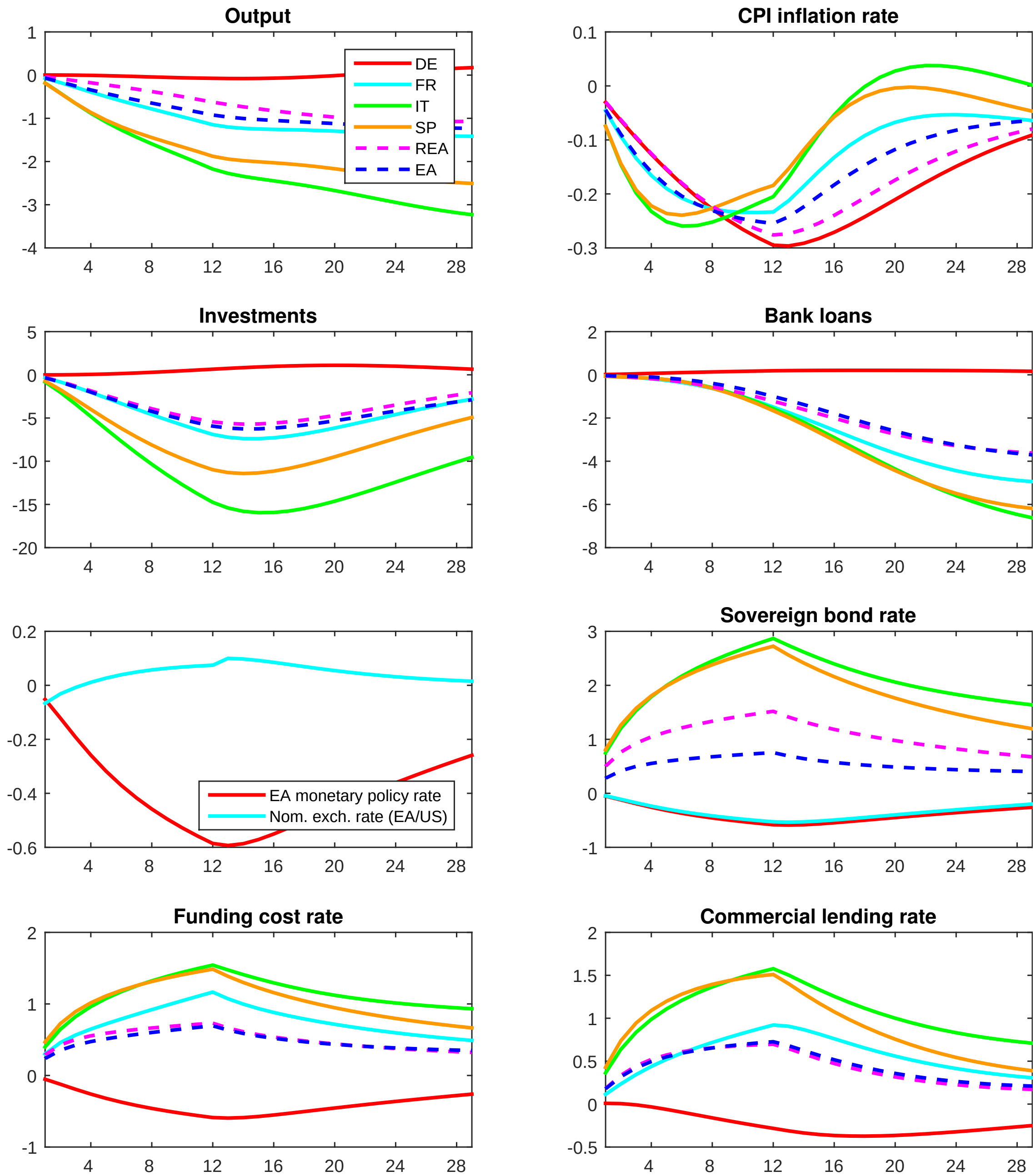
Notes: DE = Germany; FR = France; SP = Spain; IT = Italy; REA = Rest of euro area; ROW = Rest of the world. In annualised terms.

Figure 5: Increase in **sovereign spreads in Italy, Spain and rest of euro area** - Symmetric calibration



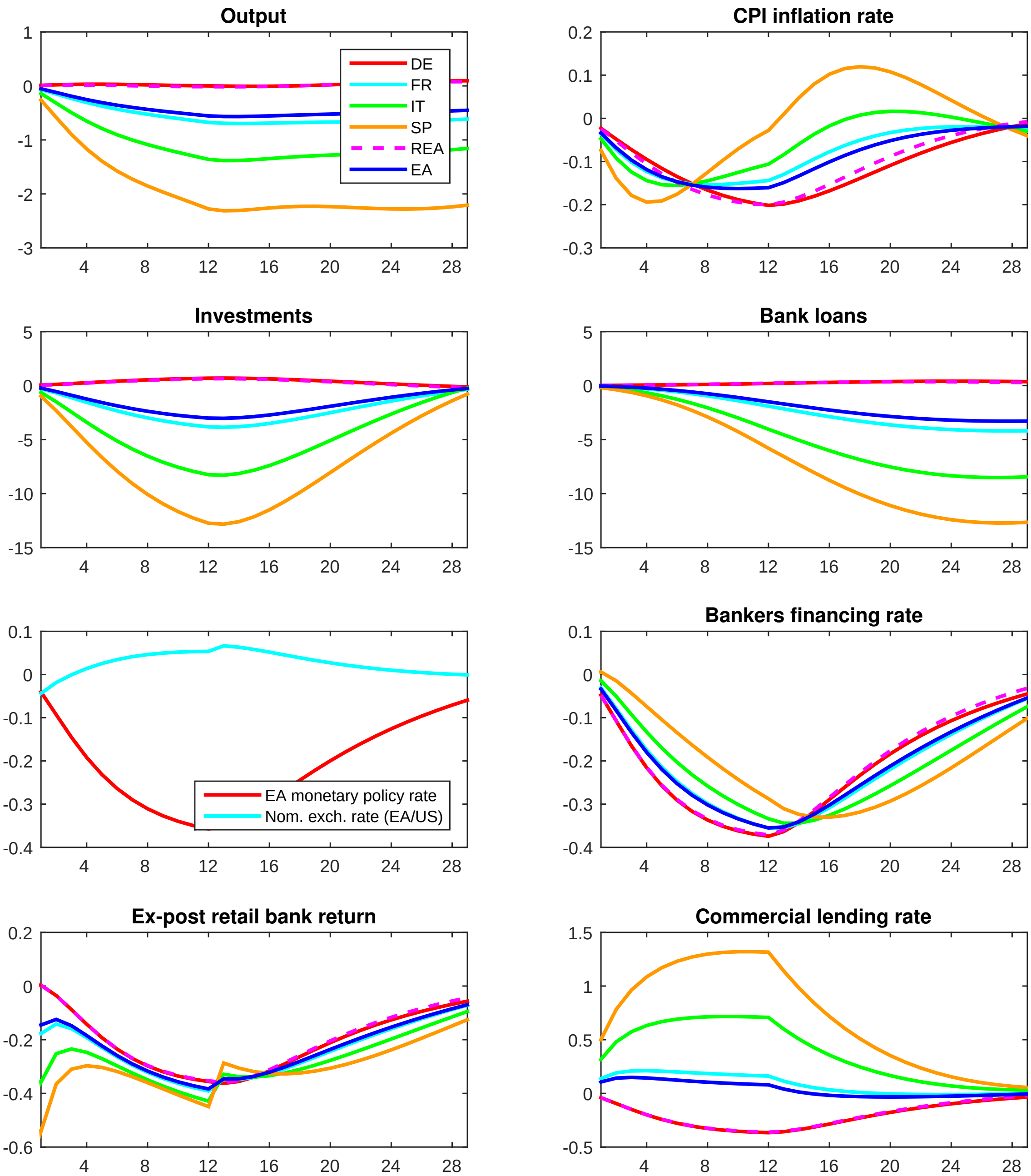
Notes: increase of the loss given default, $\xi_G^{\max}$, in Italy, Spain and rest of euro area, so that sovereign bond yields increase to crisis levels for three years; shock is persistent, i.e. follows an AR(1) process with autocorrelation being 0.95. Horizontal axis: quarters. Vertical axis: percentage deviations from baseline, except for inflation and interest rates which are expressed as annual percentage-point deviations. GDP, its components and bank loans are reported in real terms.

Figure 6: Increase in **sovereign spreads in Italy, Spain and rest of euro area** and **bank funding cost in France** - Benchmark calibration



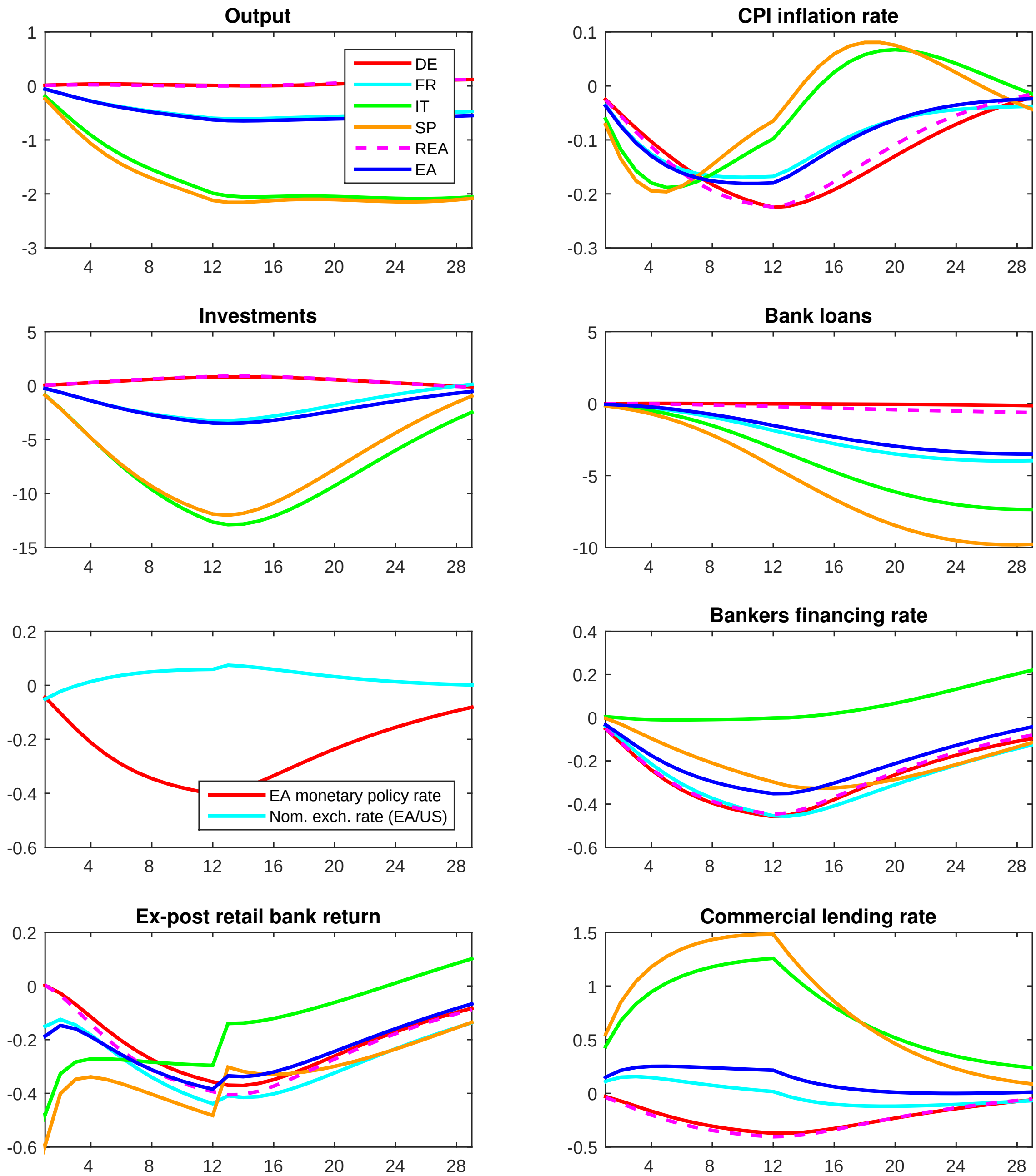
Notes: increase of the loss given default, $\xi_G^{\max}$, in Italy, Spain and rest of euro area and funding cost in France, so that sovereign bond yields and funding cost increase to crisis levels for three years; shock is persistent, i.e. follows an AR(1) process with autocorrelation being 0.95. Horizontal axis: quarters. Vertical axis: percentage deviations from baseline, except for inflation and interest rates which are expressed as annual percentage-point deviations. GDP, its components and bank loans are reported in real terms.

Figure 7: Increase in **entrepreneurs riskiness in France, Italy and Spain -** Symmetric calibration



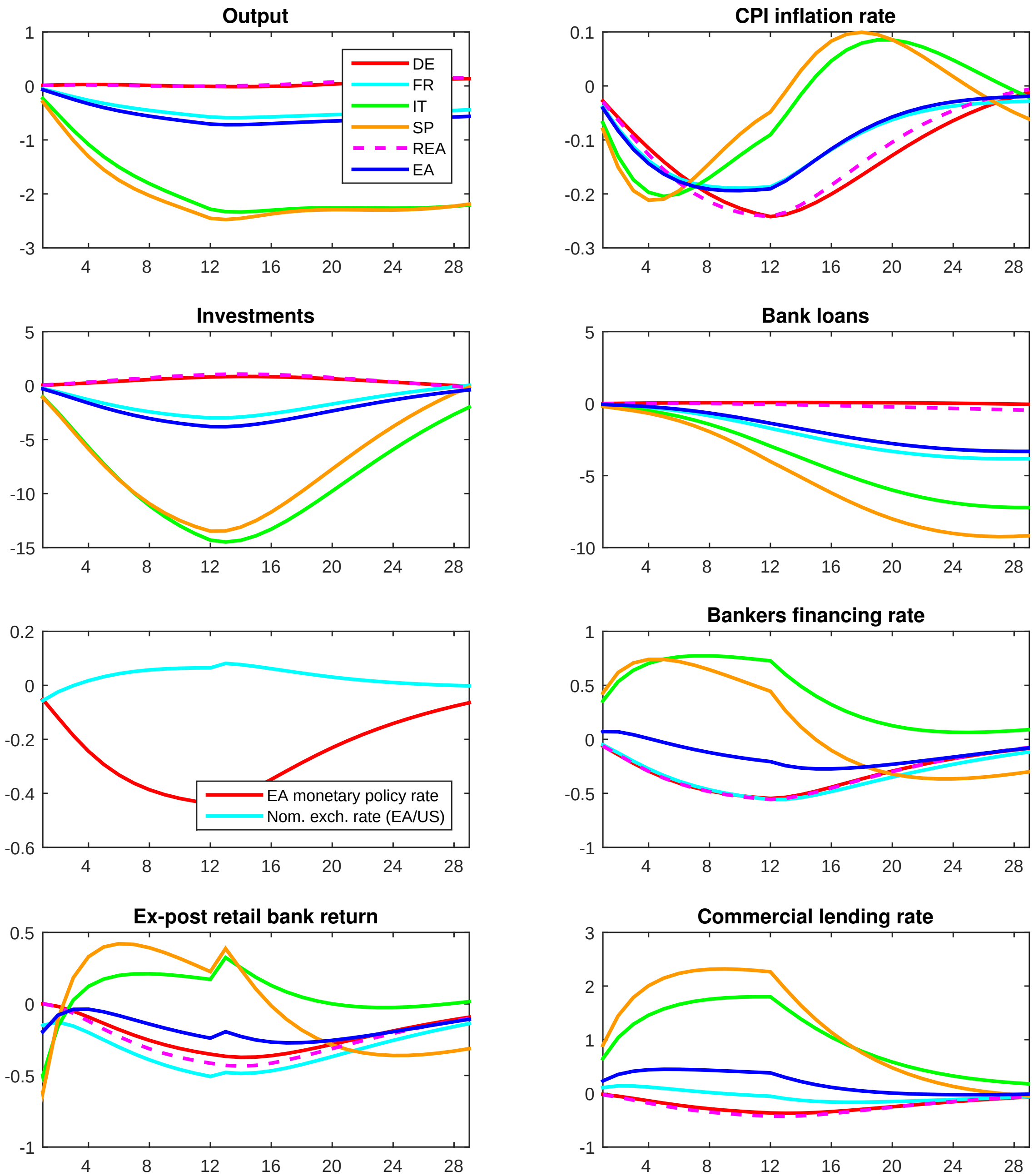
Notes: increase of the standard deviation of the multiplicative idiosyncratic shock of entrepreneurs, σ_e, in France, Italy and Spain for three years, so that the contribution of entrepreneurs expected losses to commercial lending rates increase to crisis levels for three years; shock is persistent, i.e. follows an AR(1) process with autocorrelation being 0.95. Horizontal axis: quarters. Vertical axis: percentage deviations from baseline, except for inflation and interest rates which are expressed as annual percentage-point deviations. GDP, its components and bank loans are reported in real terms.

Figure 8: Increase in **entrepreneurs riskiness shock in France, Italy and Spain -** Benchmark calibration



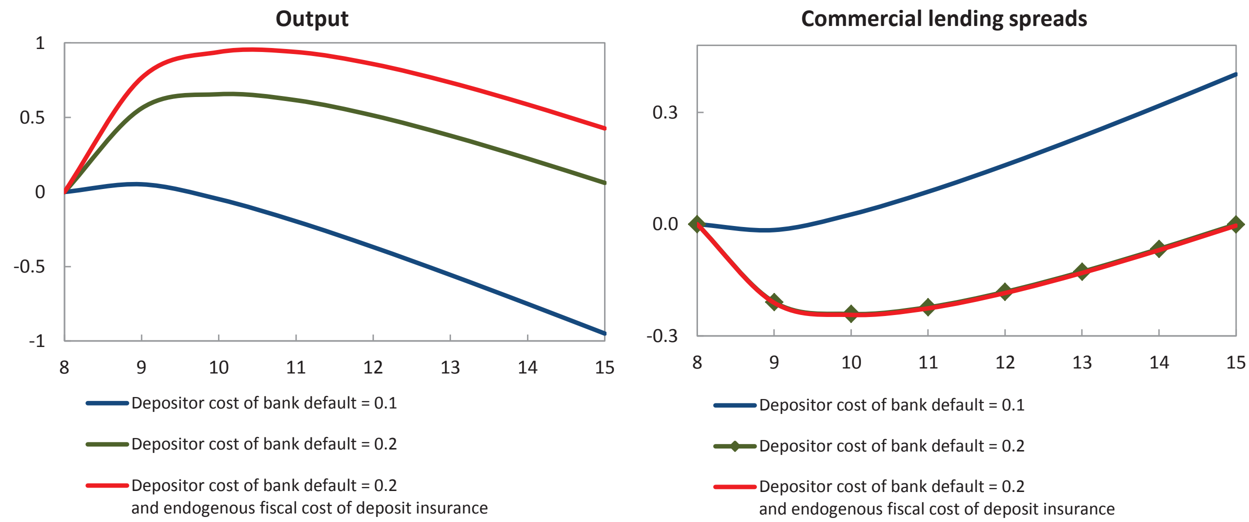
Notes: increase of the standard deviation of the multiplicative idiosyncratic shock of entrepreneurs, σ_e, in France, Italy and Spain for three years, so that the contribution of entrepreneurs expected losses to commercial lending rates increase to crisis levels for two years; shock is persistent, i.e. follows an AR(1) process with autocorrelation being 0.95. Horizontal axis: quarters. Vertical axis: percentage deviations from baseline, except for inflation and interest rates which are expressed as annual percentage-point deviations. GDP, its components and bank loans are reported in real terms.

Figure 9: Increase in **entrepreneurs riskiness shock in France, Italy and Spain** - Benchmark calibration with dynamic risk weights



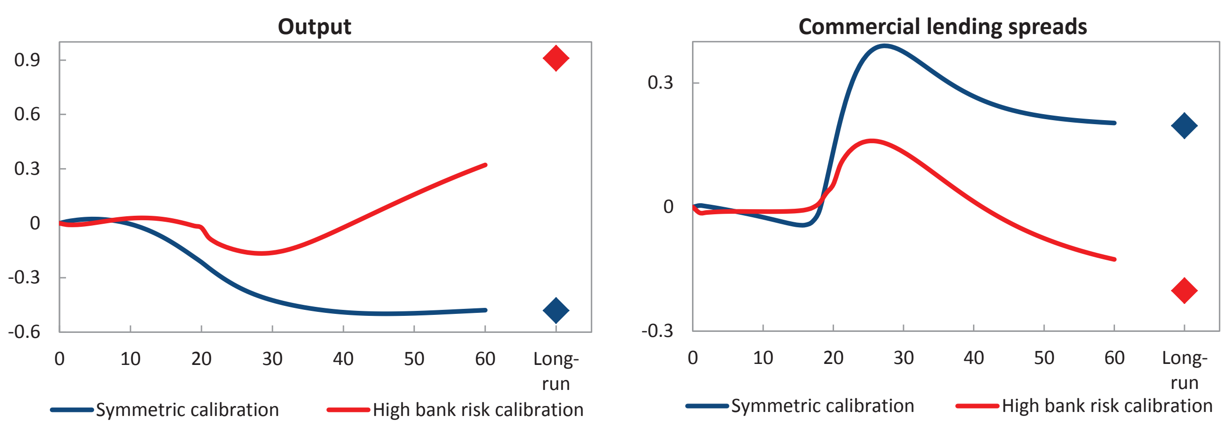
Notes: increase of the standard deviation of the multiplicative idiosyncratic shock of entrepreneurs, σ_e, in France, Italy and Spain for three years, so that the contribution of entrepreneurs expected losses to commercial lending rates increase to crisis levels for three years; shock is persistent, i.e. follows an AR(1) process with autocorrelation being 0.95. Horizontal axis: quarters. Vertical axis: percentage deviations from baseline, except for inflation and interest rates which are expressed as annual percentage-point deviations. GDP, its components and bank loans are reported in real terms.

Figure 10: Steady-state sensitivity to capital requirements - High bank risk calibration



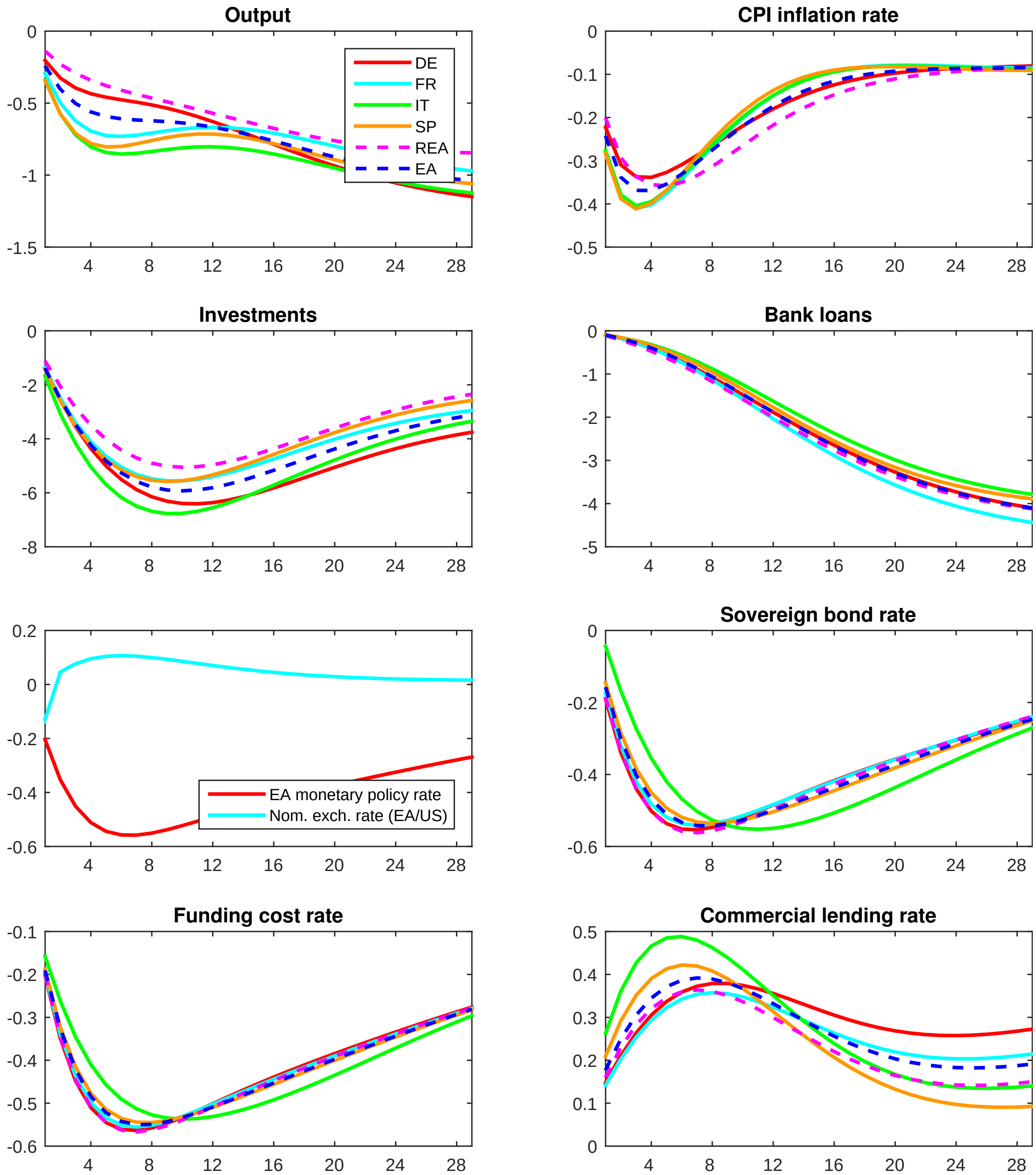
Notes: Incremental increase of capital requirements in the steady state, from 8 to 15 percent. Horizontal axes: Capital requirements in percent. Vertical access: **euro area output** expressed as percentage deviation from initial steady state, and **euro area commercial lending rate spread** (annualised), both expressed percentage deviations from initial steady state. Initial steady state corresponds to capital requirements of 8 percent.

Figure 11: Dynamic adjustment to higher capital requirements



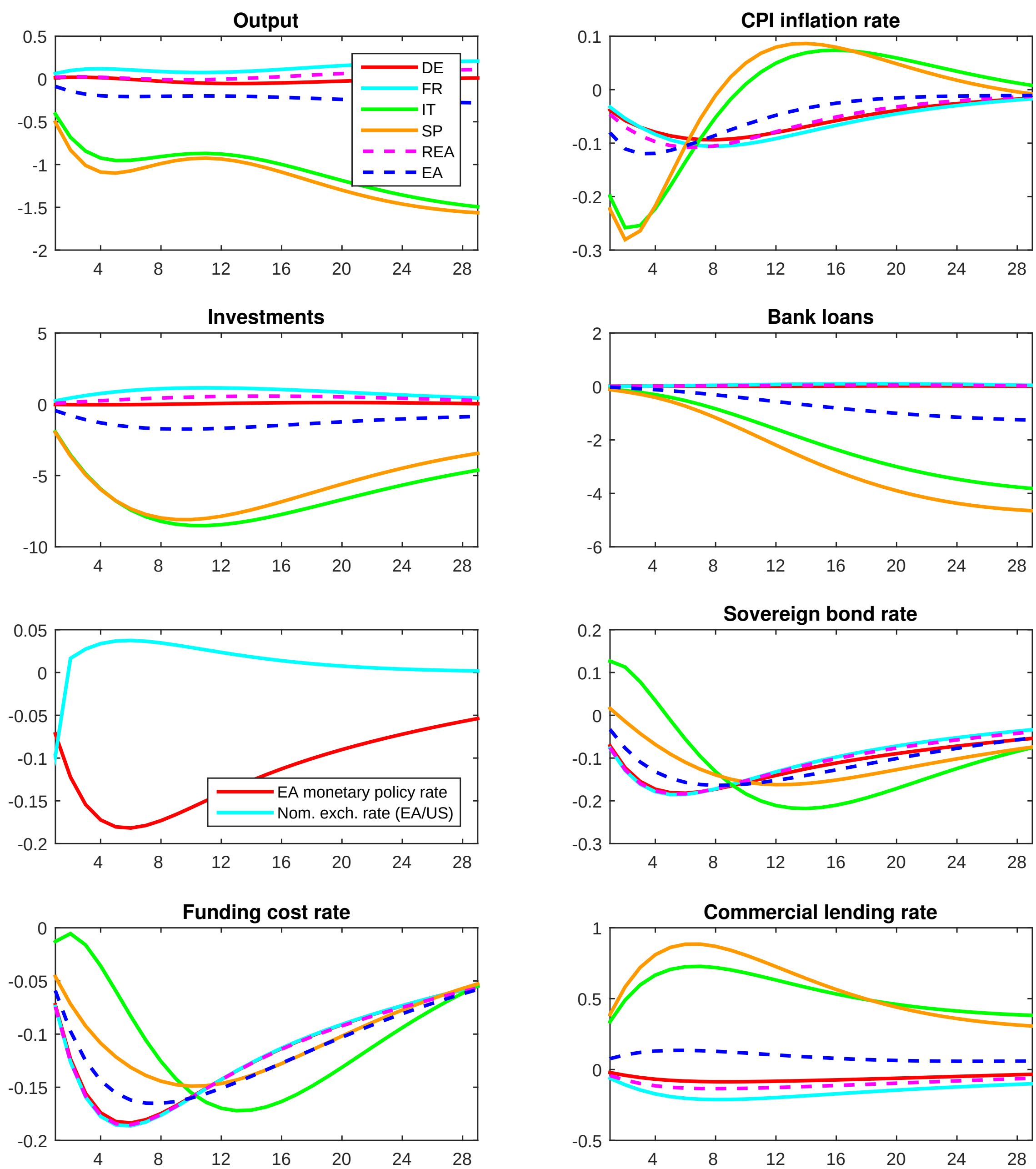
Notes: Anticipated increase in five years of capital requirements by 25 percent, with five years gradual phase-in arrangements. Horizontal axes: quarters. Vertical access: **euro area output** expressed as percentage deviation from initial steady state, and **euro area commercial lending rate spread** (annualised), both expressed percentage deviations from initial steady state. High bank risk calibration corresponds to a depositor cost of bank default of 0.2 and endogenous fiscal cost of deposit insurance.

Figure 12: Increase in **regulatory requirements** - Benchmark calibration



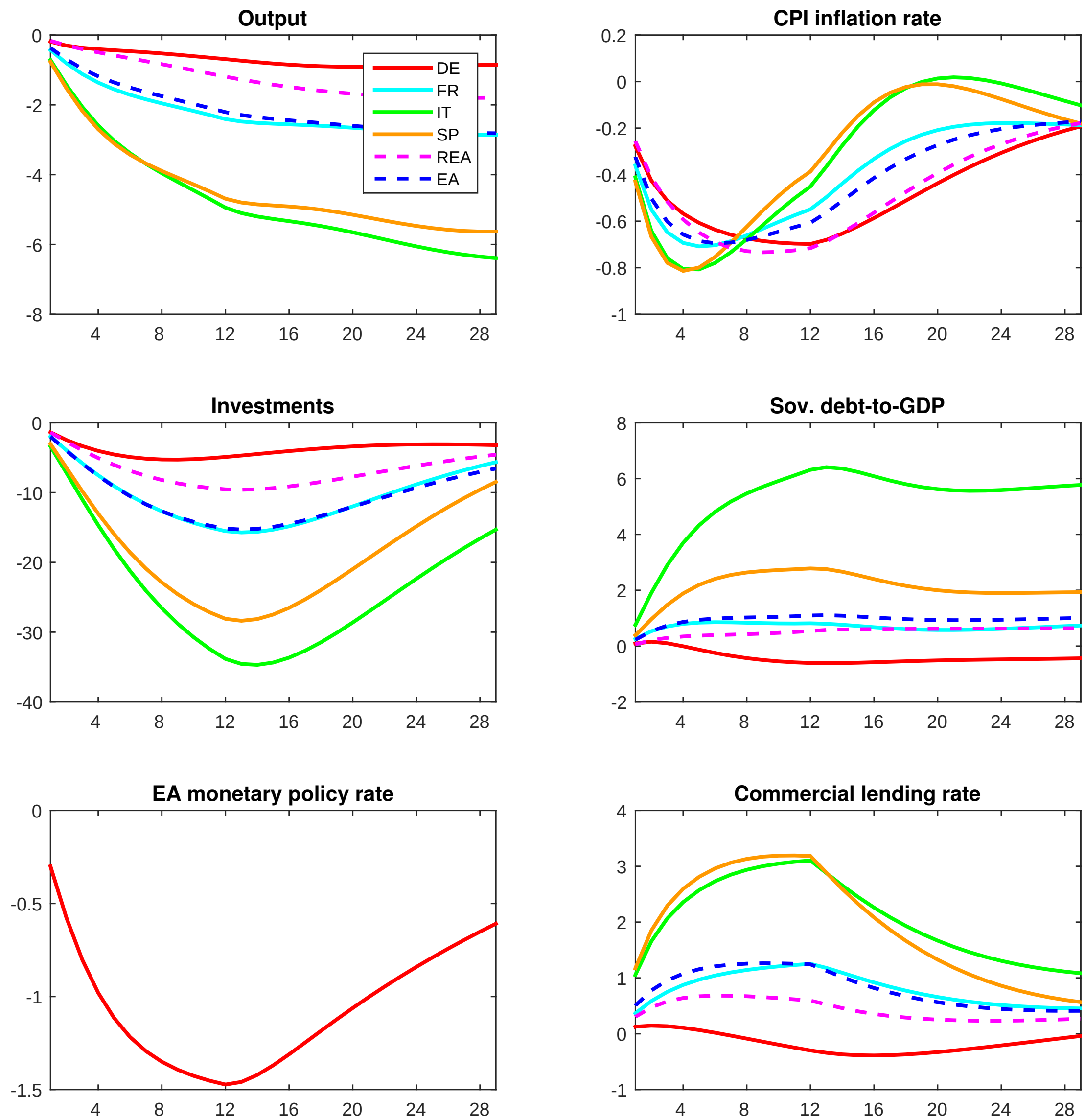
Notes: increase of euro area regulatory requirements by 4 percentage points; policy is permanent and gradually implemented within approximately a three-year horizon. Horizontal axis: quarters. Vertical axis: percentage deviations from baseline, except for inflation and interest rates which are expressed as annual percentage-point deviations. GDP, its components and bank loans are reported in real terms.

Figure 13: Increase in **regulatory requirements** only for **Italy and Spain** - Benchmark calibration



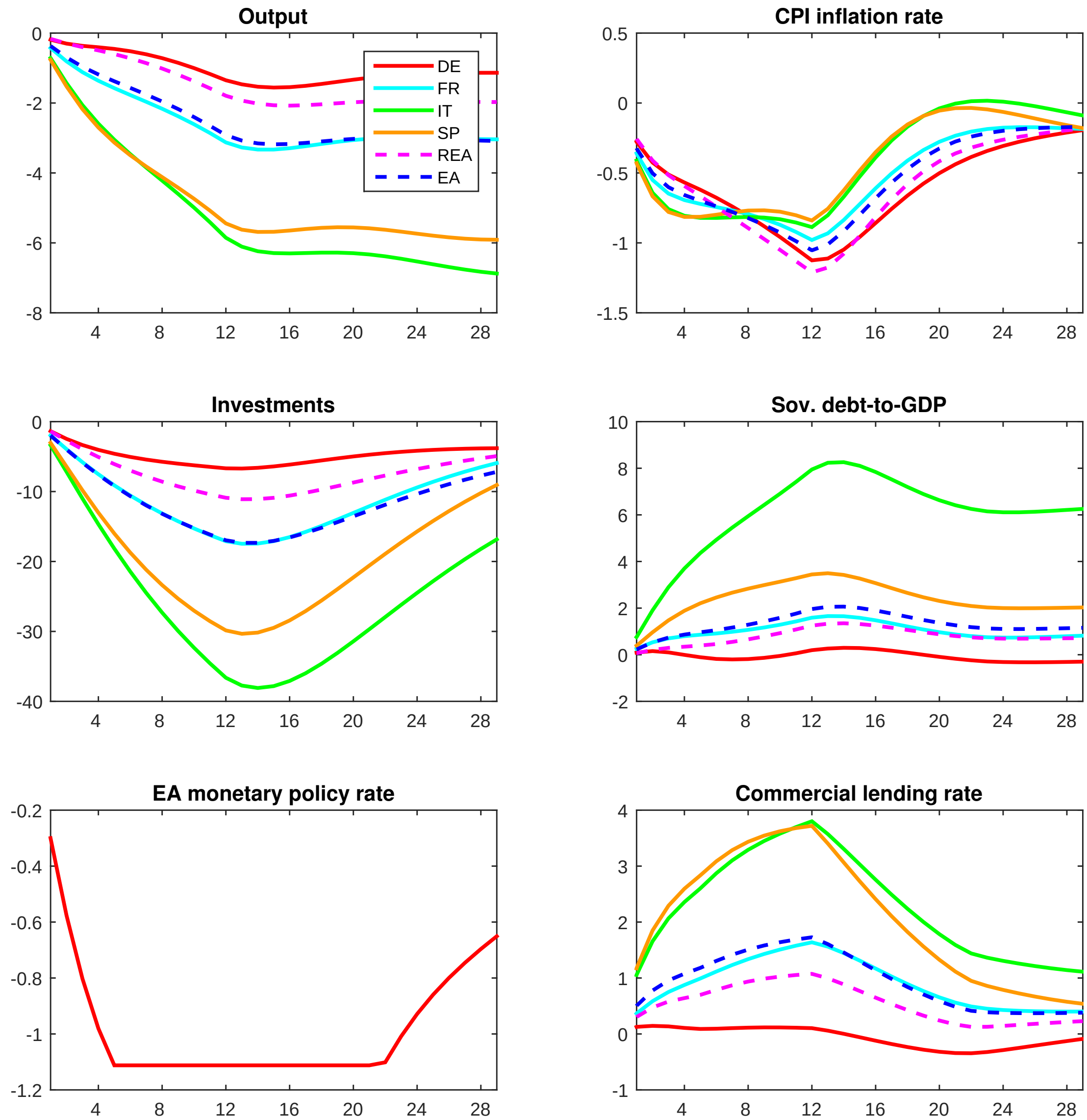
Notes: increase of regulatory requirements by 4 percentage points in Italy and Spain; policy is permanent and gradually implemented within approximately a three-year horizon. Horizontal axis: quarters. Vertical axis: percentage deviations from baseline, except for inflation and interest rates which are expressed as annual percentage-point deviations. GDP, its components and bank loans are reported in real terms.

Figure 14: **Cumulative impact of the financial crisis -** Benchmark calibration



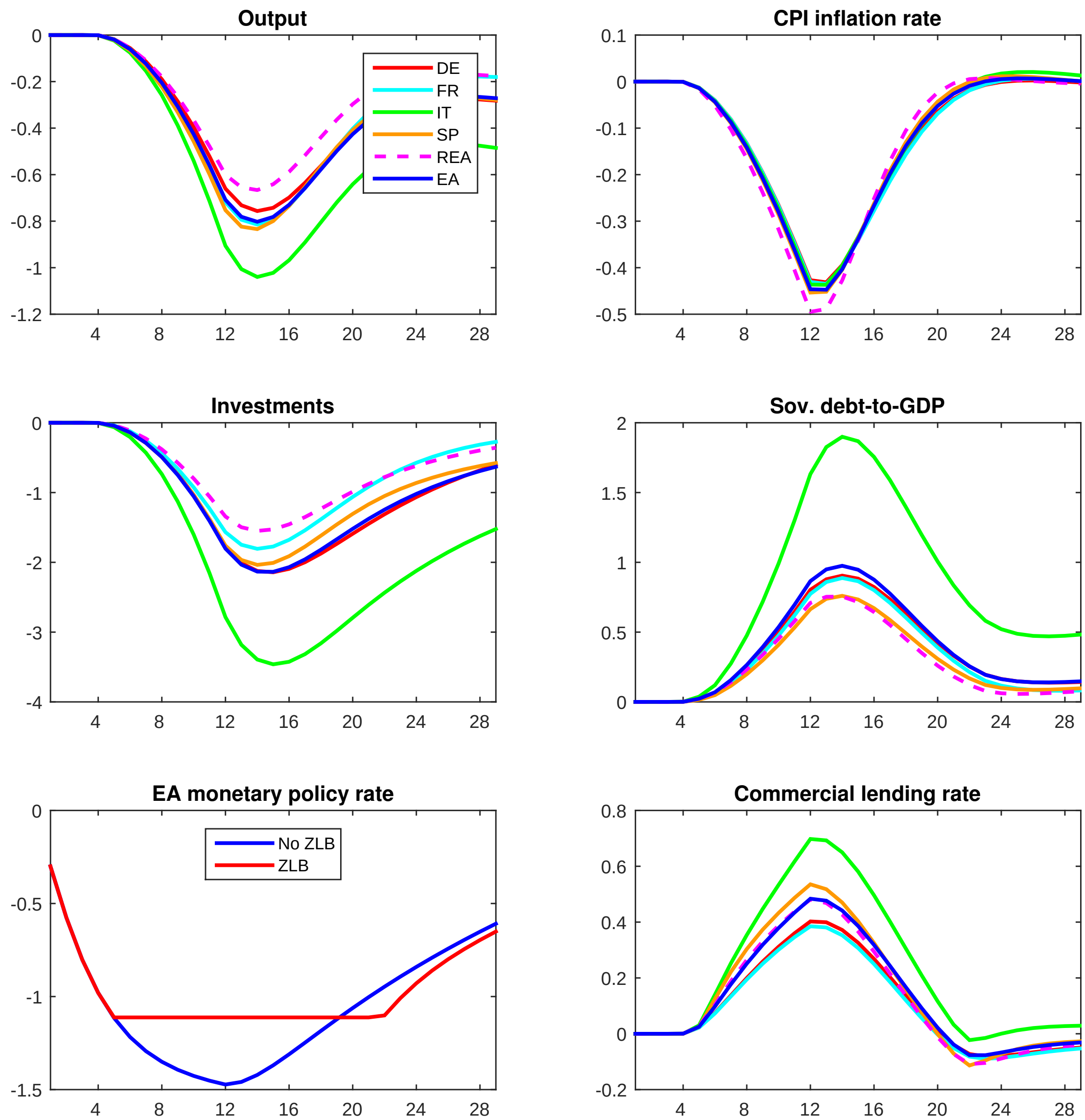
Notes: increase of the loss given default, $\xi_G^{\max}$, in Italy, Spain and rest of euro area, increase of the funding cost in France, so that sovereign bond yields and funding cost increase to crisis levels for three years; increase of the standard deviation of the multiplicative idiosyncratic shock of entrepreneurs, σ_e, in France, Italy and Spain for three years, so that the contribution of entrepreneurs expected losses to commercial lending rates increase to crisis levels for three years; increase of euro area regulatory requirements by 4 percentage points; policy is permanent and gradually implemented within approximately a three-year horizon. Shocks are persistent, i.e. follows an AR(1) process with autocorrelation being 0.95, except regulatory requirements which is permanent. Horizontal axis: quarters. Vertical axis: percentage deviations from baseline, except for inflation, interest rates and debt-to-GDP ratio which are expressed as annual percentage-point deviations. GDP and its components are reported in real terms.

Figure 15: **Cumulative impact of the financial crisis subject to the zero lower bound -** Benchmark calibration



Notes: increase of the loss given default, $\xi_G^{\max}$, in Italy, Spain and rest of euro area, increase of the funding cost in France, so that sovereign bond yields and funding cost increase to crisis levels for three years; increase of the standard deviation of the multiplicative idiosyncratic shock of entrepreneurs, σ_e, in France, Italy and Spain for three years, so that the contribution of entrepreneurs expected losses to commercial lending rates increase to crisis levels for three years; increase of euro area regulatory requirements by 4 percentage points; policy is permanent and gradually implemented within approximately a three-year horizon. Shocks are persistent, i.e. follows an AR(1) process with autocorrelation being 0.95, except regulatory requirements which is permanent. Horizontal axis: quarters. Vertical axis: percentage deviations from baseline, except for inflation, interest rates and debt-to-GDP ratio which are expressed as annual percentage-point deviations. GDP and its components are reported in real terms.

Figure 16: **Cumulative impact of the zero lower bound -** Benchmark calibration



Notes: increase of the loss given default, $\xi_G^{\max}$, in Italy, Spain and rest of euro area, increase of the funding cost in France, so that sovereign bond yields and funding cost increase to crisis levels for three years; increase of the standard deviation of the multiplicative idiosyncratic shock of entrepreneurs, σ_e, in France, Italy and Spain for three years, so that the contribution of entrepreneurs expected losses to commercial lending rates increase to crisis levels for three years; increase of euro area regulatory requirements by 4 percentage points; policy is permanent and gradually implemented within approximately a three-year horizon. Shocks are persistent, i.e. follows an AR(1) process with autocorrelation being 0.95, except regulatory requirements which is permanent. Horizontal axis: quarters. Vertical axis: percentage deviations from baseline, except for inflation, interest rates and debt-to-GDP ratio which are expressed as annual percentage-point deviations. GDP and its components are reported in real terms.