Design and Coordination of Macroprudential Policy in the Eurozone with International Banks

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Abstract

This paper seeks to find the optimal design of macroprudential policies in the Eurozone by testing different levels of implementation: federal or national, in a coordinated way or not. Using Bayesian techniques, we estimate an asymmetric two-country DSGE model that allows for cross-border loan facilities where monetary and macroprudential policies can play a role in mitigating the risk of the financial system. We divide the dataset of the Euro Area between core and peripheral countries to take into account the recent structural divergences of business and credit cycles. First, introducing macroprudential policy clearly increases welfare from 0.004% and 0.376% of unconditional consumption. Greater welfare gains are observed for the coordination scheme with national implementation. Second, cross-border loans are not a critical feature to assess the systemic risk at the national level. Finally concerning the interactions between monetary and macroprudential policy, we find that the implementation of monetary policy should only aim to maintain price stability in the Eurosystem: the financial and price stability mandates should remain separated.

JEL classification: E32; E44; E52; F36; F41;

Keywords: Monetary and Macroprudential policy, Banking Union, Euro Area, Banking Globalization, Financial Accelerator, DSGE Two-Country Model, Bayesian Estimation

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1 Introduction

The 2008 financial turmoil highlighted the need to contain systemic risk as through macroprudential measures. Broadly defined, the final objective of macroprudential policy is to prevent or mitigate systemic risks that arise from developments within the financial system, taking into account macroeconomic developments, so as to avoid periods of widespread distress. However, despite the general agreement in considering financial stability as an additional objective to ensure macroeconomic stability, the nature of the operational framework is still under debate.

The debate on the way macroprudential measures should be implemented is even more challenging for countries belonging to the European monetary union. As underlined by Loisel (2014), this group of countries has a single monetary authority (the European Central Bank), a common macroprudential authority (the European Systemic Risk Board, hereafter ESRB) and national macroprudential authorities. Currently, supervisory and regulatory frameworks remain fragmented along national lines, while the coordination and internalization of cross-border spillovers are achieved at by the ESRB through a (non-binding) ‘act or explain’ mechanism. A key problem thus arises to determine how these different actors may interact in the definition of the macroprudential measures. The conduct of macroprudential measures in the Eurozone thus covers two complementary levels: the standard question analyzing how macroprudential policy should be articulated with monetary policy must be completed by a second one focusing on how should the federal and national levels related to macroprudential policy be organized?

To our knowledge the design and the question of the coordination of macroprudential measures in the Eurozone have initially been approached by Pariès et al. (2011) and Quint and Rabanal (2013). More particularly, Quint and Rabanal (2013) find that there are no negative spillover effects of regulation from one member state to another via a two country DSGE model of the Eurozone. Having macroprudential policies set at the national or EMU wide levels will therefore not change the outcome. Their model focuses on the interaction between financial and housing cycles. As a consequence, it includes a financial accelerator mechanism on the household side, such that changes in the balance sheet of borrowers due to house price fluctuations affect the spread between lending and deposit rates. In their paper they find that there is no gain of coordinating macroprudential policy. However, this result is obtained in a setting that ignores cross border-bank loans, which is a key component of financial integration in the EMU and may constitute a critical feature to assess the systemic risk at the national level and, by so, to take the right macroprudential decision.

The aim of this paper is to evaluate the question of the coordination of macroprudential policy measures in a monetary union, where banks provide the main funding for investment, and where banking activity is characterized by the possibility to engage in

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2 In countries with a high share of foreign banks and in the absence of information on parent institutions and their exposures, it is difficult to assess domestic systemic risk. Foreign branches, in particular, can become “shadow banks” for the host supervisor and thus increase the systemic risk at the national level.
cross border lending. The conduct of macroprudential measures at the national level rests on the fact that economic and financial cycles are determined by national developments\(^3\). However, this approach can be harmful in a monetary union where banks can engage in cross border lending. This situation gives rise to externalities that may lead to the interest of cooperation\(^4\).

To this aim, we build and estimate a two-country DSGE model that accounts for the key role of banks in the EMU in providing the main financial resources to national and foreign firms. Our model accounts for several sources of rigidities to enhance the empirical relevance of the model. The set of real rigidities encompasses consumption habits, investment adjustment costs, loan demand habits. Regarding nominal rigidities, we account for stickiness in final goods prices, wages and loan interest rates. The model is estimated with Bayesian methods on Eurozone quarterly data over the sample period 1999Q1 to 2013Q2. In line with our two country framework, we split Eurozone’s countries in two groups. In the first group we aggregate data for countries with a current account surplus over the sample period (Austria, Belgium, Germany, Finland, France, Luxembourg, Netherlands and Portugal), while in the second group, we aggregate data for countries with a current account deficit over the sample period (Spain, Greece, Ireland, Italy and Portugal). As in Quint and Rabanal (2013), the macroprudential tool affects lending conditions through the spread between loan and interbank interest rates.

DSGE models provide two main interest for dealing with the question at hand. First, in this setting it is possible to derive the optimal value for macroprudential tools and to perform welfare analysis to rank the alternative macroprudential coordination schemes. Second, as this structural model is amendable to counterfactual analysis, we can evaluate the efficiency of such measures to cope with financial problems in the Eurozone.

We get a first set of results for the way macroprudential policy should be organized, on welfare based considerations. As Suh (2014), we find that this policy requires an institutional design that separates macroprudential policy from monetary policy: adding macroprudential considerations on the conduct of monetary policy does not affect welfare in the monetary union (with respect to the optimal rule). Macroprudential and monetary policy should remain separated: a credit growth adjusted Taylor rule does not increase welfare according to our calculations. This result accounts for specific features of the Eurozone: As the ECB can only react to average European values, it only accounts for the average financial stress. This solution leads to an under reaction of the ECB. All welfare gains that are obtained through the optimized Taylor rule.

As the main question turns out to be the coordination between national authorities, we contrast four possibilities of organization of macroprudential policies: (i) In the first situation, according to the home country principle, there is no international coordination

\(^3\)Furthermore, such instruments may be particularly relevant for countries that are part of the Eurozone, as monetary policy can no longer be tailored to domestic circumstances and fiscal policy is constrained by institutional barriers such as the Stability and Growth Pact.

\(^4\)As underlined by IMF (2013, key issues, p31), financial integration poses a range of specific challenges for the effectiveness of national macroprudential policies. First, lack of forceful macroprudential action in one country can increase the likelihood of crises, imposing negative externalities on other countries. Second, national policies to contain risks from a rapid build-up of domestic credit can lead to an increase in the provision of cross-border credit. Third, policies to strengthen the resilience of systemic institutions in one country can cause their activities to migrate to other countries. Fourth, where financial institutions have affiliates in multiple jurisdictions, this complicates the assessment of systemic risk and can lead to conflicts between home and host authorities.
as national macroprudential policies are set on national commercial banks; (ii) in the second situation, according to the host country principle, there is a bilateral coordination as national macroprudential policies are set on resident commercial banks; (iii) in the third situation, relying on the subsidiarity principle, the decision of relevant measures are set at the federal level and the implementation of this measures at the national level; (iv) in the last situation, the same value is imposed on the macroprudential parameter for all countries. We find that introducing macroprudential policy clearly increases welfare in the Eurozone. However, cross-border loans reintroduce a ranking in the design of Eurozone’s macroprudential framework, as welfare gains lie between 0.004% (for solution iv) and 0.376% (for solution iii) of unconditional consumption, depending on the choice of the coordination scheme. The optimal solution is the subsidiarity one, as it solves the externality problem (evaluation of the systemic risk in each country and spillovers coming for the implementation of specific national measures).

A second set of result concerns the macroeconomic effect of macroprudential measures. This question is treated through a counterfactual analysis. We outline the fact that preventive macroprudential measures leaning against the wind provides macro-financial stability, as it clearly decreases the variance of investment in peripheral countries. The impact is more limited for peripheral countries. Finally, looking for the curative features of macroprudential measures, we find that macroprudential policy is able to encourage the recovery of the economy by increasing the profitability of investment projects. However, we find that macroprudential measures have a clear different impact on both sides on the European union: it has no impact on core countries’ activity while it has a limited impact on activity in the periphery, as it only damps the negative transmission of the shock after 10 quarters. The main curative impact of this policy is observed on the peripheral investment slow down, as the investment fall is reduced and the recovery is clearly increased after 2 periods.

The paper is organized as follows: Section 2 describes the financial and macroprudential components of the model; section 3 takes the model to the data; section 4 provides a welfare ranking of the macroprudential policies; section 5 provides a counterfactual analysis; section 6 concludes.

2 Cross Border Bank Loans and the Macroprudential Setting

Our model describes a monetary union made of two asymmetric countries $i \in \{h, f\}$ (where $h$ is for home and $f$ for foreign) of relative sizes $n$ and $1 - n$ inspired by (Kołasa, 2009). As shown in Fig. 1, each country is populated by consumers, intermediate and final producers, entrepreneurs, capital suppliers and a banking system. Regarding the conduct of macroeconomic policy, we assume national fiscal authorities and a common central bank. The implementation of the macroprudential policy is left open, and discussed below. We account for several sources of rigidities to enhance the empirical relevance of the model\(^5\). This section goes into details on the determination of national interest rates, cross border banking and on the description of the macropru-

\(^5\)The set of real rigidities encompasses consumption habits, investment adjustment costs, loan demand habits. Regarding nominal rigidities, we account for stickiness in final goods prices and loan/deposit interest rates.
dential scheme. The rest of the model and general equilibrium conditions are standard and presented in Section A.

2.1 Entrepreneurs and the Demand for Loans

In this setting, the demand for loans comes from entrepreneurs that want to finance investment. In each economy, the representative entrepreneur $e \in [0, 1]$ finances the capital renting of intermediate firms. In period $t$, entrepreneur $e$ conducts a great number of heterogenous projects with total value $Q_{i,t}K_{i,t+1}(e)$, (where $Q_{i,t}$ is the price of capital and $K_{i,t+1}(e)$ is the amount of capital financed). These projects are financed by his net wealth ($N_{i,t}(e)$ in real terms of the consumption basket) and by loans from the banking system ($L_{i,t+1}(e)$). Taking into account loan demand habits ($h_k^i$) to fit the data, the balance sheet of the representative entrepreneur writes,

$$Q_{i,t}K_{i,t+1}(e) - N_{i,t+1}(e) = L_{i,t+1}^H(e).$$  \hspace{1cm} (1)

where $L_{i,t+1}^H(e) = L_{i,t+1}(e) - h_k^i(L_{i,t+1}(e))$ stands for the loan demand habits$^6$. The entrepreneur has access to domestic and foreign banks to meet its balance sheet. The total amount borrowed by the representative entrepreneur writes,

$$L_{i,t+1}(e) = \left((1 - \alpha^L_i)^{1/\nu} L_{h,i,t+1}(e)^{(\nu - 1)/\nu} + \left(\alpha^L_i\right)^{1/\nu} L_{f,i,t+1}(e)^{(\nu - 1)/\nu}\right)^{\nu/(\nu - 1)},$$  \hspace{1cm} (2)

where parameter $\nu$ is the elasticity of substitution between domestic and foreign loans, $\alpha^L_i$ represents the percentage of cross-border loan flows in the monetary union and $L_{h,i,t+1}(e)$ (resp. $L_{f,i,t+1}(e)$) the amount of domestic (resp. foreign) loans demanded by entrepreneur $e$ in country $i$. The total cost of loans, $P_{i,t}^L$, is thus defined according to,

$$P_{i,t}^L(e) = \left((1 - \alpha^L_i) \left( R_{h,t}^L(e) \right)^{1-\nu} + \alpha^L_i \left( R_{f,t}^L(e) \right)^{1-\nu}\right)^{1/(1-\nu)},$$  \hspace{1cm} (3)

$^6$We introduce loans demand habits because we use in the estimation the outstanding amount of loans with different maturities. DSGE models only incorporate one-period loans, the problem of implementing different maturities becomes tractable by adding demand habits on loans.
where \( R_{h,t}^L(e) \) (resp. \( R_{f,t}^L(e) \)) is the cost of loans obtained from home (resp. foreign) banks by entrepreneur \( e \) in country \( i \). The decision to borrow from a particular bank is undertaken on the basis of relative national interest rates,

\[
L_{h,i,t+1}(e) = \left(1 - \alpha_i^L \right) \left[ \frac{R_{h,t}^L(e)}{P_i^L(e)} \right]^{-\nu} L_{i,t+1}(e) \quad \text{and} \quad L_{f,i,t+1}(e) = \alpha_i^L \left[ \frac{R_{f,t}^L(e)}{P_i^L(e)} \right]^{-\nu} L_{i,t+1}(e).
\]

(4)

The investment projects undertaken by the entrepreneur are risky and differ with respect to their individual return. To model individual riskiness, we assume that each project has an individual return equal to \( \omega R_{i,t}^k \), i.e. that the aggregate return of investment projects in the economy \( R_{i,t}^k \) is multiplied by a random value \( \omega \in [\omega_{\min}^i; +\infty) \) (drawn from a Pareto distribution\(^7\)). Defining the value for a profitable project by \( \bar{\omega}_{i,t}(e) = E(\omega | \omega \geq \omega_{i,t}^C(e)) \) (where \( \omega_{i,t}^C(e) \) is the critical value of \( \omega \) that distinguishes profitable and non profitable projects), the profit function of entrepreneur \( e \) writes,

\[
\Pi_{i,t+1}(e) = \begin{cases} \bar{\omega}_{i,t+1} \left( 1 + R_{i,t+1}^k \right) Q_{i,t} K_{i,t+1}(e) - \left( 1 + P_{i,t+1}^L(e) \right) L_{i,t+1}^H(e) \quad \text{w/ probability } \eta_{i,t+1}(e) \\ 0 \quad \text{w/ probability } 1 - \eta_{i,t+1}(e) \end{cases}
\]

(5)

where \( \eta_{i,t+1}(e) = Pr[\omega \geq \omega_{i,t}^C(e)] \) is the time-varying expected share of gainful projects.

As in De Grauwe (2010), since entrepreneurs cannot screen the value of \( \bar{\omega}_{i,t+1}(e) \) \textit{ex ante}, their forecasts regarding the profitability of a given project are pessimistic (i.e., biased downwards): the perceived \textit{ex ante} value of profitable projects is defined by the isoleastic function,

\[
g\left(\bar{\omega}_{i,t+1}, \varepsilon_{i,t}^Q \right) = \gamma_i \left( \bar{\omega}_{i,t+1} \right)^{\frac{\varepsilon_{i,t}^Q}{(\varepsilon_{i,t}^Q - 1)}} \left( \varepsilon_{i,t}^Q \right)^{\frac{1}{(\varepsilon_{i,t}^Q - 1)}},
\]

where \( \varepsilon_{i,t}^Q \) is an AR(1) process\(^8\), \( \gamma_i \) is the elasticity of the external finance premium\(^9\) and \( \gamma_i \) is a scale parameter\(^10\). In this expression, the exogenous shock is affected by exponent \( 1/(\varepsilon_{i,t}^Q - 1) \) to normalize to unity the impact of the financial shock \( \varepsilon_{i,t}^Q \) in the log deviation form of the model.

Thus, \textit{ex-ante} the entrepreneur chooses a capital value of \( K_{i,t+1}(e) \) that maximizes its expected profit, \( \Pi_{i,t}^E(e) \), defined as,

\[
\max_{\{K_{i,t+1}(e)\}} \mathbb{E}_t \left\{ \eta_{i,t+1}^\pi \left[ g \left( \bar{\omega}_{i,t+1}, \varepsilon_{i,t}^Q \right) \left( 1 + R_{i,t+1}^k \right) Q_{i,t} K_{i,t+1}(e) - \left( 1 + P_{i,t+1}^L(e) \right) L_{i,t+1}^H(e) \right] \right\}.
\]

(6)

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\( ^7 \) With respect to the standard framework standardly used in the literature (Bernanke et al., 1999), we assume that the heterogeneity in the return of investment project undertaken by firms is modeled using a Pareto distribution. This device commonly used in other branches of the economic literature provides a series of interesting features in the analysis and allows an easier estimation of the financial amplification. See Section B for detail about the computation of \( \omega \).

\( ^8 \) This shock affects the expected profitability of financial projects by rising in exogenously the risk premium implying an increase in the cost of capital and hence a reduction in investment as underlined by Gilchrist et al. (2009b) for the US economy. This shock also captures the notion that the riskiness of entrepreneurs varies over time as in Christiano et al. (2010).

\( ^9 \) The elasticity of the external finance premium expresses the degree of bias in estimating the expected rentability of entrepreneurs’ projects such that if \( \omega > 1 \) and \( \gamma_i > 0 \) then \( \bar{\omega} > g(\bar{\omega}) \). Expressed \textit{à la} De Grauwe (2010), \( \mathbb{E}_t^{\pi_\omega} \bar{\omega}_{i,t+1} = \mathbb{E}_t \gamma_i \left( \bar{\omega}_{i,t+1} \right)^{\frac{1}{(\varepsilon_{i,t}^Q - 1)}} \) where \( \mathbb{E}_t^{\pi_\omega} \) is the expectation operator of pessimistic entrepreneurs.

\( ^10 \) This parameter is needed to make the steady state independent of \( \varepsilon_{i,t}^Q \), such that \( \gamma_i = \omega^{1/(1-\varepsilon_i^Q)} \).
Using the characteristics of the Pareto distribution, the expected spread required by representative entrepreneur \(e\) to undertake the decision to finance firms’ investment is,

\[
S_{i,t} (e) = \frac{E_b (1 + R_{i,t+1}^k)}{1 + P_{i,t}^k (e)} = \kappa_{i,t} \left[ \frac{\kappa - 1}{\kappa - 1} \left( 1 - \frac{N_{i,t+1} (e)}{Q_{i,t} K_{i,t+1} (e)} \right) \right]^{\kappa_i} e^{\varepsilon_{i,t}^Q}
\]

The size of the accelerator is determined by the elasticity of the external finance premium \(\kappa_i\). For \(\kappa_i > 0\), the external finance premium is a positive function of the leverage ratio, \(Q_{i,t} K_{i,t+1} (e) / N_{i,t+1} (e)\), so that an increase in net wealth induces a reduction of the external finance premium. This phenomenon disappears if \(\kappa_i = 0\). Concerning the exogenous movements of the external finance premium, a positive realization of \(\varepsilon_{i,t}^Q\) means that entrepreneurs require a higher expected profitability of capital \(E_t (1 + R_{i,t+1}^k)\) to finance investment for a given level of lending conditions \(1 + P_{i,t}^L\). This means that as they require a higher rentability, they become more pessimistic. Furthermore, a shock that hits the entrepreneur net wealth \(N_{i,t+1} (e)\) will also affect the rentability of the physical capital in the economy. As the rentability of capital is a cost for the intermediate sector, a variation in the net wealth will have aggregate consequences on goods supply through the channel of the capital market as underlined by Gilchrist et al. (2009b). Thus the net wealth of the entrepreneur in the next period is equal to,

\[
N_{i,t+1} (e) = (1 - \tau^E) \Pi_{i,t}^E (e) e^{\varepsilon_{i,t}^N}, \tag{7}
\]

where \(\varepsilon_{i,t}^N\) is an exogenous process of net wealth creation/destruction as in Christiano et al. (2010) and \(\tau^E\) is a proportional tax. Anticipating symmetry between entrepreneurs in equilibrium and aggregating, the log-linear expression of the external finance premium \(S_{i,t}\) (i.e. \(\hat{s}_{i,t}\)) writes as in Bernanke et al. (1999),

\[
\hat{s}_{i,t} = E_t \hat{s}_{i,t+1}^k - \hat{p}_{i,t}^L = \kappa_i \left( \hat{q}_{i,t} + \hat{k}_{i,t+1} - \hat{n}_{i,t+1} \right) + \varepsilon_{i,t}^Q. \tag{8}
\]

### 2.2 The Banking Sector and the Determination of Interest Rates

The total number of banks in the monetary union is normalized to one. The representative bank \(b \in [0,1]\) in country \(i\) collects deposits from households and lends to firms. The balance sheet of the bank writes,

\[
L_{i,t+1}^s (b) = D_{i,t+1} (b) + L_{i,t+1}^{RF} (b) + BK_{i,t+1} (b). \tag{9}
\]

In this expression, \(L_{i,t}^s\) is the total level of loans supplied by bank \(b\), \(D_{i,t} (b)\) is the total level of deposit services offered by bank \(b\) of country \(i\) to households, \(L_{i,t+1}^{RF} (b)\) is the one-period refinancing loans to banks by the ECB and \(BK_{i,t+1} (b)\) is the bank capital. The representative bank sets the rate of interest \(R_{i,t}^L (b)\) and \(R_{i,t}^{RF} (b)\).

Banks finance heterogenous investment projects conducted by home and foreign entrepreneurs, some of these projects are gainful with a probability \(\bar{n}_{i,t+1}\). Following Bernanke et al. (1999), if the borrower’s project is gainful, the representative bank obtains \(\bar{n}_{i,t+1} (1 + R_{i,t}^L (b)) L_{i,t+1}^s (b)\), whereas if the entrepreneur’s project is insolvent the bank must pay auditing costs \(\mu^b\) to obtain its loan (i.e., \((1 - \mu^b) (1 - \bar{n}_{i,t+1}) (1 + R_{i,t}^L (b)) L_{i,t+1}^s (b)\),
thereby the expected value of next period earnings is,

\[
E_{t} \Pi_{i,t+1}^{b} (b) = \left[ E_{t} \tilde{n}^{\pi}_{i,t+1} + (1 - \mu^{b}) (1 - \tilde{n}^{\pi}_{i,t+1}) \right] \left( 1 + R_{i,t}^{L} (b) \right) L_{i,t+1}^{\ast} (b)
\]

Revenues from loan supply activities

\[
-(1 + R_{t}) L_{RF}^{i,t+1} (b) - (1 + R_{D}^{i,t}) D_{i,t+1} (b).
\]

ECB refinancing cost  
Deposit cost

In this setting, we assume that there is no discrimination between borrowers, so that the representative and risk-neutral bank serves both domestic and foreign entrepreneur without taking into account specificities regarding the national viability of projects. Bank default expectation regarding entrepreneurs’ projects is defined by a geometric average,

\[
\tilde{n}^{\pi}_{i,t+1} = (\tilde{n}^{\pi}_{h,t+1})^{(1-\alpha^{h}_{t})} (\tilde{n}^{\pi}_{f,t+1})^{\alpha^{L}_{t} (\tilde{n}^{\pi}_{h})^{\alpha^{f}_{t}}}. 
\]

Concerning bank capitals, we follow Hirakata et al. (2009) by assuming the law of motion of the net wealth is made of the profits of the previous period,

\[
BK_{i,t+1} (b) = (1 - \tau^{bk}) \Pi_{i,t}^{b} (b)
\]

Where \(\tau^{bk}\) denotes a proportional tax on the revenues of the bank\(^{11}\).

As in Pariès et al. (2011), we take into account the imperfect pass-through of policy rate on bank lending/deposit rates. We suppose that banks set their interest rates on a staggered basis with some degree of nominal rigidity à la Calvo.

**Loan supply decisions**

The determination of interest rate on loans is as follows: the representative bank \(b\) maximizes expected profit from Eq. (10) with respect to \(L_{i,t+1}^{\ast} (b)\) to obtain the expression of the marginal cost of producing new loans,

\[
1 + MC_{i,t}^{L} (b) = \frac{(1 + R_{t})}{[1 - \mu^{b} (1 - E_{t} \tilde{n}^{\pi}_{i,t+1})]}
\]

The representative retail bank \(b \in [0; 1]\) acts monopolistically to provide loans to entrepreneurs. It determines the interest rate on loans contracted by entrepreneurs. Assuming that it is able to modify its loan interest rate with a probability \(1 - \theta_{i}^{L}\), it chooses \(R_{i,t}^{L} (b)\) to maximize its expected sum of profits,

\[
\max_{\{R_{i,t}^{L}(b)\}} \mathbb{E}_{t} \left\{ \sum_{\tau=0}^{\infty} \left( \theta_{i}^{L} \beta^{\tau} \right) \frac{\lambda^{c}_{i,t+\tau+t}}{\lambda^{c}_{i,t}} \left[ R_{i,t}^{L} (b) - MC_{i,t+\tau}^{L} \right] L_{i,t+1+\tau} (b) \right\},
\]

subject to the demand constraint, \(L_{i,t+1+\tau} (b) = \left( R_{i,t}^{L} (b) / R_{i,t+\tau}^{L} \right)^{-\epsilon_{L}} L_{i,t+1+\tau}, \tau > 0\), where \(L_{i,t} (b)\) denotes the quantity of differentiated banking loans \(b\) that is used in loans packer production. Finally, the interest rate that solves the FOC for the bank that is allow to modify its interest rate, it is such that,

\[
\mathbb{E}_{t} \sum_{\tau=0}^{\infty} \left( \theta_{i}^{L} \beta^{\tau} \right) \frac{\lambda^{c}_{i,t+\tau+t}}{\lambda^{c}_{i,t}} \left[ R_{i,t}^{L} (b) - \frac{\epsilon_{L}}{\epsilon_{L} - 1} MC_{i,t+\tau}^{L} \right] L_{i,t+1+\tau} (b) = 0
\]

\(^{11}\)This tax is necessary to solve up the model in steady state. Bernanke et al. (1999) and Hirakata et al. (2011) also add a proportional cost in law of motion of the net wealth.
Deposit supply decisions

We proceed accordingly for the determination of deposit interest rate. The nominal marginal cost of one unit of deposit denoted by $MC^D_{i,t}$ is the same across banks and is related to the ECB refinancing rate,

$$1 + MC^D_{i,t} (b) = 1 + MC^D_{i,t} = (1 + R_t)$$

(14)

Assuming sticky deposit rates, for the bank that is allowed to modify its interest rate with a probability $\theta_i^D$, the expected sum of profits writes,

$$\max_{\{R^D_{i,t}(b)\}} \mathbb{E}_t \left\{ \sum_{\tau=0}^{\infty} (\theta_i^D)^\tau \frac{X_{i,t+\tau}^e}{X_{i,t}^e} \left[ MC^D_{i,t+\tau} - R^D_{i,t} (b) \right] D_{i,t+1+\tau} (b) \right\},$$

(15)

under the constraint, $D_{i,t+1+\tau} (b) = (R^D_{i,t} (b) / R^D_{i,t+\tau})^{-\mu_{i,t+\tau} / (\mu_{i,t+\tau} - 1)} D^d_{i,t+1+\tau}$, $\forall \tau > 0$, where $\mu_{i,t} = \Delta / (\Delta - 1) + \varepsilon_{i,t}$ is the time-varying markup subject to the exogenous deposit rate-push shock process $\Delta_{i,t}$. The interest rate that solves the FOC for the bank that is allowed to modify its interest rate writes,

$$\sum_{\tau=0}^{\infty} (\theta_i^D)^\tau \frac{X_{i,t+\tau}^e}{X_{i,t}^e} \frac{1}{\mu_{i,t+\tau} - 1} \left[ R^D_{i,t} (b) - \mu_{i,t+\tau} MC^D_{i,t+\tau} \right] D_{i,t+1+\tau} (b) = 0$$

(16)

2.3 The Different Levels and Designs of Implementation of Macroprudential Policy

In this paper, we analyze countercyclical macroprudential policies that are set either at the EMU or at the national levels. As in Quint and Rabanal (2013), we introduce a macroprudential tool that affects the general equilibrium of the economy through the lending conditions of commercial banks. A tightening of credit conditions due to macroprudential measures increases the interest rate faced by borrowers. A branch of the literature focuses on the role of credit growth as a leading indicators of asset price busts as Quint and Rabanal (2013), Fatas and et al. (2009) and Bailliu et al. (2012).

In the presence of macroprudential regulations, we suppose that the macroprudential instrument reacts to nominal credit growth by modifying the marginal cost of credit (see Eq. (12)) in the economy\(^{12}\),

$$1 + MC^{L}_{i,t} = \frac{(1 + R_t) (MP_{i,t})^{\phi_i}}{1 - \mu^b \left( 1 - \mathbb{E}_t \eta_{i,t+1}^\phi \right)}$$

(17)

Where $MP_{i,t}$ is the macroprudential instrument with a degree of reaction $\phi_i$. We consider that macroprudential authorities are concerned by credit growth and lean against the build-up of emerging financial imbalances. As shown in Table 1, our analysis of the optimal level of coordination of macroprudential policies contrasts up to five situations:

a) At a federal level, the monetary policy rule is augmented to allow the policy interest rate to react to the average credit growth in Eq. (A.7) as follows, $MP_{i,t} = (L^{s}_{h,t} / L^{s}_{h,t-1})^n \left( L^{s}_{f,t} / L^{s}_{f,t-1} \right)^{1-n}$.

\(^{12}\)Under staggered interest rates, the diffusion of the macroprudential policy is imperfect and takes into account the imperfect interest rate pass-through.
Common/Di¤erent Penalization Macroprudential Objective

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<thead>
<tr>
<th>Instrument</th>
<th>Penalization level</th>
<th>Macrop. Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knot</td>
<td>$\phi_k = \phi_f$</td>
<td>$R_t = f(\pi_{u,t}, Y_{u,t}) \times (\Delta L_{u,t})^b$</td>
</tr>
<tr>
<td>Federal</td>
<td>$\phi_h = \phi_f$</td>
<td>$(\Delta L_{u,t})^b$ (semi-wide supply)</td>
</tr>
<tr>
<td>National</td>
<td>$\phi_h \neq \phi_f$</td>
<td>$(\Delta L_{i,t})^b$ (domestic supply)</td>
</tr>
<tr>
<td>Host</td>
<td>$\phi_h \neq \phi_f$</td>
<td>$(\Delta L_{i,t})^b$ (domestic demand)</td>
</tr>
<tr>
<td>Home</td>
<td>$\phi_h \neq \phi_f$</td>
<td>$(\Delta L_{i,t})^b$</td>
</tr>
</tbody>
</table>

Note: a variable $X_{u,t}$ is a union-wide variable $X_{u,t} = (X_{h,t})^b (X_{f,t})^b$.

Table 1: Different levels of implementation of Macroprudential policy

b) At a federal level, macroprudential authorities penalize the average growth of credit by affecting proportionally the lending rate of bank in Eq. (17) with a common degree of penalization $\phi_h = \phi_f$. According to the supranational principle, we assume that coordination is implemented at the federal level by taking into account average developments in the Eurozone systemic risk.

c) At a national level, macroprudential authorities take into account the heterogeneity of the members of the Eurozone by having country specific degree of penalty ($\phi_h \neq \phi_f$) but in a coordinated way such that the macroprudential instrument writes,

$\mathcal{MP}_{i,t} = (L_{h,t}^s / L_{h,t-1}^s)^n (L_{f,t}^s / L_{f,t-1}^s)^{1-n}$. According to the host country principle, there is a bilateral coordination as national macroprudential policies are set on resident commercial banks.

d) Without coordination, we assume that countries are only interested in their domestic credit supply growths, then the macroprudential instrument is $\mathcal{MP}_{i,t} = L_{i,t}^s / L_{i,t-1}^s$.

e) The last situation relying on the subsidiarity principle, macroprudential authorities are only concerned by their domestic credit demand from home entrepreneurs, then the macroprudential tool writes $\mathcal{MP}_{i,t} = L_{i,t}^s / L_{i,t-1}^s$ where $L_{i,t}$ is the aggregate loan demand by entrepreneurs of country $i$.

3 Estimation

3.1 Data

We split the Eurozone in two groups: core and periphery. Since EMU creation, countries with current account surpluses belong to the core country group, other countries belong to the peripheral group\textsuperscript{13}. France is at middle of the road since its current account had been positive from 1999 to 2003, we make the hypothesis that France is still a core country despite its recent current account deficits. The model is estimated with Bayesian methods on Eurozone quarterly data over the sample period 1999Q1 to 2013Q3, which makes 59 quarterly observations for each variable (except for financial variables). The dataset includes 15 times series as presented in appendix: real GDP (Eurostats), real consumption (Eurostats), real investment (Eurostats), the ECB refinancing operation rate (Eurostats, one year maturity), the HICP (ECB, overall index, deseasonalized using a multiplicative decomposition), the overnight deposit rate of households and firms.

\textsuperscript{13}Core countries: Austria, Belgium, Germany, Finland, France, Luxembourg, Netherland and Portugal. Peripheral countries: Spain, Greece, Ireland, Italy and Portugal.
(ECB), the outstanding amount of loan and lending rate to non-financial corporations (ECB, 2003-2013, deseasonalized using a multiplicative decomposition). Data with a trend are made stationary using a linear trend and are divided by the population. We also demean the data because we do not use the information contained in the observable mean. Fig. 2 plots the transformed data.

![Graphs of various economic variables](image)

Figure 2: Observable variables

### 3.2 Calibration and Priors

The complete set of calibrated parameters is reported in Table 2. We fix a small number of parameters commonly used in the literature of real business cycles models\(^{14}\): these include \(\beta\) the discount factor, \(\delta\) the quarterly depreciation rate, \(\alpha\) the capital share in the production and the share of steady state hours worked \(\bar{H}\). The government expenditures to GDP ratio is set at 24%\(^{15}\). Concerning \(\varepsilon_p\) the substitutability between final good varieties, it is calibrated as in Smets and Wouters (2007) at 10 which roughly implies a markup of 11%. Regarding financial parameters, we fix \(\bar{N}/\bar{K}\) the net worth to capital ratio of entrepreneur as in Gerali et al. (2010). The steady state value of spreads \((\bar{R} - \bar{R}^D \text{ and } \bar{R}^L - \bar{R}^D)\) and the bank balance sheet \((\bar{D}/\bar{L} \text{ and } \bar{B}/\bar{L})\) are calibrated on their average values observed in the data. The annual share of insolvent entrepreneurs’ projects \(\bar{\eta}^s\) is fixed at 2.5% and the quarterly cost of audit \(\mu^b\) is 0.12, those values are comparable to Bernanke et al. (1999) and Hirakata et al. (2009). Following Kolasa (2009), we set the parameter governing the relative size of the core area \(n\) to 65%, which is the share implied by nominal GDP levels averaged over the period 1999-2013.

Our priors are listed in Table 4. Overall, they are either relatively uninformative or consistent with earlier contributions to Bayesian estimations. For a majority of new Keynesian models’ parameters, i.e. \(\sigma_i^c, \sigma_i^L, h_i^c, \theta_i^p, \xi_i^p, \lambda_i^I, \phi^x, \phi^\Delta\) and shocks

\(^{14}\)The Euro area was created in 1999, so our sample is relatively short, following Smets and Wouters (2007) we calibrate rather than estimate structural parameters which are known to be weakly identified (we do not estimate parameters that determine the steady state of the model).

\(^{15}\)On average, Euro Area households consumption represents 56% of the GDP and investment 20%, then the exogenous spending-GDP ratio is straightforward to derive.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>0.99</td>
<td>Discount factor</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.025</td>
<td>Depreciation rate</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.36</td>
<td>Capital share</td>
</tr>
<tr>
<td>$H$</td>
<td>1/3</td>
<td>Steady state hours worked</td>
</tr>
<tr>
<td>$\varepsilon_p$</td>
<td>10</td>
<td>Substitution between varieties</td>
</tr>
<tr>
<td>$R - \bar{R}^D$</td>
<td>1.5/400</td>
<td>Refinancing rate minus the deposit rate</td>
</tr>
<tr>
<td>$\bar{R}^h - \bar{R}^D$</td>
<td>4.3/400</td>
<td>Credit rate minus the deposit rate</td>
</tr>
<tr>
<td>$G/Y$</td>
<td>0.24</td>
<td>Government expenditures to GDP ratio</td>
</tr>
<tr>
<td>$\bar{N}/\bar{K}$</td>
<td>0.3</td>
<td>Net worth to capital ratio</td>
</tr>
<tr>
<td>$\bar{D}/\bar{L}$</td>
<td>0.46</td>
<td>Deposit to loan ratio</td>
</tr>
<tr>
<td>$\bar{B}\bar{K}/\bar{L}$</td>
<td>0.11</td>
<td>Bank capital to loans ratio</td>
</tr>
<tr>
<td>$\mu^b$</td>
<td>0.12</td>
<td>Auditing costs</td>
</tr>
<tr>
<td>$\bar{\eta}^s$</td>
<td>0.025/0.25</td>
<td>Insolvency share of investment projects</td>
</tr>
<tr>
<td>$n$</td>
<td>0.65</td>
<td>Share of core countries in total EMU</td>
</tr>
</tbody>
</table>

Table 2: Calibration of the model (all parameters are on a quarterly basis)

processes parameters, we use the prior distributions close to Smets and Wouters (2003, 2007) and Kolasa (2009). The Calvo probabilities are assumed to be around 0.5 for prices, credit rates and deposit rates, which are quite uninformative and rely largely on Smets and Wouters (2003, 2007) and Pariès et al. (2011). Concerning international macroeconomic parameters, our priors are inspired by Lubik and Schorfheide (2006): for the final goods market openness $\alpha^C_i$ and $\alpha^I_i$, we choose a beta prior of mean 0.12 and 0.05 of standard deviation\(^16\), while for the credit market openness we choose 0.5 and 0.2 for prior distribution\(^17\), at last substituabilities between home/foreign credit and final goods are set to 1.5 with standard deviations of 0.5. We set the prior for the elasticity of the external finance premium $\zeta_i$ to a beta distribution with prior mean equal to 0.05 and standard deviation 0.02 consistent with previous financial accelerator estimations (Gilchrist et al., 2009a; Bailliu et al., 2012). Adjustment cost on deposits $\chi^D_i$ is supposed to fluctuate around 0.0007 with a standard deviation of 0.0004, this prior is compatible with the findings of Schmitt-Grohé and Uribe (2003). Finally, in order to catch up the correlation and co-movement between countries’ aggregates, we estimate the cross-country correlation between structural shocks. Our priors are inspired by in Jondeau et al. (2006) and Kolasa (2009), we set the mean of the prior distribution for the shock correlations between core countries and peripheral countries to 0 with a large standard deviation of 0.4.

\(^{16}\)The intra-zone openness is calculated by Eyquem and Poutineau (2010) at $\alpha^C_i = \alpha^I_i = 0.04$ and $\alpha^C_h = \alpha^I_h = 0.09$. Ours priors are chosen to be near these values.

\(^{17}\)The prior for $\alpha^D_i$ is less informative than for $\alpha^C_i$ and $\alpha^I_i$ because Ueda (2012) suggests that credit market intrazone openness is around 0.35 in the Eurozone. Then a prior distribution with a mean 0.12 would be too much opinionated.


### 3.3 Posteriors and Fit of the model

The methodology is standard to the Bayesian estimations of DSGE models\(^{18}\). Table 4 reports the prior and posterior distributions of the parameters of the model. Overall, all structural parameters are estimated significantly different from zero. Comparing our estimates of deep parameters with the baseline of Smets and Wouters (2003) for the Euro Area, we find higher standard deviations for all the shocks, this mainly comes from the 2007 financial crisis captured by our model as strong negative productivity and demand shocks followed by persistent financial shocks (see the decomposition of investment growth in Fig. 4 for further details). Concerning the parameters characterizing the investment adjustment cost, consumption habits, labour disutility and the weight on output growth, our estimates are also very close to Smets and Wouters (2003).

Turning to the degree of price stickiness, the monetary policy smoothing and the weight on inflation, our posterior distributions are close to the estimates of Christiano et al. (2010). Finally, we find evidence that only two cross-country correlations are significant: productivity and deposit cost-push shocks.

The main differences between core and peripheral countries explain the divergence of business cycles since the creation of the EMU. The gap between core and periphery originates from both shocks and structural parameters. The estimated standard deviation of shocks is larger in peripheral countries. The persistence of shocks is similar between countries except for the collateral shock: entrepreneurs net wealth in peripheral countries experience large and volatile innovations. The disynchronization of the business cycles are also driven by price and rate stickiness, capital demand habits and investment adjustment costs. The diffusion of monetary policy is not symmetric, particularly for the credit market where the rate stickiness is more important in the peripheral area than in the core one.

Concerning the home bias in the consumption and investment baskets of households and capital producers, the model slightly overestimates the openness of the goods market compared to the findings of Eyquem and Poutineau (2010). The estimation of the credit market openness is interesting, as underlined by Brunnermeier et al. (2012), cross-border banking within the euro area experienced explosive growth, especially after around 2003, helping to fuel property booms in Ireland and southern European countries. The model captures this feature as the degrees of openness of the credit market in peripheral countries is 46% and 7% in core countries.

To assess how well the model fits the data, we present in Table 5 and in Fig. 3 the

\(^{18}\)Interest rates data are annualized, we take into account this maturity by multiplying by 4 the rates in the measurement equation. The number of shocks and observable variables are the same to avoid stochastic singularity issue. Recalling that \(i \in \{h, f\}\), the vectors of observables \(\mathcal{Y}_t^{obs} = [\Delta \log \bar{Y}_{t,t}, \Delta \log \bar{C}_{t,t}, \Delta \log \bar{I}_{t,t}, R_{t}, \bar{\pi}_{t,t}, \Delta \log \bar{L}_{t,t}, \bar{R}_{t}^{L}, \bar{R}_{t}^{D}]^{'}\) and measurement equations \(\mathcal{Y}_t = [\bar{y}_{i,t} - \bar{y}_{i,t-1}, \bar{c}_{i,t} - \bar{c}_{i,t-1}, \bar{\pi}_{i,t} - \bar{\pi}_{i,t-1}, 4\bar{r}_t, \bar{\pi}_{t,4}^{L} - \bar{\pi}_{t,4}^{L-1}, 4\bar{r}_{t,4}^{L}, 4\bar{r}_{t,4}^{D}]^{'}\), where \(\Delta\) denotes the temporal difference operator, \(X_t\) is per capita variable of \(X_t\) and \(\bar{X}_t\) is the loglinearized version of \(X_t\). The model matches the data setting \(\mathcal{Y}_t^{obs} = \bar{Y} + \mathcal{Y}_t\) where \(\bar{Y}\) is the vector of the mean parameters, we suppose this is a vector of all 0. The posterior distribution combines the likelihood function with prior information. To calculate the posterior distribution to evaluate the marginal likelihood of the model, the Metropolis-Hastings algorithm is employed. We compute the posterior moments of the parameters using a sufficiently large number of draws, having made sure that the MCMC algorithm converged. To do this, a sample of 250,000 draws was generated, neglecting the first 50,000. The scale factor was set in order to deliver acceptance rates of between 20 and 30 percent. Convergence was assessed by means of the multivariate convergence statistics taken from Brooks and Gelman (1998).
second moments of the observable variables and their counterpart in the model. The model does reasonably well in explaining the standard deviation of all variables except for deposit rates, despite allowing for different degrees of nominal rigidities via the introduction of Calvo contracts. Nevertheless, the model captures well the persistence of all aggregates except for consumption in the core area. Our model incorporates an imperfect credit market with real rigidities, this way the model does a good job in predicting the standard deviation and persistence of investment and credit in both area. Concerning the cross-country correlations, the model does reasonably well in capturing the co-movement of all aggregates, however the model underestimates the cross-country correlation between home and foreign output and investment.

4 The Welfare Ranking of alternative Macroprudential schemes

This section discusses the implementation of macroprudential measures in the Monetary Union, accounting for two main situations: (i) the introduction of a macroprudential instrument in the monetary policy rule and (ii) the implementation of macroprudential policy measures at the national level (accounting for alternative international coordination schemes). Results that are reported in Table 6 show that, in all cases, the improvement in consumer’s welfare lies between 0.000% and 0.376% of their permanent consumption, depending on the instrument and on the coordination scheme. To get these results, we use the estimated parameters and shock processes given in Table 4. Permanent consumption gains are computed on a second order approximation to the household utility function of each country and to the equilibrium conditions of the model\textsuperscript{19}. Since the optimal policy is conducted at the EMU-wide level, we assume that policy makers maximize the welfare index of all citizens of the Eurozone\textsuperscript{20}.

First, we evaluate the consequences of taking into account macroprudential concerns in the conduct of monetary policy. We contrast three situations regarding the interest rate rule of the central bank: an estimated Taylor rule, an optimal Taylor rule and an optimal Taylor rule extended to account for credit growth at the union level. First, we evaluate the welfare gains obtained by optimizing the parameters of the Taylor rule with respect to the estimated value. As in Quint and Rabanal (2013), the optimized coefficients of the estimated Taylor rule suggest stronger responses to Euro Area CPI inflation than the estimated coefficients. The empirical rule implies a decrease in welfare representing 0.056 % of permanent consumption in the monetary union. As observed, core countries are more impacted by a lower concern of authorities on inflation than the periphery (the decrease of permanent consumption by 0.072% is the twice of the

\textsuperscript{19}In the quantitative simulation, we first search for weights attached to inflation $\phi^\pi$ and GDP growth $\phi^{\Delta Y}$ in the Taylor rule that gives the highest unconditional welfare of households from Eq. (A.2). Here, we maintain the autoregressive parameter of the policy rule $\rho^R$ at its estimated value since it has low effects on welfare. Based on the grid search by 0.01 unit, we limit our attention to policy coefficients in the interval $(1, 3]$ for $\phi^\pi$, $[0, 3]$ for $\phi^{\Delta Y}$ (Schmitt-Grohé and Uribe, 2007), and in the interval $[0, 3]$ for macroprudential instruments $\phi_h$ and $\phi_f$.

\textsuperscript{20}We consider that the monetary authorities are concerned by the union-wide welfare, $W_{n,t} = nW_{h,t} + (1 - n)W_{f,t}$. Following Adjemian et al. (2008), we account for the lower bound by adding to the welfare index a term penalizing the nominal deposit rate variance $\lambda_R (R^D_{n,t} - \bar{R}^D_n)^2$ where $\lambda_R = 0.077$ Woodford (2003).
one in the periphery). Regarding the macroeconomic side, the optimal rule clearly reduces the standard deviation of inflation but has no impact on real aggregates (the standard deviation of output and business synchronization between Eurozone’s countries are unaffected). As reported, introducing macroprudential concerns in the conduct of monetary policy has no effect on welfare with respect to the optimal Taylor rule. As the monetary authority focuses on union-wide averages, the financial stress observed for peripheral countries is diluted.

The picture is totally different when macroprudential measures are implemented at the national level. Independently of the coordination scheme, national macroprudential measures improve welfare, as they take into account the national nature of financial cycles. However, one shall note that in all cases, permanent consumption increases at the union level, and that the periphery countries benefit from this policy (in contrast, core countries’ permanent consumption is in most cases not affected by such measures). The results reported for the three national rules clearly show that welfare gains are higher when national macroprudential rules are coordinated. This general result departs from the one obtained by Quint and Rabanal because our setting accounts for cross border loans that can be considered as a source of externalities between the member countries of the monetary union.

First, applying uncoordinated macroprudential measures (namely, each authority reacts to the increase in the loan supply of national banks) improves welfare in both part of the EMU (permanent consumption increases by 0.246% on average at the union level and by 0.562% for the periphery). In this situation, national authorities can react to financial developments in their economies. As there is more stress in the periphery, the parameter of reaction is very high in this part of the monetary union. However, welfare gains are limited in this situation, as authorities have a bad evaluation of the nature of systemic risk: they do not take into account the total amount of loans contracted by entrepreneurs but the total amount of loans distributed by the banks that are located in their economy. In this situation, they neglect loans that have been contracted abroad by national entrepreneurs.

We report two further situations. Assuming that national authorities are able to react to the amount of loans contracted by entrepreneurs (i.e., by so, they take macroprudential measures with respect to the amount of loans that are provided in their economy by both domestic and foreign banks), they get a better understanding of national systemic risk. This system eliminates the shadow nature of the foreign banks that operate domestically. In this situation, the union per capita consumption increases by 0.354% (this figure combines a net increase of 0.801% for the periphery and an increase of 0.007% for the core countries). To understand the optimality of the non coordinated home country rule, one has to remind that focussing on national developments allows authorities to target the right financial disequilibrium that affects each country but neglects externalities in the transmission of such measures coming from cross border loans. Alternatively, the main externality takes the form of a mismeasurement of national systemic risk. Foreign branches can become “shadow banks” for the host supervisor and thus increase the systemic risk at the national level.

Finally in the situation where national authorities fully cooperate (namely, there is a joint optimization of the reaction parameters) they are able to account for externalities concerning both the evaluation of the national systemic risk and the spillovers in the cross border transmission of national macroprudential measures. In this situation,
the union per capita consumption increases by 0.376%. However, this situation leads to a welfare transfer between the members of the monetary union, as permanent consumption increases by 0.949% in the periphery while it decreases by 0.06% in the core countries. The best result is obtained for the credit rule under the coordinated policy (subsidiarity rule). Regarding these rules one shall note that it is optimal to define the proper reaction of national authorities at the federal level and leave them implementing the optimal policy. This type of coordination is much better than delegating both decision and implementation powers to the same federal entity. By doing so, the optimal policy account for the fact that financial cycles remain clearly national while financial systems are integrated and interconnected through cross-border activities. This scheme endogenises the externality coming from cross border flows in the decision process while it uses directly the national channel to impact directly the origin of the trouble. However, one shall note that the cooperative equilibrium clearly affects the macroeconomic outcome in the monetary union, regarding the standard deviation of inflation. Cooperation leads to too much emphasis on macroprudential concerns in the implementation of policy decision, and, by reducing the optimal value of the Taylor parameter on inflation, increases the standard deviation of inflation. As core countries are less affected by financial problems, less concern on inflation deteriorates their welfare. Finally, these policies do not have any effect on the business cycles synchronization between core and foreign countries.

Our results are in line with Jeanne and Korinek (2013) as we find that coordinated macroprudential policy is the best solution. Since authorities have to find the best balance between national and federal levels in implementing the macroprudential framework, it is not surprising that the greater welfare gains are recorded for the coordination scheme that combines the federal decision step (to account for externalities) with national implementation schemes (to account for the national nature of financial cycles). Macroprudential and monetary policy should remain separated: a credit growth adjusted Taylor rule does not increase welfare according to our calculations.

However, beside figures, the last question to be discussed is to determine the best enforceable solution. According to the evidence found above, things militate in favor of a national implementation of macroprudential measures at the national level (i.e., that is closer to financial developments). The host country principle based on the management of loan demand seems to be the most enforceable solution. This leads to the highest increase in union wide welfare, given the fact that, there is no national loss, no impact on the standard deviation of inflation (which is important, given the status of the ECB that focuses on price stability), and that it is relatively light (as it only implies an exchange of informations between countries regarding the operation of national banks abroad). Turning to figures, between the three situations, the host principle increase permanent consumption by 43%, while the increase in consumption between the two latter case is only 6%, in the meanwhile, the standard deviation increases by 11%.

5 The impact of Macroprudential Policies: a counterfactual analysis

Broadly defined, the final objective of macroprudential policy is to prevent or mitigate systemic risks that arise from developments within the financial system, taking into
Table 3: Standard deviation of model generated investment under different implementation schemes

<table>
<thead>
<tr>
<th>std($\hat{I}_{h,t}$)</th>
<th>No M.P.</th>
<th>Coordinated</th>
<th>Supply Adjusted</th>
<th>Demand Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.65</td>
<td>0.82</td>
<td>0.71</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>std($\hat{I}_{f,t}$)</td>
<td>1.12</td>
<td>0.75</td>
<td>0.91</td>
<td>0.64</td>
</tr>
</tbody>
</table>

account macroeconomic developments, so as to avoid periods of widespread distress. As this structural model is amendable to counterfactual analysis, this section discusses how the implementation of macroprudential measures would have performed either task in the Eurozone. In the first counterfactual exercise, we evaluated how the use of macroprudential instruments would have prevented financial problems and affected the volatility of investment. In the second counterfactual simulation, we analyse whether such measures would have mitigated the financial turmoil.

5.1 The preventive impact of a macroprudential policy

We analyze how macroprudential measures could prevent boom-bust dynamics on credit markets. Using the estimated sequence of shocks from 1999 to 2013, we simulate how investment would have evolved in both part of the monetary union, depending on the implementation of macroprudential measures. Fig. 6 and Table 3 display the model generated investment under the standard optimal monetary policy and compare it with the different levels of implementation of optimal macroprudential rules as discussed above. We focus on investment because in our model credit shocks are the main drivers of investment. Indeed the standard deviation of model generated investment over the period is lower under demand adjusted macroprudential policy (0.64) and coordinated solution (0.75) than without macroprudential policy (1.12). Turning to the core countries, introducing macroprudential instruments enhance investment before the financial crisis, more particularly the coordinated solution tends to have the best performance before the turmoil and the worst after.

5.2 The curative impact of a macroprudential policy

We perform another counterfactual exercise by simulating the system response to the estimated shock of the financial crisis (2009Q1). We report in Fig. 7 the IRFs of an aggregated shock as measured by the sum of all shocks that affected each part of the
Eurozone in the first quarter of 2009 (taken as the date of the diffusion of the financial crisis in the Eurozone). We then describe the core (periphery) response to this shock, depending on the macroprudential policy chosen by the national authorities. We contrast three situations, depending on whether the optimal Taylor rule is implemented without macroprudential measures, or whether it is amended with national macroprudential measures designed over the demand for loans or with coordinated macroprudential measures.

The model catches up the 2009Q1 crisis by a strong reduction in productivity (around -3%), a rise of investment adjustment cost (roughly 6%), a negative spending shock (4%), a collateral crunch shock of 4% in the peripheral countries and an external premium shock of 1% in the two countries.

As shown, Fig. 7 the impact of macroprudential measures differs across the two components of the monetary union. One of the key feature of the model that measures the financial distress in the economy is the share of profitable investment projects $\eta_{i,t}$. In Fig. 7, we plot the share of profitable investment projects under the two scenarios. Macroprudential policy is able to encourage the recovery of the economy by increasing the profitability of investment projects.

However, we find that macroprudential measures have a clear different impact on both side on the European union, on activity and investment. This kind of measure has no impact on core countries’ activity while it has a limited impact on activity in the periphery, as it only dampens the negative transmission of the shock after 10 quarters. Concerning investment, the result is more ambiguous. The peripheral investment slow down is reduced by the macroprudential policy and the recovery is clearly increased after 2 periods. These countries clearly benefit from coordinated measures, which accelerate investment recovery.

However, we get much more ambiguous results for core countries as, in this part of the monetary union, investment drop is surprisingly accelerated by macroprudential policies. This phenomenon can be explained by the fact that the optimized value of the coefficient on inflation $\delta^*$ in the interest rate rule is lower (2.42) with macroprudential policy than without (2.85). In this case, although the recovery of investment in the core countries would require a higher reduction of interest rates, monetary authorities would react less to deflation under macroprudential measure, which leads to an additional drop in investment in the core countries.

6 Conclusion

The aim of this paper was to evaluate the effect of cross-border loans on the optimal implementation of macroprudential policies in a monetary union. We build and estimate a two country DSGE model that accounts for the key role of banks in the EMU in providing the main financial resources to national and foreign firms. This last feature introduces some new dimensions regarding the optimal policy mix needed between the national and federal levels in the implementation of Macroprudential measures.

We find that introducing macroprudential policy clearly increases welfare in the Eurozone depending on the choice of the coordination scheme. The greater welfare gains are recorded for the coordination scheme that combines the federal decision step

\textsuperscript{21} We don’t plot other macroprudential policies because the coordinated solution is the best in terms of welfare.
with national implementation schemes. Second, we find that cross border loans are not a critical feature to assess systemic risk at the national. Putting aside the subsidiarity (optimal) solution, the host country principle for setting rules clearly dominates both the home country principle and the federal coordination policy solutions. Turning to the use of capital requirements as an additional tool to dampen systemic risk, we again find that national setting procedures give better results than a common federal rule that only targets the average value of aggregates in the Eurozone. Finally, giving macroprudential power to the central bank has no effect on the standard deviation of the inflation rate or on the standard deviation of activity.

These results cast some doubts on the planned evolution of the Single Supervising Mechanism (SSM) undertaken by the ESRB that aims at introducing more symmetry in macroprudential practices between countries, and at putting some tools directly in the hands of the federal macroprudential agency. These solutions have been found suboptimal with regards to the current situation that combines a federal evaluation of the problems and a national implementation of the policy.
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A The rest of the model

Due to the asymmetry between countries, for each variable denoted $X_{i,t}$, we aggregate households, firms, entrepreneurs and banks using the following aggregator of quantities $X^q_{i,t}$ and prices $X^p_{i,t}$ for agent $x \in [0, 1]$,

$$\mathcal{G} \left( X^q_{i,t} \right) = \begin{cases} \int_0^h X^q_{i,t} (x) \, dx & \text{for } i = h \\ \int_0^f X^q_{i,t} (x) \, dx & \text{for } i = f \end{cases} \quad \text{and} \quad \mathcal{G} \left( X^p_{i,t} \right) = \begin{cases} \frac{1}{n} \int_0^h X^p_{i,t} (x) \, dx & \text{for } i = h \\ \frac{1}{1-n} \int_1^f X^p_{i,t} (x) \, dx & \text{for } i = f \end{cases} \quad (A.1)$$

A.1 Households

In each economy there is a continuum of identical households who consume, save and work in intermediate firms. The total number of households is normalized to 1. The representative household $j \in [0, 1]$ maximizes the welfare index,

$$\max_{\{c_{i,t}(j), h_{i,t}(j), d^d_{i,t+1}(j)\}} \mathbb{E}_t \sum_{\tau=0}^{\infty} \beta^\tau e^{\beta_{i,t+\tau}} \left[ \frac{(C_{i,t+\tau}(j) - h_t^c C_{i,t-1+\tau})^{1-\sigma_t}}{1 - \sigma_t} - \frac{H_{i,t+\tau}(j)}{1 + \sigma_t} \right],$$

subject to,

$$\frac{W_{i,t}^{d_h}}{p_{i,t}^c} H_{i,t}(j) + (1 + R_{i,t-1}^D) \frac{D^d_{i,t}(j)}{p_{i,t}^c} + \frac{\Pi_{i,t}^y(j)}{p_{i,t}^c} + \frac{\bar{M}_i(j)}{p_{i,t}^c} = C_{i,t}(j) + \frac{D^d_{i,t+1}(j)}{p_{i,t}^c} + \frac{T_{i,t}(j)}{p_{i,t}^c} + \frac{P_{i,t}^d}{p_{i,t}^c} \cdot AC_{i,t}^D(j)$$

Here, $C_{i,t}(j)$ is the consumption index, $h_t^c \in [0; 1]$ is a parameter that accounts for external consumption habits, $H_{i,t}(j)$ is labor effort, $\epsilon_{i,t}^\beta$ is an exogenous AR(1) shock to household preferences. The income of the representative household is made of labor income (with nominal wage, $W_{i,t}$), interest payments for deposits, (where $D^d_{i,t}(j)$ stands for the deposit subscribed in period $t-1$ and $1 + R_{i,t-1}^D$ is the gross nominal rate of interest between period $t-1$ an period $t$), and earnings $\Pi_{i,t}^y(j)$ from shareholdings. The representative household spends this income on consumption, deposits and tax payments (for a nominal amount of $T_{i,t}(j)$). Finally, he has to pay quadratic adjustment costs to buy new deposit services (Schmitt-Grohé and Uribe, 2003), according to the function,

$$AC_{i,t}^D(j) = \frac{X^D_{p_{i,t}^d(j)}}{2D^d_{i,t}(j)} \left( D^d_{i,t+1}(j) - D^d_{i,t}(j) \right)^2,$$

where $D^d_{i,t}(j)$ is the steady state level of deposits. In order to make the households/banks deposit problem tractable in the steady state\(^{22}\), we assume that households hold a constant quantity of real money balances\(^{\text{H}}\).

The first order conditions that solve this problem can be summarized with an Euler condition,

$$\frac{\beta R_{i,t}^D}{1 + P_{i,t}^c AC_{i,t}^D(j)} = \mathbb{E}_t \left\{ \frac{\epsilon_{i,t}^\beta}{\epsilon_{i,t+1}^\beta} \frac{P_{i,t}^c}{p_{i,t}^c} \left( \frac{C_{i,t+1}(j) - h_t^c C_{i,t-1}(j)}{C_{i,t}(j) - h_t^c C_{i,t-1}(j)} \right)^{\sigma_t} \right\} \quad (A.3)$$

\(^{22}\)The lending supply is asymmetric between the two areas which implies asymmetric refinancing operations and deposits. In order to have symmetric households in steady state between core and periphery, we suppose that households hold a constant quantity of real money balances.
and a labor supply function,

\[ \frac{W_{i,t}}{P^e_{i,t}} = \chi_i H_{i,t} (j)^{1/\tau} (C_{i,t} (j) - h_i^e C_{i,t-1})^{\sigma_i}. \] (A.4)

The consumption basket of the representative household and the consumption price index of country \( i \) are,

\[ C_{i,t} (j) = (1 - \alpha_i C_i^e)^{1/\nu} C_{h,t} (j)(\mu - 1)/\nu + (\alpha_i C_i^e)^{1/\nu} C_{f,t} (j)(\nu - 1)/\mu \] and

\[ P^e_{i,t} = (1 - \alpha_i C_i^e) P^d_{h,t} + \alpha_i C_i^e P^d_{f,t} \] where \( \mu \) is the elasticity of substitution between the consumption of home \((C_{h,t} (j))\) and foreign \((C_{f,t} (j))\) goods and \( \alpha_i C_i^e \) is the degree of openness of the economy \( i \). In this model, we assume home bias in consumption, so that \( \alpha_i C_i^e < \frac{1}{2} \).

### A.2 Firms

This sector is populated by two groups of agents: intermediate firms and final firms. Intermediate firms produce differentiated goods \( i \), chooses labor and capital inputs, and set prices according to the Calvo model. Final goods producers act as a consumption bundler by combining national intermediate goods to produce the homogenous final good\(^{23}\).

Concerning the representative intermediate firm \( i \in [0, 1] \), it has the following technology,

\[ Y_{i,t} (i) = e^{\epsilon_i K_{i,t} (i)} H_{i,t}^d (i) \] where \( Y_{i,t} (i) \) is the production function of the intermediate good that combines capital \( K_{i,t} (i) \), labor \( H_{i,t}^d (i) \) and technology \( e^{\epsilon_i} \) (an AR(1) productivity shock). Intermediate goods producers solve a two-stages problem. In the first stage, taken the input prices \( W_{i,t} \) and \( Z_{i,t} \) as given, firms rent inputs \( H_{i,t}^d (i) \) and \( K_{i,t} (i) \) in a perfectly competitive factor markets in order to minimize costs subject to the production constraint. The first order condition leads to the marginal cost expression,

\[ MC_{i,t} (i) = \frac{1}{e^{\epsilon_i K_{i,t}}} \left( \frac{Z_{i,t}}{\alpha} \right) \left( \frac{W_{i,t}}{(1 - \alpha)} \right)^{(1 - \alpha)}. \] (A.5)

From the cost minimization problem, inputs also satisfy,

\[ \alpha H_{i,t}^d (i) W_{i,t} = Z_{i,t} K_{i,t} (i) (1 - \alpha). \]

In the second-stage, firm \( i \) sets the price according to a Calvo mechanism. Each period firm \( i \) is not allowed to reoptimize its price with probability \( \theta_i^p \) but price increases of \( \xi_i^p \in [0; 1] \) at last period’s rate of price inflation, \( P_{i,t} (i) = \pi_{i,t-1}^e P_{i,t-1} (i) \). The firm allowed to modify its selling price with a probability \( 1 - \theta_i^p \) chooses \( \{P_{i,t} (i)\} \) to maximize its expected sum of profits,

\[ \max_{\{P_{i,t} (i)\}} \mathbb{E}_t \left\{ \sum_{\tau=0}^{\infty} (\theta_i^p \beta)^\tau \frac{\lambda_{i,t+\tau}^e}{\lambda_{i,t}^e} \left[ P_{i,t}^e (i) \prod_{k=1}^\tau \pi_{i,t+k-1}^e MC_{i,t+k} - Y_{i,t+\tau}^d (i) \right] \right\}, \]

under the demand constraint,

\[ Y_{i,t+\tau}^d (i) = \left( \prod_{k=1}^\tau \pi_{i,t+k-1}^e P_{i,t+k}^e (i) / P_{i,t+\tau}^d \right)^{-\theta_i^p} Y_{i,t+\tau}^d, \forall \tau > 0, \]

where \( Y_{i,t}^d \) represents the quantity of the goods produced in country \( i \), \( \lambda_{i,t}^e \) is the

---

\(^{23}\)Final good producers are perfectly competitive and maximize profits, \( P_{i,t} Y_{i,t}^d - \int_0^1 P_{i,t} (i) Y_{i,t} (i) di \), subject to the production function \( Y_{i,t}^d = \left( \int_0^1 Y_{i,t} (i) (\epsilon_p - 1)/\epsilon_p di \right)^{\epsilon_p/(\epsilon_p - 1)} \). We find the intermediate demand functions associated with this problem are,

\[ Y_{i,t} (i) = (P_{i,t} (i)/P_{i,t}^d)^{-\epsilon_p} Y_{i,t}^d, \forall i. \] where \( Y_{i,t}^d \) is the aggregate demand.
household marginal utility of consumption. The first order condition that defines the price of the representative firm $i$ is,

$$
P_{i,t}^*(i) = \frac{\epsilon_p}{(\epsilon_p - 1)} \mathbb{E}_t \left\{ \sum_{\tau=0}^{\infty} \left( \frac{\beta_i^\tau}{\lambda_i^\tau} \right)^\tau MC_{i,t+k} Y_{i,t+\tau} (i) \right\}.
$$

(A.6)

### A.3 Monetary Policy

The central bank of the monetary union follows an interest rate rule defined by,

$$
\left( \frac{1 + R_t}{1 + \bar{R}} \right) = \left( \frac{1 + R_{t-1}}{1 + \bar{R}} \right)^\rho \left( \frac{\pi_{u,t}^c}{\pi_{u,t-1}^c} \right)^{\phi^u} \left( \frac{\mathcal{M}\mathcal{P}_{t}^F}{\phi} \right)^{(1-\rho)} \varepsilon_t^R
$$

(A.7)

where $R_t$ is the interest rate set by the central bank, $\rho$ is the interest rate smoothing coefficient, $\varepsilon_t^R$ is an exogenous monetary policy shock common to the monetary union members, $\phi^u$ is the level of reaction to inflation, $\phi^y$ is the GDP growth target and $\mathcal{M}\mathcal{P}_{t}^F$ is a taylored macroprudential instrument that can be used by the central bank to react to financial disequilibrium developments if $\phi \neq 0$. In the case where $\phi^{FED} = 0$, we get the standard Taylor rule. In this expression, union-wide inflation and GDP growth are defined by a geometric average that account for the relative size of each country, $\pi_{u,t}^c = (\pi_{h,t}^c)^n (\pi_{f,t}^c)^{1-n}$ and $Y_{u,t} = (Y_{h,t})^n (Y_{f,t})^{1-n}$.

### A.4 Capital Suppliers

Capital suppliers are homogeneous and distributed over a continuum normalized to one. The representative capital supplier $k \in [0;1]$ acts competitively to supply a quantity $K_{i,t+1} (k)$ of capital. Investment is costly, i.e. the capital supplier pays an adjustment cost $AC_{i,t}^I (k)$ on investment, such that $AC_{i,t}^I (k) = \frac{\lambda_i^c}{2} \left( \varepsilon_{i,t}^I I_{i,t} (k) / I_{i,t-1} (k) - 1 \right)^2$ where $\varepsilon_{i,t}^I$ is an exogenous adjustment cost shock on investment. The capital stock of the representative capital supplier thus evolves according to, $K_{i,t+1} (k) = \left( 1 - AC_{i,t}^I (k) \right) I_{i,t} (k) + (1 - \delta) K_{i,t} (k)$. The capital supplier produces the new capital stock $Q_{i,t} K_{i,t+1} (k)$ by buying the depreciated capital $Q_{i,t} (1 - \delta) K_{i,t} (k)$ and investment goods $P_{i,t} I_{i,t} (k)$, where

$$
I_{i,t} (k) = \left( (1 - \alpha_i^I)^{1/\mu} \beta_i^I k^u (k)^{(\mu-1)/\mu} + \alpha_i^I \right)^{\mu/(\mu-1)}
$$

and $P_{i,t} = \left( (1 - \alpha_i^I) (P_{h,t})^{1-\mu} + \alpha_i^I \right)^{\mu}$. In this expression, parameter $\mu$ is the elasticity of substitution between domestic and foreign goods in investment and $\alpha_i^I < 0.5$ measures the degree of investment diversification in the monetary union between home and foreign countries. The representative capital supplier chooses $I_{i,t} (k)$ to maximize profits,

$$
\max_{\{I_{i,t}(k)\}} \mathbb{E}_t \left\{ \sum_{\tau=0}^{\infty} \beta \frac{\lambda_i^c}{\lambda_i^e} \left[ Q_{i,t} \left( 1 - AC_{i,t}^I (k) \right) - P_{i,t}^I \right] I_{i,t} (k) \right\},
$$

where $\beta \frac{\lambda_i^c}{\lambda_i^e}$ is the household stochastic discount factor. The price of capital renting thus solves,

$$
Q_{i,t} = P_{i,t}^I + Q_{i,t} \frac{\partial \left( I_{i,t} (k) AC_{i,t}^I (k) \right)}{\partial I_{i,t} (k)} + \beta \mathbb{E}_t \frac{\lambda_i^c}{\lambda_i^e} Q_{i,t+1} \frac{\partial \left( I_{i,t+1} (k) AC_{i,t+1}^I (k) \right)}{\partial I_{i,t} (k)}.
$$
Thus, the real return from holding one unit of capital from $t$ to $t+1$ is determined by,

$$\mathbb{E}_t \frac{(1 + R_{i,t+1}^b)}{\pi_{i,t+1}^G} = \mathbb{E}_t \left[ \frac{Z_{i,t+1}/P_{i,t+1}^G + (1 - \delta) Q_{i,t+1}/P_{i,t+1}^G}{Q_{i,t}/P_{i,t}^G} \right] \quad (A.8)$$

### A.5 Governments

National governments finance public spending by charging a proportional taxes on the bank capital $\tau^{bk}$, net wealth of entrepreneurs $\tau^E$ and by receiving a total value of taxes $\mathcal{G}(T_{i,t}(j))$ from households. The budget constraint of the national government writes,

$$\mathcal{G}(T_{i,t}(j)) + \tau^E \mathcal{G}(P_{i,t} N_{i,t} (e)) + \tau^{bk} \mathcal{G}(P_{i,t}BK_{i,t}(b)) = P_{i,t} G_{i,t} = P_{i,t} G_{i,t} \varepsilon_{i,t}^G$$

$G_{i,t}$ is the total amount of public spending in the $i^{th}$ economy that follows and AR(1) shock process. The government demand for home goods writes, $G_{i,t}(i) = (P_{i,t}(i)/P_{i,t})^{-\tau^G} G_{i,t}$.

### A.6 Aggregation and Market Equilibrium

In this model, there are 8 country specific structural shocks for $i \in \{h, f\}$ such that, $\varepsilon_{i,t} = \varepsilon_{i,t-1}^f + \eta_{i,t}, \forall s = \{\beta, A, G, I, Q, N, D\}$ and one common shock in the Taylor rule where $\rho_1^\beta$, $\rho_1^A$, $\rho_1^G$, $\rho_1^I$, $\rho_1^Q$, $\rho_1^N$, $\rho_1^D$ and $\rho^R$ are autoregressive roots of the exogenous variables, $\eta_{i,t}, \eta_{i,t}^A, \eta_{i,t}^G, \eta_{i,t}^I, \eta_{i,t}^Q, \eta_{i,t}^N, \eta_{i,t}^D$ and $\eta_{i,t}^R$ are standard errors that are mutually independent, serially uncorrelated and normally distributed with zero mean and variances $\sigma_{i,t}^2, \sigma_{i,t}^2_A, \sigma_{i,t}^2_G, \sigma_{i,t}^2_I, \sigma_{i,t}^2_Q, \sigma_{i,t}^2_N, \sigma_{i,t}^2_D$ and $\sigma_{i,t}^2_R$ respectively. A general equilibrium is defined as a sequence of quantities $\{Q_i\}_{t=0}^\infty$ and prices $\{P_i\}_{t=0}^\infty$ such that for a given sequence of quantities $\{Q_i\}_{t=0}^\infty$ and the realization of shocks $\{S_i\}_{t=0}^\infty$, the sequence $\{P_i\}_{t=0}^\infty$, guarantees the equilibrium on the capital, labor, loan, intermediate goods and final goods markets.

After (i) aggregating all agents and varieties in the economy, (ii) imposing market clearing for all markets, (iii) assuming that countries are mirror images of one another in terms of market openness, (iv) substituting the relevant demand functions, we deduce the general equilibrium conditions of goods, loans and deposit services markets.

#### Goods Market

The aggregate price index of the national goods evolves according to,

$$P_{i,t}^{1-\tau^G} = \theta_p^G \left( P_{i,t-1}^{1-\tau^G} \left( \frac{P_{i,t-2}}{P_{i,t-2}} \right)^{\tau^G_{i,t-2}} \right)^{\tau^G_{i,t-1}} + (1 - \theta_p^G) \left( P_{i,t}^{1-\tau^G} \right)$$

(A.9)

The equilibrium condition on the final goods market writes is defined by the aggregation of the demand function from final goods producers, $\mathcal{G}(Y_{i,t}(i)) = Y^d_{i,t} \mathcal{G}(P_{i,t}(i)/P_{i,t})^{-\tau^G}$ where $\mathcal{G}(Y_{i,t}(i)) = e^{\varepsilon_{i,t}^A} \mathcal{G}(K_{i,t}(i) + H_{i,t}(i)^{1-\alpha})$ is the aggregation of intermediate goods suppliers and $Y^d_{i,t}$ is the resources constraint. Thus, replacing the demand functions of foreign and home goods (consumption and investment), we finally obtain the home final
goods market equilibrium in the home country,

\[
\frac{Y_{h,t}}{\Delta p_{h,t}} = (1 - \alpha_h^C) \left( \frac{P_{h,t}}{P_{e,t}} \right)^{-\mu} C_{h,t} + (1 - \alpha_f^I) \left( \frac{P_{h,t}}{P_{f,t}} \right)^{-\mu} \left( 1 + AC_{h,t}^D \right) I_{h,t} \tag{A.10}
\]

\[+ \frac{n - 1}{n} \left( \alpha_f^C \left( \frac{P_{h,t}}{P_{e,t}} \right)^{-\mu} C_{f,t} + \alpha_f^I \left( \frac{P_{h,t}}{P_{f,t}} \right)^{-\mu} \left( 1 + AC_{f,t}^D \right) I_{f,t} \right) + G_{h,t} + AC_{h,t}^D.
\]

where \(\Delta p_{h,t} = G \left( \frac{P_{t,i}}{P_{t,i}} \right)^{-\epsilon_p}\) denotes the price dispersion term, which is induced by the assumed nature of price stickiness, is inefficient and entails output loss. To close the model, adjustment costs on deposits are entirely home biased \(AC_{t,t}^{D} = G(AC_{t,t}^{D} (i) \left( \frac{\epsilon_p-1}{\epsilon_p} \right) \frac{\epsilon_f}{\epsilon_p-1})\), the associated demand function writes, \(AC_{t,t}^{D} (i) = (P_{t,i} (i) / P_{t,i})^{-\epsilon_p} AC_{t,t}^{D}\).

### Loan Market

Concerning the equilibrium on loan market, it is defined by the aggregate demand function from retail banks, \(G \left( L_{t,t+1}^L (b) \right) = \Delta L_{t,t} L_{t,t+1}^d\), where \(\Delta L_{t,t} = G \left( \frac{R_{t,i}^L (b)}{R_{t,i}^L} \right)^{-\epsilon_L}\) is the credit rate dispersion term and \(L_{t,t+1}^d\) is the aggregate demand from home and foreign entrepreneurs, and is defined by, \(L_{t,t+1}^d = G \left( L_{h,t+1}^i \right) + G \left( L_{f,t+1}^i \right)\). Recalling that entrepreneurs \(e\) borrow to domestic and foreign banks with varieties \(b\) produced by wholesale branches, the equilibrium finally writes in the home country,

\[L_{h,t+1}^i = \left(1 - \alpha_h^L \right) \left[ \frac{R_{h,t}^L}{P_{h,t}} \right]^{-\nu} L_{h,t+1} + \frac{n - 1}{n} \alpha_f^L \left[ \frac{R_{f,t}^L}{P_{f,t}} \right]^{-\nu} L_{f,t+1} \Delta h_{t,t} \tag{A.11}\]

Aggregate loan rate index evolves according to,

\[\left( R_{t,i}^L \right)^{1-\epsilon_L} = \theta_i^L \left( R_{t,i-1}^L \right)^{1-\epsilon_L} + (1 - \theta_i^L) \left( R_{t,i}^L \right)^{1-\epsilon_L} \tag{A.12}\]

### Deposit Market

Eventually the equilibrium on deposit market is defined by the aggregate demand for deposits services of households and the aggregate supply from deposit packers. Aggregating the demand function from deposit packers leads to the equilibrium on this market, \(G \left( D_{t,t+1}^d (j) \right) = \Delta D_{t,t} G \left( D_{t,t+1} (j) \right)\), where \(\Delta D_{t,t} = G \left( R_{t,i}^D (b) / R_{t,i}^D \right)^{-\mu_i (D_{t,t+1})} \) is the interest rate dispersion term, while the aggregate deposit rate index evolves according to,

\[\left( R_{t,i}^D \right)^{1-\epsilon_D} = \theta_i^D \left( R_{t,i-1}^D \right)^{1-\epsilon_D} + (1 - \theta_i^D) \left( R_{t,i}^D \right)^{1-\epsilon_D} \tag{A.13}\]

### B Pareto distribution of financial contracts

We assume that each entrepreneur \(e \in [0, 1]\) conducts a mass \(\omega \in [\omega_{\min}, +\infty[\) of heterogeneous investment projects, they are risky so that some of the projects will have negative profits. To model individual riskiness, we assume that the aggregate return of investment projects \(1 + R_{t,i}^k\), is multiplied by a random value \(\omega\) (drawn from a Pareto distribution), so that the net return of its individual project is, \(\omega (1 + R_{t,i}^k)\). Since he
must repay to the bank $L_{t+1}^H(e)$ given a borrowing rate $P_{t,t}^L(e)$, the net profit of the $\omega^{th}$ project is $\omega \left(1 + R_{t,t}^k \right) Q_{t,t-1} K_{t,t}(e, \omega) - \left(1 + P_{t,t-1}^L(e) \right) L_{t,t}^H(e, \omega)$. To separate profitable investment project from non-profitable ones, there exists a critical value (a cutoff point) defined as $\omega_{i,t}^C(e)$ such that the project just breaks even. Thereby the threshold is computed by,

$$
\omega_{i,t}^C(e) \left(1 + R_{t,t}^k \right) Q_{t,t-1} K_{t,t}(e, \omega_{i,t}^C) = \left(1 + P_{t,t-1}^L(e) \right) L_{t,t}^H(e, \omega_{i,t}^C) \quad \text{(B.1)}
$$

Recall that $\omega \sim \mathcal{P}(\kappa, \omega_{\min})$ where $\omega \in [\omega_{\min}; +\infty]$, $\kappa$ is the shape parameter and $\omega_{\min}$ is the minimum bound of $\omega$. The conditional expectation of $\omega$ when entrepreneur’s project is gainful is, $\eta^c \bar{\omega} = \int_{\omega^C} \omega f(\omega) d\omega$, while the conditional expectation of $\omega$ when entrepreneur’s project is insolvent is, $(1 - \eta^c) \bar{\omega} = \int_{\omega_{\min}}^{\omega^C} \omega f(\omega) d\omega$. The share of profitable projects is computed as, $\eta^c = \Pr[\omega \geq \omega^C] = \int_{\omega^C} f(\omega) d\omega = (\omega_{\min}/\omega^C)^k$. The conditional expectation is computed via, $\bar{\omega} = E[\omega | \omega \geq \omega^C] = \int_{\omega^C} \omega f(\omega) d\omega / \int_{\omega^C} f(\omega) d\omega = \frac{\kappa}{\kappa - 1} \omega^C$. Since $E[\omega] = \eta^c E[\omega | \omega \geq \omega^C] + (1 - \eta^c) E[\omega | \omega < \omega^C] = 1$, then $\bar{\omega} = (1 - \eta^c \bar{\omega}) / (1 - \eta^c)$.
### SHOCK PROCESS AR(1)

<table>
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<tr>
<th></th>
<th>Prior distributions</th>
<th>Posterior distribution [5%-95%]</th>
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<tr>
<td></td>
<td>Shape</td>
<td>Mean</td>
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<td>Productivity</td>
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<tr>
<td>Gov. Spending</td>
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<td>External Fin. Prem. root</td>
<td>$\rho^\chi_i$ $\mathcal{B}$ 0.7 0.10 0.78 [0.67:0.89] 0.81 [0.72:0.89]</td>
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<tr>
<td>Bank Deposit root</td>
<td>$\rho^\delta_i$ $\mathcal{B}$ 0.7 0.10 0.68 [0.59:0.76] 0.68 [0.58:0.78]</td>
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<tr>
<td>Monetary Policy root</td>
<td>$\rho^R_i$ $\mathcal{B}$ 0.7 0.10 0.38 [0.28:0.47]</td>
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<tr>
<td>Correlation Productivity</td>
<td>corr$_{\gamma_i}^A$ $\mathcal{N}$ 0 0.4 0.42 [0.24:0.59]</td>
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<tr>
<td>Correlation Spending</td>
<td>corr$_{\gamma_i}^G$ $\mathcal{N}$ 0 0.4 0.03 [-0.18:0.25]</td>
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<tr>
<td>Correlation Preferences</td>
<td>corr$_{\gamma_i}^\beta$ $\mathcal{N}$ 0 0.4 -0.16 [-0.39:0.07]</td>
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<tr>
<td>Correlation Investment</td>
<td>corr$_{\gamma_i}^\delta$ $\mathcal{N}$ 0 0.4 0.06 [-0.15:0.26]</td>
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<tr>
<td>Correlation Collateral</td>
<td>corr$_{\gamma_i}^\zeta$ $\mathcal{N}$ 0 0.4 -0.17 [-0.73:0.37]</td>
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<tr>
<td>Correlation EFP</td>
<td>corr$_{\gamma_i}^\chi$ $\mathcal{N}$ 0 0.4 -0.01 [-0.29:0.26]</td>
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<tr>
<td>Correlation Deposits</td>
<td>corr$_{\gamma_i}^\delta$ $\mathcal{N}$ 0 0.4 0.94 [0.91:0.97]</td>
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### STRUCTURAL PARAMETERS

<table>
<thead>
<tr>
<th></th>
<th>Prior distributions</th>
<th>Posterior distribution [5%-95%]</th>
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<tbody>
<tr>
<td></td>
<td>Shape</td>
<td>Mean</td>
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<tr>
<td>Consumption aversion</td>
<td>$\sigma^\xi_i$ $\mathcal{G}$ 1.5 0.25 1.05 [0.76:1.33] 1.26 [0.93:1.60]</td>
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<tr>
<td>Labour Disutility</td>
<td>$\sigma^\gamma_i$ $\mathcal{G}$ 2 0.75 1.68 [0.70:2.59] 1.33 [0.53:2.12]</td>
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<tr>
<td>Consumption Inertia</td>
<td>$h^\beta_i$ $\mathcal{B}$ 0.7 0.10 0.33 [0.22:0.43] 0.48 [0.39:0.58]</td>
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<tr>
<td>Calvo Prices</td>
<td>$\theta^\xi_i$ $\mathcal{B}$ 0.5 0.10 0.72 [0.65:0.79] 0.66 [0.56:0.75]</td>
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<tr>
<td>Indexation Prices</td>
<td>$\xi^\beta_i$ $\mathcal{B}$ 0.5 0.15 0.20 [0.06:0.34] 0.31 [0.11:0.50]</td>
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<tr>
<td>Calvo Loan Rates</td>
<td>$\theta^\gamma_i$ $\mathcal{B}$ 0.5 0.10 0.48 [0.40:0.56] 0.58 [0.51:0.65]</td>
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<tr>
<td>Calvo Deposit Rates</td>
<td>$\theta^\delta_i$ $\mathcal{B}$ 0.5 0.10 0.74 [0.69:0.78] 0.70 [0.64:0.76]</td>
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<tr>
<td>Investment A.C. Cost</td>
<td>$\lambda^\alpha_i$ $\mathcal{N}$ 4 1.5 4.42 [2.72:6.17] 5.84 [3.99:7.80]</td>
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<tr>
<td>E.F.P. Elasticity</td>
<td>$\zeta^\lambda_i$ $\mathcal{N}$ 0.05 0.02 0.05 [0.02:0.09] 0.08 [0.04:0.13]</td>
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<tr>
<td>Loan Demand</td>
<td>$h^\beta_i$ $\mathcal{B}$ 0.7 0.10 0.75 [0.63:0.87] 0.86 [0.79:0.92]</td>
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<tr>
<td>Deposit A.C. cost</td>
<td>$100 \times \lambda^\alpha_i$ $\mathcal{N}$ 0.07 0.04 0.10 [0.04:0.16] 0.10 [0.04:0.15]</td>
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<tr>
<td>Final Market Openness</td>
<td>$\alpha^\alpha_i$ $\mathcal{B}$ 0.12 0.05 0.15 [0.10:0.20] 0.12 [0.06:0.19]</td>
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<tr>
<td>Inv. Market Openness</td>
<td>$\alpha^\gamma_i$ $\mathcal{B}$ 0.12 0.05 0.11 [0.04:0.17] 0.14 [0.06:0.22]</td>
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<tr>
<td>Credit Market Openness</td>
<td>$\alpha^\delta_i$ $\mathcal{B}$ 0.5 0.15 0.07 [0.02:0.12] 0.46 [0.37:0.53]</td>
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<tr>
<td>Substitutability Goods</td>
<td>$\mu_i$ $\mathcal{G}$ 1.5 0.5 3.18 [2.23:4.08]</td>
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<tr>
<td>Substitutability Loans</td>
<td>$\nu_i$ $\mathcal{G}$ 1.5 0.5 0.72 [0.43:1.01]</td>
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<tr>
<td>MPR Smoothing</td>
<td>$\rho_i$ $\mathcal{B}$ 0.7 0.10 0.84 [0.82:0.87]</td>
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<td>MPR Inflation</td>
<td>$\phi^\beta_i$ $\mathcal{N}$ 1.5 0.25 1.96 [1.71:2.22]</td>
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<td>MPR GDP</td>
<td>$\phi^\gamma_i$ $\mathcal{N}$ 0.125 0.05 0.16 [0.09:0.24]</td>
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Marginal log-likelihood -586.70

Table 4: Prior and Posterior distributions of structural parameters and shock processes. Note: $\mathcal{G}$ denotes the Inverse Gamma distribution, $\mathcal{B}$ the Beta, $\mathcal{N}$ the Normal, $\mathcal{G}$ the Gamma.
Figure 3: Dynamic correlations of the main variables: observable variables (blue) and 90% confidence band interval generated by the estimated model centered around the asymptotic mean.
Figure 4: Historical contributions to Investment (year-on-year % change generated by
the model).

Note: The solid blue line depicts the quarterly growth rate in real investment (per
capita) expressed in percentage point deviations from the model’s steady state. The
colored bars depict the estimated contributions of the various groups of shocks (Supply:
home productivity; Demand: home public spending, home preferences & investment
adjustment costs; Financial: home external finance premium, deposit cost push & net
worth; Foreign: previously mentioned foreign shocks; Monetary Policy: shock in the
ECB taylor rule).

Observable variable
Figure 5: Prior and posterior distributions of parameters.
Table 5: Empirical and Theoretical Standard deviations

<table>
<thead>
<tr>
<th></th>
<th>$\Delta Y_{h,t}$</th>
<th>$\Delta C_{h,t}$</th>
<th>$\Delta I_{h,t}$</th>
<th>$\Delta L_{h,t}^s$</th>
<th>$\pi_{h,t}^c$</th>
<th>$R_{h,t}^t$</th>
<th>$R_{h,t}^D$</th>
<th>$\Delta Y_{f,t}$</th>
<th>$\Delta C_{f,t}$</th>
<th>$\Delta I_{f,t}$</th>
<th>$\Delta L_{f,t}^s$</th>
<th>$\pi_{f,t}^c$</th>
<th>$R_{f,t}^t$</th>
<th>$R_{f,t}^D$</th>
<th>$R_t$</th>
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<tr>
<td>Empirical</td>
<td>0.78</td>
<td>0.6</td>
<td>1.66</td>
<td>1.25</td>
<td>0.3</td>
<td>1</td>
<td>0.36</td>
<td>0.94</td>
<td>0.91</td>
<td>2.08</td>
<td>2.25</td>
<td>0.36</td>
<td>0.76</td>
<td>0.34</td>
<td>1.26</td>
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<tr>
<td>Theoretical</td>
<td>0.76</td>
<td>0.73</td>
<td>1.77</td>
<td>1.47</td>
<td>0.45</td>
<td>1.35</td>
<td>0.97</td>
<td>0.91</td>
<td>0.94</td>
<td>2.21</td>
<td>2.14</td>
<td>0.47</td>
<td>1.83</td>
<td>0.99</td>
<td>1.56</td>
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Table 6: Welfare-based Performance of Macroprudential Rules
Figure 6: Counterfactual paths of investment (millions euro) under different optimal implementation schemes: no macroprudential policy (green crossed), coordinated macroprudential policy (red circled), Non coordinated macroprudential policy - Host principle (blue dashed) and Non coordinated macroprudential policy - Home principle (black dotted), and the CEPR Recession Indicator for Euro Area Business Cycles (shaded area).

Figure 7: The financial crisis episode: system response after simulating the financial crisis (2009Q1 shocks) under the optimal policy regime and the optimal coordinated macroprudential policy.