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Macroprudential policy and imbalances in the euro area

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Since its creation the euro area suffered from imbalances between its core and peripheral members. This paper checks whether macroprudential policy applied to the peripheral countries could contribute to providing more macroeconomic stability in this region. To this end we build a two-economy macrofinancial model and simulate the effects of macroprudential policy (regulating the loan-to-value ratio) when the core and the periphery are exposed to asymmetric shocks. We find that macroprudential policy is able to substantially lower the amplitude of credit and output fluctuations in the periphery. However, for the policy to be effective, it should be decentralized. Very similar conclusions hold when welfare is considered as the optimality criterion.

1. Introduction

Since the euro area was created, large imbalances have built up in some of its member countries. These imbalances concerned in particular the housing market. As can be seen from Fig. 1, residential investment in Greece, Ireland, Portugal and Spain, a group of euro area members that we will refer to as the periphery, nearly doubled from 1999 to 2006, while it stagnated in the rest (core) of the currency union. A qualitatively similar picture can be observed for mortgage loans and real house prices: while their growth was moderate in the core, they were booming in the periphery. These developments

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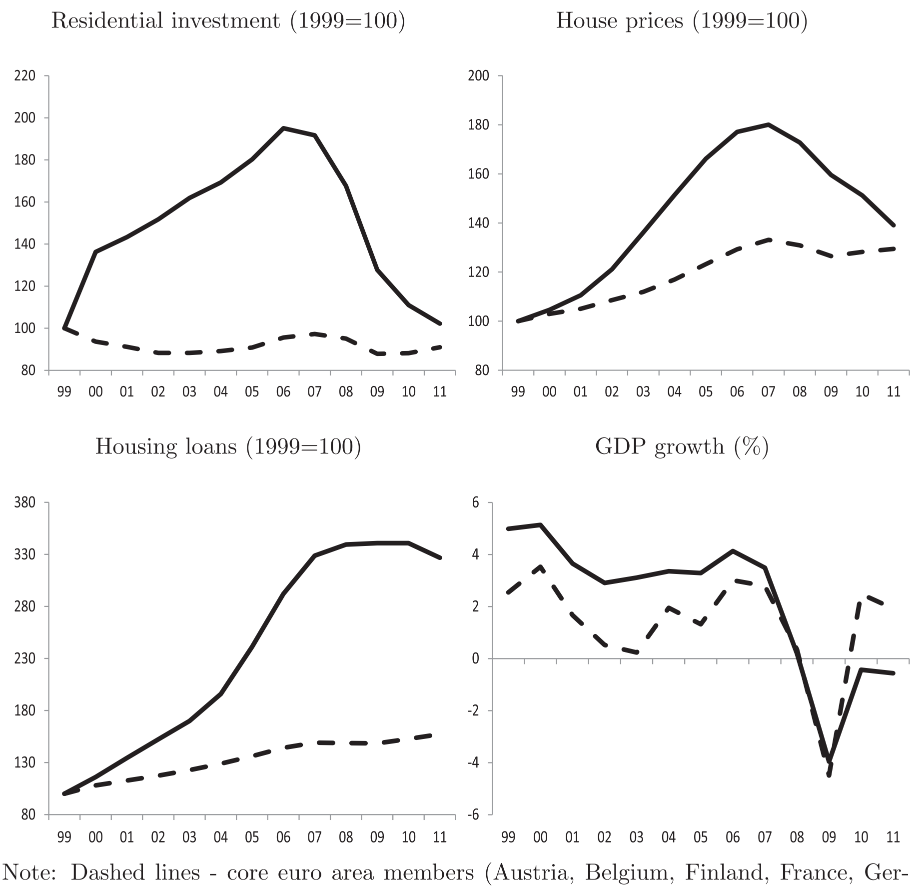
contributed to substantial GDP growth differentials within the euro area, i.e. countries experiencing housing booms were growing at a relatively high pace. These trends reversed when the housing market bubble burst, leading to a sharp slowdown in the peripheral economies. A subsequent deterioration of fiscal revenues sparked tensions in the financial markets that spread over the whole Europe, severely undermining the stability of the banking system and even threatening a break-up of the common currency area.

It has been established in the literature that the main source of these asymmetric developments was a sharp fall in the periphery's interest rates following their euro area accession, combined with an easy access to cross-border borrowing as well as asymmetric shocks to housing market prices (see e.g. ECB, 2003; Honohan and Leddin, 2006; Blanchard, 2007; Andrés et al., 2010).



Note: Dashed lines - core euro area members (Austria, Belgium, Finland, France, Germany, Italy, Luxembourg, Netherlands), solid lines - peripheral euro area members (Greece, Ireland, Portugal and Spain). For each country, GDP is real gross domestic product (source: Eurostat), residential investment is real gross fixed capital formation in dwellings (source: Eurostat), house prices are residential property prices of new and existing houses and flats (source: BIS), while housing loans are defined as outstanding amounts of lending for house purchase (source: ECB SDW). The last two series are deflated by HICP (source: Eurostat). The aggregates for both regions are calculated as sums (residential investment, loans and GDP) or GDP-weighted averages (house prices).

Fig. 1. Stylized facts on imbalances in the euro area.

Can such large imbalances be prevented or at least mitigated using standard macroeconomic policy instruments? Clearly, the common interest rate set by the ECB at the area-wide level hardly responds to asymmetric developments in the periphery and hence can provide no stabilization in face of country-specific shocks. Exchange rate devaluation, a solution used on several occasions in the pre-EMU period to re-align competitiveness within Europe, is also no longer an option once in the euro area. Finally, the fiscal policy is limited by well-known political economy constraints and implementation lags.

In this paper we check if appropriately designed macroprudential policy can provide more stability in the euro area periphery. To this end, we set up a two-country DSGE model with housing frictions in the spirit of Iacoviello (2005). In this model, borrowers face a binding collateral constraint, i.e. their debt cannot exceed a certain fraction of their housing stock. We assume that this fraction, called the loan-to-value (LTV) ratio, is fully controlled by the macroprudential authority.

There are two reasons for choosing the LTV as our preferred macroprudential policy instrument. First, as already mentioned, imbalances in the euro area were, to a substantial extent, driven by developments in the housing markets of the peripheral countries. From this perspective, the LTV ratio seems to be a natural candidate to prevent imbalances. Second, the recent EU bank capital regulations (CRD IV/CRR 2013), that also make some references to macroprudential tools, do not include LTV ratios in the EU-wide regulation and hence more discretion is allowed for their application for macroprudential purposes. In particular, this makes their application on a country basis more likely compared to alternative instruments (e.g. capital buffers).[1]

Our main findings can be summarized as follows. First, LTV policy is able to substantially lower the amplitude of credit and output fluctuations in the periphery. Second, the largest gains from this policy originate from housing market and (common) monetary policy shocks, i.e. the types of disturbances that have been found important drivers of the observed divergences within the euro area. Third, decentralized macroprudential policy is much more successful than a common one. Our main findings are supported when, instead of output volatility, we use welfare maximization as our optimality criterion. Decentralized macroprudential policy is able to raise welfare in the periphery by more than its centralized variant.

Our paper is related to a growing literature looking at the performance of various macroprudential policy rules. Lambertini et al. (2013) consider a news driven model of the housing market and find that a countercyclical LTV rule responding to credit growth can stabilize the economy better than the interest rate. Funke and Paetz (2012) examine LTV rules in a New Keynesian model for Hong Kong and argue that a non-linear rule, responding only to very high changes in property prices, performs better than a standard Taylor-like one. Based on experiments with three macroeconomic models, Angelini et al. (2011) report substantial stabilization gains from a countercyclical rule introduced by the Basel III reform package. Christensen et al. (2011) develop a DSGE model with banks and bank capital, finding desirable stabilization properties of countercyclical bank leverage regulation in response to financial shocks and a lower efficiency of such a rule after technology shocks. Darracq-Pariés et al. (2011) estimate a DSGE model with financial frictions affecting both households and firms using the euro area data, concluding that a countercyclical bank capital regulation can provide a strong support to macroeconomic stabilization, but also lead to excessive volatility in bank balance sheets. Angeloni and Faia (2013) find that the best combination of monetary and macroprudential policies includes mildly countercyclical capital ratios and response of monetary policy to assets prices or bank leverage. However, none of the papers reviewed above discuss macroprudential policy in the context of a heterogeneous monetary union. The paper that comes closest to ours is a recent contribution by Quint and Rabanal (2014), who build a DSGE model of the euro area and use it to analyze the interaction of monetary and macroprudential policies.

[1] In principle, one could be concerned that if the LTV rule in the periphery is applied independently from the core, agents might try to circumvent it. For instance, if borrowing conditions in one region become more stringent, its impatient households could try to borrow in the other region. This possibility is explicitly ruled out in our model. We motivate this assumption by the observation that mortgage lending is relatively hard to decouple from physical proximity of the bank and the borrower. This is confirmed by the very low share of cross-border loans to households in the euro area (less than 1% according to the 2014 ECB report “Financial Integration in Europe”), despite differences in local banking regulations.

The rest of the paper is structured as follows. Section two describes the model and section three its calibration. Section four discusses the transmission mechanisms of the macroprudential policy instrument. Our main quantitative results are presented in section five and some robustness checks are discussed in section six. Section seven concludes.

2. Model

We consider a two country DSGE model with collateral constraints modeled as in Iacoviello (2005). These two countries form a monetary union. We call one of them the core and the other the periphery. Measure ω of agents reside in the periphery and $\omega^* = 1 - \omega$ in the core. Both economies are populated by patient households (who save in equilibrium) and impatient households (who borrow in equilibrium), as well as producers of consumption goods, housing and intermediate goods. Union-wide monetary policy is conducted according to a Taylor rule, while macroprudential policy instruments can be adjusted at a country level. In this paper, we employ the following notational convention: variables without an asterisk refer to the periphery, while variables with an asterisk pertain to the core. Since both countries have a symmetric structure, we describe the problems of agents in the periphery only.

2.1. Households

In each economy there are two types of households indexed by ι on a unit interval: patient $\iota \in P \equiv [0, \omega_P]$ and impatient $\iota \in I \equiv (\omega_P, 1]$.[2] Hence, the measure of patient agents is ω_P, while that of impatient households is $\omega_I = 1 - \omega_P$.

2.1.1. Patient households

Patient households work $n_{P,t}$, accumulate housing $\chi_{P,t}$, consume $c_{P,t}$ and deposit savings in the banking sector $D_{P,t}$ at the risk-free rate R_t.[3] We also assume that they own physical capital k_P (fixed at the aggregate level), which they rent to firms at the rate $R_{k,t}$, as well as all firms and banks in the economy, which pay them dividends $\Pi_{P,t}$.

Patient households maximize

$$U_{P,t} = E_0 \left\{ \sum_0^{\infty} \beta_P^t \left[e^{\varepsilon_{u,t}} \frac{\left(c_{P,t}(\iota) - \xi_c c_{P,t-1}\right)^{1-\sigma_c}}{1-\sigma_c} + e^{\varepsilon_{u,t}} e^{\varepsilon_{\chi,t}} A_\chi \frac{\left(\chi_{P,t}(\iota) - \xi_\chi \chi_{P,t-1}\right)^{1-\sigma_\chi}}{1-\sigma_\chi} - A_n \frac{n_{P,t}(\iota)^{1+\sigma_n}}{1+\sigma_n} \right] \right\} \tag{1}$$

subject to the budget constraint

$$\begin{aligned} & P_t c_{P,t}(\iota) + P_{\chi,t}\left(\chi_{P,t}(\iota) - \left(1-\delta_\chi\right)\chi_{P,t-1}(\iota)\right) + D_{P,t}(\iota) \\ & \quad \le W_{P,t}(\iota) n_{P,t}(\iota) + R_{k,t} k_P(\iota) + R_{t-1} D_{P,t-1}(\iota) + \Pi_{P,t}(\iota) \end{aligned} \tag{2}$$

where P_t, $P_{\chi,t}$ and $W_{P,t}$ are, respectively, the price of consumption goods, the price of housing and patient households' nominal wage. Moreover, β_P denotes patient agents' discount rate, while A_χ and A_n are the weights of housing and labor in utility. The inverse of the intertemporal elasticity of substitution in consumption is denoted by σ_c, that in housing by σ_χ, while σ_n is the inverse Frisch elasticity of labor supply. Housing stock depreciates at the rate δ_χ. Consumption and housing services are subject to external habit persistence ξ_c and ξ_χ, respectively. There are two preference shocks, both following independent AR(1) processes: intertemporal preference shock $\varepsilon_{u,t}$ and housing preference shock $\varepsilon_{\chi,t}$.

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[2] We employ the following notational convention: all variables denoted with a subscript P or I are expressed per patient or impatient household, respectively, while all other variables are expressed per all households. For example, k denotes per capita capital and since only patient households own capital, capital per patient households is equal to $k_P = k/\omega_P$.

[3] We calibrate the model so that patient households save and never borrow. Therefore, to simplify notation, we eliminate loans (which they would not take anyway) from their budget constraint. Similarly, we do not include deposits in impatient households' budget constraint (4).

2.1.2. Impatient households

Impatient households optimize by choosing consumption $c_{I,t}$, housing services $\chi_{I,t}$ and labor supply $n_{I,t}$. They maximize their lifetime utility function that is similar to that of patient households. The only difference is that they discount the future utility flows more heavily ($\beta_I < \beta_P$), which makes them natural borrowers. Access to credit $L_{I,t}$ is subject to the following collateral constraint

$$R_{L,t}L_{I,t}(\iota) \le m_{\chi,t}E_t\{P_{\chi,t+1}\}(1-\delta_\chi)\chi_{I,t}(\iota) \tag{3}$$

where $m_{\chi,t}$ is the LTV ratio set by the macroprudential authority, and $R_{L,t}$ is the interest rate on loans.

The budget constraint of impatient households takes the following form

$$P_t c_{I,t}(\iota) + P_{\chi,t}(\chi_{I,t}(\iota) - (1-\delta_\chi)\chi_{I,t-1}(\iota)) + R_{L,t-1}L_{I,t-1}(\iota) \le W_{I,t}(\iota)n_{I,t}(\iota) + L_{I,t}(\iota) \tag{4}$$

where $W_{I,t}$ denotes impatient households' nominal wage.

2.1.3. Labor market

Both patient and impatient households supply monopolistically distinct labor services to competitive aggregators, who transform them into homogenous labor input according to

$$n_t = \left[\omega_P n_{P,t}^{\frac{\phi_n - 1}{\phi_n}} + \omega_I n_{I,t}^{\frac{\phi_n - 1}{\phi_n}}\right]^{\frac{\phi_n}{\phi_n - 1}} \tag{5}$$

where

$$n_{P,t} = \left[\int_0^1 n_{P,t}(\iota)^{\frac{1}{\mu_w}} \mathrm{d}\iota\right]^{\mu_w}, \quad n_{I,t} = \left[\int_0^1 n_{I,t}(\iota)^{\frac{1}{\mu_w}} \mathrm{d}\iota\right]^{\mu_w} \tag{6}$$

In the above formulas, ϕ_n is the elasticity of substitution between labor supplied by the two types of households, while μ_w determines the elasticity of substitution between individual labor varieties.

We assume that wages for both types of households $W_{P,t}$ and $W_{I,t}$ are sticky.[4] In each period, with probability $1-\theta_w$, each household receives a Calvo signal to reoptimize her wages. Otherwise, wages are indexed according to $\pi_{\zeta_w,t} = \zeta_w \pi_{t-1} + (1-\zeta_w)\pi$, where $\pi_t \equiv P_t/P_{t-1}$ and π denote inflation and its steady state level, respectively, while ζ_w controls the degree of wage indexation to past inflation. We assume perfect risk sharing across households of the same type.[5] As a result, wage stickiness does not create additional heterogeneity in consumption and housing choices between the agents.

2.2. Producers

In our economy there are several types of firms, all owned by patient households. Consumption and housing producers use intermediate goods to produce consumption and housing goods, respectively. Monopolistically competitive intermediate goods producers produce differentiated goods by employing capital and labor.

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[4] There are two reasons for including sticky wages in our model. First, wage stickiness helps us to match the moments implied by the model to the data as it makes impatient households' labor income, and hence consumption, more stable. Second, staggered wage adjustment has a potential to significantly affect welfare analysis (see Erceg et al., 2000), which we use as one of the criteria to evaluate alternative policies.

[5] Perfect risk sharing implies that the budget constraints (2) and (4) implicitly include net payments from insurance against individual wage risk.

2.2.1. Consumption good producers

Perfectly competitive consumption good producers purchase domestic and foreign varieties of differentiated intermediate goods $c_H(i)$ and $c_F(i)$ to produce a homogeneous good according to the following technology

$$c_t = \left((1-\eta_H)^{\frac{1}{\phi_C}} c_{F,t}^{\frac{\phi_C - 1}{\phi_C}} + \eta_H^{\frac{1}{\phi_C}} c_{H,t}^{\frac{\phi_C - 1}{\phi_C}} \right)^{\frac{\phi_C}{\phi_C - 1}} \tag{7}$$

where

$$c_{H,t} = \left(\int_0^1 c_{H,t}(i)^{\frac{1}{\mu}} di \right)^{\mu}, \quad c_{F,t} = \left(\int_0^1 c_{F,t}(i)^{\frac{1}{\mu}} di \right)^{\mu} \tag{8}$$

In the formulas above, η_H determines home bias in consumption, ϕ_n is the elasticity of substitution between domestic and foreign consumption goods, while μ determines the elasticity of substitution between differentiated intermediate goods.

2.2.2. Housing producers

In each period, perfectly competitive housing goods producers purchase undepreciated housing from the previous period and produce new housing stock according to the following formula

$$\chi_t = (1-\delta)\chi_{t-1} + \varepsilon_{i\chi,t}\left(1 - S_\chi\left(\frac{i_{\chi,t}}{i_{\chi,t-1}}\right)\right) i_{\chi,t} \tag{9}$$

where $i_{\chi,t}$ stands for housing investment, produced only with domestic intermediate inputs

$$i_{\chi,t} = \left(\int_0^1 i_{\chi,t}(i)^{\frac{1}{\mu}} di \right)^{\mu} \tag{10}$$

and $\varepsilon_{i\chi,t}$ denotes an AR(1) housing investment specific technology shock. Housing investment adjustment cost is given by $S_\chi\left(\frac{i_{\chi,t}}{i_{\chi,t-1}}\right) = \frac{\kappa_\chi}{2}\left(\frac{i_{\chi,t}}{i_{\chi,t-1}} - 1\right)^2$, where $\kappa_\chi > 0$.

2.2.3. Intermediate goods producers

Intermediate goods producers, indexed by i, combine labor and capital with the following technology

$$c_{H,t}(i) + \frac{1-\omega}{\omega} c^*_{H,t}(i) + i_{\chi,t}(i) = z_t k(i)^{\alpha} n_t(i)^{1-\alpha} \tag{11}$$

where z_t denotes a productivity shock that follows an AR(1) process. They operate in a monopolistically competitive environment and set their prices according to the Calvo scheme. In each period, each producer i receives with probability $1 - \theta$ a signal to reoptimize her price. Otherwise, prices are indexed according to $\pi_{\zeta,t} = \zeta\pi_{t-1} + (1-\zeta)\pi$, where ζ controls the degree of indexation to past inflation.

2.3. Banks

A continuum of monopolistically competitive banks indexed by j supply loans to impatient households, refinancing them by accepting deposits D_t from patient households at the rate R_t and borrowing the rest (or lending the surplus) $\tilde{D}^*_t$ in the foreign interbank market at the rate $\varrho_t R^*_t$.[6] A representative bank in the periphery maximizes

[6] The risks premium evolves according to $\varrho_t = 1 + \xi(\exp(d_t - d) - 1)$, where d_t is the debt-to-GDP ratio of the periphery while d denotes its steady-state level. Perfect substitutability between domestic and foreign interbank market loans implies the following relationship: $R_t = \varrho_t R^*_t$. The risk premium is introduced only to render the model stationary. In our calibration, we set ξ to a very small value so that the difference between R_t and R^*_t is negligible.

$$\mathbb{E}_0\left\{\beta_P\frac{u_{P,t+1}}{P_{t+1}}\left[R_{L,t}(j)L_t(j)-R_tD_t(j)-S_{t+1}\rho_tR_t^*\tilde{D}_t^*(j)\right]\right\} \tag{12}$$

subject to the flow of funds constraint

$$L_t(j)=D_t(j)+S_t\tilde{D}_t^*(j) \tag{13}$$

and the demand for loans implied by the following Dixit–Stiglitz loan aggregator

$$\omega_I L_{I,t}=\left[\int_0^1 L_t(j)^{\frac{1}{\mu_L}}\mathrm{d}j\right]^{\mu_L} \tag{14}$$

where $u_{P,t}$ is marginal utility of patient households' real income.

2.4. Closing the model

2.4.1. GDP and balance of payments

We define aggregate output (GDP) as

$$y_t\equiv c_{H,t}+c_{H,t}^*\frac{1-\omega}{\omega}+i_{\chi,t} \tag{15}$$

and the law of motion of the periphery's net foreign debt $\tilde{D}_t^*$ can be written as

$$\tilde{D}_t^*=P_{F,t}c_{F,t}-\frac{1-\omega}{\omega}P_{H,t}^*c_{H,t}^*+\varrho_{t-1}R_{t-1}^*\tilde{D}_{t-1}^* \tag{16}$$

where $P_{H,t}^*$ and $P_{F,t}$ denote the price of, respectively, exports and imports of the periphery. We also impose a standard set of market clearing conditions for the financial, housing, final goods and factor markets.

2.4.2. Monetary policy

We assume that the monetary authority reacts to union-wide variables, i.e. it sets the policy rate according to the following Taylor rule

$$\frac{R_t^*}{R^*}=\left(\frac{R_{t-1}^*}{R^*}\right)^{\gamma_R^*}\left[\left(\frac{\tilde{\pi}_t}{\tilde{\pi}^*}\right)^{\gamma_\pi^*}\left(\frac{\tilde{y}_t}{\tilde{y}}\right)^{\gamma_y^*}\right]^{1-\gamma_R^*}e^{\varepsilon_{R,t}^*} \tag{17}$$

where

$$\tilde{y}_t\equiv\omega y_t+(1-\omega)y_t^*$$
$$\tilde{\pi}_t\equiv(\pi_t)^{\omega}\left(\pi_t^*\right)^{1-\omega}$$

Here, γ_π^* and γ_y^* control the strength of policy rate response to inflation and output, respectively, while γ_R^* controls the degree of interest rate smoothing. The variables without time subscripts denote their respective steady state values and $\varepsilon_{R,t}^*$ is an i.i.d. monetary policy shock.

2.4.3. Macroprudential policy

The macroprudential authority sets the LTV ratio according to the following simple feedback rule[7]

$$\frac{m_{\chi,t}}{m_\chi}=\left(\frac{l_t}{l}\right)^{\gamma_{ml}}\left(\frac{p_{\chi,t}}{p_\chi}\right)^{\gamma_{mp}}\left(\frac{y_t}{y}\right)^{\gamma_{my}} \tag{18}$$

[7] Following the literature, we treat $m_{\chi,t}$ as a policy parameter. Some other papers treat it as exogenous stochastic process (Gerali et al., 2010) or make it dependent on productivity (Iacoviello and Pavan, 2013).

In the formulas above, m_χ is the steady state LTV ratio, while γ_{ml}, γ_{ml} and γ_{ml} determine the size of instrument reaction to percentage deviations of real loans, house prices and output, respectively, from their steady state values. Hence, the macroprudential authority's main concern is to stabilize the financial sector, with some weight also attached to macroeconomic stability.

The rule given by equation (18) assumes that the macroprudential authority in the periphery acts independently from that in the core. In some of simulations we also look at the common policy outcomes, in which case the LTV ratio is determined as follows

$$\frac{m_{\chi,t}}{m_\chi} = \frac{m^*_{\chi,t}}{m^*_\chi} = \left(\frac{\tilde{l}_t}{\tilde{l}}\right)^{\gamma_{ml}} \left(\frac{\tilde{p}_{\chi,t}}{\tilde{p}_\chi}\right)^{\gamma_{mp}} \left(\frac{\tilde{y}_t}{\tilde{y}}\right)^{\gamma_{my}} \tag{19}$$

where

$$\tilde{l}_t \equiv \omega l_t + (1-\omega) l^*_t$$
$$\tilde{p}_{\chi,t} \equiv \omega p_{\chi,t} + (1-\omega) p^*_{\chi,t}$$

which means that it responds to area-wide rather than to region-specific variables.

3. Calibration

3.1. Structural parameters

This paper's focus is on a small member of a currency union facing stabilization challenges due to asymmetric shocks. To keep the exposition transparent, in our calibration we abstract from any structural heterogeneity within the union. More specifically, the core and periphery are assumed to differ only in size and shock realizations.[8] The calibrated values of structural parameters are summarized in Table 1. The unit of time is one quarter.

We set the relative size of the periphery to 10%, which roughly corresponds to the GDP share of Spain in the euro area. This calibration also implies that the core is very much like a closed economy, following a self-oriented monetary policy. The share of home-made goods in the periphery's consumption basket is set to 0.7, consistently with the average import content of private consumption estimated in Bussiere et al. (2013) for the euro area member states. Correcting this figure for the relative country size as in Sutherland (2005) implies the import share in the core's consumption of 0.03.

Households' preferences, production technology, as well as labor and product market real rigidities are calibrated in line with the literature. The elasticity of the residential investment adjustment cost is set to 30. This value is substantially larger than estimated by Lombardo and McAdam (2012), but proved crucial in matching the relative volatility of residential investment. While calibrating nominal rigidities, we follow closely Christoffel et al. (2008). The monetary policy feedback rule is also parametrized consistently with estimated DSGE models for the euro area.

Several parameters are calibrated to match a few key steady state ratios, reported in Table 3, using the euro area 1995–2011 averages as targets.[9] These include the housing and labor weights in utility, the housing stock depreciation rate, the relative size of impatient agents, the physical capital stock, transfers from patient to impatient households and markups in financial intermediation.

3.2. Stochastic properties

Business cycle fluctuations in our model monetary union are driven by nine stochastic shocks. These include four pairs of region-specific shocks to productivity, preferences, relative housing preferences

[8] The consequences of structural housing market heterogeneity within a monetary union are analyzed by Rubio (2014).

[9] Data on interest rates and national accounts are taken from Eurostat. Consistently with the model setup, which abstracts from government spending and business investment, as well as assumes balanced trade in the steady state, we define the empirical counterpart of output not as total GDP, but as the sum of private consumption and residential investment. Data on mortgage loans and housing stock come from the ECB Statistical Data Warehouse (SDW).

Table 1
Calibration – parameters.

Parameter	Value	Description
β_P, β_P^*	0.99	Discount factor, patient HHs
β_I, β_I^*	0.975	Discount factor, impatient HHs
δ_χ, δ_χ^*	0.01	Housing stock depreciation rate
ω_I, ω_I^*	0.55	Share of impatient HHs
A_χ, A_χ^*	2.43	Weight on housing in utility function
A_n, A_n^*	225	Weight on labor in utility function
σ_c, σ_c^*	2	Inverse of intertemporal elasticity of substitution in consumption
σ_χ, σ_χ^*	2	Inverse of intertemporal elasticity of substitution in housing
σ_n, σ_n^*	2	Inverse of Frisch elasticity of labor supply
ξ_c, ξ_c^*	0.7	Degree of external habit formation in consumption
ξ_χ, ξ_χ^*	0.7	Degree of external habit formation in housing
θ_w, θ_w^*	0.75	Calvo probability for wages
ζ_w, ζ_w^*	0.5	Indexation parameter for wages
μ_w, μ_w^*	1.2	Steady state labor markup
ϕ_n, ϕ_n^*	6	Elasticity of substitution btw. patient and impatient labor
t, t^*	0.25	Real transfers from patient to impatient HHs
μ, μ^*	1.2	Steady state product markup
θ_H, θ_F^*	0.9	Calvo probability for domestic prices
θ_F, θ_H^*	0.75	Calvo probability for export prices
ζ_H, ζ_F, ζ_H^*, ζ_F^*	0.5	Indexation parameter for prices
α, α^*	0.3	Output elasticity with respect to physical capital
k, k^*	6.5	Physical capital stock per capita
κ_χ, κ_χ^*	30	Housing investment adjustment cost
μ_L, μ_L^*	1.0047	Loan markup
m_χ, m_χ^*	0.75	Steady state LTV ratio
π, π^*	1.005	Steady state inflation
ξ	0.001	Elasticity of risk premium wrt. foreign debt
γ_R	0.9	Interest rate smoothing in Taylor rule
γ_π	2	Response to inflation in Taylor rule
γ_y	0.15	Response to output in Taylor rule
ω	0.1	Share of periphery in monetary union
η_c	0.7	Share of domestic goods in consumption basket (periphery)
$\eta_c^* = \frac{\omega(1-\eta_c)}{(1-\omega)}$	0.03	Share of imported goods in consumption basket (core)
ϕ_c, ϕ_c^*	1.5	Elasticity of substitution btw. home and foreign goods

and housing investment technology, all modeled as first-order autoregressive processes, and one common monetary shock, assumed to be white noise. For simplicity, we assume that the inertia and volatility of shocks of a given type do not differ between the core and periphery. However, given the paper's focus on imbalances within a currency union, we assume that shocks are uncorrelated across the two regions. As a robustness check we allow shocks to be correlated.

Our calibration of the shock processes is summarized in Table 2. The aim was to match the standard moments of the euro area data and to be at the same time consistent with the empirical literature. As reported in Table 4, the model is successful in matching the volatilities of the main macro-categories, even though it somewhat underestimates the volatility of house prices and overestimates that of inflation and the mortgage interest rate. Except for loans and inflation, the inertia implied by our calibration is also broadly in line with the data. The model does a somewhat worse job at matching comovement between the main variables: it generates too little positive correlation of consumption with residential investment, real house prices and mortgage loans, while implying too negative correlation between consumption and the lending rate or inflation. Overall, given the model's simplicity and a relatively small number of shocks, its ability to match the key moments can be considered satisfactory.

As the last step of the model validation, we discuss the role it assigns to individual shocks in driving business cycle fluctuations. The variance decomposition results for the core are reported in Table 5. Due to its small size, shocks hitting the periphery do not have any significant effect on the rest of the monetary union. According to the model, consumption in the core is mainly driven by preference

Table 2
Calibration – stochastic shocks.

Parameter	Value	Description
ρ_z, ρ_z^*	0.95	Productivity shock – autocorrelation
σ_z, σ_z^*	0.007	Productivity shock – standard deviation
ρ_u, ρ_u^*	0.99	Preference shock – autocorrelation
σ_u, σ_u^*	0.016	Preference shock – standard deviation
ρ_χ, ρ_χ^*	0.99	Housing preference shock – autocorrelation
$\sigma_\chi, \sigma_\chi^*$	0.01	Housing preference shock – standard deviation
ρ_i, ρ_i^*	0.95	Investment specific shock – autocorrelation
σ_i, σ_i^*	0.012	Investment specific shock – standard deviation
σ_R	0.0011	Monetary shock – standard deviation

Table 3
Steady state ratios.

Steady state ratio	Value
Import to output ratio (periphery)	0.27
Import to output ratio (core)	0.003
Residential investment to output ratio	0.094
Capital-output ratio (annual)	2.0
Hours worked	0.33
Housing wealth to output ratio (annual)	2.32
Debt to output ratio (annual)	0.75
Spread (annualized)	0.019
Relative consumption of impatient HHs	0.75

shocks, with an important role of productivity shocks. The latter also drive a significant share of fluctuations in residential investment. However, it is the two housing market shocks (housing preference and residential investment) that account for the bulk of movements in this variable. Housing market shocks are also important for loans, but the monetary policy shock explains more than 40 percent of their variance. Investment specific shocks are crucial in generating fluctuations in real house prices. Finally, productivity shocks account for the bulk of movements in inflation and the lending rate. We note that many of these implications are consistent with the VAR evidence reported in Musso et al. (2011). This concerns in particular the dominant role of housing market shocks in driving residential investment and real house prices.

Turning to the variance decomposition for the periphery (see Table 6), our model assigns a substantial role to shocks originating abroad. This does not apply to residential investment, which is driven

Table 4
Moment matching – euro area.

Variable	Standard dev.		Autocorrelation		Corr. With cons.	
	Data	Model	Data	Model	Data	Model
Consumption	2.25	2.23	0.97	0.99	1.00	1.00
Residential investment	6.97	6.98	0.97	0.99	0.81	0.20
Mortgage loans	5.51	5.51	0.98	0.85	0.89	0.28
Real house prices	3.94	3.14	0.98	0.94	0.65	0.27
Mortgage interest rate	0.30	0.42	0.98	0.96	−0.07	−0.71
Inflation	0.28	0.40	0.32	0.96	0.19	−0.57

Note: All variables are quarterly euro area aggregates for the period 1996–2011. Consumption is defined as real final consumption expenditure of households, residential investment is real gross fixed capital formation in dwellings, inflation is the quarterly change in HICP, while the mortgage interest rate is quarterly interest on housing loans to households. All these variables are taken from Eurostat. Real house prices are defined as residential property prices of new and existing houses and flats, while mortgage loans are defined as outstanding amounts of lending for house purchase. Both series come from the ECB SDW and are deflated by HICP. Trending variables (consumption, residential investment, mortgage loans and real house prices) are expressed as log-deviations from linear trends.

Table 5
Variance decomposition – core.

Variable ∖ shock	Productivity	Preference	Housing pref.	Invest. specific	Monetary
Consumption	16.4	71.2	1.5	2.3	8.5
Residential invest.	36.6	3.0	36.2	24.0	0.2
Mortgage loans	2.0	0.3	24.3	31.7	41.5
Real house prices	20.0	0.3	6.7	63.0	9.9
Mortg. interest rate	70.6	11.7	0.1	1.8	14.7
Inflation	66.4	27.1	0.1	0.5	4.8

almost entirely by domestic disturbances. At the other extreme, domestic shocks explain very little of fluctuations in the periphery's inflation and credit cost.

4. Macroprudential policy transmission

In this section we briefly show how our macroprudential policy tool works. To this end, on Fig. 2 we present the impulse response functions to a shock to the macroprudential policy rule in the periphery (18). Just for the purpose of this illustration, we treat the LTV ratio as a purely exogenous AR(1) process with autocorrelation equal to 0.9. This choice is motivated by the fact that, in contrast to monetary policy rules, there is hardly any evidence on how macroprudential policymakers behave. Therefore, any specific parametrization of the feedback rule would be clearly arbitrary.

Let us now discuss the impulse responses. A negative shock to the LTV ratio implies a tightening of lending standards for impatient households. They have to cut back borrowing and hence reduce their consumption and housing stock. Lower demand for housing drives its price down, amplifying the initial shock as the value of collateral declines. As both consumption and residential investment decline, so does output. Since the periphery has a small weight in the common currency area, the interest rate barely moves and hence does not help much to stabilize the economy. Importantly, the effects of changes in the LTV ratio on inflation are very small so using this policy is unlikely to significantly change the monetary authority's ability to meet its traditional price stability objective.

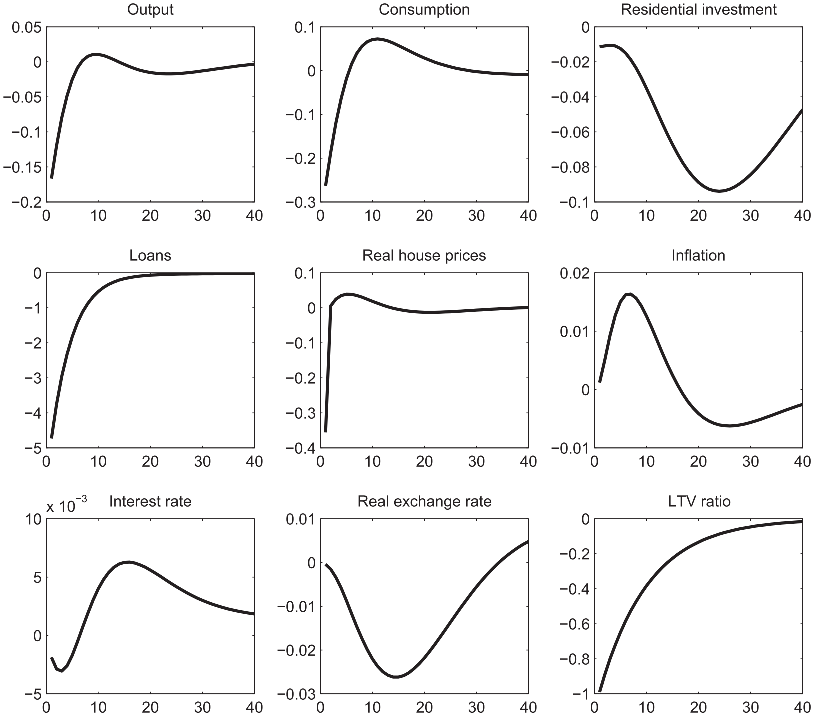
Overall, macroprudential policy can significantly affect the volume of mortgage loans and, in consequence, also house prices and the level of economic activity. This makes it a potentially useful tool not only to stabilize the financial sector, but possibly also the real economy.

5. Effects of macroprudential policy

We are now ready to use our model to check whether macroprudential policy is able to improve the financial and macroeconomic situation in the peripheral economy facing asymmetric shocks. Unless stated otherwise, macroprudential policy is applied independently for the periphery, i.e the rule responds to region-specific variables. This contrasts with the monetary policy setup, implemented by the common central bank, which reacts to area-wide output and inflation. Note that in our baseline calibration the peripheral economy is small (it constitutes only 10% of the currency area), and hence the common interest rate is almost completely determined by the developments in the foreign (core) economy.

Table 6
Variance decomposition – periphery.

Variable/shock	Productivity	Preference	Housing pref.	Invest. specific	Foreign
Consumption	16.8	60.9	1.0	0.9	20.4
Residential invest.	24.8	6.7	33.8	28.9	5.8
Mortgage loans	4.7	1.6	25.7	21.5	46.5
Real house prices	4.0	3.4	8.4	53.6	30.6
Mortg. interest rate	1.3	0.2	0.0	0.0	98.5
Inflation	7.7	0.8	0.0	0.1	91.4



Note: All variables are expressed in per cent. Inflation and the interest rate are annualized.

Fig. 2. Impulse responses to a macroprudential policy shock.

Our evaluation uses two independent optimality criteria. The first one is based on the ability of macroprudential policy to reduce both credit and output volatility in the periphery. This refers to the well documented practice of central banks to smooth the business cycle and ensure financial sector stability. The second criterion checks to what extent macroprudential policy can improve welfare of the periphery's households. In both cases, we optimize the parameters defining the LTV rule given by equation (18), holding its functional form fixed and making sure that the rule does not imply unrealistically high volatility of the instrument. More precisely, the standard deviation of the LTV ratio is limited to 10%.

We start with the volatility criterion and present the effects of macroprudential policy in form of the efficient frontiers. These are obtained by plotting the standard deviations of credit and output under policies that choose the feedback coefficients in equation (18) such that they minimize the following loss function

$$\lambda var(l_t) + (1-\lambda) var(y_t) \tag{20}$$

for various $\lambda \in [0,1]$ and subject to constraint $var(m_{\chi,t}) \leq 0.1^2$, where $var(\bullet)$ denotes the unconditional variance. When considering the outcomes of common macroprudential policy, i.e. setting the LTV ratios at the same level in both regions, these are obtained by solving a similar set of problems, except that the periphery's variables in equation (20) are replaced with the respective area-wide aggregates.

The dashed line in Fig. 3 shows the thus obtained output-credit volatility trade-off, together with outcomes available under alternative institutional setups, including common (solid line) or no (square mark) macroprudential policy. We also illustrate the workings of a more aggressive common monetary policy and no LTV adjustments (diamond mark), in which case the response of the interest rate in the Taylor rule γ_π^* is increased from 2 to 3. The volatilities presented in the figure are normalized by the standard deviations of loans and output in the periphery under the assumption the periphery does not participate in the common currency area, i.e. runs independent monetary policy under a floating exchange rate. In this benchmark case, depicted by the circle, the core and periphery's monetary authorities follow self-oriented Taylor rules with a functional form and parametrization as in equation (17).

The main conclusions from these calculations are as follows. First, joining the monetary union raises the volatility of output by somewhat more than 10% and decreases that of loans by around 5%. This is clearly the consequence of fixing the exchange rate and replacing monetary policy that reacts to domestic developments with one that reacts (mainly) to foreign fluctuations.[10] Second, substituting independent monetary policy with independent macroprudential policy can help stabilizing the economy. In particular, even though this policy cannot bring the periphery to where it would be if it stayed out of the monetary union, appropriate adjustments of the LTV ratio can substantially decrease the volatility of both output and loans in this region. Actually, introducing such policy can virtually eliminate fluctuations in credit at no cost in terms of output variability while the maximum attainable decrease in the standard deviation of output without increasing that of loans amounts to about 5%. Third, the outcomes observed in the periphery if the LTV ratio is constrained to be the same in the whole monetary union (common macroprudential policy) are much less favorable for this region. In this case, even though so defined policy can potentially bring more stability to the periphery's financial and real sectors, the scale of feasible improvement is much lower compared to the independent policy outcomes. Fourth, the trade-off faced by the macroprudential authority is very steep in the output-credit volatility space. This means that, as one could expect, such policy is efficient at stabilizing credit market developments, but its ability to smooth fluctuations in real economic activity is rather limited. Finally, adjusting the common interest rate more aggressively is no substitute for macroprudential policy. Even though some reduction in output volatility can be thus obtained, but only at a cost of destabilizing the credit market, and this arrangement is clearly dominated by independent macroprudential policy or some of outcomes available under its common variant.

Our second optimality measure is welfare. As before, we search for such a parametrization of the macroprudential policy rule given by equation (18) that maximizes social welfare. More precisely, the independently operating policy maker tries to maximize aggregate welfare defined as the unconditional (ergodic) mean of (see e.g. Rubio, 2011; Lambertini et al., 2013)

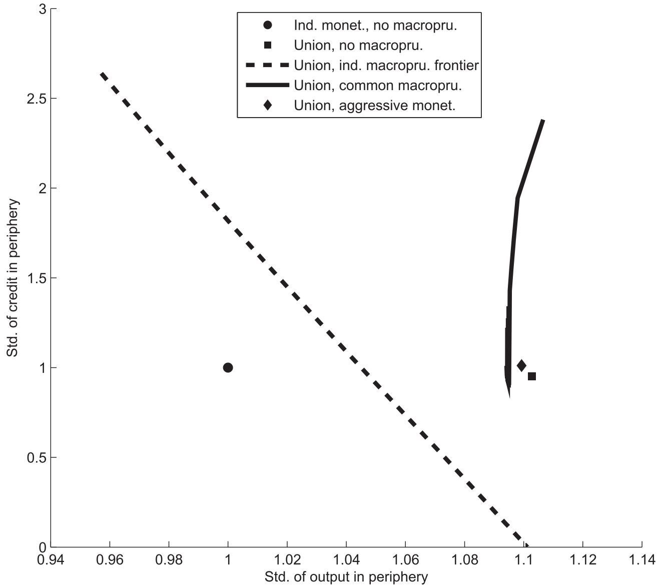
$$\omega_P(1-\beta_P)U_{P,t} + \omega_I(1-\beta_I)U_{I,t} \tag{21}$$

and computed using a second-order approximation to the model equilibrium conditions. In the case of common policy, the macroprudential authority maximizes the weighted average of (21) and its core counterpart, with weights given by the respective size of each region in the monetary union. Additionally, in both cases, we look at the welfare implications of such defined optimal policy for each of the two household types in the periphery.

Table 7 presents the results. Welfare is presented in consumption equivalent units, defined as percent of lifetime consumption that the periphery's households would be willing to forgo to live with rather than without macroprudential policy. We find that appropriately designed independent LTV policy is able to improve aggregate welfare quite substantially. However, so defined optimal macroprudential policy does not constitute a Pareto improvement as it is only impatient agents that benefit from this policy while the patient ones suffer welfare losses. The main reason for it is the link between borrowers and savers via the credit market. More specifically, whenever the macroprudential authority uses the LTV ratio to affect lending to impatient households, it necessarily affects the amount of deposits that patient households hold.[11] For instance, since income of both types of agents is positively

[10] At this point, one thing should be made clear in order to avoid misinterpretation of the results. Our stochastic environment does not include shocks that directly affect the exchange rate (e.g. risk premium shocks) and that possibly disappear after adopting the common currency. For this reason, in our model, joining the union is unequivocally detrimental for output variability, while in real life the net outcome is *ex ante* unclear.

[11] More precisely, this link is one-to-one in a closed economy and somewhat weakened in an open economy setup because of international capital flows, but still exists because of imperfect international financial markets (risk premium affecting cross-border borrowing costs) and non-zero size of the periphery relative to the core.



Note: The dashed line presents the output-credit volatility trade-off for the periphery of the monetary union if the LTV ratio in this region is set independently. The solid line shows the outcomes in the periphery if the LTV ratio is set at the union level (solid line). The square mark indicates the outcome under no macroprudential policy (constant LTV ratio), while the diamond illustrates the variant with more aggressive common monetary policy ($\gamma_\pi^* = 3$). The output and credit volatilities are normalized by the values that would hypothetically be observed if the periphery conducted independent monetary policy and no macroprudential policy (circle mark).

Fig. 3. Macroprudential policy trade-off in the periphery.

correlated, any attempt to smooth consumption of one group comes usually at a cost of destabilizing that of the other.

As regards the implications of this policy for the volatility of output and loans, which are the focus of our first evaluation criterion, we find that it somewhat decreases the former and virtually eliminates the latter. Moreover, the welfare maximizing policy leads to more stable house prices. These results indicate that this type of policy should mainly focus on stabilizing the credit and housing market. Turning to the consequences of common policy, the gains reaped by the periphery are positive, but much smaller and do not lead to a Pareto improvement. Importantly, area-wide macroprudential policy actually delivers little financial stability to the periphery as it decreases the volatility of credit in this region only by a relatively small amount.

Summing up the results obtained using both the volatility and welfare criteria, we can conclude that the macroprudential policy can bring more stability to the periphery or improve aggregate welfare. However, for these effects to be sizable, the policy must be decentralized, i.e. the instruments set at a country level. The intuition behind this result is an analogue to monetary policy: responding to area-wide aggregates essentially means ignoring fluctuations specific to the (small) periphery.

In order to get a better understanding of the underlying mechanisms, we run an additional experiment that checks whether decentralized macroprudential policy is able to trade off some shocks better than others. This is an important question in the debate on euro area imbalances, given the evidence that asymmetric interest rate or housing shocks played a major role in driving these

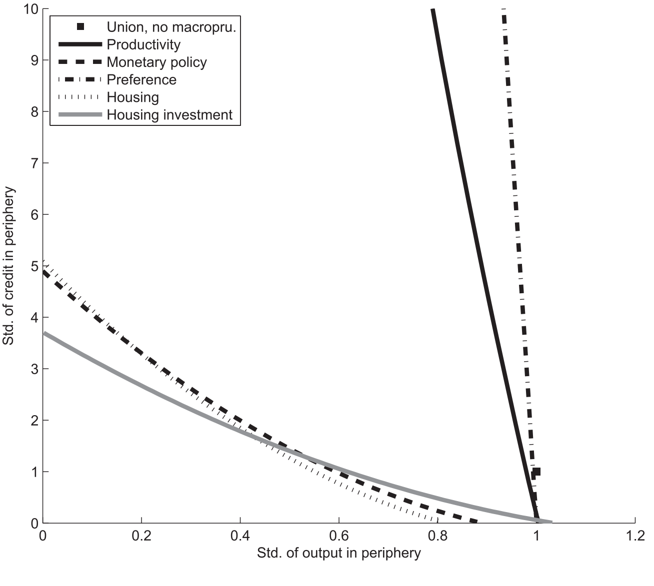
Table 7
Effects of welfare maximizing macroprudential policy on the periphery.

	Independent	Common
Welfare – total	0.20	0.04
Welfare – patient HHs	−0.10	−0.04
Welfare – impatient HHs	0.39	0.10
Std. of output	−0.14	−0.69
Std. of credit	−100.0	−3.73
Std. of house prices	−1.79	−0.78

Note: Welfare gains are presented in percent of lifetime consumption. The standard deviations are expressed as percent difference from the no macroprudential policy case.

imbalances. To answer this question, we redo our calculations with one shock turned on at a time. While doing this, we concentrate on shocks specific to the peripheral economy. Fig. 4 presents the output-credit volatility trade-off (with each of the two variables normalized by their respective standard deviations in the case of no macroprudential policy). It is clear that frontiers for shocks related to the housing market (housing preference and investment specific) and to monetary policy have a smaller slope than those for productivity and preference shocks, meaning that large reductions in output volatility do not necessarily lead to financial instability. Moreover, for this group of shocks the potential improvement achievable by appropriate adjustments in the LTV ratio is much bigger, i.e. the frontiers lie further away from the no-policy outcome indicated by the square mark.

The picture (see Table 8) is similar if one takes aggregate welfare as the optimality criterion. Macroprudential policy can achieve the largest welfare gains when facing housing preference, interest rate and housing investment specific shocks. Overall, these findings strengthen our conclusion that macroprudential policy seems well designed to deal with the kind of asymmetries and imbalances that plague the euro area.



Note: The figure presents the output-credit volatility trade-off for macroprudential policy set independently by the periphery's authority. Shocks are applied separately.

Fig. 4. Efficient policy frontiers for LTV policy in the periphery (shocks applied separately).

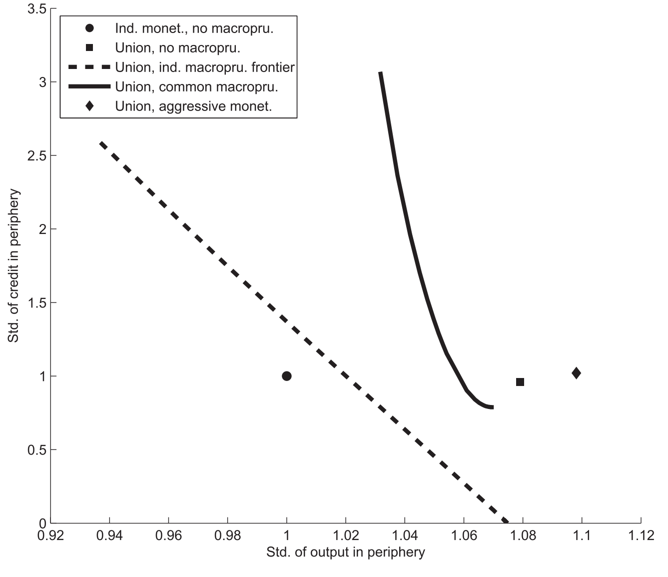
Table 8
Welfare effects of macroprudential policy on the periphery by shocks.

	Productivity	Housing	Housing investment	Monetary	Intertemporal preference
Total	0.02	0.19	0.05	0.07	0.02
Patient HHs	0.02	−0.10	−0.03	−0.08	−0.02
Impatient HHs	0.02	0.36	0.10	0.16	0.05

Note: Welfare gains are presented in percent of lifetime consumption. Results are based on simulations run with only one respective shock at a time (the parameters of the shock as in the calibration).

6. Robustness check – correlated shocks

Our baseline assumption was that shocks in the core and periphery are uncorrelated. However, it has been documented in the literature that this correlation can be positive. For instance, Jondeau and Sahuc (2008) estimate a DSGE model for France, Germany and Italy and find cross-country correlations of productivity and preference shocks ranging from −0.03 to 0.19 and 0.17 to 0.31, respectively. Hence, as a robustness check, we repeat our most important results assuming conservatively that all shocks (except for the common monetary policy shock) have a correlation of 0.3 between the core and periphery. Since, in the baseline model, this modification implies only small changes to the moments reported in Table 4, we decided not to recalibrate the model. Compared to our benchmark results, one should expect the gains from independent macroprudential policy to be smaller and those from its



Note: The dashed line presents the output-credit volatility trade-off for the periphery of the monetary union if the LTV ratio in this region is set independently. The solid line shows the outcomes in the periphery if the LTV ratio is set at the union level (solid line). The square mark indicates the outcome under no macroprudential policy (constant LTV ratio), while the diamond illustrates the variant with more aggressive common monetary policy ($\gamma_\pi^* = 3$). The output and credit volatilities are normalized by the values that would hypothetically be observed if the periphery conducted independent monetary policy and no macroprudential policy (circle mark).

Fig. 5. Macroprudential policy trade-off in the periphery (correlated shocks).

common variant larger as, with correlated shocks, common policy actions driven mainly by developments in the core should be also to some extent adequate for the periphery.

Fig. 5 presents the policy trade-offs in the case of correlated shocks for independent and common macroprudential policy. As before, the results are normalized against the case of no macroprudential policy and independent monetary policy. As it is clear from comparing Figs. 3 and 5, the general picture remains unchanged. In line with our expectations, both the loss from giving up monetary independence and the gain from adopting independent macroprudential policy become somewhat smaller. Interestingly, more aggressive common monetary policy now offers no alternative to macroprudential policy as it generates an increase in the volatility of both output and credit.

Similarly, while considering welfare gains from independent macroprudential policy, we find that allowing for moderate correlation of shocks between the core and periphery affects our conclusions very little (see Table 9).

7. Conclusions

In this paper we check whether macroprudential policy can contribute to stabilizing a monetary union hit by asymmetric shocks. Our question is directly motivated by the imbalances that have arisen since the creation of the euro area between its “core” and “peripheral” members. As documented in the literature, these imbalances were mainly driven by asymmetric interest rate adjustments and housing market developments.

To answer this question, we construct a dynamic stochastic general equilibrium model of two regions forming a monetary union and run a number of simulations, showing how the peripheral economy behaves under various policy assumptions. In particular, we test the working of macroprudential policy oriented at regulating the loan-to-value ratio and check whether it can stabilize the economy when independent monetary policy is lost. Additionally, we consider the case of common macroprudential policy and show how it changes the outcome for the periphery. Finally, we test whether macroprudential policy is particularly efficient at stabilizing the economy hit by particular shocks.

Our findings are as follows. First, appropriate adjustments in the LTV ratio can substantially lower the volatility of credit and output in the periphery. Second, such policy is also able to raise households' welfare. However, it is not Pareto-efficient as it can raise either patient or impatient households' utility. Third, macroprudential policy is particularly efficient at trading-off monetary policy shocks and shocks related to the housing market. Since these disturbances are the usual suspects behind the asymmetric developments between the core and the periphery of the euro area, this conclusion strengthens our case for macroprudential policy as a stabilizing tool. However, this being our fourth conclusion, if macroprudential policy is to efficiently prevent desynchronization of business and financial cycles between the core and the periphery, it should be decentralized. The welfare analysis also points in this direction.

All in all, we find that macroprudential policy can potentially play an important role in preventing the emergence of imbalances between members of a monetary union, especially if it is applied on a decentralized basis.

Table 9
Effects of welfare maximizing macroprudential policy on the periphery (correlated vs. uncorrelated shocks).

	Independent (uncorrelated shocks)	Independent (correlated shocks)
Welfare – total	0.20	0.19
Welfare – patient HHs	−0.10	−0.10
Welfare – impatient HHs	0.39	0.36
Std. of output	−0.14	−0.40
Std. of credit	−100.0	−97.9
Std. of house prices	−1.79	−1.69

Note: Welfare gains are presented in percent of lifetime consumption. The standard deviations are expressed as percent difference from the no macroprudential policy case.

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References

Andrés, J., Hurtado, S., Ortega, E., Thomas, C., 2010. Spain in the euro: a general equilibrium analysis. SERIEs 1 (1), 67–95.
Angelini, P., Clerc, L., Cúrdia, V., Gambacorta, L., Gerali, A., Locarno, A., Motto, R., Roeger, W., den Heuvel, S.V., Vlcek, J., 2011. Basel III: Long-term Impact on Economic Performance and Fluctuations. BIS Working Papers 338. Bank for International Settlements.
Angeloni, I., Faia, E., 2013. Capital regulation and monetary policy with fragile banks. J. Monetary Econ. 60 (3), 311–324.
Blanchard, O., 2007. Adjustment within the euro. The difficult case of Portugal. Portuguese Econ. J. 6 (1), 1–21.
Bussiere, M., Callegari, G., Ghironi, F., Sestieri, G., Yamano, N., July 2013. Estimating trade elasticities: demand composition and the trade collapse of 2008–2009. Am. Econ. J. Macroecon. 5 (3), 118–151.
Christensen, I., Meh, C., Moran, K., 2011. Bank Leverage Regulation and Macroeconomic Dynamics. Working Papers. Bank of Canada.
Christoffel, K., Coenen, G., Warne, A., 2008. The New Area-wide Model of the Euro Area – a Micro-founded Open-economy Model for Forecasting and Policy Analysis. Working Paper Series 944. European Central Bank.
Darracq-Pariés, M., Sorensen, C.K., Rodriguez-Palenzuela, D., 2011. Macroeconomic propagation under different regulatory regimes: evidence from an estimated DSGE model for the euro area. Int. J. Central Bank. 7 (4), 49–113.
ECB, 2003. Inflation Differentials in the Euro Area: Potential Causes and Policy Implications. ECB Report. European Central Bank.
Erceg, C.J., Henderson, D.W., Levin, A.T., 2000. Optimal monetary policy with staggered wage and price contracts. J. Monetary Econ. 46 (2), 281–313.
Funke, M., Paetz, M., 2012. A DSGE-based Assessment of Nonlinear Loan-to-value Policies: Evidence from Hong Kong. BOFIT Discussion Papers 11/2012. Bank of Finland, Institute for Economies in Transition.
Gerali, A., Neri, S., Sessa, L., Signoretti, F.M., 2010. Credit and banking in a DSGE model of the euro area. J. Money, Credit Bank. 42 (s1), 107–141.
Honohan, P., Leddin, A.J., 2006. Ireland in EMU – more shocks, less insulation? Econ. Soc. Rev. 37 (2), 263–294.
Iacoviello, M., 2005. House prices, borrowing constraints, and monetary policy in the business cycle. Am. Econ. Rev. 95 (3), 739–764.
Iacoviello, M., Pavan, M., 2013. Housing and debt over the life cycle and over the business cycle. J. Monetary Econ. 60 (2), 221–238.
Jondeau, E., Sahuc, J.-G., June 2008. Optimal monetary policy in an estimated DSGE model of the euro area with cross-country heterogeneity. Int. J. Central Bank. 4 (2), 23–72.
Lambertini, L., Mendicino, C., Teresa Punzi, M., 2013. Leaning against boom-bust cycles in credit and housing prices. J. Econ. Dyn. Control 37 (8), 1500–1522.
Lombardo, G., McAdam, P., 2012. Financial market frictions in a model of the Euro area. Econ. Model. 29 (6), 2460–2485.
Musso, A., Neri, S., Stracca, L., 2011. Housing, consumption and monetary policy: how different are the US and the euro area? J. Bank. Finance 35 (11), 3019–3041.
Quint, D., Rabanal, P., June 2014. Monetary and macroprudential policy in an estimated DSGE model of the euro area. Int. J. Central Bank. 10 (2), 169–236.
Rubio, M., 2011. Fixed- and variable-rate mortgages, business cycles, and monetary policy. J. Money, Credit Bank. 43 (4), 657–688.
Rubio, M., 2014. Housing-market heterogeneity in a monetary union. J. Int. Money Finance 40 (C), 163–184.
Sutherland, A., 2005. Incomplete pass-through and the welfare effects of exchange rate variability. J. Int. Econ. 65 (2), 375–399.