Macrprudential policy and imbalances in the euro area∗

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PRELIMINARY

Abstract

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 DSGE model and simulate the effects of macroprudential policies under the assumption of asymmetric shocks hitting the core and periphery. Macroprudential policy is able to partly make up for the loss of independent monetary policy in the periphery. Moreover, LTV policy seems more efficient than regulating capital adequacy ratios. However, for the policies to be effective, they must be decentralized. Area-wide policy may even aggravate the problem.

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1 Introduction

Since the euro area was created, large imbalances have built up in some of its relatively poor members. These imbalances concerned in particular the housing market. As can be seen from Figure 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 contributed to substantial inflation differentials, which undermined the booming countries’ price competitiveness as the exchange rate devaluation was no longer an option. Swelling current account deficits and a sharp deterioration of fiscal revenues after bursting of the housing bubble sparked tensions on 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 origin of these asymmetric developments was a sharp fall in the periphery’s interest rates following the EMU accession, combined with an easy access to cross-border borrowing (see e.g. ECB, 2003; Honohan and Leddin, 2006; Blanchard, 2007; Andrés et al. (2010)). However, evidence from estimated dynamic stochastic general equilibrium (DSGE) models also points at asymmetric shocks to productivity and preferences (Andrés et al., 2010) or housing market prices (in’t Veld et al., 2012) as important drivers of the observed divergences between the core and the periphery.

Can such large asymmetries 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 developments in the periphery and hence can provide no stabilization in face of country-specific shocks. 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) and a banking sector similar to Gerali et al. (2010). We use this model to investigate the effectiveness of two policy instruments, adjusted countercyclically in response to output and credit fluctuations. One is defined as the maximum loan-to-value (LTV) ratio for mortgage loans and has been used as a stabilization tool in Hong Kong. The second instrument, mostly known from the Basel Committee Recommendations, is the minimal capital adequacy (CA) ratio imposed on commercial banks.

Our main findings can be summarized as follows. First, both macroprudential policies are able to lower output volatility in the periphery, even for reasonable volatility of the respective policy instruments. In this respect, a countercyclical LTV policy ranks better than its CA counterpart. Second, macroprudential policy is particularly efficient at offsetting housing
market and (common) monetary policy shocks, i.e. those types of disturbances that have been found to be important drivers of the observed divergences within the euro area. Third, only decentralized macroprudential policy can be successful. Setting its instruments at the area-wide level lowers output volatility in the periphery by relatively little (CA policy) or is not able to stabilize it at all (LTV policy).

Our paper is related to a growing literature looking at the performance of various macroprudential policy rules. Lambertini et al. (2011) 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 property price changes, 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 CA 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. However, none of these papers discuss macroprudential policy in the context of a heterogeneous monetary union.

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 two macroprudential policy instruments. Section five presents our main quantitative results. Section six concludes.

2 Model

We consider a two country DSGE model with collateral constraints, as proposed by Iacoviello (2005). These two countries form a monetary union. We call one of the countries the core and the other the periphery. Measure \( \omega \) of agents resides in the periphery and \( \omega^* = (1 - \omega) \) in the core. Economies in both countries are populated by patient households (who save in equilibrium) and impatient households (who borrow in equilibrium). Moreover, there are producers of consumption goods, housing and intermediate goods. Union-wide monetary policy is conducted according to a Taylor rule and the conduct of macroprudential policy is described in more detail later. In this paper we employ the following notational convention, variables without asterisk denote the periphery and with asterisk the core (for example \( c_t \) is consumption in the periphery and \( c_t^* \) in the core). Moreover, since both countries have symmetric structure we describe problems in the periphery only.
2.1 Households

In each economy there are two types of households indexed by $i$ on a unit interval: patient $i \in P \equiv [0, \omega_P]$ and impatient $i \in I \equiv (\omega_P, 1]$.

1 For convenience we denote the measure of impatient households as $\omega_I = 1 - \omega_P$.

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 policy rate $R_t$.

We also assume that they own all firms and banks in the economy, which pay them dividends $\Pi_P$. 

Patient households maximize:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta_t^{\pi} \left( \frac{(c_{P,t}(i) - \xi_c c_{P,t-1})^{1-\sigma_c}}{1-\sigma_c} + \xi_{u,t} A_{\chi} \left( \chi_{P,t}(i) - \xi_{\chi} \chi_{P,t-1} \right)^{1-\sigma_{\chi}} \right) - A_n \frac{n_{P,t}(i)^{1+\sigma_n}}{1+\sigma_n} \right\}$$

subject to the budget constraint

$$P_t c_{P,t}(i) + P_{\chi,t} \chi_{P,t}(i) - (1 - \delta_{\chi}) \chi_{P,t-1}(i) + D_t(i) \leq W_P n_{P,t}(i) + r_{k,t} k_P + R_t - 1 D_{P,t-1}(i) + \Pi_P$$

where $P_t$, $P_{\chi,t}$, $W_P$, $\delta_{\chi}$ and $\beta_P$ are, respectively, the price of consumption goods, the price of housing, the patient households’ nominal wage, the depreciation rate of housing and the discount rate. Moreover, $\xi_c$ and $\xi_{\chi}$ denote the degree of external habit formation for consumption and housing goods respectively. There are two preference shocks: (1) an intertemporal preference shock $\varepsilon_{u,t}$, which follows an AR(1) process with persistence $\rho_u$ and standard deviation of innovations $\sigma_u$; and (2) a housing preference shock $\varepsilon_{\chi,t}$ which follows an AR(1) process with persistence $\rho_{\chi}$ and standard deviation of innovations $\sigma_{\chi}$. Additionally, we assume that capital $k_P$ in the economy is constant and owned by patient households.

2.1.2 Impatient households

Impatient households - similarly as patient - optimize by choosing consumption $c_{I,t}$, housing services $\chi_{I,t}$, and labor supply $n_{I,t}$. They maximize the following lifetime utility function

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1We employ the following notational convention: all variables denoted with superscript $P$ or $I$ are expressed per patient or impatient household, respectively, while all other variables are expressed per all households. For example, $k_t$ denotes per capita capital and since only patient households own capital, capital per patient households is equal to $k_{P,t} = k_t / \omega_P$.

2We calibrate the model so that patient households save and never borrow. Therefore, to simplify notation, we eliminate credits (which they would not take anyway) from their budget constraint. Similarly, we eliminate deposits from impatient households’ budget constraint (7).
We also assume that each impatient household $\iota$ can take differentiated loans $L_{I,t}(\iota, j)$ from banks $j \in [0,1]$. These loans are aggregated according to the following formula

$$L_{I,t}(\iota) = \left[ \int_0^1 L_{I,t}(\iota, j) \frac{1}{1-\mu_L} dj \right]^{\mu_L}$$

where $\mu_L$ determines the elasticity of substitution between loan varieties. Their availability for households is subject to the following collateral constraint

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

where $m_{\chi}$—LTV ratio and $R_{L,t}$—the interest rate on loans, defined as

$$R_{L,t} = \left[ \int_0^1 R_{L,t}(j) \frac{1}{1-\mu_L} \right]^{1-\mu_L}$$

The budget constraint of impatient households takes the following form

$$P_{c_{I,t}}(\iota) + P_{\chi,t}(\chi_{I,t}(\iota) - (1-\delta_{\chi}) \chi_{I,t-1}(\iota)) + \int_0^1 R_{L,t-1}(j)L_{I,t-1}(\iota, j) dj \leq W_{I,t}n_{I,t}(\iota) + L_{I,t}(\iota)$$

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

From the household problem we get the following demand for differentiated loans from bank $j$, $L_{I,t}(j)$

$$L_{I,t}(j) = \left( \frac{R_{L,t}(j)}{R_{L,t}} \right)^{\frac{\mu_L}{1-\mu_L}} L_{I,t}$$

where, in equilibrium, $L_{I,t}(\iota, j) = L_{I,t}(j)$ and $L_{I,t}(\iota) = L_{I,t}$ for all $\iota \in I$.

2.1.3 Labor market

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

$$n_t = \left[ \frac{1}{\omega_P} n_{P,t}^{\phi_P-1} + (1-\omega_P) \frac{1}{\omega_n} n_{I,t}^{\phi_n-1} \right]^{\frac{\phi_n}{\phi_n-1}}$$
where
\[
\begin{align*}
    n_{P,t} &= \left[ \frac{1}{\omega_P} \int_0^{\omega_P} n_{P,t}(t) \frac{1}{\mu_w} dt \right]^{\mu_w} \\
    n_{I,t} &= \left[ \frac{1}{\omega_I} \int_0^{\omega_I} n_{I,t}(t) \frac{1}{\mu_w} dt \right]^{\mu_w}
\end{align*}
\]

We assume that wages for both types of households \(W_{P,t}\) and \(W_{I,t}\) are sticky. In each period, each household receives the Calvo signal to reoptimize wages with probability \((1 - \theta_w)\). 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 \(\pi\) denote inflation and its steady state value, respectively.

We assume perfect risk sharing across households of the same type. 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 and therefore using their discount factor. Consumption and housing producers use intermediate goods to produce consumption and housing goods, respectively. Intermediate goods producers produce distinct intermediate goods employing capital (the aggregate stock of capital is fixed) and labor. They operate in a monopolistically competitive environment.

#### 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 consumption goods according to the following technology
\[
c_t = \left( (1 - \eta_H) \frac{1}{\phi_c} c_{H,t}^{\phi_{c}-1} + \eta_H \frac{1}{\phi_c} c_{H,t}^{\phi_{c}-1} \right)^{\phi_{c}}
\]
where
\[
\begin{align*}
    c_{H,t} &= \left( \int_0^1 c_{H,t}(i) \frac{1}{\mu_c} di \right)^{\mu_c} \\
    c_{F,t} &= \left( \int_0^1 c_{F,t}(i) \frac{1}{\mu_c} di \right)^{\mu_c}
\end{align*}
\]

#### 2.2.2 Housing producers

In each period, perfectly competitive housing goods producers purchase undepreciated housing stocks from the previous period and produce new housing according to the following
\[
\chi_t = (1 - \delta) \chi_{t-1} + \varepsilon_{\chi,t} \left( 1 - S_{\chi} \left( \frac{i_{\chi,t}}{i_{\chi,t-1}} \right) \right) i_{\chi,t}
\]

(15)

where \( i_{\chi,t} \) denotes housing investment, produced with only domestic inputs

\[
i_{\chi,t} = \left( \int_0^1 i_{\chi,t}(i) \frac{1}{\mu_{\chi}} di \right)^{\mu_{\chi}}
\]

(16)

and \( \varepsilon_{\chi,t} \) denotes a housing investment specific technology shock, which follows an AR(1) process with persistence \( \rho_{\chi} \) and standard deviation of innovations \( \sigma_{\chi} \). Moreover, we assume that

\[
S_{\chi} \left( \frac{i_{\chi,t}}{i_{\chi,t-1}} \right) = \kappa_{\chi} \left( \frac{i_{\chi,t}}{i_{\chi,t-1}} - 1 \right)^2,
\]

where \( \kappa_{\chi} > 0 \).

### 2.2.3 Intermediate goods producers

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

\[
c_{H,t}(i) + \frac{1 - \omega}{\omega} c^*_H(i) + i_{\chi,t} = z_t k(i)^{\alpha} n_t(i)^{1-\alpha}
\]

(17)

where \( z_t \) denotes a productivity shock that follows an AR(1) process with persistence \( \rho_z \) and standard deviation of innovations \( \sigma_z \). 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 its price. Otherwise, prices are indexed according to

\[
\pi_{\zeta,t} = \zeta \pi_{t-1} + (1 - \zeta) \pi.
\]

### 2.3 Banking

In our economy banks consist of two branches: wholesale and retail. Both branches operate independently from each other. The wholesale branch operates in a competitive environment, but is subject to capital requirements. Following Gerali et al. (2010), we assume exogenous capital requirements that we use as a policy instrument. Capital requirements introduce a wedge between the lending and borrowing rate. Additionally, monopolistic competition in the retail branch enlarges the wedge.

#### 2.3.1 Wholesale banking

In our economy, bank capital \( K_{b,t} \) accumulates with proceedings from both wholesale and retail branches. We assume that a fraction \( \omega_b \) of banks profits (from both branches) \( J_{b,t} \) is kept for bank capital creation and the rest is repaid to shareholders (in our case private households). Additionally, since resources are used in banking activity, we assume that banking capital depreciates at the rate \( \delta_b \). The bank capital of bank \( j \) evolves according to
the following formula
\[ K_{b,t}(j) = (1 - \delta_b)K_{b,t-1}(j) + \omega_bJ_{b,t}(j) \] (18)

Moreover, we impose a quadratic costs $\psi_t$ (parametrized by coefficient $\kappa_b$) on wholesale banks for deviating from the target capital to assets ratio $v_t$.

The wholesale branch takes loans in the domestic interbank market $\tilde{L}_{Hb,t}(j)$, at the policy rate $R_t$, loans in the foreign interbank market $\tilde{L}_{Fb,t}$, at the policy rate adjusted for risk premium $\varrho_t R^*_t$, and uses them together with bank capital to finance loans $L_{b,t}(j)$ extended to retail banks at the rate $R_{Lb,t}$

\[ L_{b,t}(j) = \tilde{L}_{Hb,t}(j) + \tilde{L}_{Fb,t} + K_{b,t}(j) \] (19)

Note, the risks premium behaves according to the following formula
\[ \varrho_t = 1 + \xi \left( \exp \left( \frac{d_t}{y_t} - \frac{d}{y} \right) - 1 \right) \] (20)

where $d_t = (\tilde{L}_{Fb,t} + \frac{1-\omega}{\omega} \tilde{L}^*_{Hb,t})/P_t$ denotes the real net debt of the periphery against the core, $y_t$ denotes real output and the variables without time subscripts their respective steady state values. The branch goal is to maximize, taking the interest rates as given, the discounted sum of real cash flows\(^3\)

\[ E_0 \sum_{t=0}^{\infty} \frac{\Lambda_{0,t+1}}{P_{t+1}} \left[ R_{Lb,t}L_{b,t} - R_t \tilde{L}_{Hb,t} - \varrho_t R^*_t \tilde{L}_{Fb,t} - \psi(L_{b,t}, K_{b,t}) \right] \] (21)

where
\[ \psi_t(L_{b,t}, K_{b,t}) = \frac{\kappa_b}{2} \left( \frac{K_{b,t}}{L_{b,t}} - v_t \right)^2 K_{b,t} \] (22)

subject to (18) and (19).

The quadratic costs drives a spread between the policy rate and the wholesale lending rate. The first order conditions of the above problem give

\[ R_{Lb,t} = R_t - \kappa_b \left( \frac{K_{b,t}}{L_{b,t}} - v_t \right) \left( \frac{K_{b,t}}{L_{Hb,t}} \right)^2 \] (23)

as well as the equality of the interest rates between the periphery and the core

\[ R_t = \varrho_t R^*_t. \] (24)

\(^3\)Note, that since banks are owned by patient households we use the discount factor from patient household $\Lambda_{0,t} = \beta^t u_c(t)/u_c(0)$, where $u_c(t)$ denotes the derivative of instantaneous utility function in period $t$ with respect to $c_t$. 

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2.3.2 Retail banking

Retail banks operate in a monopolistically competitive environment and set the interest rate $R_{L,t}(j)$ to maximize

$$ (R_{L,t+1}(j) - R_{Lb,t})L_t(j) $$

given (8) (note that $\omega_t L_{I,t}(j) = L_t(j)$).

By solving the banks’ problem subject to the demand for loans from impatient households, we get the following equilibrium relation between the retail lending rate and the wholesale lending rate

$$ R_{L,t} = \mu_L R_{Lb,t} $$

2.4 Macropuindential policy

In our model we study the effects of two macroprudential policy instruments. Throughout the paper we consider at most one tool at a time, when the given tool is not used it is kept at the steady state level. The macroprudential authority can control the LTV ratio according to the following rule

$$ m_{X,t} = (1 - \gamma_m)m_X + \gamma_m m_{X,t-1} + (1 - \gamma_m)\gamma_{my} \left( \frac{y_t}{y} - 1 \right) $$

or the capital adequacy ratio using the following rule

$$ v_t = (1 - \gamma_v)v + \gamma_v v_{t-1} + (1 - \gamma_v)\gamma_{vy} \left( \frac{y_t}{y} - 1 \right) $$

2.5 Closing the model

2.5.1 GDP and Balance of Payments

We define GDP as

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

and the balance of payments is

$$ \frac{1 - \omega}{\omega} P_{H,t} c_{H,t}^* d_t = P_{F,t} c_{F,t} + \rho_{t-1} R_{t-1}^* d_{t-1} $$

where $P_{H,t}^*$ and $P_{F,t}$ denote the price of, respectively, exports and imports of the periphery.
2.5.2 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

\[
\frac{R_t^*}{R_t^{*\text{t}}} = \left( \frac{R_{t-1}^*}{R_t^{*\text{t}}} \right)^{\gamma_R} \left[ \left( \frac{\tilde{\pi}_t^*}{\pi_t^*} \right)^{\gamma_{\pi}} \left( \frac{\tilde{y}_t^*}{y_t^*} \right)^{\gamma_y} \right]^{1-\gamma_R} e^{\varepsilon_{R,t}^*} \tag{31}
\]

where

\[
\tilde{y}^* = \omega y_t + (1 - \omega)y_t^*
\]
\[
\tilde{\pi}_t^* = (\pi_t)^\omega (\pi_t^*)^{1-\omega}
\]

Note variables without time subscripts denote their respective steady state values and \(\varepsilon_{R,t}^*\) is a monetary policy shock with a standard deviation \(\sigma_{R}^*\).

2.5.3 Market clearing

We impose a standard set of market clearing conditions. Housing market clearing implies

\[
\omega_P^* \chi_{P,t} + \omega_I^* \chi_{I,t} = \chi_t \tag{32}
\]

and the consumption good resource constraint is

\[
\omega_P^* c_{P,t} + \omega_I^* c_{I,t} = c_t \tag{33}
\]

Factor markets clear when

\[
\int_0^1 k_t(i) = \omega_P^* k_{P,t} \tag{34}
\]
\[
\int_0^1 n_t(i) = n_t \tag{35}
\]

Finally, we have market clearing for loans

\[
L_{b,t} = \int_0^1 L_t(j) dj = \int_0^1 \int_{\tau \in I} L_{I,t}(\tau, j) d\tau dj. \tag{36}
\]

Note, that there is no corresponding market clearing for deposits since they are cleared by open market operations necessary to keep the policy rate (which is the same as deposit rate) at the target level.
3 Calibration

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, in our calibration the core and periphery differ only in size and shock realizations. The calibrated values of structural parameters are summarized in Table 1. Throughout, the unit of time is one quarter.

We set the relative size of the periphery to 1%, which roughly corresponds to the GDP share in the euro area of such countries like Greece, Ireland or Portugal. This calibration also implies that the core is essentially 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 Bussière et al. (2011) 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 0.003.

Households’ preferences are calibrated in line with the literature. The discount factors for patient and impatient households are set to 0.99 and 0.975, respectively, similarly to Iacoviello and Neri (2010). The inverse of the intertemporal elasticity of substitution in consumption and housing, as well as the inverse of the Frisch elasticity of labor supply are all set to 2, as it is common in the macro literature. The degree of habit formation in consumption and housing are both calibrated at 0.7. The LTV ratio is set to 0.75.

We choose the same steady-state markups in the labor and product markets of 20%. As in Coenen et al. (2008), the elasticity of substitution between domestic and imported consumption goods is calibrated at 1.5, while that between labor of patient and impatient households at 6. The capital share in output is set to a standard value of 0.3.

While calibrating nominal rigidities, we follow closely Christoffel et al. (2008). The Calvo probabilities for wages, domestic prices and export prices are set to 0.75, 0.9 and 0.75, respectively. The corresponding indexation parameters are all calibrated at 0.5. 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. The sensitivity of the risk premium is fixed at 0.001, which ensures that foreign debt is stabilized at zero in the long run without substantially affecting the model’s short-run dynamics.

The target ratio of bank capital to loans is set to 0.1, roughly in line with the average capital adequacy ratios maintained by European commercial banks. The share of retained profits in the banking sector is calibrated at 0.85. This implies a dividend payout ratio that

\(^4\)To be specific, Coenen et al. (2008) distinguish between Ricardian and rule-of-thumb consumers, the latter having no access to financial markets.
is lower than the EU average over the period 2000-2008 reported by Onali (2012). However, a more conservative dividend policy looks more likely in the aftermath of the financial crisis. The bank capital adjustment cost curvature is set to 10, consistently with the estimates in Gerali et al. (2010).

As regards the monetary policy feedback rule, we assume a standard set of parameters, i.e. interest rate smoothing equal to 0.9, the long-run response to inflation of 2 and that to output equal to 0.15. This parametrization is roughly consistent with estimated DSGE models for the euro area. The steady state inflation rate is set to 0.5% quarterly, in line with the ECB inflation target.

Several parameters are calibrated to match a few key steady state ratios, reported in Table 3, using the euro area 1995-2011 averages as the targets. We fix the housing weight in utility at 2.34 to match the steady state housing stock to output ratio of 2.32. We assume that the housing stock depreciates at 1% quarterly, which implies the long-run residential investment share in output equal to 9.4%. The weight of impatient agents is calibrated at 0.55 to match the steady state mortgage debt to output ratio of 76%. Setting the physical capital stock to 6.5 and labor weight in utility to 880 allows us to match the long-run capital-output ratio of 2 and the share of time spent at work of 33%. Following Coenen et al. (2008), we calibrate the transfers from patient to impatient households such that the steady state per capita consumption of the latter is not more than 25% lower than that of the former. The markup in financial intermediation is calibrated to fit the average spread between the lending rate and the policy rate of 190 bp annually. Finally, fixing the bank capital depreciation rate at 0.048 ensures that the bank capital to loans ratio is exactly on target in the steady state.

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 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.

Our calibration of the shock processes is summarized in Table 2. It is aimed to match the standard moments of the euro area data and to be at the same time consistent with the empirical literature. We assume a standard value of 0.95 for the inertia of technology shocks. Following Parie’s et al. (2011), housing preference shocks are assumed substantially more persistent. The same applies to the other pair of preference shocks, which helps in

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5 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 the housing stock come from the ECB database.
matching a positive correlation between consumption and residential investment observed in the data. The standard deviations of all shocks are broadly consistent with the estimated DSGE models for the euro area.

The results of the moment matching are summarized in Table 4. The model is quite successful in matching the volatilities of the main macro-categories. In particular, it gets the standard deviations of consumption, residential investment and loans more or less right, 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 the 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 a 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 core. According to the model, consumption in the core is mainly driven by preference 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 specific) that account for the bulk of movements in this variable. Housing market shocks are also important for loans, but it is the monetary policy shock that explains most of the 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 broadly 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 almost entirely by domestic disturbances. At the other extreme, domestic shocks play very little role in explaining fluctuations in the periphery’s inflation and credit cost.

4 The effects of macroprudential policy

In this section we discuss how our macroprudential policy tools work. To this end, on Figures 2-6 we present impulse response functions to various shocks and explain how transmission
of the shocks changes once macroprudential policy is turned on. Several conclusions can be drawn.

First, starting with the case of no macroprudential policy, impulse responses follow a pattern well known from the literature either on new-Keynesian or macrofinancial models. For instance, in response to a productivity shock investment and output increase, while inflation declines. In response to a monetary policy shock both real and nominal variables decline (with the obvious exception of the interest rate). The consumption preference shock raises consumption and output. Shocks to housing preference and housing investment, while less familiar from the literature, also give intuitive responses. For instance after the former, loans increase and households attempt to acquire housing. As a result house prices increase which triggers a surge in residential investment. This translates into higher output and inflation. After a housing investment shock residential investment becomes more profitable and increases. This crowds out private consumption and dampens house prices, decreasing available collateral and lending. In the short term the overall impact on output is negative, but later GDP increases. Higher demand translates into higher inflation.

Second, and probably more interesting, we discuss the modification to impulse responses generated by macroprudential policy. Let us first analyze the LTV policy described by equation (27).\(^6\) Consistently with its mandate and functional form, this policy dampens the impact of all shocks on output. The way it works its way through the economy is related to the collateral constraint (5). For instance, tighter LTV standards decrease the available amount of loans thus trimming consumption and lowering output and inflation.

The second policy tool described by equation (28) has similar macroeconomic effects as regards direction, but its impact on the economy is much weaker. This is related to the different channels it works through. While LTV policy affects directly the amount of lending, the capital adequacy policy has a significant ingredient of price effects. Tighter capital adequacy standards increase banks’ costs and so contribute to higher lending rates. The subsequent fall in lending results from higher borrowing costs.

From many perspectives both policies have similar effects. First, in case of shocks that initially move output and inflation in the same direction macroprudential policy oriented at stabilizing output stabilizes inflation as well. This is for instance the case of a housing preference shock. Things look different after supply side (e.g. productivity) shocks, when output and inflation move in opposite directions. In such cases macroprudential policy has a destabilizing impact on inflation. Second, one should note that macroprudential policy dampens the effects of monetary policy shocks on inflation and output. This, together with

\(^6\)For generating impulse responses we choose policy rule parameters from the efficient frontiers described in Section 5 (Figures 7 and 8) such that the LTV standard deviation equals 2.5% (\(\gamma_m = 0.75\) and \(\gamma_{my} = -25\)) and the CA standard deviation equals 1% (\(\gamma_v = 0.99\) and \(\gamma_{vy} = 60\)). These values have been chosen arbitrarily to represent relatively active policies.
earlier findings, shows the potential for conflicts between the two policies.\footnote{This problem has already been discussed in the literature (e.g. Angelini et al., 2010). In our study we do not explore it further.}

5 Simulations and results

We are now ready to use our model for simulation purposes. We proceed in several steps. As a starting point we show the performance of our small (peripheral) economy under the assumption of not participating in the common currency area. The country runs independent monetary policy under a floating exchange rate. Next, we fix the exchange rate and assume monetary policy is taken over by the common central bank. While the latter reacts formally to area-wide output and inflation, given our baseline calibration where the small economy constitutes only 1% of the currency area, its reactions are almost completely determined by the performance of the large (foreign) economy. This means that the small economy looses protection against asymmetric shocks provided by monetary policy and exchange rate adjustment. Further on, we turn on macroprudential policy in the domestic economy and check, whether it is able to make up for the loss of independent monetary policy in the environment of asymmetric shocks. Finally, we check whether independent (decentralized) macroprudential policy can be substituted by an area-wide policy.

One important caveat is related to the precise design of macroprudential rules. While the functional form and parametrization of monetary policy rules has been researched in detail, not much is known about macroprudential rules. Since experience of supervisors does not offer any guidance yet, we decided to present a broad range of results in the form of policy frontiers. We define our policy trade-off space as consisting of the variability of output and of the respective policy instrument. This can be seen as an analogue to the more familiar case of monetary policy, which faces trade-offs between the variability of output, inflation and the interest rate. In contrast to monetary policy, macroprudential supervision is supposed to use instruments specific to the performance of bank credit with the objective of stabilizing cyclical developments. However, similarly to monetary authorities they seem unlikely to allow for too much variability of their instruments.

In order to present the trade-off and potential gains from introducing macroprudential policy we conduct stochastic simulations (with shocks as described in Section 3) and run a grid search over various parameters of the macroprudential rules (27) and (28). In particular in case of the LTV rule we allow $\gamma_m$ to vary between 0 and 0.99 with a step of 0.03 and $\gamma_{my}$ to vary between -100 and 0 with increment 10. In case of the rule for capital requirements $\gamma_v$ is allowed to change from 0 to 0.99 with a step of 0.03 and $\gamma_{vy}$ from 0 to 100 with increment 10.

Next, we find the efficient policy frontier, by selecting the points that envelope our results.

\begin{align*}
\end{align*}
towards the origin.

Figure 7 depicts the policy frontier for the LTV policy together with level of output volatility under independent monetary policy. Since the latter clearly depends on the strength of central bank’s response to output deviations, in addition to our baseline calibration we also show it assuming a stronger feedback from output to interest rates. The upper left point of the frontier denotes inactive macroprudential policy. Moving along the frontier increases the variance of the instrument (macroprudential policy becomes more active) and, up to a certain point, reduces the variance of output.

The main conclusions from the Figure are as follows. First, joining the monetary union raises volatility of output from 1.70% to 1.99%. This is clearly the consequence of substituting monetary policy that reacts to domestic developments with one that reacts (mainly) to foreign ones. Second, substituting independent monetary policy with macroprudential policy can help stabilizing the economy. To what extent it is possible to compensate for the loss of the flexible exchange rate and independent monetary policy depends on the assumed Taylor rule parameter. In our baseline calibration ($\gamma_y = 0.15$) this is possible with relatively low volatility of the instrument ($\sigma_{m_x} \simeq 0.5\%$). However, to compete with more active independent monetary policy ($\gamma_y = 0.5$) requires substantially larger volatility of the instrument ($\sigma_{m_x} \simeq 1.9\%$).

Let us now move to the second policy instrument $\nu$. Its working is described on Figure 8. While the pattern looks similar, the details differ substantially from the previous policy. CA policy is able to lower output volatility as well, but its effectiveness is much lower. For instance with a 1 percentage point volatility of the instrument, output volatility is decreased only by 0.2 percentage points. Making up for the loss of independent monetary policy under the assumption of relatively inactive monetary policy ($\gamma_y = 0.15$) requires $\sigma_{\nu} \simeq 1.8\%$ and more active independent monetary policy ($\gamma_y = 0.5$) cannot be beaten.

In our second experiment we check whether macroprudential policy is able to trade off some shocks better than others. This is an important question in the debate on euro area imbalances, since it can be presumed that shocks related to e.g. asymmetric interest rate or housing shocks could have played an important role in driving the imbalances. To answer this question we run stochastic simulations with one shock turned on at a time. Doing this we concentrate on shocks specific to the peripheral economy. Figures 9-10 present the efficient policy frontiers for LTV and CA policies respectively. LTV policy is most efficient at trading off shocks related to the housing market (housing preference and investment spe-

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8At 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.
cific) and to monetary policy. CA policy is best for housing preference shocks, although, as described before, overall this policy can reduce volatilities to a lesser extent than LTV policy. Both policies do a particularly bad job in stabilizing the economy after productivity shocks. 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.

Our final experiment aims at checking how well common macroprudential policy would work as compared to decentralized policy. To this end we conduct two grid searches assuming the same macroprudential policy for the whole euro area and independent policies in the core and periphery. The results (policy frontiers for volatilities in periphery) are depicted on Figures 11-12. It is clear that common macroprudential policy fares much worse then the decentralized one. For the LTV instrument common policy is almost completely inefficient - the efficient frontier consists of only three points. In most cases LTV policy raises both output and instrument volatility in the peripheral economy. For the CA instrument (Figure 12) common policy is able to efficiently trade-off output and instrument volatility, but the outcome is much worse than under policy independence.

6 Conclusions

In this paper we ask the question 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. To this end we construct a dynamic, stochastic general equilibrium model of two regions forming a monetary union. In addition to standard features of a new-Keynesian model our framework features independently regulated banking sectors that grant loans to households subject to collateral constraints.

Next we run a number of simulations, showing how the peripheral economy behaves under various policy assumptions. In particular, we test two types of macroprudential policy (on oriented at regulating the Loan-to-value ratio and one focused on the capital adequacy ratio) and check whether they 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, the two macroprudential policies are able to lower output volatilities in the periphery, even to levels lower than what would be obtained under independent monetary policy (without macroprudential policy). Of course this comes at the cost of increasing volatility of the respective policy instrument. Second, macroprudential policy is particularly efficient at trading-off monetary policy shocks and shocks related to the housing market. Since these shocks are the usual suspects behind the asymmetric devel-
opments between core and periphery of the euro area, this conclusion strengthens our case for macroprudential policy as a stabilizing tool. However, (this being our third conclusion), if macroprudential policy is to prevent desynchronization of business cycles between the core and periphery it must be decentralized. Common macroprudential policy either lowers output volatility in periphery by much less than a decentralized one (CA policy) or is not able to stabilize the peripheral economy at all (LTV policy).

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. The main prerequisite is, however, that the policy be applied on a decentralized basis. Common policy does not solve the problem.
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Gerali, Andrea, Stefano Neri, Luca Sessa, and Federico M. Signoretti (2010) ‘Credit and banking in a DSGE model of the euro area.’ Journal of Money, Credit and Banking 42(s1), 107–141


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### Tables and figures

#### Table 1: Calibration - parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_P, \beta_P^*$</td>
<td>0.99</td>
<td>Discount factor, patient HHs</td>
</tr>
<tr>
<td>$\beta_I, \beta_I^*$</td>
<td>0.975</td>
<td>Discount factor, impatient HHs</td>
</tr>
<tr>
<td>$\delta_P, \delta_P^*$</td>
<td>0.01</td>
<td>Housing stock depreciation rate</td>
</tr>
<tr>
<td>$\omega_I, \omega_I^*$</td>
<td>0.55</td>
<td>Share of impatient HHs</td>
</tr>
<tr>
<td>$A_X, A_X^*$</td>
<td>2.43</td>
<td>Weight on housing in utility function</td>
</tr>
<tr>
<td>$A_n, A_n^*$</td>
<td>880</td>
<td>Weight on labor in utility function</td>
</tr>
<tr>
<td>$\sigma_c, \sigma_c^*$</td>
<td>2</td>
<td>Inverse of intertemporal elasticity of substitution in consumption</td>
</tr>
<tr>
<td>$\sigma_P, \sigma_P^*$</td>
<td>2</td>
<td>Inverse of intertemporal elasticity of substitution in housing</td>
</tr>
<tr>
<td>$\sigma_n, \sigma_n^*$</td>
<td>2</td>
<td>Inverse of Frisch elasticity of labor supply</td>
</tr>
<tr>
<td>$\xi_c, \xi_c^*$</td>
<td>0.7</td>
<td>Degree of external habit formation in consumption</td>
</tr>
<tr>
<td>$\xi_X, \xi_X^*$</td>
<td>0.7</td>
<td>Degree of external habit formation in housing</td>
</tr>
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<td>$\theta_w, \theta_w^*$</td>
<td>0.75</td>
<td>Calvo probability for wages</td>
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<td>$\zeta_w, \zeta_w^*$</td>
<td>0.5</td>
<td>Indexation parameter for wages</td>
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<td>$\mu, \mu^*$</td>
<td>1.2</td>
<td>Labor markup</td>
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<tr>
<td>$\alpha, \alpha^*$</td>
<td>6</td>
<td>Elasticity of substitution btw. labor of patient and impatient HHs</td>
</tr>
<tr>
<td>$t, t^*$</td>
<td>0.51</td>
<td>Real transfers from patient to impatient HHs</td>
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<tr>
<td>$\mu_L, \mu_L^*$</td>
<td>1.0047</td>
<td>Loan markup</td>
</tr>
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<td>$m_X, m_X^*$</td>
<td>0.75</td>
<td>Steady state LTV ratio</td>
</tr>
<tr>
<td>$\nu, \nu^*$</td>
<td>0.1</td>
<td>Steady state target bank capital to loans ratio</td>
</tr>
<tr>
<td>$\kappa_b, \kappa_b^*$</td>
<td>10</td>
<td>Curvature of capital requirement penalty function</td>
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<tr>
<td>$\omega_b, \omega_b^*$</td>
<td>0.85</td>
<td>Share of retained profits in the banking sector</td>
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<td>$\delta_b, \delta_b^*$</td>
<td>0.048</td>
<td>Bank capital depreciation rate</td>
</tr>
<tr>
<td>$\pi, \pi^*$</td>
<td>1.005</td>
<td>Steady state inflation</td>
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<tr>
<td>$\xi$</td>
<td>0.001</td>
<td>Elasticity of risk premium wrt. foreign debt</td>
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<td>$\gamma_R$</td>
<td>0.9</td>
<td>Interest rate smoothing in Taylor rule</td>
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<td>$\gamma_\pi$</td>
<td>2</td>
<td>Response to inflation in Taylor rule</td>
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<tr>
<td>$\gamma_\pi^*$</td>
<td>0.15</td>
<td>Response to output in Taylor rule</td>
</tr>
<tr>
<td>$\omega$</td>
<td>0.01</td>
<td>Share of periphery in monetary union</td>
</tr>
<tr>
<td>$\eta_c$</td>
<td>0.7</td>
<td>Share of domestic goods in consumption basket (periphery)</td>
</tr>
<tr>
<td>$\eta_c^*$</td>
<td>0.003</td>
<td>Share of imported goods in consumption basket (core)</td>
</tr>
<tr>
<td>$\phi_c, \phi_c^*$</td>
<td>1.5</td>
<td>Elasticity of substitution btw. home and foreign goods</td>
</tr>
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### Table 2: Calibration - stochastic shocks

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
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<tbody>
<tr>
<td>$\rho_z, \rho_z^*$</td>
<td>0.95</td>
<td>Productivity shock - autocorrelation</td>
</tr>
<tr>
<td>$\sigma_z, \sigma_z^*$</td>
<td>0.0065</td>
<td>Productivity shock - standard deviation</td>
</tr>
<tr>
<td>$\rho_u, \rho_u^*$</td>
<td>0.99</td>
<td>Preference shock - autocorrelation</td>
</tr>
<tr>
<td>$\sigma_u, \sigma_u^*$</td>
<td>0.013</td>
<td>Preference shock - standard deviation</td>
</tr>
<tr>
<td>$\rho_x, \rho_x^*$</td>
<td>0.99</td>
<td>Housing preference shock - autocorrelation</td>
</tr>
<tr>
<td>$\sigma_x, \sigma_x^*$</td>
<td>0.008</td>
<td>Housing preference shock - standard deviation</td>
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<tr>
<td>$\rho_i, \rho_i^*$</td>
<td>0.95</td>
<td>Investment specific shock - autocorrelation</td>
</tr>
<tr>
<td>$\sigma_i, \sigma_i^*$</td>
<td>0.011</td>
<td>Investment specific shock - standard deviation</td>
</tr>
<tr>
<td>$\sigma_R$</td>
<td>0.0013</td>
<td>Monetary shock - standard deviation</td>
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### Table 3: Steady state ratios

<table>
<thead>
<tr>
<th>Steady state ratio</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Import to output ratio (periphery)</td>
<td>0.27</td>
</tr>
<tr>
<td>Import to output ratio (core)</td>
<td>0.003</td>
</tr>
<tr>
<td>Residential investment to output ratio</td>
<td>0.094</td>
</tr>
<tr>
<td>Capital-output ratio (annual)</td>
<td>2.0</td>
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<tr>
<td>Hours worked</td>
<td>0.33</td>
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<tr>
<td>Housing wealth to output ratio (annual)</td>
<td>2.32</td>
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<tr>
<td>Debt to output ratio (annual)</td>
<td>0.76</td>
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<tr>
<td>Bank capital to loans ratio</td>
<td>0.1</td>
</tr>
<tr>
<td>Spread (annualized)</td>
<td>0.019</td>
</tr>
<tr>
<td>Relative consumption of impatient HHs</td>
<td>0.77</td>
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</table>

### Table 4: Moment matching - core

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Data</td>
<td>Model</td>
<td>Data</td>
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<tr>
<td>Consumption</td>
<td>2.25</td>
<td>2.07</td>
<td>0.97</td>
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<tr>
<td>Residential investment</td>
<td>6.97</td>
<td>6.99</td>
<td>0.97</td>
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<tr>
<td>Mortgage loans</td>
<td>5.51</td>
<td>5.41</td>
<td>0.98</td>
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<tr>
<td>Real house prices</td>
<td>3.94</td>
<td>3.18</td>
<td>0.98</td>
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<tr>
<td>Mortgage interest rate</td>
<td>0.30</td>
<td>0.42</td>
<td>0.98</td>
</tr>
<tr>
<td>Inflation</td>
<td>0.28</td>
<td>0.39</td>
<td>0.32</td>
</tr>
</tbody>
</table>

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 mortgage interest rate is quarterly interest on housing loans to households. All these variables are taken from Eurostat. Real estate 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 SWD 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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Productivity</th>
<th>Preference</th>
<th>Housing pref.</th>
<th>Inv. specific</th>
<th>Monetary</th>
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<tbody>
<tr>
<td>Consumption</td>
<td>20.1</td>
<td>63.4</td>
<td>1.5</td>
<td>2.5</td>
<td>12.5</td>
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<td>Residential investment</td>
<td>42.4</td>
<td>3.4</td>
<td>30.5</td>
<td>23.3</td>
<td>0.4</td>
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<tr>
<td>Mortgage loans</td>
<td>3.2</td>
<td>0.8</td>
<td>17.4</td>
<td>26.8</td>
<td>51.8</td>
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<tr>
<td>Real house prices</td>
<td>21.0</td>
<td>0.2</td>
<td>4.9</td>
<td>58.8</td>
<td>15.2</td>
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<td>Mortgage interest rate</td>
<td>69.8</td>
<td>12.7</td>
<td>0.2</td>
<td>2.2</td>
<td>15.1</td>
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<tr>
<td>Inflation</td>
<td>69.4</td>
<td>24.9</td>
<td>0.1</td>
<td>0.4</td>
<td>5.2</td>
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### Table 6: Variance decomposition - periphery

<table>
<thead>
<tr>
<th>Variable</th>
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<th>Preference</th>
<th>Housing pref.</th>
<th>Inv. specific</th>
<th>Foreign</th>
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<tbody>
<tr>
<td>Consumption</td>
<td>28.9</td>
<td>32.8</td>
<td>1.5</td>
<td>1.5</td>
<td>35.3</td>
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<tr>
<td>Residential investment</td>
<td>29.6</td>
<td>0.6</td>
<td>31.1</td>
<td>32.1</td>
<td>6.6</td>
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<tr>
<td>Mortgage loans</td>
<td>2.3</td>
<td>2.2</td>
<td>19.4</td>
<td>19.4</td>
<td>56.7</td>
</tr>
<tr>
<td>Real house prices</td>
<td>3.2</td>
<td>0.6</td>
<td>6.7</td>
<td>52.8</td>
<td>36.7</td>
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<tr>
<td>Mortgage interest rate</td>
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<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>99.4</td>
</tr>
<tr>
<td>Inflation</td>
<td>5.9</td>
<td>0.1</td>
<td>0.0</td>
<td>0.1</td>
<td>93.9</td>
</tr>
</tbody>
</table>
Figure 1: Stylized facts on imbalances in the euro area

Residential investment

House Prices

Housing loans

Price level

Note: The dashed line represents core members and the solid line peripheral members.
Figure 2: Impulse responses to a productivity shock
Figure 3: Impulse responses to a monetary policy shock

- Output
- Consumption
- Residential investment
- Loans
- Real house prices
- Lending rate
- Inflation
- LTV
- Capital adequacy ratio
Figure 4: Impulse responses to a consumption preference shock

- Output
- Consumption
- Residential investment
- Loans
- Real house prices
- Lending rate
- Inflation
- LTV
- Capital adequacy ratio

Legend:
- no policy
- LTV policy
- CA policy
Figure 5: Impulse responses to a housing preference shock

- Output
- Consumption
- Residential investment
- Loans
- Real house prices
- Lending rate
- Inflation
- LTV
- Capital adequacy ratio

Legend:
- solid line: no policy
- dashed line: LTV policy
- dotted line: CA policy
Figure 6: Impulse responses to a housing investment shock
Figure 7: Efficient policy frontier for LTV policy (composition of shocks)

Note: Dots denote the policy frontier for LTV policy under monetary union. Horizontal lines denote the standard deviation of output under independent monetary policy with denoted value of $\gamma_y$. 
Figure 8: Efficient policy frontier for CA policy (composition of shocks)

Note: Dots denote the policy frontier for CA policy under monetary union. Horizontal lines denote the standard deviation of output under independent monetary policy with denoted value of $\gamma_y$. 


Figure 9: Efficient policy frontiers for LTV policy under various shocks
Figure 10: Efficient policy frontiers for CA policy under various shocks
Figure 11: Efficient policy frontiers for common and decentralized LTV policy
Figure 12: Efficient policy frontiers for common and decentralized CA policy