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Working Paper no. 23

December 2012

**CEPREMAP**

CENTRE POUR LA RECHERCHE ECONOMIQUE ET SES APPLICATIONS

142, rue du Chevaleret — 75013 Paris — France

<http://www.cepremap.ens.fr>

# Macroprudential Measures, Housing Markets, and Monetary Policy

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18 November 2012

## Abstract

The recent financial crisis has raised the discussion among policy makers and researchers on the need of macroprudential policies to avoid systemic risks in financial markets. However, these new measures need to be combined with the traditional ones, namely monetary policy. The aim of this paper is to study how the interaction of macroprudential and monetary policies affect the economy. We take as a baseline a dynamic stochastic general equilibrium (DSGE) model which features a housing market in order to evaluate the performance of a rule on the loan-to-value ratio (LTV) interacting with the traditional monetary policy conducted by central banks. We find that, introducing the macroprudential rule mitigates the effects of booms on the economy by restricting credit. Furthermore, when both policies are active, interest-rate shocks have weaker effects on the economy. From a normative perspective, results show that the combination of monetary policy and the macroprudential rule is unambiguously welfare enhancing, especially when monetary policy does not respond to output and house prices and only to inflation.

Keywords: Macroprudential, monetary policy, collateral constraint, credit

JEL Classification: E32, E44, E58

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*"Looking forward, it is clear that the global recovery cannot be sustained without adequate policy actions devoted to long-term economic stability and a healthier financial system [...] In particular, experience suggests that preemptive prudential measures that seek to moderate credit and asset price booms can complement traditional monetary policy actions."* Jaime Caruana, June 17, 2010.

## 1 Introduction

The recent financial crisis has made it evident the necessity of introducing policies and regulations that adapt to changes in the financial environment. In a fragile global economy, traditional measures have not seemed to be sufficient to avoid the crisis and have a fast and effective recovery. The complexity and the fragility of financial markets have contributed to the extent of the recession and the high level of unemployment and make obvious the new regulatory approach. The growing interconnection of financial markets raises an urgent need of having a sound financial system. The crisis and its consequences have opened a real debate about the reforms that need to be made in the financial and regulatory system, and in the policy instruments that have to be used in order to avoid similar episodes.

The new direction of policy interventions may be a so-called macroprudential approach to mitigate the risk of the financial system as a whole, that is, the systemic risk. The term macroprudential refers to the use of prudential tools to explicitly promote the stability of the financial system in a global sense, not just the individual institutions. The goal of this kind of regulation and supervision would be to avoid the transmission of financial shocks to the broader economy.

This debate was the focus of the 13th annual International Banking Conference, sponsored by the International Monetary Fund and the Federal Reserve Bank of Chicago on September 23-24 2010. There, participants discussed about the theory behind macroprudential (financial system level) regulations and analyzed the inadequacy of past supervisory practices that relied exclusively on microprudential (individual firm level) policy.

The Financial Stability Board, the Bank for International Settlements and the International Monetary Fund define macroprudential policy as “a policy that uses primarily prudential tools to limit systemic or system-wide financial risk, thereby limiting the incidence of disruptions in the provision of key financial services that can have serious consequences for the real economy, by dampening the build-up of financial imbalances and building defences that contain the speed and sharpness of subsequent downswings and their effects on the economy; identifying and addressing common exposures, risk

concentrations, linkages and interdependencies that are sources of contagion and spillover risks that may jeopardize the functioning of the system as a whole<sup>1</sup>.”

The same institutions define systemic risk as “a risk of disruption to financial services that is caused by an impairment of all or parts of the financial system and has the potential to have serious negative consequences for the real economy<sup>2</sup>”. (For these purposes, “financial services” include credit intermediation, risk management and payment services)

In the aftermath of the crisis, policymakers and researchers coincide in the need to change the regulatory framework to a macroprudential view. However, it has become evident that we do not totally understand what systemic risk means and how it affects the macroeconomy. Then, in order to implement a sound macroprudential policy, it is important to fully understand the interactions between the financial sector, institutions and markets, other policies, and the macroeconomy. Furthermore, under a new regulation setting, we need to think again about the effectiveness of traditional policies such as monetary policy. It is crucial to understand how the new macroprudential measures affect the conduction of monetary policy and to monitor and evaluate those policies. In the short run, monetary policy actions to activate the recovery will only have its proper effect if they are transmitted through a correctly working financial system. A stable financial system may deliver a monetary policy transmission mechanism in which the goals of the central bank are achieved in a more effective manner. In the long run, macroprudential policies conducted by central banks may reinforce the primary objectives of monetary policy, apart from ensuring a financial stability objective. Moderating credit and asset price cycles may help achieve the long-run price stability and stable economic growth objective. All this is a real challenge for central bankers and policy makers. Research is needed in order to assess not only the effects of specific macroprudential policy instruments but also what the interactions with the standard monetary policy are.

Following this line of research, this paper uses a dynamic stochastic general equilibrium (DSGE) model with features a housing market in order to evaluate the effects on the main macroeconomic variables and on welfare of a rule on the loan-to-value ratio (LTV).

The interaction between housing markets, macroprudential and monetary policy is crucial. Following Volcker (2010), dangerous excesses in housing markets together with other prolonged disequilibria in the economy accounted for the severity of the recession and the elated financial turmoil. The rapid rise in

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<sup>1</sup>See Financial Stability Board, Bank for International Settlements and International Monetary Fund (2011), page 2.

<sup>2</sup>See Financial Stability Board, Bank for International Settlements and International Monetary Fund (2009).

the sub-prime mortgage was the initial cause of the financial crisis.

The modelling framework consists of an economy composed by borrowers and savers. A microfounded general equilibrium model is needed in order to explore all the interrelations that appear between the real economy and the financial system. Furthermore, such a model can deal with welfare-related questions. The reason to have these two types of consumers in the model is that in a model with a representative agent, borrowing is zero and thus, it is not possible to impose restrictions on credit. Furthermore, borrowers face a collateral constraint which is more or less tight depending on the LTV ratio. A rule on this LTV ratio introduces a macroprudential policy on the economy, in the sense that the ratio will be more restrictive whenever house prices and output increase in the economy. We evaluate the effects of this macroprudential policy both from a positive and a normative point of view. From a positive perspective, results show that with this rule booms are moderated because a tighter limit on credit is set. When we combine this rule with monetary policy, we find that monetary policy has weaker effects on the economy when macroprudential policies are active because the latter policy restricts the financial accelerator effects. From a normative perspective we also obtain several interesting results: First, unambiguously, when monetary policy and a rule for the LTV ratio interact, the introduction of this macroprudential measure is welfare enhancing. Second, welfare gains increase when the LTV responds more aggressively to changes in output and house prices. Lastly, when the interest rate responds to inflation, output and house prices instead of only to inflation, the welfare improvement is comparable to the one obtained by introducing the explicit macroprudential rule to the LTV. That is, welfare gains are larger if monetary policy only responds to inflation. The reason for that is that when the Taylor rule for the interest rate also responds to output and house prices the financial accelerator is less strong and this could be interpreted as a macroprudential measure by itself. Introducing an extra macroprudential tool may be redundant.

The rest of the paper continues as follows. Section 2 presents some evidence on some macroprudential experiences. Section 3 describes the model. Section 4 presents results from simulations. Section 5 concludes.

## 2 Evidence

There have been some central banks that have implemented measures to moderate credit and asset price booms, complementing the traditional monetary policy. If something authorities have learned with

the crisis is that microprudential supervision is not enough because there are many institutions whose complex networks create systemic risk. Thus, macroprudential supervision is needed to measure and manage the overall levels of risk in financial markets.

Just as examples of macroprudential experiences, not being exhaustive<sup>3</sup>, we can mention some cases. For some central banks, quoting Caruana (2010), “because of the euros, the interest rate was not an available tool. Macroprudential policy was the only option<sup>4</sup>.” There is also some macroprudential experience in emerging markets, especially in Asia. Among the tools that have been used, we find countercyclical capital buffers linked to credit growth, countercyclical provisioning, LTV limits or direct controls on lending to specific sectors. Most of those “Asian” instruments were taken during phases of rapid credit increase, but some were also imposed in the aftermath of the crisis. Measures were generally calibrated from starting from existing microprudential settings with adjustments for particular macro circumstances that were seen as relevant. For instance, an 80% LTV maximum is widely seen by these nations as a norm or benchmark for residential real estate loans from a microprudential point of view, and a number of economies have caps at this level. Tightenings of this instrument typically took the form of 10 or 20 percentage point reductions, some of which were reversed when conditions in the targeted markets were seen to have normalized.

Also the Bank of Spain has introduced some macroprudential measures such as the dynamic or statistical provisioning for loan loss reserves since mid-2000. This measure had a microprudential role, as it was applied to individual institutions, and a macroprudential purpose, due to its countercyclical impact, which damps excess procyclicality in the financial system. Under this system, banks must make provisions against credit growth according to historical loss information for different types of loans. This practice gave banks a greater cushion than they would otherwise have had, and kept their fragility from further deepening the downturn [See Saurina (2009a,b) and Caruana (2010)].

McCauley (2009) showed that emerging market central banks have been regular practitioners of macroprudential policy and gave as an example the Reserve Bank of India’s decision to raise the Basel I weights on mortgages and other household credit in 2005. Caruana (2010) compared this policy with imposing or lowering maximum LTV ratios. The Committee on the Global Financial System proposed a similar macroprudential measure in 2010 to promote greater stability in haircuts in securities markets<sup>5</sup>.

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<sup>3</sup>For an exhaustive review see Financial Stability Board, Bank for International Settlements and International Monetary Fund (2009).

<sup>4</sup>Pages 24-25.

<sup>5</sup>See Committee on the Global Financial System (2010a).

In the USA, the Dodd-Frank Wall Street reform and Consumer Protection Act of 2010 mandated that a Financial Stability Oversight Council monitor and manage system-wide risk.

In 2009, the Committee on the Global Financial System (CGFS) conducted a very complete survey on the use of macroprudential instruments with the help of 33 central banks<sup>6</sup>. The CGFS saw that macroprudential instruments or interventions had been widely applied and were viewed as more effective than monetary policy in addressing specific imbalances. The most common measures have been instruments to limit credit supply to specific sectors that are seen as prone to excessive credit growth. These include several restrictions on mortgage lending (caps on LTV ratios or debt/income ratios) and credit card lending limits. Some emerging market economies have used reserve requirements to prevent the build-up of domestic imbalances arising from international capital flows. Instruments targeting the size or composition of bank balance sheets (such as loan-to-deposit ceilings, institution-specific capital additions or time-varying capital charges) seem to have been less frequently used, a range of such instruments have been introduced in response to the financial crisis, or are, at that time, under consideration.

### 3 Model Setup

The economy features patient and impatient households, a final goods firm, and a central bank which conducts monetary policy. Households work and consume both consumption goods and housing. Patient and impatient households are savers and borrowers, respectively. Borrowers are credit constrained and need collateral to obtain loans. The representative firm converts household labor into the final good. The central bank follows a Taylor rule for the setting of interest rates.

#### 3.1 Savers

Savers maximize their utility function by choosing consumption, housing and labor hours:

$$\max_{C_{s,t}, H_{s,t}, N_{s,t}} E_0 \sum_{t=0}^{\infty} \beta_s^t \left[ \log C_{s,t} + j_t \log H_{s,t} - \frac{(N_{s,t})^\eta}{\eta} \right],$$

where  $\beta_s \in (0, 1)$  is the patient discount factor,  $E_0$  is the expectation operator and  $C_{s,t}$ ,  $H_{s,t}$  and  $N_{s,t}$  represent consumption at time  $t$ , the housing stock and working hours, respectively.  $1/(\eta - 1)$  is the labor supply elasticity,  $\eta > 0$ .  $j_t$  represents the weight of housing in the utility function. We assume that  $\log(j_t) = \log(j) + u_{j,t}$ , where  $u_{j,t}$  follows an autoregressive process. A shock to  $j_t$  represents a shock

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<sup>6</sup>See Committee on the Global Financial System (2010b).

to the marginal utility of housing. These shocks directly affect housing demand and therefore can be interpreted as a proxy for exogenous disturbances to house prices.

Subject to the budget constraint:

$$C_{s,t} + b_t + q_t (H_{s,t} - H_{s,t-1}) = \frac{R_{t-1}b_{t-1}}{\pi_t} + w_{s,t}N_{s,t}, \quad (1)$$

where  $b_t$  denotes bank deposits,  $R_t$  is the gross return from deposits,  $q_t$  is the price of housing in units of consumption, and  $w_{s,t}$  is the real wage rate. The first order conditions for this optimization problem are as follows:

$$\frac{1}{C_{s,t}} = \beta_s E_t \left( \frac{R_t}{\pi_{t+1} C_{s,t+1}} \right), \quad (2)$$

$$w_t^s = (N_{s,t})^{\eta-1} C_{s,t}, \quad (3)$$

$$\frac{j_t}{H_{s,t}} = \frac{1}{C_{s,t}} q_t - \beta_s E_t \frac{1}{C_{s,t+1}} q_{t+1}. \quad (4)$$

Equation (2) is the Euler equation, the intertemporal condition for consumption. Equation (4) represents the intertemporal condition for housing, in which, at the margin, benefits for consuming housing equate costs in terms of consumption. Equation (3) is the labor-supply condition.

## 3.2 Borrowers

Borrowers solve:

$$\max_{C_{b,t}, H_{b,t}, N_{b,t}} E_0 \sum_{t=0}^{\infty} \beta_b^t \left[ \log C_{b,t} + j_t \log H_{b,t} - \frac{(N_{b,t})^\eta}{\eta} \right],$$

where  $\beta_b \in (0,1)$  is impatient discount factor, subject to the budget constraint and the collateral constraint:

$$C_{b,t} + \frac{R_{t-1}b_{t-1}}{\pi_t} + q_t (H_{b,t} - H_{b,t-1}) = b_t + W_{b,t}N_{b,t}, \quad (5)$$

$$E_t \frac{R_t}{\pi_{t+1}} b_t = k_t E_t q_{t+1} H_{b,t}, \quad (6)$$



where  $B_t$  denotes bank loans and  $R_t$  is the gross interest rate.  $k_t$  can be interpreted as a loan-to-value ratio. The borrowing constraint limits borrowing to the present discounted value of their housing holdings. The first order conditions are as follows:

$$\frac{1}{C_{b,t}} = \beta_b E_t \left( \frac{R_t}{\pi_{t+1} C_{b,t+1}} \right) + \lambda_t R_t, \quad (7)$$

$$w_{b,t} = (N_{b,t})^{\eta-1} C_{b,t}, \quad (8)$$

$$\frac{j_t}{H_{b,t}} = \frac{1}{C_{b,t}} q_t - \beta_b E_t \left( \frac{1}{C_{b,t+1}} q_{t+1} \right) - \lambda_t k_t E_t (q_{t+1} \pi_{t+1}). \quad (9)$$

where  $\lambda_t$  denotes the multiplier on the borrowing constraint.<sup>7</sup> These first order conditions can be interpreted analogously to the ones of savers.

### 3.3 Firms

#### 3.3.1 Final Goods Producers

There is a continuum of identical final goods producers that aggregate intermediate goods according to the production function

$$Y_t = \left[ \int_0^1 Y_t(z)^{\frac{\varepsilon-1}{\varepsilon}} dz \right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad (10)$$

where  $\varepsilon > 1$  is the elasticity of substitution between intermediate goods. The final good firm chooses  $Y_t(z)$  to minimize its costs, resulting in demand of intermediate good  $z$ :

$$Y_t(z) = \left( \frac{P_t(z)}{P_t} \right)^{-\varepsilon} Y_t. \quad (11)$$

The price index is then given by:

$$P_t = \left[ \int_0^1 P_t(z)^{1-\varepsilon} dz \right]^{\frac{1}{\varepsilon-1}}. \quad (12)$$

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<sup>7</sup>Through simple algebra it can be shown that the Lagrange multiplier is positive in the steady state and thus the collateral constraint holds with equality.

### 3.3.2 Intermediate Goods Producers

The intermediate goods market is monopolistically competitive. Following Iacoviello (2005), intermediate goods are produced according to the production function:

$$Y_t(z) = A_t N_{s,t}(z)^\alpha N_{b,t}(z)^{(1-\alpha)}, \quad (13)$$

where  $\alpha \in [0, 1]$  measures the relative size of each group in terms of labor. This Cobb-Douglas production function implies that labor efforts of constrained and unconstrained consumers are not perfect substitutes. This specification is analytically tractable and allows for closed form solutions for the steady state of the model. This assumption can be economically justified by the fact that savers are the managers of the firms and their wage is higher than the one of the borrowers.<sup>8</sup>

$A_t$  represents technology and it follows the following autoregressive process:

$$\log(A_t) = \rho_A \log(A_{t-1}) + u_{At}, \quad (14)$$

where  $\rho_A$  is the autoregressive coefficient and  $u_{At}$  is a normally distributed shock to technology.

Labor demand is determined by:

$$w_{s,t} = \frac{1}{X_t} \alpha \frac{Y_t}{N_{s,t}}, \quad (15)$$

$$w_{b,t} = \frac{1}{X_t} (1 - \alpha) \frac{Y_t}{N_{b,t}}, \quad (16)$$

where  $X_t$  is the markup, or the inverse of marginal cost.<sup>9</sup>

The price-setting problem for the intermediate good producers is a standard Calvo-Yun setting. An intermediate good producer sells its good at price  $P_t(z)$ , and  $1 - \theta, \in [0, 1]$ , is the probability of being able to change the sale price in every period. The optimal reset price  $P_t^*(z)$  solves:

$$\sum_{k=0}^{\infty} (\theta\beta)^k E_t \left\{ \Lambda_{t,k} \left[ \frac{P_t^*(z)}{P_{t+k}} - \frac{\varepsilon/(\varepsilon-1)}{X_{t+k}} \right] Y_{t+k}^*(z) \right\} = 0. \quad (17)$$

The aggregate price level is then given by:

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<sup>8</sup>It could also be interpreted as the savers being older than the borrowers, therefore more experienced.

<sup>9</sup>Symmetry across firms allows us to write the demands without the index  $z$ .

$$P_t = \left[ \theta P_{t-1}^\varepsilon + (1 - \theta) (P_t^*)^{1-\varepsilon} \right]^{1/(1-\varepsilon)}. \quad (18)$$

Using (17) and (18), and log-linearizing, we can obtain a standard forward-looking New Keynesian Phillips curve  $\hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} - \psi \hat{x}_t + u_{\pi t}$ , that relates inflation positively to future inflation and negatively to the markup ( $\psi \equiv (1 - \theta)(1 - \beta\theta)/\theta$ ).  $u_{\pi t}$  is a normally distributed cost-push shock.<sup>10</sup>

### 3.4 Monetary Policy

We consider a generalized Taylor rule which responds to inflation, output and house prices:

$$R_t = \rho R_{t-1} + (1 - \rho) \left[ (1 + \phi_\pi^R) \pi_t + \phi_y^R y_t + \phi_q^R q_t \right] + \varepsilon_{Rt}, \quad (19)$$

where  $0 \leq \rho \leq 1$  is the parameter associated with interest-rate inertia, and  $\phi_\pi^R \geq 0$ ,  $\phi_y^R \geq 0$ ,  $\phi_q^R \geq 0$  measure the response of interest rates to current inflation, output and house prices, respectively.  $\varepsilon_{Rt}$  is a white noise shock with zero mean and variance  $\sigma_\varepsilon^2$ . The reason for considering this generalized Taylor rule is that by making the central bank respond to house prices, we are giving the institution a way to implement a macroprudential policy. Notice that increasing the interest rate whenever house prices increase is restricting credit booms in the economy<sup>11</sup>.

### 3.5 A Macroprudential Rule for the LTV

In standard models, the LTV ratio is a fixed parameter which is not affected by economic conditions. However, we can think of regulations of LTV ratios as a way to moderate credit booms. When the LTV ratio is high, the collateral constraint is less tight. And, since the constraint is binding, borrowers will borrow as much as they are allowed to. Lowering the LTV tightens the constraint and therefore restricts the loans that borrowers can obtain. Recent research on macroprudential policies has proposed Taylor-type rules for the LTV ratio so that it reacts inversely to variables such that the growth rates of GDP, credits, the credit-to-GDP ratio or house prices. These rules can be a simple illustration of how a macroprudential policy could work in practice. Here, we assume that there exists a macroprudential

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<sup>10</sup>Variables with a hat denote percent deviations from the steady state.

<sup>11</sup>Kannan et al. (2012) also consider an extended Taylor rule that responds to credit growth in order to make the central bank act in a macroprudential way.

Taylor-type rule for the LTV ratio, so that it responds to output and house prices:

$$k_t = k_{SS} - \phi_y^k y_t - \phi_q^k q_t, \quad (20)$$

where  $k_{SS}$  is a steady state value for the loan-to-value ratio, and  $\phi_y^k \geq 0$ ,  $\phi_q^k \geq 0$  measure the response of the loan-to-to value to output and house prices, respectively. This kind of rule would deliver a lower LTV ratio in booms, when output and house prices are high, therefore restricting the credit in the economy and avoiding a credit boom derived from good economic conditions<sup>12</sup>.

### 3.6 Equilibrium

The market clearing conditions are as follows:

$$Y_t = C_{s,t} + C_{b,t}. \quad (21)$$

The total supply of housing is fixed and it is normalized to unity:

$$H_{s,t} + H_{b,t} = 1. \quad (22)$$

## 4 Simulation

### 4.1 Parameter Values

The discount factor for savers,  $\beta_s$ , is set to 0.99 so that the annual interest rate is 4% in steady state. The discount factor for the borrowers is set to 0.98.<sup>13</sup> The steady-state weight of housing in the utility function,  $j$ , is set to 0.1 in order for the ratio of housing wealth to GDP to be approximately 1.40 in the steady state, consistent with the US data. We set  $\eta = 2$ , implying a value of the labor supply elasticity of 1.<sup>14</sup> For the parameters controlling leverage, we set  $k$  to 0.90, in line with the US data.<sup>15</sup> The labor income share for savers is set to 0.64, following the estimate in Iacoviello (2005). For the Taylor rule, we consider as a benchmark the case in which  $\phi_\pi^R = 0.5$ ;  $\phi_y^R = 0$ ;  $\phi_q^R = 0$ . For  $\rho$  we use 0.8, which also

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<sup>12</sup>Funke and Paetz (2012) consider a non-linear version of this macroprudential rule for the LTV.

<sup>13</sup>Lawrance (1991) estimated discount factors for poor consumers at between 0.95 and 0.98 at quarterly frequency. We take the most conservative value.

<sup>14</sup>Microeconomic estimates usually suggest values in the range of 0 and 0.5 (for males). Domeij and Flodén (2006) show that in the presence of borrowing constraints this estimates could have a downward bias of 50%.

<sup>15</sup>See Iacoviello (2011).

reflects a realistic degree of interest-rate smoothing<sup>16</sup>.

We consider three types of shocks, a monetary policy shock, a technology shock, and a housing demand shock. The latter can be interpreted as a house price shock, since it is directly transmitted to house prices. We assume that technology,  $A_t$ , follows an autoregressive process with 0.9 persistence and a normally distributed shock. We also assume that the weight of housing on the utility function is equal to its value in the steady state plus a shock which follows an autoregressive process with 0.95 persistence.<sup>17</sup>For the reactions parameters in the LTV rule we tentatively use .05 and perform a sensitivity analysis to this value. Table 1 presents a summary of the parameter values used:

| <b>Parameter Values</b> |     |  |
|-------------------------|-----|--|
| $\beta_s$               | .99 | Discount Factor for Savers                       |
| $\beta_b$               | .98 | Discount Factor for Borrowers                    |
| $j$                     | .1  | Weight of Housing in Utility Function            |
| $\eta$                  | 2   | Parameter associated with labor elasticity       |
| $k$                     | .9  | Loan-to-value ratio                              |
| $\alpha$                | .64 | Labor share for Savers                           |
| $X$                     | 1.2 | Steady-state markup                              |
| $\theta$                | .75 | Probability of not changing prices               |
| $\rho_A$                | .9  | Technology persistence                           |
| $\rho_j$                | .95 | Housing demand shock persistence                 |
| $\rho$                  | .8  | Interest-Rate-Smoothing Parameter in Taylor Rule |
| $\phi_\pi^R$            | .5  | Inflation parameter in Taylor Rule               |
| $\phi_y^k$              | .05 | Output parameter in LTV Rule                     |
| $\phi_q^k$              | .05 | House price parameter in LTV Rule                |

Table 1: Parameter values. Baseline model

## 4.2 Impulse Responses

In this section, we simulate the impulse responses of the baseline model given a positive technology shock and a house-price shock. Both shocks represent a boom for the economy, in the sense that they

<sup>16</sup>As in McCallum (2001).

<sup>17</sup>The persistence of the shocks is consistent with the estimates in Iacoviello and Neri (2010).

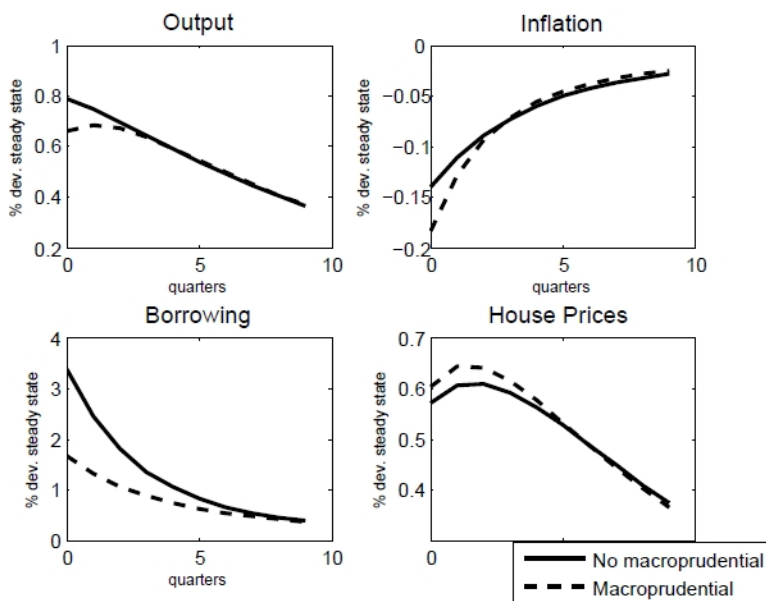


Figure 1: Impulse Responses to a technology shock. Macroprudential versus no macroprudential

increase output, house prices and therefore borrowing and consumption. Then, in order to assess how the macroprudential rule interacts with monetary policy, we consider a monetary policy shock.

#### 4.2.1 Technology shock

Figure (1) presents the impulse responses to a 1 percent shock to technology. Given the increase in technology, output increases and thus, consumption for all agents increases. Borrowing increases and borrowers demand more housing, which is compensated by a decrease in the housing by the savers, given that the supply of housing is fixed. The increase in house prices increases consumption for borrowers further, given the collateral constraint they face. In this model, wealth effects are present through the collateral constraint. Situations in which house prices increase make the value of the collateral higher, and thus, wealth effects expand the economy even further. The increase in output activates the LTV rule and the collateral constraint becomes tighter. We see that, in this case, the effects on borrowing of the shock are not so strong. Since borrowers cannot borrow as much as they would do with a higher LTV, consumption and housing demand do not increase as much. This leads to a weaker response of output and inflation when the macroprudential rule is active. These results show that macroprudential regulation could help monetary policy to achieve its primary objective, price stabilization.

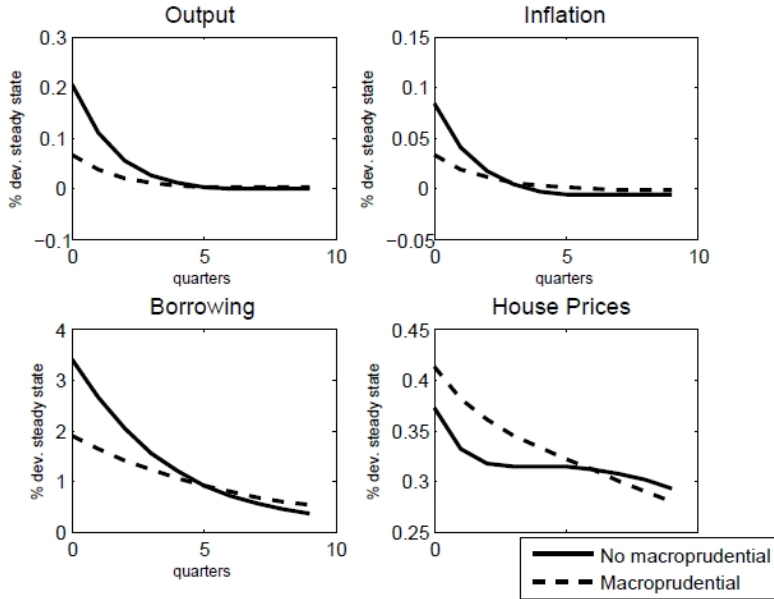


Figure 2: Impulse Responses to a housing demand shock. Macroprudential versus no macroprudential

#### 4.2.2 Housing demand shock

Impulse responses also show how, given the same house price shock, consumption, housing, borrowing and house price responses are softened by the macroprudential measure. In figure 2 we can see the effects of a 25 percent house price shock. For the same reasons stated in the previous case, the increase in house prices directly affects the collateral constraint and borrowers are able to borrow more out of their housing collateral, which is worth more now. Wealth effects permits them consume both more houses and consumption goods. The increase in house prices is therefore transmitted to the real economy and output increases. When house prices increase, the macroprudential rule becomes active and the LTV ratio decreases, therefore restricting the credit in the economy. As in the previous case, consumption and housing demand do not increase as much when the macroprudential rule is in action.

#### 4.2.3 Monetary policy shock

In this section, we consider, for simplicity, the case in which  $\phi_{\pi}^R = 0.5$ ;  $\phi_y^R = 0$ ;  $\phi_q^R = 0$ , that is, monetary policy responds only to inflation, which is empirically plausible, since the main goal of most central banks is price stability.

Figure (3) shows impulse responses for a monetary policy shock, a one standard deviation increase in the interest rate. We see that monetary policy has stronger effects when the macroprudential measure

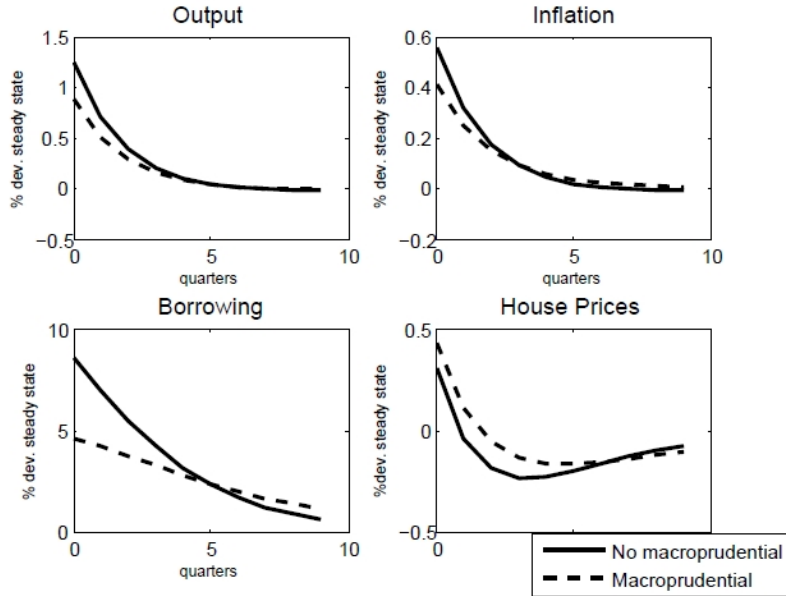


Figure 3: Impulse-Responses to an expansionary monetary policy (decrease in interest rate). Macroprudential versus no macroprudential

is not active. The macroprudential policy mitigates the effects of monetary policy because it restricts borrowing. An expansionary monetary policy measure means a decrease in the interest rate. This, in turn increases output and house prices. Output increases because the decrease in the interest rate stimulates the economy through borrowing. House prices increase because they are an asset price which inversely moves with interest rates. The increase in prices, makes the collateral more valuable and this gives an extra push to output. However, when a macroprudential rule is applied, the borrowing constraint becomes tighter and the financial accelerator effects that the collateral constraint introduces are weaker. Then, the impact on output and inflation of a decrease in the interest rate is not as strong.

## 5 Welfare Measure

To assess the normative implications of the different policies, we numerically evaluate the welfare derived in each case. As discussed in Benigno and Woodford (2008), the two approaches that have recently been used for welfare analysis in DSGE models include either characterizing the optimal Ramsey policy, or solving the model using a second-order approximation to the structural equations for given policy and then evaluating welfare using this solution. As in Mendicino and Pescatori (2007), we take this latter



approach to be able to evaluate the welfare of the two types of agents separately.<sup>18</sup> The individual welfare for savers, borrowers, and the financial intermediary, respectively, as follows:

$$W_{s,t} \equiv E_t \sum_{m=0}^{\infty} \beta_s^m \left[ \log C_{s,t+m} + j \log H_{s,t+m} - \frac{(N_{s,t+m})^\eta}{\eta} \right], \quad (23)$$

$$W_{b,t} \equiv E_t \sum_{m=0}^{\infty} \beta_b^m \left[ \log C_{b,t+m} + j \log H_{b,t+m} - \frac{(N_{b,t+m})^\eta}{\eta} \right], \quad (24)$$

Following Mendicino and Pescatori (2007), we define social welfare as a weighted sum of the individual welfare for the different types of households:

$$W_t = (1 - \beta_s) W_{s,t} + (1 - \beta_b) W_{b,t}. \quad (25)$$

Each agent's welfare is weighted by her discount factor, respectively, so that the all the groups receive the same level of utility from a constant consumption stream.<sup>19</sup>

However, in order to make the results more intuitive, we present welfare changes in terms of consumption equivalents. We use as a benchmark the welfare evaluated when the macroprudential policy is not active and compare it with the welfare obtained when such policy is implemented. Since we are interested in calculating the welfare benefit of introducing a macroprudential policy and therefore we convert the difference between those values in consumption equivalent units to obtain an understandable measure. The consumption equivalent measure defines the constant fraction of consumption that households should give away in order to obtain the benefits of the macroprudential policy. Then, when there is a welfare gain, households would be willing to pay in consumption units for the measure to be implemented because it is welfare improving. We present welfare results as the equivalent in consumption units of this welfare improvement. We will multiply results by -1, so that a positive value means a welfare gain, that is, how much the consumer would be willing to pay to obtain the welfare improvement. We evaluate welfare at the steady state when the macroprudential policy is not active and at the steady state when it is, the derivation of the welfare benefits in terms of consumption equivalent units is as follows:

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<sup>18</sup>We used the software Dynare to obtain a solution for the equilibrium implied by a given policy by solving a second-order approximation to the constraints, then evaluating welfare under the policy using this approximate solution, as in Schmitt-Grohe and Uribe (2004). See Monacelli (2006) for an example of the Ramsey approach in a model with heterogeneous consumers.

<sup>19</sup>Welfare is normalized by the steady-state consumption.

$$CE_s = 1 - \exp \left[ (1 - \beta_s) (W_s^{MP} - W_s^*) \right], \quad (26)$$

$$CE_b = 1 - \exp \left[ (1 - \beta_b) (W_b^{MP} - W_b^*) \right], \quad (27)$$

$$CE = (1 - \beta_s) CE_s + (1 - \beta_b) CE_b, \quad (28)$$

where the superscripts in the welfare values denote the benchmark case when macroprudential policies are not introduced and the case in which they are, respectively<sup>20</sup>.

## 5.1 Welfare Analysis

In this section, we numerically evaluate welfare, first when the Taylor rule is the only policy tool and then when it interacts with the macroprudential rule, that is, the rule to the LTV. We consider different cases; first, a Taylor rule which responds just to inflation, second, a Taylor rule which responds to inflation and output and finally, a Taylor rule which responds to inflation, output and house prices. For the macroprudential rule, first we consider the case in which the reaction parameters are zero, that is, when the rule is not active, and then we consider three different positive values for sensitivity. Tables 2-5 show the results:

### 5.1.1 Welfare comparison across Taylor rules (No LTV Rule)

The following table displays how welfare changes when the Taylor rule is responding to inflation and output and to inflation, output, and house prices, with respect to the benchmark case in which is only responding to inflation. As pointed out by Iacoviello (2005), a Taylor rule in which the output parameter is set to zero amplifies the financial accelerator mechanism since the central bank does not intervene when output falls. Then, introducing a response to output in the policy rule makes it more restrictive. If, additionally, the interest rate also responds to house prices, the Taylor rule becomes even tougher. In some sense, we could interpret these extended rules as being macroprudential by themselves, since they are constraining the financial accelerator by increasing the interest rates in booms and therefore constraining credit. The first column of Table 2 displays the welfare gains of a Taylor rule that responds

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<sup>20</sup>We follow Ascari and Ropele (2009).

to output and inflation with respect to a Taylor rule which only responds to inflation. Notice that in this case the macroprudential LTV rule is not active, we set its reaction parameters to zero. We can observe that the economy gains in terms of welfare because the financial system becomes more stable. If the Taylor rule also responds to house prices<sup>21</sup>, the welfare gains are even larger. Iacoviello (2005) shows that a Taylor rule which responds to asset prices does not yield significant gains in terms of output and inflation stabilization. However, it may yield gains in terms of financial stabilization and this gives higher welfare to the economy. Then, through allowing the Taylor rule to respond to output and house prices, the central bank is implementing a macroprudential policy and extending its goals not only to stabilize inflation but also to stabilize the financial system through moderating the financial accelerator effect.

| Consumption Equivalents | $\phi_{\pi}^R = 0.5; \phi_y^R = 0.5; \phi_q^R = 0 / \phi_y^k = \phi_q^k = 0$ | $\phi_{\pi}^R = 0.5; \phi_y^R = 0.5; \phi_q^R = 0.1 / \phi_y^k = \phi_q^k = 0$ |
|-------------------------|--|--|
| Total                   | 0.87   | 1.50   |
| Savers                  | -0.72  | -0.78  |
| Borrowers               | 44.09  | 75.25  |

Table 2: Welfare gains. Taylor rule responding to inflation versus inflation, output and house prices

### 5.1.2 LTV Rule interacting with Taylor rule responding to inflation

In this section we check how the Taylor rule interacts with a macroprudential rule, that is, a rule for the LTV ratio. As a first experiment, we consider a Taylor rule that responds only to inflation, that is, the priority of the central bank is to stabilize prices<sup>22</sup>. Thus, the reaction parameters of the rule would be  $\phi_{\pi}^R = 0.5; \phi_y^R = 0; \phi_q^R = 0$ . Then, we consider a rule to the LTV ratio, that is, a macroprudential rule. We take different values for the parameters in order to observe the sensitivity of the results with respect to the aggressiveness of the rule. Table 3 presents the results in consumption equivalents, that is, how much agents would pay in terms of consumption in order to have a macroprudential rule in the economy. Then, a positive number means that agents are willing to pay in order to be in that situation because it is welfare improving:

<sup>21</sup>We set the reaction parameter of house prices equal to 0.1, following Iacoviello (2005).

<sup>22</sup>This kind of rule would be consistent with a central bank such as the ECB, that explicitly states as a first priority inflation stabilization.

| Consumption Equivalents | $\phi_y^k = \phi_q^k = 0.025$ | $\phi_y^k = \phi_q^k = 0.05$ | $\phi_y^k = \phi_q^k = 0.1$ |
|-------------------------|-------------------------------|------------------------------|-----------------------------|
| Total                   | 0.23                          | 0.71                         | 1.70                        |
| Savers                  | -0.49                         | -0.63                        | -0.73                       |
| Borrowers               | 11.62                         | 35.70                        | 85.37                       |

Table 3: Welfare gains, given different values for the LTV reaction parameters. Taylor rule responding to inflation.

We see that, using both policy measures at the same time is unambiguously welfare enhancing. Welfare of borrowers increases with the introduction of the macroprudential rule because tightening the collateral constraint avoids situations of overindebtedness in which debt repayments are a burden for them and can benefit from more financial stability in the economy. This welfare gain is at the expense of savers, who lose from having this measure in the economy, given that they are not financially constrained. However, the borrower's welfare gain compensates the loss of the savers and globally, the measure is welfare increasing. We also see in the table that welfare increases by more, the larger the response of the LTV to house prices and output is. We can conclude then that the economy gains in terms of welfare with the introduction of this rule because it gives financial stability.

### 5.1.3 LTV Rule interacting with Taylor rule responding to inflation and output

Secondly, we consider a Taylor rule that responds to inflation and output, that is, although the first priority of the central bank is to stabilize prices, it also takes into account output growth<sup>23</sup>. Thus, the reaction parameters of the rule would be  $\phi_\pi^R = 0.5$ ;  $\phi_y^R = 0.5$ ;  $\phi_q^R = 0$ . This Taylor rule is interacting with the macroprudential rule. Table 4 shows the results.

| Consumption Equivalents | $\phi_y^k = \phi_q^k = 0.025$ | $\phi_y^k = \phi_q^k = 0.05$ | $\phi_y^k = \phi_q^k = 0.1$ |
|-------------------------|-------------------------------|------------------------------|-----------------------------|
| Total                   | 0.02                          | 0.04                         | 0.05                        |
| Savers                  | -0.28                         | -0.37                        | -0.44                       |
| Borrowers               | 1.29                          | 2.09                         | 2.73                        |

Table 4: Welfare gains, given different values for the LTV reaction parameters. Taylor rule responding to inflation and output.

<sup>23</sup>This kind of rule would be consistent with a central bank such as the Federal Reserve, that also takes into account output and unemployment when making monetary policy decisions.

Qualitatively, results are maintained with respect to the previous case. However, we see that welfare gains are not as large as in the case in which the central bank has only one objective. The reason for that is that, as we have seen, introducing a positive output reaction to the interest rate restricts the financial accelerator effect in the economy, that is, it is a macroprudential policy by itself. Therefore, introducing an extra macroprudential policy, although it helps stabilizing the financial system, can be redundant.

#### 5.1.4 LTV Rule interacting with Taylor rule responding to inflation, output and house prices

Finally, we consider the full Taylor rule that responds to inflation, output, and also house prices. Now, the reaction parameters of the Taylor rule would be  $\phi_{\pi}^R = 0.5$ ;  $\phi_y^R = 0.5$ ;  $\phi_q^R = 0.1$ . Table 5 displays the results:

| Consumption Equivalents | $\phi_y^k = \phi_q^k = 0.025$ | $\phi_y^k = \phi_q^k = 0.05$ | $\phi_y^k = \phi_q^k = 0.1$ |
|-------------------------|-------------------------------|------------------------------|-----------------------------|
| Total                   | 0.01                          | 0.02                         | 0.025                       |
| Savers                  | -0.23                         | -0.31                        | -0.36                       |
| Borrowers               | 0.82                          | 1.22                         | 1.45                        |

Table 5: Welfare gains, given different values for the LTV reaction parameters. Taylor rule responding to inflation, output and house prices.

We see that, in this case, when the interest rate is also responding to output and house prices, the gains are even smaller than in the previous case because monetary policy responding to output and asset prices is acting an even stronger macroprudential measure than in the previous case. The gains of introducing an additional macroprudential tool are marginal, as compared with the first case. Then, we can conclude that the central bank, by an appropriate combination of parameter values in the Taylor rule could do the job of a macroprudential regulator. However, the goals of the central bank should be extended to not only to keeping inflation low but also to have a stable financial system. The open question here would be if these two objectives could be in conflict at some point and it would be better to have a separate institution in charge of the stability of the financial system. An optimal monetary policy analysis would be needed in order to assess which are the combination of values of the reaction parameters which would maximize welfare and make policy recommendations on this issue.

## 6 Concluding Remarks

In this paper we have aimed at analyzing the impact of macroprudential policies both on the main economic variables and on welfare. In particular, we consider a macroprudential rule on the LTV ratio. We find that introducing a macroprudential tool mitigates the effects of booms in the economy by restricting credit. In terms of welfare, this rule on the LTV is unambiguously welfare enhancing for the economy because it yields a more stable financial system.

When we study how the macroprudential rule on the LTV ratio interacts with the traditional monetary policy transmission mechanism channel, we observe that, from a positive perspective, monetary policy has weaker effects on the economy when macroprudential policies are active. This may lead to think that macroprudential regulation could help monetary policy to achieve its primary objective, price stabilization. From a normative perspective we find several interesting results: First, unambiguously, when monetary policy and a rule for the LTV ratio interact, the introduction of this macroprudential measure is welfare enhancing. Second, welfare gains increase when the LTV responds more aggressively to changes in output and house prices. However, when the interest rate responds to output and house prices instead of only to inflation, the welfare improvement is comparable to the one obtained by introducing the explicit macroprudential rule to the LTV. The reason for that is that this extended Taylor rule could be considered macroprudential by itself because it restricts the financial accelerator effect. Then, introducing an extra macroprudential measure gives much smaller welfare gains.

As an extension, in order to assess the combination of policies that would be welfare maximizing and conclude if the macroprudential policy should be conducted by the central bank or a separate institution, a rigorous optimal monetary policy analysis would be needed.

# Appendix

## Steady-State of the main model

### Main Equations

$$\frac{1}{C_{s,t}} = \beta^s E_t \left( \frac{R_t}{\pi_{t+1} C_{s,t+1}} \right), \quad (29)$$

$$w_t^s = (N_{s,t})^{\eta-1} C_{s,t}, \quad (30)$$

$$\frac{j}{H_{s,t}} = \frac{1}{C_{s,t}} q_t - \beta^s E_t \frac{1}{C_{s,t+1}} q_{t+1}. \quad (31)$$

$$\frac{1}{C_{b,t}} = \beta^b E_t \left( \frac{R_t}{\pi_{t+1} C_{b,t+1}} \right) + \lambda_t R_t, \quad (32)$$

$$w_{b,t} = (N_{b,t})^{\eta-1} C_{b,t}, \quad (33)$$

$$\frac{j}{H_{b,t}} = \frac{1}{C_{b,t}} q_t - \beta^b E_t \left( \frac{1}{C_{b,t+1}} q_{t+1} \right) - \lambda_t^b k_t E_t (q_{t+1} \pi_{t+1}). \quad (34)$$

$$E_t \frac{R_t}{\pi_{t+1}} b_t = k_t E_t q_{t+1} H_{b,t}, \quad (35)$$

$$C_{b,t} + q_t H_{b,t} + \frac{R_{t-1} b_{t-1}}{\pi_t} = q_t H_{b,t-1} + w_{b,t} L_{b,t} + b_t, \quad (36)$$

$$w_{s,t} = \frac{1}{X_t} \alpha \frac{Y_t}{N_{s,t}}, \quad (37)$$

$$w_{b,t} = \frac{1}{X_t} (1 - \alpha) \frac{Y_t}{N_{b,t}}, \quad (38)$$

$$\hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} - \psi \hat{x}_t + u_{\pi t} \quad (39)$$

$$W_{s,t} \equiv E_t \sum_{m=0}^{\infty} \beta_s^m \left[ \log C_{s,t+m} + j \log H_{s,t+m} - \frac{(N_{s,t+m})^\eta}{\eta} \right], \quad (40)$$

$$W_{b,t} \equiv E_t \sum_{m=0}^{\infty} \beta_b^m \left[ \log C_{b,t+m} + j \log H_{b,t+m} - \frac{(N_{b,t+m})^\eta}{\eta} \right], \quad (41)$$

$$W_t = (1 - \beta_s) W_{s,t} + (1 - \beta_b) W_{b,t}. \quad (42)$$

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