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Macroprudential Measures, Housing Markets, and Monetary Policy

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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. 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, loan-to-value

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 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.[1]

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 clear 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 alnalyze 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

[1] This topic 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.

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 has been crucial for the current crisis. Excesses in housing markets together with other disequilibria in the economy were the center of this severe recession and the elated financial turmoil.[2]

In this paper, 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 is that in a model with a representative agent, borrowing is zero and thus, it is not possible to impose restrictions on credit. Moreover, 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

[2] See Volcker (2010).

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.

This paper is related to different strands of the literature. It follows the line of the seminal paper Iacoviello (2005) that introduces a financial accelerator that works through the housing sector, adding to the flourishing literature on Iacoviello-type models. Our paper uses this kind of framework to evaluate macroprudential policies. In particular, we use a rule to the LTV. In the same line, Gruss and Sgherri (2009) analyses the welfare effects of procyclical loan-to-value ratios in a real business cycle model with borrowing constraints. Funke and Paetz (2012) uses a non-linear rule on the LTV and finds that it can help reduce the transmission of house price cycles to the real economy. Second, it is related to papers that study the interaction between monetary policy and macroprudential measures. For instance, Borio and Shim (2007) emphasizes the complementary role of macroprudential policy to the monetary policy and its supportive role as a built-in stabilizer. As well, N'Diaye (2009) shows that the monetary policy can be supported by countercyclical prudential regulation. Suh (2011) evaluates the effectiveness of various macroprudential policy rules given different shocks, using a policy evaluation measure in terms of inflation and output volatility. Angelini, Neri and Panetta (2012) shows interactions between macroprudential (LTV and capital requirements ratios) and monetary policies. They find that the macroprudential policies are most helpful to counter financial shocks that lead the credit and asset price booms. In a similar way, Kannan, Rabanal and Scott (2012) examines a monetary policy rule that reacts to prices, output and changes in collateral values with a macroprudential instrument based on the LTV. They remark the importance of identifying the source of the shock of the housing or price boom when assessing policy optimality. Our paper is close to Kannan et al. (2012). However, we take into consideration as a benchmark, a Taylor rule that only responds to inflation, an option that they disregard. We follow the discussion in Iacoviello (2005) in which he also imposes a value of zero in the output reaction parameter in the Taylor rule for benchmark simulations. Iacoviello (2005) claims that this assumption amplifies the financial accelerator, since the central bank does not intervene when output falls. We find that this has important implications for the welfare effects of macroprudential policies. In fact, our results show that with this particular specification of the Taylor rule, the welfare benefits of introducing an LTV rule are found to be the largest. This is a valuable contribution that not only helps understanding the interaction of the financial accelerator and the macroprudential tool in Iacoviello-type models but also has policy implications. Our findings suggest that economies with central banks with small responses to the output gap may find larger welfare improvements when independent macroprudential tools are implemented.

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 introduced 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. For some central banks, quoting Caruana (2010), [3] "because of the euros, the interest rate was not an available tool. Macroprudential policy was the only option".

Just as examples of macroprudential experiences, not being exhaustive,[4] we can mention some cases. There is 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 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.

[3] Pages 24-25.

[4] For an exhaustive review see Financial Stability Board, Bank for International Settlements and International Monetary Fund (2009).

Also the Bank of Spain 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.[5]

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.[6] 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 add-ons 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

[5] See Committee on the Global Financial System (2010a).
[6] See Committee on the Global Financial System (2010b).

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 $\log(j_t) = \log(j) + u_{Jt}$, where u_{Jt} follows an autoregressive process. A shock to j_t represents a shock 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:

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

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. F_t are lump-sum profits received from the firms. The first order conditions for this optimization problem are as follows:

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

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

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

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:

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

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

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:

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

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

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

where λ_t denotes the multiplier on the borrowing constraint.[7] These first order conditions can be interpreted analogously to the ones of savers.

[7] 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 Firms

3.3.1 Final Goods Producers

There is a continuum of identical final goods producers that operate under perfect competition and flexible prices. They aggregate intermediate goods according to the production function

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

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:

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

The price index is then given by:

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

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:

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

where $\alpha \in [0,1]$ measures the relative size of each group in terms of labor.[8] 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.[9]

A_t represents technology and it follows the following autoregressive process:

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

[8] Notice that the absolute size of each group is one.

[9] It could also be interpreted as the savers being older than the borrowers, therefore more experienced.

where ρ_A is the autoregressive coefficient and u_{At} is a normally distributed shock to technology. We normalize the steady-state value of technology to 1.

Labor demand is determined by:

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

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

where X_t is the markup, or the inverse of marginal cost.[10]

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:

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

where $\varepsilon/(\varepsilon-1)$ is the steady-state markup.

The aggregate price level is then given by:

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

Using (17) and (18), and log-linearizing, we can obtain a standard forward-looking New Keynesian Phillips curve $\widehat{\pi}_t = \beta E_t \widehat{\pi}_{t+1} - \psi \widehat{x}_t + u_{\pi t}$, 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.[11]

3.4 Monetary Policy

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

$$R_t = (R_{t-1})^{\rho} \left((\pi_t)^{(1+\phi_\pi^R)} \left(\frac{Y_t}{Y} \right)^{\phi_y^R} \left(\frac{q_t}{q} \right)^{\phi_q^R} R \right)^{1-\rho} \varepsilon_{Rt}, \tag{19}$$

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. ε_{Rt} is

[10] Symmetry across firms allows us to write the demands without the index z.
[11] Variables with a hat denote percent deviations from the steady state.

a white noise shock with zero mean and variance σ_{ε}^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.[12] We consider as a benchmark the case in which $\phi_{\pi}^R \geq 0$, $\phi_y^R = 0$, $\phi_q^R = 0$.

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

$$k_t = k_{SS} \left(\frac{Y_t}{Y}\right)^{-\phi_y^k} \left(\frac{q_t}{q}\right)^{-\phi_q^k}, \tag{20}$$

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.[13]

3.6 Equilibrium

The market clearing conditions are as follows:

$$Y_t = C_{s,t} + C_{b,t}. \tag{21}$$

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

[12] 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.

[13] Funke and Paetz (2012) consider a non-linear version of this macroprudential rule for the LTV.

$$H_{s,t} + H_{b,t} = 1. \tag{22}$$

4 Simulation

4.1 Parameter Values

The discount factor for savers, β_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.[14] 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.[15] For the parameters controlling leverage, we set k to 0.90, in line with the US data.[16] 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 ρ we use 0.8, which also reflects a realistic degree of interest-rate smoothing.[17]

We consider two types of shocks for our impulse responses, 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.[18] 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:

[14] Lawrance (1991) estimated discount factors for poor consumers at between 0.95 and 0.98 at quarterly frequency. We take the most conservative value.

[15] 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%.

[16] See Iacoviello (2011).

[17] As in McCallum (2001).

[18] The persistence of the shocks is consistent with the estimates in Iacoviello and Neri (2010).

Parameter Values		
β_s	.99	Discount Factor for Savers
β_b	.98	Discount Factor for Borrowers
j	.1	Weight of Housing in Utility Function
η	2	Parameter associated with labor elasticity
k	.9	Loan-to-value ratio
α	.64	Labor share for Savers
X	1.2	Steady-state markup
θ	.75	Probability of not changing prices
ρ_A	.9	Technology persistence
ρ_j	.95	Housing demand shock persistence
ρ	.8	Interest-Rate-Smoothing Parameter in Taylor Rule
ϕ_π^R	.5	Inflation parameter in Taylor Rule
ϕ_y^k	.05	Output parameter in LTV Rule
ϕ_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 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 impulse responses to a 1 percent shock to technology. Given the technology shock, output increases and thus, consumption for all agents goes up. Borrowing rises 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 pushes 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

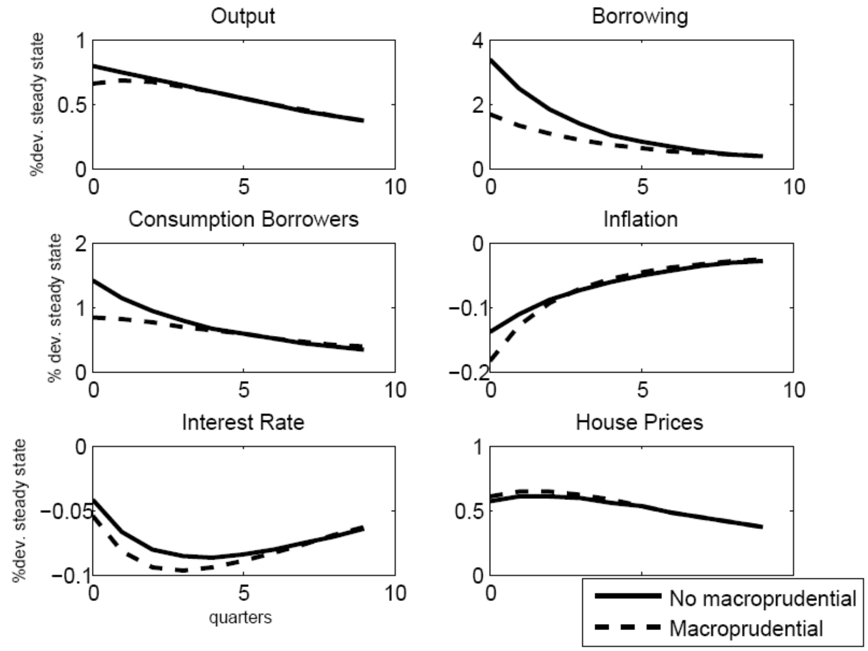

Figure 1: Impulse Responses to a technology shock. Macroprudential versus no macroprudential

expand the economy even further. The rise 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 when the macroprudential rule is active. Given that inflation is decreasing, interest rates also decrease. In the macroprudential case, inflation decreases by more because of the fall in demand by borrowers. Then, the interest rate drop is larger in this case. House prices, since they are an asset price, move inversely with interest rates. This is why, in the macroprudential scenario house prices are slightly above.

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

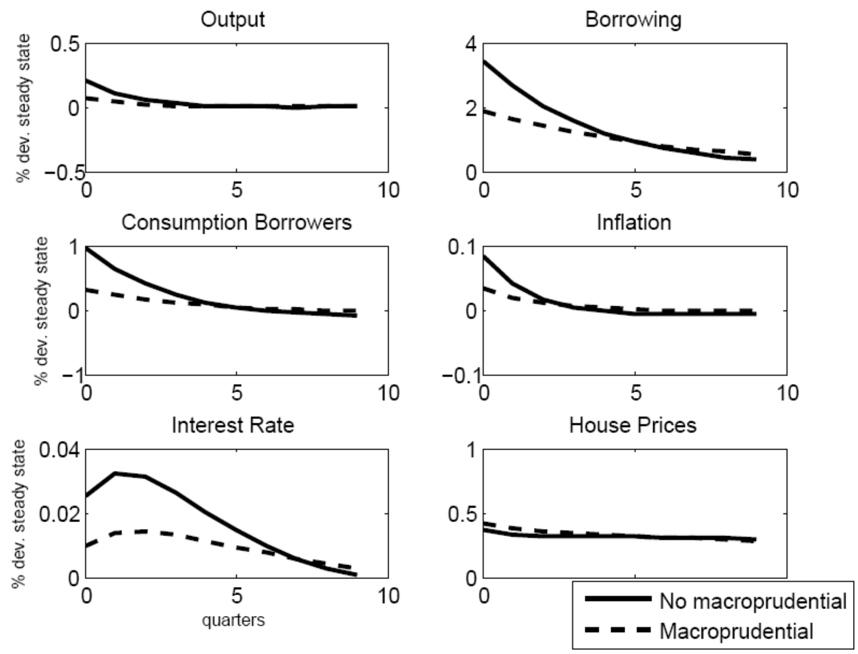

Figure 2: Impulse Responses to a housing demand shock. Macroprudential versus no macroprudential

ratio decreases, therefore restricting the credit in the economy. As in the previous case, consumption and housing demand from the borrowers do not increase as much when the macroprudential rule is in action. In this case, since inflation increases, the interest rate also goes up. This increase in the interest rate pushes house prices down, more strongly when the macroprudential rule is not active.

5 Welfare

5.1 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.[19] The individual welfare for savers, borrowers, and the financial intermediary, respectively, as follows:

[19] 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.

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

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

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

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

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.[20]

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:

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

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

[20] Welfare is normalized by the steady-state consumption.

$$CE = (1 - \beta_s)\, CE_s + (1 - \beta_b)\, CE_b, \tag{28}$$

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.[21]

5.2 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:

5.2.1 Welfare comparison across Taylor rules (No LTV Rule)

The following table displays welfare changes with respect to the benchmark Taylor rule in which interest rates responds only to inflation. First, we consider a Taylor rule responding to inflation and output. Then, the extended rule responding to inflation, output and house prices. 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 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,[22] the welfare gains are even larger. Iacoviello (2005) shows that a Taylor rule which responds to

[21] We follow Ascari and Ropele (2009).

[22] We set the reaction parameter of house prices equal to 0.1, following Iacoviello (2005).

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

5.2.2 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.[23] 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:

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.

[23] This kind of rule would be consistent with a central bank such as the ECB, that explicitly states as a first priority inflation stabilization.

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 overindebtness 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.

5.2.3 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.[24] 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.

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 is that, as we have seen, introducing a positive output reaction to the interest rate restricts the financial accelerator effect in the economy, then, it is a macroprudential policy by itself. Therefore, introducing an extra macroprudential policy, although it helps stabilizing the financial system, can be redundant.

[24] 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.

5.2.4 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. From a normative point of view 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 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.

This paper shows that when the Taylor rule stresses the financial accelerator because it responds just to inflation, the welfare benefits of introducing an LTV rule are found to be the largest. This is a new result that contributes to the literature on the interaction of the financial accelerator and the macroprudential tool in Iacoviello-type models. The policy implication of this finding is that economies with central banks with small responses to the output gap may find larger from macroprudential measures.

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

Main Equations

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

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

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

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

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

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

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

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

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

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

$$\widehat{\pi}_t = \beta E_t \widehat{\pi}_{t+1} - \psi \widehat{x}_t + u_{\pi t} \tag{39}$$

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

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

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

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