Macroprudential and Monetary Policy Rules: A Welfare Analysis

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Abstract

This paper studies the interaction between macroprudential and monetary policies using a dynamic stochastic general equilibrium model. The model features a housing market. There are borrowers, who need collateral to obtain loans, and savers. Monetary policy is conducted following a Taylor rule for the interest rate. The macroprudential policy is represented by a Taylor-type rule for the loan-to-value ratio reacting to output and house prices. Results show that introducing the macroprudential rule or extending the interest rate rule to respond to house prices increases welfare, since it enhances financial stability. However, when we evaluate the optimal policy mix, we find that when both policies act together in a coordinated way, monetary policy should focus on ensuring price stability while the macroprudential authority should care about financial stability.

Keywords: Macroprudential, monetary policy, collateral constraint, credit, loan-to-value, financial stability, house prices

JEL Classification: E32, E44, E58

"One of the most challenging issues relating to systemic risk management is the appropriate interactions between macroprudential and monetary policy. To what extent, if at all, should monetary policy be used to mitigate systemic risk? And to what extent, if at all, should monetary policy be coordinated with macroprudential supervision? These issues are the subject of intense debate among policymakers across the globe". Janet L. Yellen, Board of Governors of the Federal Reserve System, October 11, 2010.

1 Introduction

After the recent financial crisis, policy makers have realized that the traditional policies were not enough to avoid such episodes and that should be complemented with a new direction of policy interventions. As a result, several institutions have implemented macroprudential tools in order to explicitly promote the stability of the financial system in a global sense, not just focusing on individual companies. The goal of this kind of regulation would be to avoid the transmission of financial shocks to the broader economy. Some examples of macroprudential tools are asset-side tools (loan-to-value and debt-to-income ratio caps), liquidity-based tools (countercyclical liquidity requirements) or capital-based tools (countercyclical capital buffers, sectoral capital requirements or dynamic provisions).

However, this new set of macroprudential policies has to coexist with traditional policies, namely monetary policy. It is crucial to analyze how the new macroprudential measures affect the conduction of monetary policy and to monitor and evaluate those policies, making sure that they do not work at cross-purposes. The objective of this paper is to study the interaction between macroprudential and monetary policy.

A very important research question that we cover in this paper is whether monetary and macroprudential policies could complement each other or if the central bank, could use its interest rate instrument to foster financial stability. Some would argue that the conduct of macroprudential and monetary policy should be closely coordinated, even integrated, and then, that both macroprudential and monetary policy should be assigned to the central bank. In this case, the objectives of monetary policy should be expanded to include financial stability (Eichengreen, Rajan, and Prasad (2011), Eichengreen, El-Erian, Fraga, Ito et al. (2011)). Some others would think that macroprudential supervision should involve other regulatory agencies and the central bank should keep the only responsibility of maintaining price stability, retaining its independence. Then, monetary policy and financial-stability policy should be seen as different policies with different objectives and different instruments.

In our study, we focus on a specific macroprudential instrument; the loan-to-value ratio (LTV). The Group of Thirty (2010), a working group on macroprudential policy, recommends in its influential report, that the macroprudential supervisor considers an adjustable LTV ratio that could be varied to inhibit the swings of the economic cycle. Following this line, our model imposes a limit on borrowing, that is, loans need to be collateralized by a proportion of the value of the assets that the borrower owns. This proportion can be interpreted as an LTV. The macroprudential tool we consider is to introduce a rule that automatically increases loan-to-values when there is a boom, therefore limiting the expansion of credit.

In this paper, we propose an implementation of the macroprudential policy which is analogous to how monetary policy is conducted. In particular, we assume that the same way that the central bank follows a Taylor rule for monetary policy, the macroprudential authority also follows a linear rule to carry out the macroprudential policy. The monetary policy literature has extensively shown that simple rules result in a good performance; therefore it seems sensible to apply this kind of rules to macroprudential supervision (see, for instance, Yellen, 2010).

The objectives of the monetary and the macroprudential authority should include output, inflation and financial stability. In order to achieve these objectives, monetary policy uses the interest rate as an instrument while the macroprudential authority uses the LTV. However, there is not consensus about which institution should be in charge of which objectives. It is clear that monetary policy cares about inflation and output stabilization but the debate on whether its objectives should also include financial stability is still open.

In this paper, we assume that the objective of the central bank is to maintain output and inflation stabilization. Therefore, in a standard way, the central bank will follow a Taylor rule in which the interest rate is set responding to inflation and output. Nevertheless, in order to add to the debate, we will also consider the case of an extended Taylor rule for monetary policy which responds to house prices as well, including among the objectives of the central bank to also maintain financial stability.

On the other hand, the macroprudential regulator aims at avoiding systemic risk and excessive credit growth. The IMF (2013) states that a macroeconomic environment which gives rise to credit growth will contribute to the build-up of systemic risk. Therefore, booms that lead to increase in borrowing should be moderated. They also consider that a rise in house prices can act as a leading indicator of excessive credit growth since they lead to wealth effects that permit the increase in borrowing. Then, following this lines, we propose that the macroprudential regulator follows a Taylor-type rule in which the LTV

responds to house prices and output.

We use 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 LTV interacting with a Taylor rule for monetary policy. We consider three types of Taylor rules: a simple one that responds only to inflation; a standard rule that responds to inflation and output; and an extended rule that responds additionally to house prices. The modelling framework consists of an economy composed by borrowers and savers. This microfounded general equilibrium model allows us to explore all the interrelations that appear between the real economy and the credit market. Furthermore, such a model can deal with welfare-related questions.

Our paper is related to the strand of research that, following Iacoviello (2005), introduces a rule on the LTV interacting with monetary policy. 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. Angelini, Neri and Panetta (2012) shows interactions between 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. We contribute to this literature by analyzing the effects of macroprudential policies on welfare disentangled among different Taylor rules and explicitly showing the optimality of the policy mix when the two authorities act in a coordinated way.

From a positive perspective, our results show that when the LTV rule operates in the economy, booms are moderated because a tighter limit on credit is set. However, the goals of the macroprudential regulator and the central bank are in conflict when shocks come from the supply side. Furthermore, the central bank, by an appropriate combination of parameter values in the Taylor rule, could do the job of a macroprudential regulator. Nonetheless, the goals of the central bank should be extended to not only to keeping inflation low but also to have a stable financial system.

Within this framework, we evaluate different scenarios in terms of welfare. We study how welfare changes when the macroprudential policy is introduced in the economy and conclude that this new policy is welfare enhancing. We also study if the central bank could act as a macroprudential regulator

by introducing house prices in the interest rate rule. We find that even if the central bank could do the job of a macroprudential regulator by using the interest rate to stabilize house prices, and therefore the financial system, optimal policy analysis suggests that it is preferable to leave this objective to a macroprudential regulator with a different instrument to maximize welfare.

We also conclude that welfare gains are maximized when the central bank aims at stabilizing inflation, responding only to prices and output, and the macroprudential regulator cares about financial stability, responding to output and more strongly to house prices.

The rest of the paper continues as follows: Section 2 describes the model. Section 3 presents results from simulations. Section 4 offers a welfare analysis of the different policies. Section 5 finds the optimal parameter combination. Section 6 concludes.

2 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.[1] 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.

2.1 Savers

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

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

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:

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

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$$C_{s,t} + b_t + q_t(H_{s,t} - H_{s,t-1}) = \frac{R_{t-1}b_{t-1}}{7r_t} + w_{s,t}N_{s,t} + F_t; \tag{1}$$

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:

$$1 = 13_s E_t \left(\frac{R_t}{C_{s,t}r_{t+1}C_{s,t+1}} \right);$$

$$w^s_t = (N_{s,t})^{71-1} C_{s,t};$$

$$H_{s,t} \frac{j_t}{j^\wedge I} \frac{1}{q_{t+1}:} \frac{}{L,9_t} \quad q_t 0_s E_t {}_{Cs;t+1} \quad 1 \tag{4}$$

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.

2.2 Borrowers

Borrowers solve:

$$\max_{C_{b,t}2-8-b,t2N_{b,t}} E_0 \sum_{t=0}^{0 \; 0} {}_{1}3_t \left[\log C_{b,t} + j_t \log H_{b,t} - \frac{(N_{b,t})^{71}}{} \right];$$

where ${}_{1}3_b \in (0; 1)$ is impatient discount factor, subject to the budget constraint and the collateral constraint:

$$C_{b,t} + \frac{R_{t-1}b_{t-1}}{7r_t} + q_t(H_{b,t} - H_{b,t-1}) = b_t + W_{b,t}N_{b,t}; \tag{5}$$

$$R_t b_t = k_t E_t q_{t+1} H_{b,t} 7 r_{t+1}; \tag{6}$$

where b_t denotes bank loans and R_t is the gross interest rate. k_t can be interpreted as an LTV. The borrowing constraint limits borrowing to the present discounted value of their housing holdings. The

first order conditions are as follows:

$$\frac{1}{C_{b;t}} = \Theta_b E_t \frac{r_{t+1} C_{b;t+1}}{} + \Lambda_t R_t: \quad (\underline{R_t}) \tag{7}$$

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

$$\frac{j_t}{H_{b;t}} \sim \frac{1}{} \qquad \sim \tag{9}$$

where **Λt** denotes the multiplier on the borrowing constraint.[2] These first order conditions can be interpreted analogously to the ones of savers.

2.3 Firms

2.3.1 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

$$Y_t = [\int Y_t (z)^{e} dz$$

$$_0^1 \quad \underline{e-1} \qquad]^{\frac{e}{e-1}}; \tag{10}$$

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:

$$P_t = [\int P_t(z)^{1-\varepsilon} dz]^{\frac{e-1}{}} : \tag{12}$$

2.3.2 Intermediate Goods Producers

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

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[2]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.

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

where $a \in [0, 1]$ 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.[3]

A_t represents technology and it follows the following autoregressive process:

$$\log(A_t) = P_A \log(A_{t\_1}) + u_{At}; \tag{14}$$

where p_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:

$$W_{s;t} = \frac{1}{X_t} a \frac{Y_t}{N_{s;t}} ; \tag{15}$$

$$W_{b;t} = \frac{1}{X_t(1-a)} \frac{Y_t}{N_{b;t}}; \tag{16}$$

where X_t is the markup, or the inverse of marginal cost.[4]

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 $1 - 0$, $\in [0, 1]$; is the probability of being able to change the sale price in every period. Agents that are not able to change prices keep them fixed. The optimal reset price $P_t^*(z)$ solves:

$$E_{k=0} (00)^k E_t \left\{ A_{t;k} \left[\frac{P_{t(z)} - " = x(" - 1)_1}{P_{t-Ek}} Y^{4k}(z) = 0 \right. \right. \tag{17}$$

where $" = (" - 1)$ is the steady-state markup.

The aggregate price level is then given by:

[3] It could also be interpreted as the savers being older than the borrowers, therefore more experienced.
[4] Symmetry across firms allows us to write the demands without the index z.

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

Using (17) and (18), and log-linearizing, we can obtain a standard forward-looking New Keynesian Phillips curve $\tilde{\pi}_t = \beta E_t \tilde{\pi}_{t+1} - \kappa \tilde{x}_t + u_t$, that relates inflation positively to future inflation and negatively to the markup ($\kappa \equiv (1-\theta)(1-\beta\theta)/\theta$). u_t is a normally distributed cost-push shock.[5]

2.4 Monetary Policy

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

$$R_t = (R_{t-1})^{\rho} \left((\tilde{\pi}_t)^{(1+\phi_R)} \left(\frac{Y_t}{Y} \right)^{\phi_{R,y}} \left(\frac{q_t}{q} \right)^{\phi_{R,q}} R \right)^{1-\rho} \varepsilon_{Rt};$$ (19)

where $0 \le \rho \le 1$ is the parameter associated with interest-rate inertia, and $\phi_R > 0$; $\phi_{R,y} > 0$; $\phi_{R,q} > 0$ measure the response of interest rates to current inflation, output and house prices, respectively. ε_{Rt} is a white noise shock with zero mean and variance σ^2_ε. 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.

2.5 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. We assume that the objective of the macroprudential regulator is to avoid situations that lead to an excessive credit growth; when there is a boom in the economy or house prices increase, agents borrow more. Therefore, we take output and house prices as leading indicators of credit growth and[9] consequently consider a Taylor-type rule for the

LTV ratio, so

[5]Variables with a hat denote percent deviations from the steady state.

that it responds to output and house prices:[6]

$$k_t = k_{SS} \; \frac{(Y_t)^{\phi_{k,y}}}{(q_t)^{\phi_{k,q}}}$$

(20)

where k_{SS} is a steady state value for the loan-to-value ratio, and $\phi_{k,y} \sim 0$, $\phi_{k,q} \sim 0$ 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.

2.6 Market Clearing

The market clearing conditions are as follows:

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

(21)

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

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

(22)

3 Simulation

3.1 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.[7] 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.[8] For the parameters controlling leverage, we set k_{SS} to 0.90, in line with the US data.[9] The labor

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[6]For simplicity, and given that there is neither consensus nor empirical evidence on smoothing, to reduce the number of parameters to optimize, we opt for disregarding the smoothing parameter in the LTV rule, as in Kannan et al. (2012), Rubio and Carrasco-Gallego (2014) and Funke and Paetz (2012).

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

[8]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%.

[9]See Iacoviello (2014).

income share for savers is set to 0.64, following the estimate in Iacoviello (2005).[10] For the Taylor rule, we consider three cases which we call "the simple Taylor rule", "the Taylor rule," and "the extended Taylor rule." The simple Taylor rule only responds to inflation, so that $q_\pi = 0.5$; $q_y = 0$; $q_q = 0$, the Taylor rule, corresponds to a standard case in which $q_\pi = 0.5$; $q_y = 0.5$; $q_q = 0$ and the extended Taylor rule in which $q_\pi = 0.5$; $q_y = 0.5$; $q_q = 0.1$. For p we use 0.8, which reflects a realistic degree of interest-rate smoothing.[11]

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.[12] 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.[13] For the reactions parameters in the LTV rule we tentatively use 0.05 and perform a sensitivity analysis to this value. Table 1 presents a summary of the parameter values used:

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[10]This number is within the range of estimates in various studies, including Campbell and Mankiw (1989), which estimated from consumer Euler equations the fraction of constrained agents in the economy.

[11]As in McCallum (2001).

[12]This high persistence value for technology shocks is consistent with what is commonly reported in the literature. Smets and Wouters (2002) estimated a value of 0.822 for this parameter in Europe; Iacoviello and Neri (2010) estimated it as 0.93 for the US.

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

Table 1: Parameter Values		
$/3_s$	.99	Discount Factor for Savers
$/3_b$	.98	Discount Factor for Borrowers
j	.1	Weight of Housing in Utility Function
i	2	Parameter associated with labor elasticity
k_{SS}	.9	Loan-to-value ratio
c	.64	Labor share for Savers
X	1.2	Steady-state markup
O	.75	Probability of not changing prices
p_A	.9	Technology persistence
p_3	.95	Housing demand shock persistence
p	.8	Interest-Rate-Smoothing Parameter in Taylor Rule
$q_\sim$	.5	Inflation parameter in Taylor Rule
q_{ky}	.05	Output parameter in LTV Rule
q_{kq}	.05	House price parameter in LTV Rule

3.2 Business Cycle Properties

Table 2 presents the volatilities derived from the model with respect to those found in the data.[14] We find that the model does pretty well in matching standard deviations of the main variables, and it is the case for the three Taylor rules analysed. The standard deviation of inflation is lower than the one found in the data, especially when the Taylor rule responds only to inflation. The model does particularly well in terms of matching house price volatility.

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[14]The standard deviations are presented for a one percent increase in technology. Data moments are taken from Iacoviello and Neri (2010).

Table 2: Business Cycle Properties

	Model			Data
	Simple TR	TR	Ext TR	
a (y)	2.01	1.88	1.85	2.17
a (q)	1.83	1.89	1.90	1.87
a (yr)	0.24	0.27	0.28	0.40
a (R)	0.27	0.19	0.18	0.32

3.3 Impulse Responses

In order to gain some insight about the dynamics of the model, in this section, we simulate the impulse responses of the baseline model given a supply shock (technology shock) and demand shock (housing demand shock).

In the impulse responses, the solid line represents the situation when there is no macroprudential policy. This is the benchmark. Then, in each figure, we compare this benchmark, solid line, with the situation in which a macroprudential policy is represented by a Taylor-type rule for the LTV ratio that responds to output and house prices. Notice that we have three different monetary policies:

-When the central bank responds to inflation (Simple Taylor Rule).

-When the central bank responds to inflation and output (Taylor Rule).

-When the central bank responds to inflation, output, and house prices (Extended Taylor Rule).

The reason why we consider three types of Taylor rules is that, 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. Therefore, the introduction of a second macroprudential tool could be redundant.

Therefore, the objective of this section is to compare the responses of the combination of these three monetary policies and the macroprudential policy with respect to the benchmark for a demand shock and a supply shock.

3.3.1 Technology shock

Figure 1 shows impulse responses to a 2.24 percent standard deviation shock to technology for output, borrowing, inflation, interest rate, and house prices.[15]

The effects of the shock for output are stronger when the simple Taylor rule is in place. When the central bank follows the standard and the extended Taylor rules, the output expansion makes interest rates not to go down as much as with the simple Taylor rule. This measure reduces the impact of the shock. The macroprudential regulator reacts more strongly with respect to the benchmark when the central bank keeps the simple Taylor rule. In all cases, the increase in the LTV helps to soften the effects of the shock in output.

The highest difference appears in the borrowing with the simple TR. In this case, borrowers benefit from higher output and lower interest rate and they can borrow more. The rise in output activates the LTV rule and the collateral constraint becomes tighter. Therefore, the effects on borrowing of the shock are not so strong. The macroprudential policy can help to moderate borrowing in all cases but is more relevant in the simple TR.

Even if inflation is decreasing in all cases, it is higher when the simple TR is in place. The reason is because there is a demand impulse due to higher borrowing that leads to a higher inflation in the simple TR.

The interest rate reacts more in the simple TR because this rule reduces the interest rate only when prices are lower. The TR and the extended TR react with a lower interest rate when prices go down but the reduction is not so high because these Taylor rules respond also to a higher output with higher interest rates. In all cases, the macroprudential policy causes a higher reduction of the interest rate, greater with the simple TR, because inflation decreases by more due to the fall in demand by borrowers. Then, the interest rate drop is larger in this case.

House prices react like any other asset to the interest rate, then they increase even more when the macroprudential policy is active because the interest rate decreases by more in this case.

Figure 2 presents the responses of the LTV ratio to the technology shock. We see here that there is a conflict between the monetary policy and the macroprudential policy. The macroprudential regulator makes the LTV tighter to react to a higher output. However, the central bank is reducing the interest rate with all TR due to lower prices. This lower interest rate expands more the output and this forces the macroprudential regulator to reduce even more the LTV. The difference is lower in the extended TR

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[15]The standard deviation of the technology shock is estimated in Iacoviello (2005).
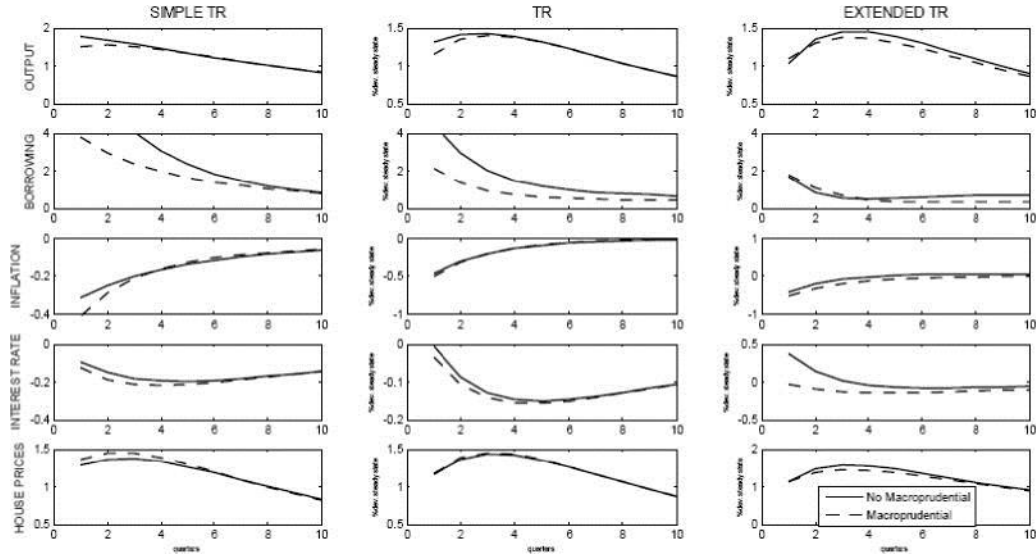
Figure 1: Impulse responses to a technology shock. Macroprudential versus no macroprudential

where the interest rate does not fall as much because the central bank also responds to a higher output. In contrast, the simple TR only reacts to prices and the conflict is stronger.

3.3.2 Housing Demand Shock

We consider a housing demand shock of a 25% standard deviation. This would generate an increase of a 25 percent in house prices. In Figure 3, we observe the impulse response functions for output, borrowing, inflation, interest rate, and house prices.

In the case of the output, 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 allow them consume both more houses and consumption goods. The increase in house prices is therefore transmitted to the real economy and output increases. When we compare the case without macroprudential policy (solid line) and with the macroprudential policy in place (dashed line), we find that in all three cases considered (simple TR, TR, and extended TR), the shock is moderated thanks to the macroprudential policy. This is due to the fact that the macroprudential policy reacts to the increase in the house prices reducing the LTV, restricting the credit in the economy. Therefore, a lower LTV moderates the demand shock decreasing credit in the economy and reducing the increase in output. There is a slight difference in the magnitude of the response function for the output in the extended TR; in this case, the central bank reacts directly to the shock in the house prices with a higher interest rate.
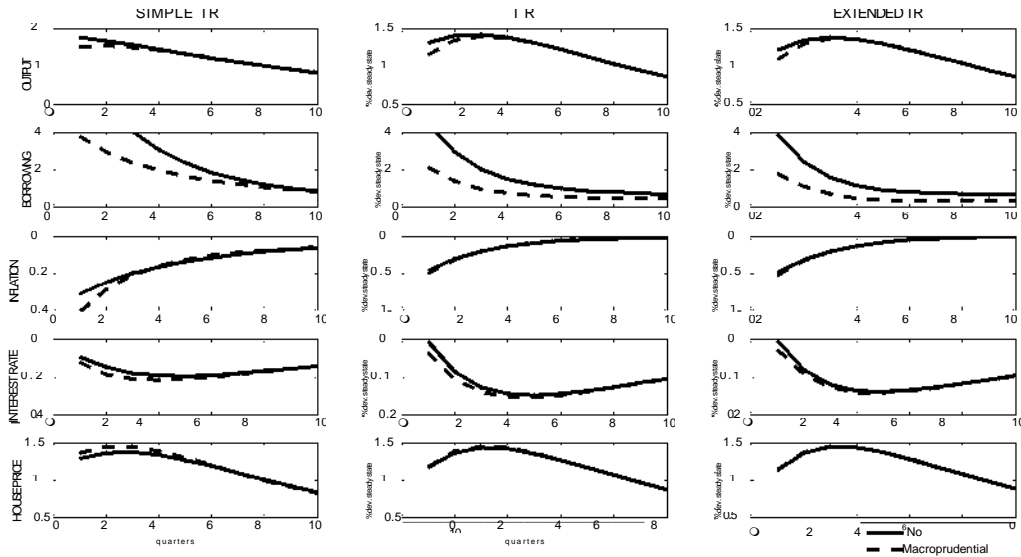
Output does not increase as much as in the other two monetary policies, both with the macroprudential policy and without it. Furthermore, all the Taylor rules respond to the higher inflation produced by the expansion of output with higher interest rates.

Borrowing is lower for the three monetary policy rules when the macroprudential policy is active: a tighter LTV makes borrowers reduce their leverage.

In the case of inflation, the macroprudential policy helps to control it in all cases. For the extended TR, inflation is even lower because the monetary policy reacts immediately to the shock with a higher interest rate.

The impulse responses for interest rate are showing significant differences. When the macroprudential policy is not active, the highest reaction appears in the extended TR because of the previously mentioned direct reaction to the shock. Then, it follows the TR, because it reacts to the increase in output and in inflation. Finally, the lower response is in the simple TR when the central bank only increases interest rate when inflation emerges. In all cases, the reaction of the central bank is moderated when the macroprudential policy is in place.

House prices'impulse responses functions are lower when the macroprudential policy is not in place because in this case the central bank reacts more in terms of the interest rate. Since the house price is the price of an asset, a higher interest rate will reduce its price. The interest rate pushes house prices down more strongly when the macroprudential rule is not active. Therefore, the boom is mitigated when the macroprudential rule is in place.

Then, with a demand side shock, monetary and macroprudential policies reinforce each other because
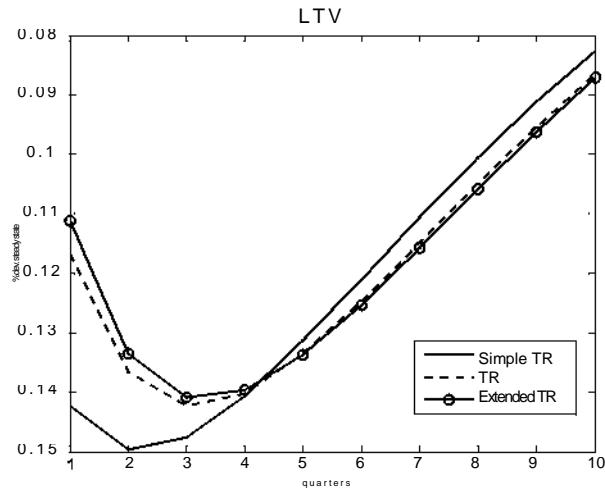
16

Figure 2: LTV response to a technology shock (macroprudential rule is active). Simple TR versus TR and extended TR

both of them aim at cutting credit in the economy with different instruments. Impulse responses show how, given the same shock, output, borrowing, inflation and house price responses are softened by the macroprudential measure. The interest rate responds more aggressively when the central bank reacts with respect to more parameters in its Taylor rule and this has an impact in output, borrowing and inflation.

Figure 4 displays the response of the LTV to a housing demand shock. We see that both policies go in the same direction. The macroprudential regulator cuts the LTV while interest rates go up, both limiting the expansion of credit. We also observe that, in this case, when we have an extended TR, the LTV does not need to respond in such a strong way as compared to the other two rules because monetary policy is already helping the macroprudential regulator to control house prices and output deviations from the steady state.

4 Welfare

4.1 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
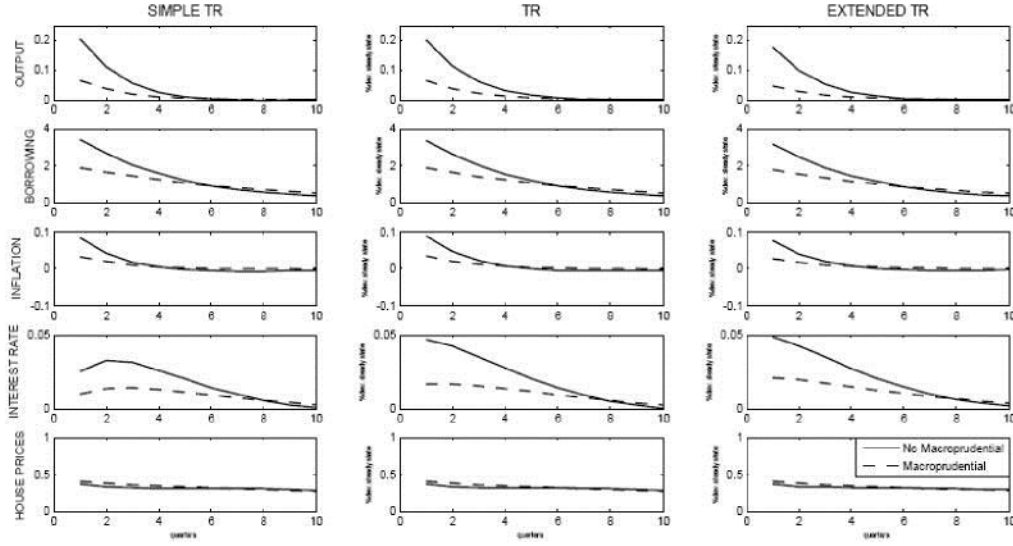
Figure 3: Impulse responses to a housing demand shock. Macroprudential versus no macroprudential

approach to be able to evaluate the welfare of the two types of agents separately.[16] The individual welfare for savers and borrowers, respectively, as follows:

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

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

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.

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. We are interested

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[16]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.
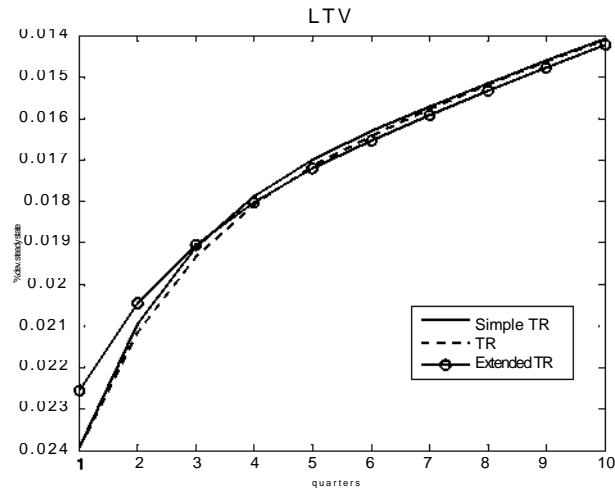
Figure 4: LTV response to a house price shock (macroprudential rule is active). Simple TR versus TR and extended TR

in calculating the welfare benefit of introducing a macroprudential policy, 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. The derivation of the welfare benefits in terms of consumption equivalent units is as follows:

$$CE_s = \exp\left[(1 - i3_s)\,(W_{MP}\right.$$

$$CE_b = \exp\left[(1 - /3_b)\,(W_{MP}^{s} - W\,)\right]_s 1, \tag{26}$$

$$_b - W\,)]_b 1, \tag{27}$$

$$CE = \exp\left[(W_b^{MP} - W\,)\right]_b 1. \tag{28}$$

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.[17]

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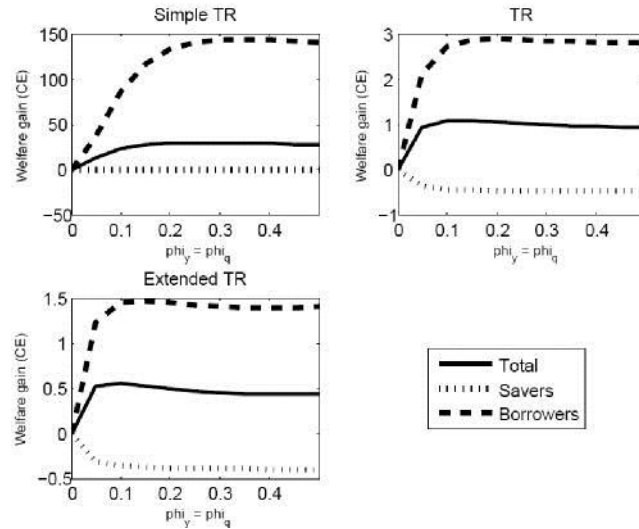[17]We follow Ascari and Ropele (2009).

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Figure 5: Welfare gains from introducing Macroprudential Policy, given Taylor rule. Borrowers, Savers, and Total

4.2 Welfare Analysis of the LTV rule, given Monetary Policy

In this section, we numerically evaluate welfare in the model. As in the impulse responses, we consider three different cases for monetary policy; first, a Taylor rule which responds just to inflation, that is, q $_\sim$ = 0.5; q $_y$ = 0; q $_q$ = *0* (simple TR), second, a Taylor rule which responds to inflation and output, that is q $_\sim$ = 0.5; q $_y$ = 0.5; q $_q$ = *0* (TR) and finally, a Taylor rule which responds to inflation, output and house prices, that is, q $_\sim$ = 0.5; q $_y$ = 0.5; q $_q$ = *0.1* (Extended TR). For the macroprudential rule, in order to simplify things and gain some insight, we restrict the analysis to the case in which both reaction parameters are equal. In the next section, we relax this restriction and find the optimal parameters.

Figures 5 and 6 show the welfare gains of introducing a macroprudential tool based on the LTV in the economy, given the Taylor rule in place. Figure 5 shows three panels comparing the welfare effects for each agent and the total for each different Taylor rule, when the parameters of the LTV rule change. Figure 6, in turn, compares the total welfare gain for the three Taylor rules.[18]

The conclusions we can obtain from the figures are the following. 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. Notice that borrowers have a collateral constraint which is always binding and this does not

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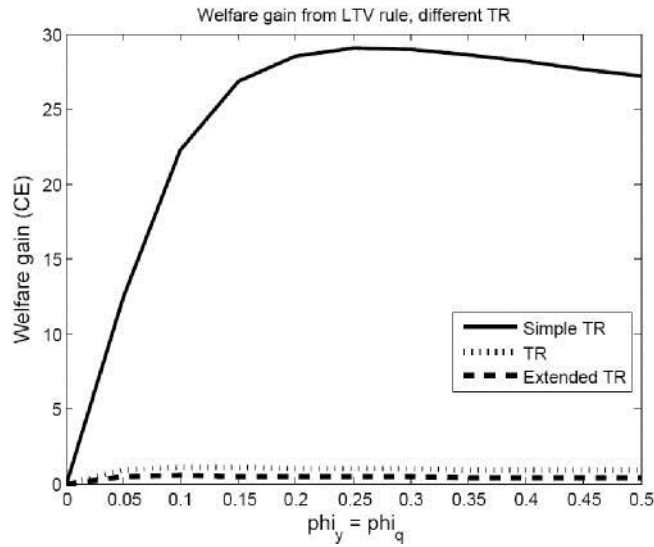[18]Welfare units are presented in percent.

Figure 6: Total welfare gains from introducing Macroprudential Policy, given Taylor rule

allow them make consumption smoothing.[19] A more stable financial system smooths their consumption path thus mitigating the negative effects of the collateral constraint. 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 borrowers welfare gain compensates the loss of the savers and globally, the measure is welfare increasing. We also see that welfare increases by more, the larger the response of the LTV to house prices and output is, but up to a point in which welfare stops increasing. Nevertheless, if we compare across Taylor rules, we see that for the standard and the extended ones, 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 and house price 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.

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.

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[19]See Rubio (2011), equation (19), for further discussion on the issue.

4.3 Optimal LTV rule, given Monetary Policy

In this subsection, we optimize the parameters of the LTV rule taking the Taylor rule parameters as given. This would be a special case in which regulators act in a non coordinated way. The macroprudential regulator would find the best response taken as given the parameters of the Taylor rule.[20] Table 3 shows results:

Table 3: Optimal Macroprudential, for given TR			
	Simple TR	TR	Extended TR
k^*_y	0.001	0.001	0.001
k^*_q	0.303	0.199	0.165
Welfare gain	30.864	1.224	0.651

We see that in order to maximize welfare, the LTV rule should respond relatively more aggressive to house prices than to output. In fact, the output response is negligible. We observe that the house price response is larger when the Taylor rule is only focusing on inflation because there is no room for financial stabilization in monetary policy. However, when the Taylor rule is extended to respond to output and house prices, the macroprudential policy does not need to be as aggressive as in the other cases because monetary policy is contributing to the same goal. Another issue to notice, as we saw in the previous section, is that welfare gains from introducing a macroprudential tool are larger in the case of the simple Taylor rule.[21]

5 Optimal Monetary and Macroprudential Policies

In this section, we find the optimal combination of policy parameters that maximizes welfare. We take as a benchmark the model with monetary policy, when the optimized Taylor rule responds to inflation and output, which is the standard case. Then, we consider two cases: one in which the Taylor rule is extended to include house prices and there is no LTV rule, so that it is a Taylor rule with a macroprudential component but just one instrument, the interest rate; and one in which we optimize both the Taylor rule and the LTV rule, so that there are two instruments, the LTV and the interest rate. This latter

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[20]To characterize the full solution of the non-coordinated game one should find the best response of the macroprudential regulator given different combinations of monetary policies and vice versa. The intersection between these two best responses would be the Nash equilibrium.

[21]Note that welfare gains are large because we are considering as a benchmark a case in which monetary policy is not optimized. Next section considers monetary policy optimization.

case would correspond to a coordinated game. In this case, we can think of a single regulator with two instruments (interest rate and LTV) and three objectives (inflation, output and financial stability), or two regulators that perfectly coordinate their actions.

Table 4 shows results of the policy optimization. The first column shows the optimal parameters of the standard Taylor rule that responds to output and inflation, that we will take as our benchmark. The second column presents the optimal parameters of the extended Taylor rule that responds to output, inflation and house prices and displays welfare gains with respect to the benchmark. Finally, the third column shows the optimal mix of parameters for both macroprudential and monetary policy, considering the extended TR for monetary policy, since it is the most general case. It also shows the welfare gains with respect to the benchmark monetary policy only scenario.[22]

Table 4: Optimal Macroprudential and Monetary Policy

	TR (Benchmark)	Extended TR	LTV and Extended TR
k_y	-	-	0.08
k_q	-	-	0.43
$R_{\sim}$	15.1	15.5	2.3
$R\,y$	8.2	8.2	0.02
$R\,q$	-	0.24	0
Welfare Gain			
Total	-	0.0006	0.645
Savers	-	-0.016	1.062
Borrowers	-	0.017	-0.201

The benchmark optimized Taylor rule (first column) is one that responds aggressively against inflation and output. If we allow for house prices in the Taylor rule (second column, extended TR), we observe that it is optimal for the central bank to have a positive response to them. This case would be equivalent to having the central bank do the job of a macroprudential regulator but with just one instrument, the interest rate. We can see that there are welfare gains from introducing house prices in the central bank rule. Gains are coming especially from borrowers, who enjoy a more stable financial system without compromising output and inflation response. Nevertheless, savers are slightly worse off, since they would prefer that the central bank focused just on inflation stabilization and did not include more objectives

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[22]Note that the standard deviation of the LTV instrument is 2.4011.

in its policy.

When we optimize over all the parameters and find the coordinated policy welfare gains with respect to the benchmark are larger (third column). In this case, gains come from the savers side. Savers are better off in a situation in which monetary policy uses its instrument to fight against inflation and the macroprudential regulator cares about financial stability with a different instrument. However, borrowers prefer the previous situation, in which financial stability is controlled through interest rates so that they can benefit from this scenario without tightening the collateral constraint. We see that the optimal macroprudential rule responds relatively more aggressively to house prices than to output because house prices appear directly in the collateral constraint and are responsible for financial stability. If we allow for monetary policy to respond to output, the optimal response is very small. Nevertheless, if we also allow the central bank to set interest rates responding to house prices, in order to enhance financial stability, it is not optimal to do so.

These results suggest that the optimal monetary policy is to fight against inflation and leave the financial stability goal for a macroprudential regulator. Even if we allow for the extended Taylor rule to take place, the optimal thing to do for the central bank is not to respond to house prices, this seems to be the job of the macroprudential regulator.

In conclusion, the central bank could use the interest rate to stabilize house prices and therefore the financial system. However, optimal policy analysis suggests that it is preferable to leave this objective to a macroprudential regulator with a different instrument.

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. We also find that monetary policy and macroprudential policy may enter in conflict when shocks come from the supply side of the economy.

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. Third, welfare gains are larger if the central bank is responding only to

inflation. 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 may be redundant.

Finally, we calculate the combination of policy parameters that maximizes welfare. We find that the optimal LTV rule is one that responds relatively more aggressively to house prices than output deviations. Results also show that welfare is maximized when the central bank focuses on fighting against inflation and leaves the goal of ensuring a stable financial system to a different institution.

Appendix

Main Equations

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

$$w^s_t = (N_{s,t})^{\varphi-1} C_{s,t}; \tag{30}$$

$$\frac{H_{s,t}}{C_{s,t}} = \frac{1}{q_t} - \beta_s E_t \frac{1}{C_{s,t+1}} q_{t+1}: \tag{31}$$

$$\frac{1}{C_{b,t}} = \sigma^b E_t \frac{r_{t+1} C_{b,t+1}}{+ \lambda_t R_t} : \frac{R_t}{} \tag{32}$$

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

$$\frac{H_{b,t}}{C_{b,t}} = q_t - \sigma_b E_t ,-, \frac{1}{C_{b,t+1}} q_{t+1} - \lambda_t E_t (q_{t+1} \pi_{t+1}) : \tag{34}$$

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

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

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

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

$$\pi_t = \beta E_t \pi_{t+1} - \varkappa x_t + u_{\pi t} \tag{39}$$

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$$W_{s;t} = E_t \sum_{m=0}^{\infty} m \log \left[C_{s;t+m} + j \log H_{s;t+m} s \quad \underline{(N_{s;t+m})} \sim \right] ; \tag{40}$$

$$W_{b;t} = E_t \sum_{m=0}^{\infty} m \log \left[C_{b;t+m} + j \log H_{b;t+m} b \quad \underline{(N_{b;t+m})} \sim \right] ; \tag{41}$$

$$W_t = (1 - 3_s) W_{s;t} + (1 - /3_b) W_{b;t}: \tag{42}$$

References

[1] Angelini, P., Neri, S., Panetta, F., (2012), Monetary and macroprudential policies, Working Paper Series 1449, European Central Bank.

[2] Ascari, G., Ropele, T., (2009), Disinflation in a DSGE Perspective: Sacrifice Ratio or Welfare Gain Ratio?, Kiel Institute for the World Economy Working Paper, 1499

[3] Benigno, P., Woodford, M., (2008), Linear-Quadratic Approximation of Optimal Policy Problems, mimeo

[4] Borio, C., Shim, I., (2007), What can (macro-) policy do to support monetary policy?, BIS Working Paper, 242

[5] Domeij, D., Flodén, M., (2006) "The Labor-Supply Elasticity and Borrowing Constraints: Why Estimates are Biased." Review of Economic Dynamics, 9, 242-262

[6] Eichengreen, B., El-Erian, M., Fraga, A., Ito, T., Pisani-Ferry, J., Prasad, E., Rajan, R., Ramos, M., Reinhart, C., Rey, H., Rodrik, D., Rogoff, K., Shin, H.S., Velasco, A., Weder di Mauro, B., and Yu, Y., (2011), "Rethinking Central Banking," Committee on International Economic Policy and Reform, www.brookings.edu

[7] Eichengreen, B., Rajan, R., and Prasad, E., (2011), "Central Banks Need a Bigger and Bolder Mandate,"Financial Times October 24, 2011.

[8] Funke, M., Paetz, M., (2012), A DSGE-Based Assessment of Nonlinear Loan-to-Value Policies: Evidence from Hong Kong, BOFIT Discussion Paper No. 11/2012

[9] Iacoviello, M., (2005) "House Prices, Borrowing Constraints and Monetary Policy in the Business Cycle." American Economic Review, 95 (3), 739-764

[10] Iacoviello, M., (2014), Financial Business Cycles, Mimeo, Federal Reserve Board

[11] Iacoviello, M. , Neri, S., (2010), "Housing Market Spillovers: Evidence from an Estimated DSGE Model,"American Economic Journal: Macroeconomics, 2, 125– 164.

[12] IMF, Monetary and Capital Markets Division, (2011), Macroprudential Policy: An Organizing Framework, mimeo, IMF

[13] IMF (2013). Key aspects of macroprudential policy: background paper, IMF Working. Paper

[14] Kannan, P., Rabanal, P., Scott, A., (2012), "Monetary and Macroprudential Policy Rules in a Model with House Price Booms", The B.E. Journal of Macroeconomics, Contributions, 12 (1)

[15] Lawrance, E., (1991), "Poverty and the Rate of Time Preference: Evidence from Panel Data", The Journal of Political Economy, 99 (1), 54-77

[16] McCallum, B., (2001), "Should Monetary Policy Respond Strongly To Output Gaps?," American Economic Review, 91(2), 258-262

[17] Mendicino, C., Pescatori, A., (2007), Credit Frictions, Housing Prices and Optimal Monetary Policy Rules, mimeo

[18] Monacelli, T., (2006), "Optimal Monetary Policy with Collateralized Household Debt and Borrowing Constraint," in conference proceedings "Monetary Policy and Asset Prices" edited by J. Campbell.

[19] N'Diaye, P., (2009), Countercyclical macro prudential policies in a supporting role to monetary policy, IMF Working Paper

[20] Rubio, M., (2011), "Fixed- and Variable-Rate Mortgages, Business Cycles, and Monetary Policy," Journal of Money, Credit and Banking, Vol. 43, No. 4

[21] Rubio, M., Carrasco-Gallego, J. A., (2014), "Macroprudential and monetary policies: Implications for financial stability and welfare", Journal of Banking & Finance, forthcoming

[22] Schmitt-Grohe, S., Uribe, M., (2004), "Solving Dynamic General Equilibrium Models Using a Second-Order Approximation to the Policy Function," Journal of Economic Dynamics and Control, 28, 755-775

[23] Smets, F., Wouters, R., (2002),An estimated stochastic dynamic general equilibrium model of the euro area, Working Paper Series 0171, European Central Bank

[24] Yellen, J.L., (2010), Macroprudential Supervision and Monetary Policy in the Post-crisis World. Speech At the Annual Meeting of the National Association for Business Economics, Denver, Colorado October 11, 2010