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Monetary and Macroprudential Policies  
under Fixed and Variable Interest Rates

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# Monetary and Macroprudential Policies under Fixed and Variable Interest Rates

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## Abstract

In this paper, I analyze the ability of monetary policy to stabilize both the macroeconomy and financial markets under two different scenarios: fixed and variable-rate mortgages. I develop and solve a New Keynesian dynamic stochastic general equilibrium model that features a housing market and a group of constrained individuals who need housing collateral to obtain loans. A given share of constrained households borrows at a variable rate, while the rest borrows at a fixed rate. I consider two alternative ways of introducing a macroprudential approach to enhance financial stability: one in which monetary policy, using the interest rate as an instrument, responds to credit growth; and a second one in which the macroprudential instrument is instead the loan-to-value ratio (LTV). Results show that when rates are variable, a countercyclical LTV rule performs better to stabilize financial markets than monetary policy. However, when they are fixed, even though monetary policy is less effective to stabilize the macroeconomy, it does a good job to promote financial stability.

Keywords: Fixed/Variable-rate mortgages, monetary policy, macroprudential policy, LTV, housing market, collateral constraint

JEL Codes: E32, E44, E52

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*" The explicit incorporation of macroprudential considerations in the nation's framework for financial oversight represents a major innovation in our thinking about financial regulation [...] This new direction is constructive and necessary, I believe, but it also poses considerable conceptual and operational challenges in its implementation". Ben Bernanke, May 5, 2011.*

## 1 Introduction

In recent years, especially during the period of the Great Moderation, monetary policy had been seen as a very powerful tool to stabilize the economy. However, in the aftermath of the crisis, new experiences have revealed that this statement is not true for all cases nor under all circumstances. First of all, the effectiveness of monetary policy may depend on structural factors in the economy. In particular, there may be institutional features, especially in housing markets, that are country-specific and that may affect the optimal conduct of policies. One source of heterogeneity, which can be crucial, is the structure of mortgage contracts. Mortgage contracts in an economy can be fixed or variable rate, and the proportion of each type of mortgages varies from country to country. The link between the policy rate and fixed rates is weaker, since the latter are more connected to longer-term rates, and thus, in this case, monetary policy is less effective.<sup>1</sup> On the other hand, with the crisis, the center of policy and academic discussions has been how to ensure a more stable financial system: a macroprudential approach to prevent the economy from situations in which problems in the financial sector are transmitted to the real sector and vice-versa. It is debatable that monetary policy alone can achieve this goal; it may need the help of other tools that help avoiding excessive credit growth. The remaining question is the following: Does the mortgage structure of the economy affect the ability of monetary policy to enhance financial stability?

In this paper, I try to shed some light on this issue. I analyze the ability of monetary policy to stabilize financial markets under two different scenarios: when the prevalent mortgage rate in the economy is variable and when it is fixed. Recent literature shows that the effectiveness of monetary policy to stabilize the macroeconomy is reduced when rates are fixed. Nevertheless, the literature is silent about whether this feature has an impact on the potential of monetary policy to promote financial stability.

There is evidence of different cross-country mortgage contracts. While fixed rate-mortgages predominate in the US, the majority of consumers borrow at a variable rate in Canada or Australia. Within

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<sup>1</sup>See Rubio (2011) or Brzoza-Brzezina (2014) for theoretical models that show that fixed rate contracts imply less effective monetary policy.

European countries, we have striking differences such that the United Kingdom or Spain, in which the vast majority of consumers have variable-rate mortgages, as opposed to Germany or France in which mortgages are fixed rate (See Table A1 in the Appendix). Rubio (2011) and Calza et al (2013) show that the structure of mortgage contracts has important implications for the transmission of monetary policy in the sense that policy rate changes are less effective when the mortgage rate is fixed. However, these papers do not touch upon the issue of whether having fixed- or variable-rate mortgages may also affect financial stability and the optimal design of macroprudential policies.

In this paper, I build a new Keynesian dynamic stochastic general equilibrium model with housing, collateral constraints, and fixed and variable-rate mortgages to study how the mortgage structure in an economy affects the optimal design of both monetary and macroprudential policies. In the model, there are three types of consumers; savers, variable-rate borrowers and fixed-rate borrowers. Borrowers need collateral in order to access credit markets which are more or less tight depending on the loan-to-value ratio (LTV). Monetary policy is conducted by the central bank. For the macroprudential policies I consider two options; one in which it is conducted by the central bank with the interest rate as an instrument, and a second one in which there is a macroprudential regulator that uses a countercyclical rule for the LTV as a macroprudential tool.

Since this is a microfounded model, it is suitable to study welfare-related issues. In this setting, there are several channels that affect welfare and that are dependent on mortgage contracts. In new Keynesian models with collateral constraints, there are two types of distortions: sticky prices and credit frictions. Savers prefer policies that alleviate the first distortion, since they own the firms. They are better off in a scenario with price stability, the goal of monetary policy. On the contrary, borrowers' welfare increases when the credit friction distortion is minimized. Then, borrowers may prefer situations that generate inflation or policies that enhance financial stability, namely macroprudential. However, these mechanisms may differ depending on whether the prevalent mortgage contract in the economy is fixed or variable rate. In the variable-rate scenario, monetary policy is more stabilizing because there is a one-for-one link between the policy rate and the borrowing rate. With respect to macroprudential policies, their effectiveness will also depend on whether the economy has fixed or variable rates, since their interaction with monetary policy will have an effect on financial stability.

With the purpose of understanding the dynamics of the baseline model and as a motivation for my study, as a first step I present impulse responses to a technology shock, for the case in which there are no macroprudential policies. I find that having variable or fixed-rate mortgages does not only affect

the macroeconomic dynamics but also the financial side of the economy. The fixed-rate economy, has a less powerful monetary policy tool but borrowers are more exposed to changes in inflation and house prices, affecting their financial capacity. Therefore, the structure of mortgage contracts should have clear implications, not only for monetary policy reaction but also for macroprudential policies, which care about financial stability. Then, it is relevant to study the optimal implementation of both monetary and macroprudential policies in the context of variable and fixed-rate mortgages.

Then, I analyze how the optimality of monetary and macroprudential policies changes depending on the mortgage structure of the economy. I define optimal policy as the one that maximizes total welfare. As mentioned, I consider two alternative ways of introducing macroprudential policies; first, a simple and automatic rule on the LTV. Following this rule, the LTV would be the instrument of the macroprudential regulator and would react to credit growth. In this way, if the economy is, for instance, entering a credit boom, the LTV will be cut, thus restricting credit in the economy and avoiding excessive credit growth. This rule, which resembles a Taylor rule for monetary policy, serves as a proxy for the macroprudential instruments that have been used by some institutions.<sup>2</sup> Alternatively, I consider including credit growth in the interest-rate rule of the central bank. In this way, the monetary authority would have one instrument, the interest rate, to take care of two objectives; macroeconomic and financial stability.

Results show that macroprudential policies increase welfare regardless of the mortgage structure prevalent in the economy. Nevertheless, when mortgages are variable rate, an LTV rule combined with monetary policy is preferable to including credit variables in the interest-rate rule. When rates are fixed, using the interest rate as an instrument both for monetary and macroprudential policy delivers higher welfare and stability than having two separate instruments. Interestingly for the fixed rate case, in which monetary policy is less effective to stabilize the macroeconomy, it is a more powerful tool to stabilize the financial system.

This paper relates to different strands of the literature. First, it introduces heterogeneity in mortgage contracts in the spirit of Rubio (2011), Calza et al. (2013), and Garriga et al. (2013). However, those studies restrict themselves to the effects of the mortgage structure on business cycles and monetary policy, without analyzing the implications for macroprudential policies. Second, it is close to the recent macroprudential literature. On the one hand, it relates with papers in which macroprudential policies

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<sup>2</sup>LTV rules have become particularly popular. See for instance, Gruss and Sgherri (2009) which 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. 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.

interact with monetary policy as in Kannan et al. (2012), Rubio and Carrasco-Gallego (2014), and Angelini et al. (2014). However, none of the above mentioned papers studies how fixed and variable-rate mortgages affect the implementation of macroprudential policies nor affect financial stability. On the other hand, my paper also explores the topic of whether monetary and macroprudential policies should be conducted by the same regulator using only one instrument and two objectives or two regulators with two different instruments. Following the same line, Beau et al. (2012) claims that it is preferable to have a combination of separate objectives for monetary and macroprudential policies. Rubio and Carrasco-Gallego (2015) also finds that monetary policy should focus on price stability while macroprudential policy should have financial stability as an instrument. Kannan et al. (2012) experiments with an augmented Taylor rule and an LTV rule as well and finds that results depend on the source of the shock considered. In my paper, I find that having two separate instruments is preferred in the case of variable-rate mortgages but the augmented Taylor rule delivers higher welfare when rates are fixed.

The paper continues as follows. Section 2 explains the basic model I build for the analysis and its dynamics. Section 3 shows the modelling of the macroprudential policies. Section 4 analyzes the normative implications of introducing macroprudential policies and displays the optimal monetary and macroprudential policy mix. Section 5 presents the conclusions. The Appendix contains graphs and tables on the empirical evidence mentioned above and model derivations.

## **2 The Baseline Model**

I consider an infinite-horizon economy in which households consume, work and demand real estate. There is a representative financial intermediary that provides mortgages and accepts deposits from consumers. Firms set prices subject to Calvo (1983)-Yun (1996) nominal rigidity. The monetary authority sets interest rates endogenously, in response to inflation and output, following a Taylor rule.

### **2.1 The Consumer's Problem**

There are three types of consumers: unconstrained consumers, constrained consumers who borrow at a variable rate, and constrained consumers who borrow at a fixed rate. Constrained individuals need to collateralize their debt repayments in order to borrow from the financial intermediary. Interest payments for both mortgages and loans cannot exceed a proportion of the future value of the current house stock. In this way, the financial intermediary ensures that borrowers are going to be able to

fulfill their debt obligations next period. As in Iacoviello (2005), I assume that constrained consumers are more impatient than unconstrained ones. This assumption ensures that the borrowing constraint is binding, so that constrained individuals do not save and wait until they have the funds to self-finance their consumption. This generates an economy in which households divide into borrowers and savers. Furthermore, borrowers are split into two groups, those who borrow at a fixed rate and those who borrow at a variable rate. The proportion of each type of borrower is fixed and exogenous. All households derive utility from consumption, housing services assumed proportional to the housing stock and leisure.

### 2.1.1 The Financial Intermediary

There is a financial intermediary which accepts deposits from savers, and extends both fixed and variable-rate loans to borrowers.<sup>3</sup> I assume a competitive framework and thus the intermediary takes the variable interest rate as given. The profits of the financial intermediary are defined as:

$$F_t = \alpha R_{t-1} b_{t-1}^{cv} + (1 - \alpha) \bar{R}_{t-1} b_{t-1}^{cf} - R_{t-1} b_{t-1}^u, \quad (1)$$

where  $F_t$  represents the profits of the financial intermediary,  $\alpha$  is the proportion of variable rates,  $R_{t-1}$  is the gross policy rate set by the central bank,  $b_{t-1}^{cv}$  and  $b_{t-1}^{cf}$  are one-period variable and fixed-rate mortgages, respectively.<sup>4</sup>  $b_{t-1}^u$  represent deposits.

In equilibrium, aggregate borrowing and saving must be equal, that is,

$$\alpha b_t^{cv} + (1 - \alpha) b_t^{cf} = b_t^u. \quad (2)$$

Substituting (2) into (1), we obtain,

$$F_t = (1 - \alpha) b_{t-1}^{cf} (\bar{R}_{t-1} - R_{t-1}). \quad (3)$$

In order for the two types of mortgage to be offered, the fixed interest rate has to be such that the intermediary is indifferent between lending at a variable or fixed rate. Hence, the expected discounted profits that the intermediary obtains by lending new debt in a given period at a fixed interest rate must be equal to the expected discounted profits the intermediary would obtain by lending it at a variable

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<sup>3</sup>In countries where FRMs are most extensively used, financial intermediaries pass on the loans to investors with long-term liabilities (such as pension funds and life-insurance companies). Short-term deposits are predominantly used to finance mortgages in countries where ARMs are commonly used. These institutional features are out of the scope of this paper.

<sup>4</sup>Notice that in this model mortgages are a flow variable.

rate:<sup>5</sup>

$$E_\tau \sum_{i=\tau+1}^{\infty} \beta^{i-\tau} \Lambda_{\tau,i} \bar{R}_\tau^* = E_\tau \sum_{i=\tau+1}^{\infty} \beta^{i-\tau} \Lambda_{\tau,i} R_{i-1}, \quad (4)$$

where  $\Lambda_{t,i} = \left( \frac{C_t^u}{C_{t+i}^u} \right)$  is the unconstrained consumer relevant discount factor. Since the financial intermediary is owned by the savers, their stochastic discount factor is applied to the financial intermediary's problem. Notice that, as stated before, variable-rate debt is one period but the portion of new debt acquired at a fixed rate is associated with a long-term contract. Since the agent is infinitely lived, the financial intermediary considers an infinitely lasting maturity in these calculations.<sup>6</sup>

We can obtain the equilibrium value of the fixed rate in period  $\tau$  from expression (4) :

$$\bar{R}_\tau^* = \frac{E_\tau \sum_{i=\tau+1}^{\infty} \beta^{i-\tau} \Lambda_{\tau,i} R_{i-1}}{E_\tau \sum_{i=\tau+1}^{\infty} \beta^{i-\tau} \Lambda_{\tau,i}}. \quad (5)$$

Equation (5) states that, for every new debt issued at date  $\tau$ , there is a different fixed interest rate that has to be equal to a discounted average of future variable interest rates. Notice that this is not a condition on the stock of debt, but on the new amount obtained in a given period. New debt at a given point in time is associated with a different fixed interest rate. Both the fixed interest rate in period  $\tau$  and the new amount of debt in period  $\tau$  are fixed for all future periods. However, the fixed interest rate varies with the date the debt was issued, so that in every period there is a new fixed interest rate associated with new debt in this period. If we consider fixed-rate loans to be long-term, the financial intermediary obtains interest payments every period from the whole stock of debt, not only from the new ones. Hence, we can define an aggregate fixed interest rate that is the one the financial intermediary effectively charges every period for the whole stock of mortgages. This aggregate fixed interest rate is composed of all past fixed interest rates and past debt, together with the current period equilibrium fixed interest rate and new amount of debt. Therefore, the effective fixed interest rate that the financial intermediary charges for the stock of fixed-rate debt every period is:

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<sup>5</sup>The fixed rate loan is priced following this non-arbitrage condition, not by applying the prices of zero-coupon bonds to the future cash flows from the new loan.

<sup>6</sup>Calza et al. (2010) also have a model in which the financial intermediary offers fixed and variable-rate mortgages. However, in their model, the two types of mortgages do not coexist. For them, the fixed-rate loan is a two-period contract while the variable-rate is one period. In my model, I allow for the two mortgages to be offered in order to be able to study intermediate cases in which a mix of the two types of contracts are present in the economy.

$$\bar{R}_t = \left\{ \begin{array}{l} \frac{\bar{R}_{t-1}b_{t-1}^{cf} + \bar{R}_t^*(b_t^{cf} - b_{t-1}^{cf})}{b_t^{cf}} \text{ if } b_t^{cf} > b_{t-1}^{cf} \\ \bar{R}_{t-1} \text{ if } b_t^{cf} \leq b_{t-1}^{cf} \end{array} \right\}. \quad (6)$$

Equation (6) states that the fixed interest rate that the financial intermediary is actually charging today is an average of what it charged last period for the previous stock of mortgages and what it charges this period for the new amount.<sup>7</sup> In the case that there is not new debt, the fixed interest rate will be equal to last period's.<sup>8</sup> Then, the same way that variable rates are revised every period, fixed-rates are revised by including the new optimal fixed interest rate for the new debt originated in this period. Importantly, this assumption is not crucial for results. Both  $\bar{R}_\tau^*$  and  $\bar{R}_t$  are practically unaffected by interest rate shocks. This assumption is a way to make the model compatible with the fact that fixed-rate loans are not one-period assets but longer term ones.<sup>9</sup>

As noted above, if any, profits from financial intermediation are rebated to the unconstrained consumers every period. Even if the financial intermediary is competitive and profits are expected to be zero, if there is a shock at a given point in time, the fact that only the variable interest rate is directly affected can generate non-zero profits.

### 2.1.2 Unconstrained Consumers (Savers)

Unconstrained consumers maximize:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left( \ln C_t^u + j \ln H_t^u - \frac{(L_t^u)^\eta}{\eta} \right), \quad (7)$$

where the superscript  $u$  stands for "unconstrained",  $E_0$  is the expectation operator,  $\beta \in (0, 1)$  is the discount factor, and  $C_t^u$ ,  $H_t^u$  and  $L_t^u$  are consumption at  $t$ , the stock of housing and hours worked, respectively;  $1/(\eta - 1)$  is the labor supply elasticity,  $\eta > 0$  and  $j > 0$  represents the weight of housing in the utility function.

The budget constraint is:

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<sup>7</sup>This expression can be interpreted in a similar way as in Calza et al. (2010). In their model, the fixed rate loan is repaid in two periods. Here, the contract is of infinite maturity but I also divide payments in two blocks, the new payments made this period for new loans and the payments for the old loans set in a compact way.

<sup>8</sup>Notice that, if  $\bar{R}_t > \bar{R}_t^*$ , remortgaging to a lower  $\bar{R}_t^*$  is not allowed in the model. The agent cannot repay the most expensive mortgages first either.

<sup>9</sup>In the real world, variable-rate mortgages are also long-term loans. That is, both loans are amortized over a long period of time. The only difference is that interest payments on adjustable-rate mortgages are variable. In the model variable-rate mortgages are modeled as one-period loans.

$$C_t^u + q_t H_t^u + b_t^u \leq q_t H_{t-1}^u + w_t^u L_t^u + \frac{R_{t-1} b_{t-1}^u}{\pi_t} + F_t^v + S_t^v, \quad (8)$$

where  $q_t$  is the real housing price and  $w_t^u$  is the real wage for unconstrained consumers. These can buy houses or sell them at the current price  $q_t$ . I assume zero housing depreciation for simplicity. As we will see, this group will choose not to borrow at all; they are the savers in this economy.  $b_t^u$  is the amount they save. They receive interest  $R_{t-1}$  for their savings.  $\pi_t$  is inflation in period  $t$ .  $S_t$  and  $F_t$  are lump-sum profits received from the firms and the financial intermediary, respectively. We can think of these consumers as the wealthy agents in the economy, who own the firms and the financial intermediary.

The first-order conditions for this unconstrained group are:

$$\frac{1}{C_t^u} = \beta E_t \left( \frac{R_t}{\pi_{t+1} C_{t+1}^u} \right), \quad (9)$$

$$w_t^u = (L_t^u)^{\eta-1} C_t^u, \quad (10)$$

$$\frac{j}{H_t^u} = \frac{1}{C_t^u} q_t - \beta E_t \frac{1}{C_{t+1}^u} q_{t+1}. \quad (11)$$

Equation (9) is the Euler equation for consumption, equation (10) is the labor-supply condition, and equation (11) is the Euler equation for housing. This states that the benefits from consuming housing must be equal to the costs at the margin.

### 2.1.3 Constrained Consumers (Borrowers)

Constrained consumers are of two types: those who borrow at a variable rate and those who do it at a fixed rate. The difference between them is simply the interest rate they face. The fixed-rate borrower faces  $\bar{R}_t$ , set by the financial intermediary, whereas the variable-rate counterpart faces  $R_t$ , set by the central bank. The proportion of variable-rate consumers is fixed and exogenous and equal to  $\alpha \in [0, 1]$ .

Constrained and unconstrained consumers are different in the way they discount the future. Constrained consumers are more impatient than unconstrained ones. I assume that constrained consumers face a limit on the debt they can acquire. The maximum amount they can borrow is proportional to the value of their collateral, in this case the stock of housing. That is, the debt repayment next period cannot exceed a proportion of tomorrow's value of today's stock of housing:

$$E_t \frac{R_t}{\pi_{t+1}} b_t^{cv} \leq k_t E_t q_{t+1} H_t^{cv}, \quad (12)$$

$$E_t \frac{\bar{R}_t}{\pi_{t+1}} b_t^{cf} \leq k_t E_t q_{t+1} H_t^{cf}, \quad (13)$$

where (12) represents the collateral constraint for the variable-rate constrained consumer and (13) is the constraint for the fixed-rate one.<sup>10</sup>  $k_t$  represents a proxy for the loan-to-value ratio and, as we will see, it is the instrument of the macroprudential authority. As we have seen with the problem of the financial intermediary,  $\bar{R}_t$  is an aggregate interest rate that contains information on all the past fixed interest rates associated with past debt. Each period, this aggregate interest rate is updated with a new interest rate linked to the new amount of debt originated in that period.

Without loss of generality, I present the problem for the variable-rate borrower, since the one for the fixed-rate is symmetric. Variable-rate borrowers maximize their lifetime utility function:

$$\max E_0 \sum_{t=0}^{\infty} \tilde{\beta}^t \left( \ln C_t^{cv} + j \ln H_t^{cv} - \frac{(L_t^{cv})^\eta}{\eta} \right), \quad (14)$$

subject to the budget constraint:

$$C_t^{cv} + q_t H_t^{cv} + \frac{R_{t-1} b_{t-1}^{cv}}{\pi_t} \leq q_t H_{t-1}^{cv} + w_t^{cv} L_t^{cv} + b_t^{cv}, \quad (15)$$

and (12), the collateral constraint.<sup>11</sup> Notice that variable-rate borrowers repay all debt every period and acquire new one at the current new interest rate. This assumption implies that the interest rate on variable rate mortgages is revised every period for the whole stock of debt and changed according to the policy rate.<sup>12</sup> In order to make the problem for fixed-rate borrowers symmetric and analogous to the existing models with borrowing constraints, I assume the same debt-repayment structure for this type of borrowers. Obviously, fixed-rate contracts are not revised every period. However, to make the model more realistic but still tractable, the fixed interest rate will be such that a revised fixed rate will be applied only on new debt, keeping constant the interest rate applied to existing debt. In this way, I reconcile the structure of the model with the fact that fixed-rate contracts are long term.<sup>13</sup>

<sup>10</sup>The superscript *cv* stands for "constrained variable" while *cf* stands for "constrained fixed"

<sup>11</sup>We will see from the firm's problem that  $w_t^{cv} = w_t^{cf} = w_t^c$ .

<sup>12</sup>This assumption is consistent with reality, in which variable interest rates are revised very frequently and changed according to an interest rate index tied to the interest rate set by the central bank.

<sup>13</sup>Another option would be to have an overlapping generation model in which we are able to keep track of the debt issued

As noted above, constrained consumers are more impatient than unconstrained ones, so that  $\tilde{\beta} < \beta$ . This assumption is crucial for the borrowing constraint to be binding and therefore, for there to be both borrowers and savers in the economy.

The first-order conditions for variable-rate constrained consumers are:

$$\frac{1}{C_t^{cv}} = \tilde{\beta} E_t \left( \frac{R_t}{\pi_{t+1} C_{t+1}^{cv}} \right) + \lambda_t^{cv} R_t, \quad (16)$$

$$w_t^{cv} = (L_t^{cv})^{\eta-1} C_t^{cv}, \quad (17)$$

$$\frac{j}{H_t^{cv}} = \frac{1}{C_t^{cv}} q_t - \tilde{\beta} E_t \left( \frac{1}{C_{t+1}^{cv}} q_{t+1} \right) - \lambda_t^{cv} k_t E_t (q_{t+1} \pi_{t+1}). \quad (18)$$

These first-order conditions differ from those of the unconstrained individuals. In the case of constrained consumers, the Lagrange multiplier on the borrowing constraint ( $\lambda_t^{cv}$ ) appears in equations (16) and (18). From the Euler equation for consumption of unconstrained consumers, we know that  $R = 1/\beta$  in steady state. If we combine this result with the Euler equation for consumption of constrained individuals we have that  $\lambda^{cv} = (\beta - \tilde{\beta})/C^{cv} > 0$  in steady state. This means that the borrowing constraint holds with equality in steady state. Since we log-linearize the model around the steady state and assume that uncertainty is low, we can generalize this result to off-steady-state dynamics. Then, the borrowing constraint is always binding, so that constrained individuals borrow the maximum amount they are allowed to and unconstrained consumers are never in debt.<sup>14</sup>

Given the borrowing amount implied by (12) at equality, consumption for variable-rate constrained individuals can be determined by their flow of funds:

$$C_t^{cv} = w_t^{cv} L_t^{cv} + b_t^{cv} + q_t (H_{t-1}^{cv} - H_t^{cv}) - \frac{R_{t-1} b_{t-1}^{cv}}{\pi_t}, \quad (19)$$

and the first-order condition for housing becomes:

$$\frac{j}{H_t^{cv}} = \frac{1}{C_t^{cv}} \left( q_t - \frac{k_t E_t (q_{t+1} \pi_{t+1})}{R_t} \right) - \tilde{\beta} E_t \left( \frac{1}{C_{t+1}^{cv}} (1 - k_t) q_{t+1} \right). \quad (20)$$

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each period. However, the model would become more complex and less comparable with the standard collateral constraint DSGE models such as Iacoviello (2005).

<sup>14</sup>This is a typical assumption for this kind of models. See Iacoviello (2005), Appendix C for a detailed analysis of when do constraints bind.

## 2.2 Firms

### 2.2.1 Final Goods Producers

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

$$Y_t = \left[ \int_0^1 Y_t(z)^{\frac{\varepsilon-1}{\varepsilon}} dz \right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad (21)$$

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

$$Y_t(z) = \left( \frac{P_t(z)}{P_t} \right)^{-\varepsilon} Y_t. \quad (22)$$

The price index is then given by:

$$P_t = \left[ \int_0^1 P_t(z)^{1-\varepsilon} dz \right]^{\frac{1}{\varepsilon-1}}. \quad (23)$$

Market clearing for the final good requires:

$$Y_t = C_t = C_t^u + C_t^c.$$

### 2.2.2 Intermediate Goods Producers

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

$$Y_t(z) = A_t L_t^u(z)^\gamma L_t^c(z)^{(1-\gamma)}, \quad (24)$$

where  $\gamma \in [0, 1]$  measures the relative size of each group in terms of labor. This Cobb-Douglas production function implies that labor efforts of constrained and unconstrained consumers are not perfect substitutes. This specification is analytically tractable and allows for closed form solutions for the steady state of the model. This assumption can be economically justified by the fact that savers are the managers of the firms and their wage is higher than the one of the borrowers.<sup>15</sup> Experimenting with a production

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<sup>15</sup>It could also be interpreted as the savers being older than the borrowers, therefore more experienced.

function in which hours are substitutes leads to very similar results in terms of model dynamics. Under the Cobb-Douglas specification each household has mass one.  $\gamma$  is a constant that represents the labor-income share of the patient household and  $L_t^u$  are total hours worked by the patient household. In the alternative specification, one needs to define the fraction of agents in the population, say  $\omega$  is the fraction of savers. Then,  $\omega L_t^u$  represents the total hours worked by the patient household. Therefore, both specifications are very similar but, while  $\gamma$  represents the economic size of savers,  $\omega$  is its absolute size.<sup>16</sup>

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

$$\log(A_t) = \rho_A \log(A_{t-1}) + u_{At}, \quad (25)$$

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

Labor demand is determined by:

$$w_t^u = \frac{1}{X_t} \gamma \frac{Y_t}{L_t^u}, \quad (26)$$

$$w_t^c = \frac{1}{X_t} (1 - \gamma) \frac{Y_t}{L_t^c}, \quad (27)$$

where  $X_t$  is the markup, or the inverse of marginal cost.<sup>17</sup>

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

$$\sum_{k=0}^{\infty} (\theta\beta)^k E_t \left\{ \Lambda_{t,k} \left[ \frac{P_t^*(z)}{P_{t+k}} - \frac{\varepsilon/(\varepsilon-1)}{X_{t+k}} \right] Y_{t+k}^*(z) \right\} = 0. \quad (28)$$

The aggregate price level is then given by:

$$P_t = \left[ \theta P_{t-1}^{1-\varepsilon} + (1-\theta) (P_t^*)^{1-\varepsilon} \right]^{1/(1-\varepsilon)}. \quad (29)$$

Using (28) and (29), and log-linearizing, we can obtain a standard forward-looking New Keynesian Phillips curve  $\hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} - \tilde{k} \hat{x}_t + u_{\pi t}$ , that relates inflation positively to future inflation and negatively

<sup>16</sup>The full derivation of this alternative specification is available upon request.

<sup>17</sup>Symmetry across firms allows us to write the demands without the index  $z$ .

to the markup ( $\tilde{k} \equiv (1 - \theta)(1 - \beta\theta)/\theta$ ).  $u_{\pi t}$  is a normally distributed cost-push shock.<sup>18</sup>

## 2.3 Aggregate Variables

Given the fraction  $\alpha$  of variable-rate borrowers, we can define aggregates across constrained consumers as  $C_t^c \equiv \alpha C_t^{cv} + (1 - \alpha) C_t^{cf}$ ,  $L_t^c \equiv \alpha L_t^{cv} + (1 - \alpha) L_t^{cf}$ ,  $H_t^c \equiv \alpha H_t^{cv} + (1 - \alpha) H_t^{cf}$ ,  $b_t^c \equiv \alpha b_t^{cv} + (1 - \alpha) b_t^{cf}$ .

Therefore, economy-wide aggregates are:  $C_t \equiv C_t^u + C_t^c$ ,  $L_t \equiv L_t^u + L_t^c$ ,  $H_t \equiv H_t^u + H_t^c$ . In this model, aggregate supply of housing is fixed, so that market clearing requires:  $H_t = H$ .<sup>19</sup>

## 2.4 Monetary Policy

The model is closed with a Taylor Rule with interest rate smoothing, to describe the conduct of monetary policy by the central bank:<sup>20</sup>

$$R_t = (R_{t-1})^\rho \left[ \pi_t^{(1+\phi_\pi)} (Y_t/Y_{t-1})^{\phi_y} R \right]^{1-\rho} \varepsilon_{Rt}, \quad (30)$$

where  $0 \leq \rho \leq 1$  is the parameter associated with interest-rate inertia.  $\phi_\pi, \phi_y > 0$  measure the response of interest rates to current inflation and output growth, respectively.  $R$  is the steady-state values of the interest rate.  $\varepsilon_{Rt}$  is a white noise shock with zero mean and variance  $\sigma_\varepsilon^2$ .

## 2.5 Dynamics

### 2.5.1 Parameter Values

I linearize the equilibrium equations around the steady state. Details are shown in the Appendix. For calibration, I consider the following parameter values: The discount factor,  $\beta$ , is set to 0.99 so that the annual interest rate is 4% in the steady state. The discount factor for borrowers,  $\tilde{\beta}$ , is set to 0.98. Lawrance (1991) estimates discount factors for poor consumers between 0.95 and 0.98 at quarterly frequency. Results are not sensitive to different values within this range. This value of  $\tilde{\beta}$  is low enough to endogenously divide the economy into borrowers and savers. The weight of housing on the utility function,  $j$ , is set to 0.1 in order for the ratio of housing wealth to GDP in the steady state to be

<sup>18</sup>Variables with a hat denote percent deviations from the steady state.

<sup>19</sup>This assumption provides an easy way to specify the supply of housing and have variable prices. A two-sector model with production of housing would not generate qualitatively different results.

<sup>20</sup>This is a realistic policy benchmark for most of the industrialized countries. A more realistic rule would also include output but it complicates building intuition about the workings of the model. Furthermore, estimations deliver a small response to the output gap in the last two decades (See Clarida, Galí and Gertler (2000)). Nevertheless, robustness checks to this specification will be performed.

consistent with the data. This value of  $j$  implies a ratio of approximately 1.40, in line with the Flow of Funds data.<sup>21</sup> I set  $\eta = 2$ , implying a value of the labor supply elasticity of 1.<sup>22</sup> For the loan-to-value ratio, I pick  $k_{SS} = 0.9$ , consistent with the evidence that in the last years borrowing constrained consumers borrowed on average more than 90% of the value of their house.<sup>23</sup> The labor income share of unconstrained consumers,  $\gamma$ , is set to 0.64, following the estimate in Iacoviello (2005). I pick a value of 6 for  $\varepsilon$ , the elasticity of substitution between intermediate goods. This value implies a steady state markup of 1.2. The probability of not changing prices,  $\theta$ , is set to 0.75, implying that prices change every four quarters. For the Taylor Rule parameters I use  $\rho = 0.8$ ,  $\phi_\pi = 0.5$ ,  $\phi_y = 0.5$ . The first value reflects a realistic degree of interest-rate smoothing.<sup>24</sup> The second and third ones, are consistent with the original parameter proposed by Taylor in 1993. For  $\alpha$ , I consider two polar cases for comparison. In the first case, the proportion of variable-rate mortgages in the economy is 0, that is, all constrained consumers in the economy borrow at a fixed rate. In the second case, the proportion of variable-rate mortgages is 1. Table 1 shows a summary of the parameter values.

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<sup>21</sup>See Table B.100. In this model, consumption is the only component of GDP. To make the ratio comparable with the data I multiply it by 0.6, which is approximately what nondurable consumption and services account for in the GDP, according to the data in the NIPA tables.

<sup>22</sup>Microeconomic estimates usually suggest values in the range of 0 and 0.5 (for males). Domeij and Flodén (2006) show that in the presence of borrowing constraints this estimates could have a downward bias of 50%.

<sup>23</sup>We can identify constrained consumers with those that borrow more than 80% of their home. In the US, among those borrowers, the average LTV ratio exceeds 90% for the period 1973-2006. See the data from the Federal Housing Finance Board.

<sup>24</sup>See McCallum (2001).

<b>Table 1: Parameter Values</b>		
$\beta$	.99	Discount Factor for Savers
$\tilde{\beta}$	.98	Discount Factor for Borrowers
$j$	.1	Weight of Housing in Utility Function
$\eta$	2	Parameter associated with labor elasticity
$k_{SS}$	.9	Loan-to-value ratio
$\gamma$	.64	Labor share for Savers
$\alpha$	0/1	Proportion of variable-rate borrowers
$X$	1.2	Steady-state markup
$\theta$	.75	Probability of not changing prices
$\rho_A$	.9	Technology persistence
$\rho$	.8	Interest-Rate-Smoothing Parameter in Taylor Rule
$\phi_\pi$	.5	Inflation Parameter in Taylor Rule

### 2.5.2 Impulse Responses

In order to gain some insight about the dynamics of the model before studying macroprudential policies, figure 1 presents impulse responses to a 1 percent positive shock to technology with 0.9 persistence. We see that the economy responds slightly more strongly after a technology shock when the majority of its borrowers have a fixed-rate mortgage.

In particular, we can see in figure 1 that a positive technology shock increases output and lowers prices. As a reaction, nominal rates decrease. However, for the fixed rate case, inflation drives the real rate and therefore it increases. House prices, which move inversely with the interest rate, increase in the case of the variable-rate economy but decrease in the fixed-rate one. For variable-rate consumers, the increase in house prices and the decrease in the interest rate make borrowing increase. And since housing is now a more valuable asset, variable-rate borrowers use this borrowing to increase both housing and consumption goods. However, for fixed-rate consumers, the increase in the real rate, together with the decrease in house prices, makes borrowing decrease. Fixed-rate borrowers prefer to decrease housing purchases in favor of consumption goods and this is why output ends up increasing slightly by more in the fixed-rate scenario.

We can see from the dynamics of the model that having variable or fixed-rate mortgages does not

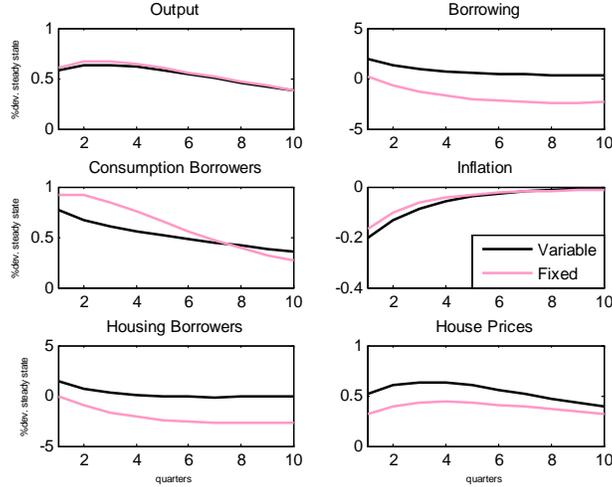


Figure 1: Impulse Responses to a Technology Shock

only affect the macroeconomy but also the financial side. The fixed-rate economy, has a less powerful monetary policy tool but borrowers are more exposed to changes in inflation and house prices. Therefore, the structure of mortgage contracts has clear implications, not only for monetary policy reaction and for macro variables but also for house prices and borrowing. Thus, it seems clear that in case of including macroprudential policies, the mortgage contracts that are prevalent in the economy will affect their implementation, since the macroprudential regulator cares about financial stability.

### 3 Modelling Macroprudential Policies

For the macroprudential policy, I will consider two options to be compared. The first one is a rule on the LTV, so that this variable responds to credit growth. The second one is an extended Taylor rule so that the interest rate, apart from responding to inflation and output, also responds to credit growth.

The first case would correspond to a situation in which macroprudential supervision should involve a regulatory agency, different from the central bank or within the central bank, that uses a different instrument for macroprudential purposes. The second case represents a world in which macroprudential and monetary policies are integrated and assigned to the central bank, which uses just one instrument, the interest rate, two achieve both macroeconomic and financial stability. In this case, the objectives of monetary policy should be expanded to include financial stability.

### 3.1 LTV Rule

As an approximation for a realistic macroprudential policy, I consider a Taylor-type rule for the loan-to-value ratio. 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 credit growth:

$$k_t = k_{SS} (b_t/b_{t-1})^{-\phi_b^k}, \quad (31)$$

where  $k_{SS}$  is the steady-state values for the loan-to-value ratio.  $\phi_b^k \geq 0$  measures the response of the loan-to-to value to credit growth. This kind of rule would deliver a lower LTV ratio in booms, when credit is growing, therefore restricting the credit in the economy and avoiding a credit boom derived from good economic conditions.

### 3.2 Macroprudential Taylor Rule

Here, I am considering the case in which the central bank is adopting a macroprudential approach and taking care about credit variables. Then, I extend the Taylor rule to not only respond to inflation and output growth but also to credit growth.

$$R_t = (R_{t-1})^\rho \left[ \pi_t^{(1+\phi_\pi)} (Y_t/Y_{t-1})^{\phi_y} (b_t/b_{t-1})^{\phi_b} R \right]^{1-\rho} \varepsilon_{Rt}. \quad (32)$$

Thus, we are giving the central bank a way to implement a macroprudential policy. Notice that increasing the interest rate when credit is growing mean restricting credit booms in the economy, since debt repayments are going up. Therefore, in this case, the goals of the central bank are extended to also include financial stability.

## 4 Normative Analysis

In this section, I introduce the above mentioned macroprudential policies and study their implications for welfare and their optimal implementation. In order to do that, first I present a measure for welfare. Then, using this measure, I analyze the optimality of monetary and macroprudential policies for both fixed and variable-rate mortgage economies and present impulse-responses using the optimized values.<sup>25</sup>

In new Keynesian models with collateral constraints, there are two types of distortions: sticky prices and credit frictions. Savers prefer policies that alleviate the first distortion, since they own the firms. They are better off in a scenario with price stability, the goal of monetary policy. However, borrowers' welfare increases when the credit friction distortion is minimized. Then, borrowers may prefer situations that generate inflation, since in this case the collateral constraint is relaxed through lower real debt repayments. On the one hand, monetary policy has effects on the constraint, directly through the interest rate that borrowers have to pay and indirectly through house prices, which make collateral be more or less valuable. On the other hand, macroprudential policies which deliver higher financial stability also lower the negative effects of the credit friction, since they provide borrowers with a scenario in which their consumption is smoother.

However, these mechanisms differ depending on whether the prevalent mortgage contract in the economy is fixed or variable rate. In the variable-rate scenario, monetary policy is more stabilizing because there is a direct link between the policy rate and the borrowing rate. Nevertheless, this link is broken for the fixed-rate case. Therefore, an economy with variable rates will be more effective to minimize the sticky price distortion, the one that affects savers. In the fixed-rate scenario, borrowing is more dependent on inflation and house prices. Although the policy rate does not affect the economy as much as in the variable-rate case, inflation affects real rates and therefore borrowing. The policy rate also has an effect on house prices, since as any asset price, they move inversely with the interest rate, and thus has also an effect on credit. Then, borrowers may prefer fixed rates because it creates a situation with more inflation and this lowers real debt repayments, thus relaxing their collateral constraint.

With respect to macroprudential policies, in the variable-rate case, the combination of monetary policy with an LTV rule would deliver more financial stability because, in a context of stable inflation, increasing LTVs in times of credit growth means containing credit. However, with fixed-rate mortgages, in which the real borrowing rate basically depends on inflation, higher inflation variability may offset

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<sup>25</sup>I define optimal policy as the one that maximizes total welfare.

the effects of increasing the LTV and more financial stability may not be achieved.

When the macroprudential policy is included in the Taylor rule, for the variable-rate case, as other studies that include credit variables in the monetary policy rule show, there may be no much gain in terms of welfare. However, for the fixed-rate case, it opens a new mechanism. Making the nominal rate respond to an additional variable which is more volatile than inflation and output makes house prices react by more than with the simple Taylor rule. This increases financial stability through the effect of monetary policy on house prices.

#### 4.1 Welfare Measure

As discussed in Benigno and Woodford (2008), the two approaches that are recently used for welfare analysis in DSGE models include either characterizing the optimal Ramsey policy, or solving the model by 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), I take this latter approach to be able to evaluate the welfare of the borrowers and savers separately and identify the trade-off which appears between them.<sup>26</sup>

The individual welfare for savers and the two types of borrowers respectively is defined as follows:

$$V_{u,t} \equiv E_t \sum_{m=0}^{\infty} \beta^m \left( \ln C_{t+m}^u + j \ln H_{t+m}^u - \frac{(L_{t+m}^u)^\eta}{\eta} \right), \quad (33)$$

$$V_{cv,t} \equiv E_t \sum_{m=0}^{\infty} \tilde{\beta}^m \left( \ln C_{t+m}^{cv} + j \ln H_{t+m}^{cv} - \frac{(L_{t+m}^{cv})^\eta}{\eta} \right), \quad (34)$$

$$V_{cf,t} \equiv E_t \sum_{m=0}^{\infty} \tilde{\beta}^m \left( \ln C_{t+m}^{cf} + j \ln H_{t+m}^{cf} - \frac{(L_{t+m}^{cf})^\eta}{\eta} \right), \quad (35)$$

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

$$V_t = (1 - \beta) V_{u,t} + \left(1 - \tilde{\beta}\right) [\alpha V_{cv,t} + (1 - \alpha) V_{cf,t}]. \quad (36)$$

Borrowers and savers' welfare are weighted by  $\left(1 - \tilde{\beta}\right)$  and  $(1 - \beta)$  respectively, so that the two groups receive the same level of utility from a constant consumption stream.

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<sup>26</sup>See Monacelli (2006) for an example of the Ramsey approach in a model with heterogeneous consumers.

To make the results more intuitive, I present welfare changes in consumption equivalents, taking as a benchmark the situation in which there are no macroprudential policies.<sup>27</sup>

## 4.2 Optimal Policy

In this subsection, I study what the mix of macroprudential and monetary policy that maximizes welfare is. In particular, given a grid of possible parameters for the LTV and the Taylor rule (both the standard and the macroprudential one), I perform a search that maximizes welfare, subject to determinacy requirements.<sup>28</sup> I do the analysis first for the benchmark case, in which there are no macroprudential policies, so that I just optimize over the parameters of the standard Taylor rule. I find the parameters both for the variable and the fixed-rate scenarios. Results are presented in Table 2:

<b>Table 2: Optimized Taylor Rule (Benchmark)</b>		
	<b>Variable Rate</b>	<b>Fixed Rate</b>
$(1 + \phi_\pi^*)$	<b>16.1</b>	<b>1.1</b>
$\phi_y^*$	8.2	0
<b>Volatilities</b>		
$\sigma_\pi$	0.21	0.52
$\sigma_y$	1.91	1.87
$\sigma_b$	1.43	27.51

Results in Table 2 represent the benchmark case, since it does not include macroprudential policies. We can see the difference in the optimality of monetary policy in both scenarios; fixed versus variable rates. For the variable-rate case, it is optimal for monetary policy to respond aggressively both against inflation and output. However, for fixed rates, since the link between the interest rate and the macroeconomic variables is weaker, it is not optimal for monetary policy to respond to any of the variables because in any case, the effect of nominal rates on the economy is inexistent, just real rates matter in this case, and they are driven by inflation. Furthermore, the nominal interest rate, in this case, also affects house prices and this also affects borrowing. In terms of stability, we see from the volatilities that a greater stability, both macroeconomic and financial, is achieved with variable-rate mortgages. Macroeconomic

<sup>27</sup>I follow Ascari and Ropele (2009).

<sup>28</sup>The Taylor Principle also holds in the model with collateral constraints, for  $(1 + \phi_\pi) \leq 1$ , there is indeterminacy.

stability is achieved because monetary policy is more effective with variable rates.<sup>29</sup> With fixed rates, on the one hand, borrowers are more exposed to changes in house prices. On the other hand, since the nominal rate is fixed, the real rate mainly depends on inflation, and this one is more volatile than in the variable-rate case. and real rates are more volatile. All this generates greater financial instability.

<b>Table 3: Optimized Taylor and LTV Rule</b>		
	<b>Variable Rate</b>	<b>Fixed Rate</b>
Taylor Rule		
$(1 + \phi_\pi^*)$	<b>1.3</b>	<b>1.08</b>
$\phi_y^*$	0.5	0
LTV Rule		
$\phi_b^{k*}$	0.8	0.02
<b>Welfare Gain</b>		
<i>Savers</i>	-0.16	-0.99
<i>Borrowers</i>	0.22	1.09
<i>Total</i>	0.024	0.03
<b>Volatilities</b>		
$\sigma_\pi^2$	0.36	0.56
$\sigma_y^2$	1.77	1.85
$\sigma_b^2$	1.07	29.51

In Table 3, I present the optimized monetary policy when it interacts with an LTV rule. We see that, in this case, for the variable-rate scenario, the optimal response for monetary policy is substantially less aggressive than in the benchmark case without macroprudential policies in place. The macroprudential LTV rule complements the role of monetary policy and both interacting together manage to achieve a more stable macroeconomic and financial scenario. However, at the expense of a slightly larger inflation volatility.<sup>30</sup> The increase in inflation volatility makes savers worse off because they care about the sticky-price friction. On the contrary, borrowers are better off for two reasons; they like higher inflation because

<sup>29</sup>See Rubio (2011) for a Taylor Curve analysis that shows that monetary policy is more efficient with variable rate mortgages and therefore the economy is always more stable under this scenario.

<sup>30</sup>This is a typical result found in the literature. Results are in line, for example, with Gelain et al (2013) which show that while macroprudential policies can stabilize some variables, they can magnify the volatility of others, especially inflation.

they have to repay their debt, and they prefer a more stable financial scenario, since this helps them smooth their consumption.

For the fixed-rate case, the optimal reaction of both monetary and macroprudential policies is smaller than in the variable-rate scenario. Monetary policy is still not effective, therefore the optimal response is minimal, as in the benchmark case. The introduction of the LTV rule has similar effects as in the variable-rate scenario. It reduces the volatility of output but increases the volatility of inflation. As remarked by Lustig (2006) and Rubio (2011), the inflation channel that relaxes borrowing constraints should be much more effective when fixed-rate mortgages are predominant, because agents care about real rates. Therefore, agents are more sensitive to changes in inflation in a fixed-rate scenario. This is the reason why borrowers' welfare gain and savers' loss are larger in this case, even though in the aggregate welfare gains are similar as in the previous case. Welfare gains however, come mainly from the fact that inflation is more volatile, but not from the financial side this time. Given that inflation is less stable, borrowers benefit in terms of debt repayments, relaxing their constraint. This offsets the constraint tightening that the LTV rule should impose. As a result, although the economy is better off, a larger financial stability is not achieved.

<b>Table 4: Optimized Macroprudential Taylor Rule</b>		
	<b>Variable Rate</b>	<b>Fixed Rate</b>
$(1 + \phi_\pi^*)$	<b>16.1</b>	<b>1.1</b>
$\phi_y^*$	6.6	0
$\phi_b^*$	<b>0.8</b>	<b>0.01</b>
<b>Welfare Gain</b>		
<i>Savers</i>	0.14	-0.99
<i>Borrowers</i>	-0.12	5.52
<i>Total</i>	0.007	1.96
<b>Volatilities</b>		
$\sigma_\pi^2$	0.19	0.24
$\sigma_y^2$	1.94	2.00
$\sigma_b^2$	1.46	7.54

In Table 4, the macroprudential policy is introduced directly in the Taylor rule, by letting the interest rate respond to credit growth. Results show that, although it is optimal to respond to credit growth, the optimal monetary policy is very similar to the case in which the central bank only responds to inflation and output. As it is common in the literature, for the standard variable rate case, welfare gains of responding to credit variables are very small.<sup>31</sup> Table 4 shows that inflation volatility is slightly lower than in the benchmark case and financial instability slightly larger. Thus, with this new optimized Taylor rule, borrowers are slightly worse off with respect to the case in which credit variables are not included in the rule because inflation is less volatile, although there are no benefits from the financial side. This is offset by the fact that savers live in a just slightly more stable world.

However, for the fixed-rate case gains are larger, mainly coming from the borrowers' side. When the nominal rate responds to credit growth, it reacts more strongly to changes in the economy. Even though the optimal response is small, credit is a volatile variable and thus the interest rate responds more strongly than with the standard Taylor rule. This has an effect on house prices and the collateral constraint is affected through this channel. For example, if there is an increase in credit, the interest rate will increase and this will decrease house prices. The fall in house prices tightens the collateral constraint and helps achieve more financial stability. A scenario with greater financial stability is beneficial for borrowers.

### 4.3 Impulse Responses

Figure 2 presents impulse responses to a technology shock for a variable-rate economy and for the optimized parameters found in Tables 2-4. The technology shock increases output and decreases inflation. As a result, the interest rate slightly increases, to respond to the increase in output, especially in the case in which the interest rate responds to credit growth. For the case in which the macroprudential policy is represented by an LTV rule, the interest rate decreases because the optimal reaction parameters in the Taylor rule are much smaller than in the other two cases. House prices move as a mirror image of interest rate and also responding to the increase in housing demand derived from better economic conditions. Since house prices increase, borrowing increases. However, the increase in borrowing is softer in the case in which macroprudential policies are present. When the macroprudential policy is incorporated in the Taylor rule, the increase in the interest rate is larger and then, borrowing increases by less on impact, although the effect is dissipated in subsequent periods. However, borrowing is really contained when

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<sup>31</sup>See for instance Iacoviello (2005), who shows with a policy frontier analysis that little is gained in terms of inflation and output stabilization by responding to asset prices.

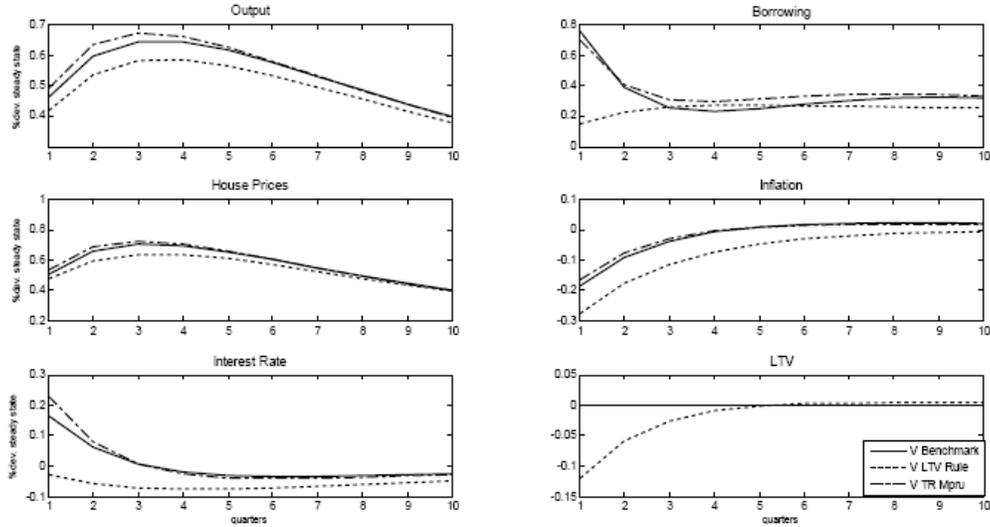


Figure 2: Impulse Responses to a Technology Shock. Variable Rate.

the LTV rule is active. In this case, as a reaction to credit growth, the macroprudential regulator cuts the LTV, making credit less accessible for borrowers. For this latter case, the macroprudential measure mitigates the effect of the technology shock.

Figure 3 displays impulse responses to a technology shock for the fixed-rate economy, for its optimized policy parameters. It is also the case that the shock causes output to increase and inflation to decrease. Optimal reaction parameters in the Taylor rule for the fixed-rate case make interest rates respond only to inflation, and in a not too aggressive matter. Therefore, since inflation decreases, nominal interest rates decrease as well for the three cases, being the fall more persistent in when interest rates also react to credit growth. However, given that the link between the policy rate and the borrowing rate is weaker with fixed rates, the real rate, that is negative inflation, is what matters for borrowers. The decrease in inflation makes the real rate to increase and therefore borrowing decreases. Although house prices increase, this does not offset the increase in the real interest rate. Furthermore, the increase in house prices is smaller in the case of credit growth being incorporated into the Taylor rule, creating an extra channel to decrease credit by more. As a result, in this case, borrowers devote less income to purchase houses and substitute by consumption goods, making output increase by more in this scenario. The decrease in credit makes the LTV to increase, when the LTV rule is active, and on impact credit does not decrease as much, although the effect fades away very quickly.

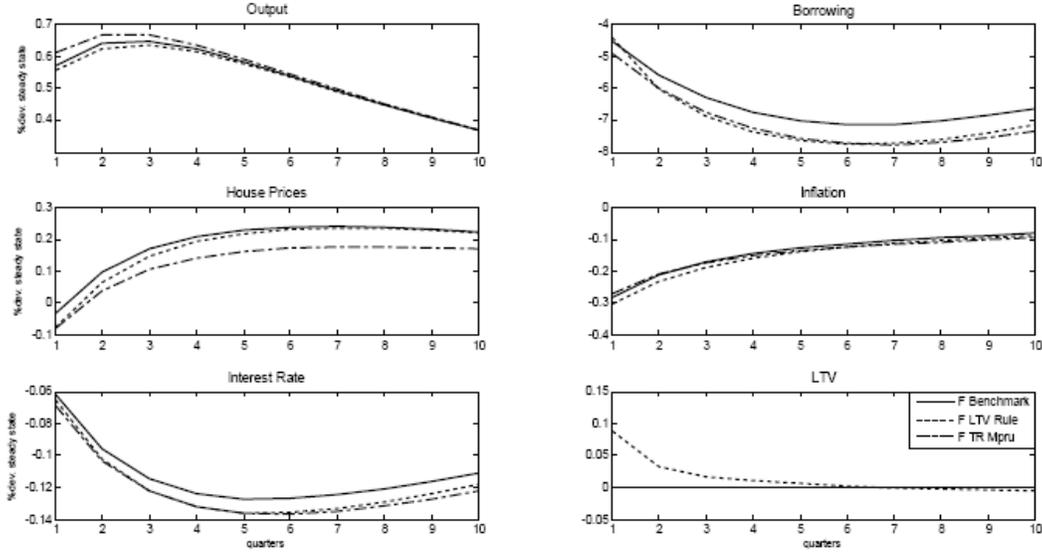


Figure 3: Impulse Responses to a Technology Shock. Fixed Rates.

## 5 Conclusions

In this paper, I study the ability of monetary policy to affect financial markets both under fixed and variable-rate mortgages. I have developed a new Keynesian general equilibrium model with housing and collateral constraints to analyze the combined effects of macroprudential and monetary policies with these two types of mortgage contracts. There are unconstrained and constrained individuals that correspond to the savers and borrowers of the economy. I explicitly introduce fixed and variable-rate mortgages, that is, constrained individuals are of two types: those who borrow at a variable rate and those who borrow at a fixed rate.

First, in order to gain some insight, I study the dynamics of the model for the case in which there are no macroprudential policies. Results show that having variable or fixed-rate mortgages does not only affect the macroeconomy but also the financial side of the economy. Therefore, the structure of mortgage contracts has clear implications, not only for monetary policy reaction and for macro variables but also for the implementation of macroprudential policies.

I propose two types of macroprudential policies. The first one is a Taylor-type rule on the LTV. In this case, the LTV would be the instrument of the macroprudential regulator, responding to credit growth. The second one is a Taylor rule for the interest rate, in which rates would respond not only to inflation and output but also to credit growth. In this second case, both monetary and macroprudential policies would be implemented with a single instrument; the interest rate.

From a normative perspective, I analyze how the optimality of monetary and macroprudential policies changes when rates in the economy are either variable or fixed. First, I perform the analysis for the benchmark case, the one that does not include macroprudential policies. For the variable-rate scenario, it is optimal for monetary policy to respond aggressively both against inflation and output. However, for fixed rates, since the link between the interest rate and the macroeconomic variables is weaker, it is not optimal for monetary policy to respond to any of the variables. A greater stability, both macroeconomic and financial, is achieved with variable-rate mortgages. Second, I study the optimality of monetary policy interacting with the LTV rule. For variable-rates, the optimal response for monetary policy is substantially less aggressive. The macroprudential LTV rule complements the role of monetary policy and both interacting together manage to achieve a more stable macroeconomic and financial environment. For the fixed-rate case, the optimal reaction of both monetary and macroprudential policies is smaller than in the variable-rate scenario. Welfare gains however, come mainly from the fact that inflation is more volatile but not from the financial side. Finally, I study the welfare and optimality implications of including credit growth directly in the Taylor rule for the interest rate. For the standard variable-rate case, welfare gains of responding to credit variables are very small. Albeit, for the fixed-rate case gains are larger, mainly coming from the borrowers' side since this delivers greater financial stability.

In conclusion, macroprudential policies are welfare enhancing regardless of the mortgage structure prevalent in the economy. Nevertheless, when mortgages are variable rate, an LTV rule combined with monetary policy is preferable to including credit variables in the interest-rate rule. When rates are fixed, using the interest rate as an instrument, both to stabilize the macroeconomy and financial markets, delivers higher welfare and stability than having two separate instruments. Thus, interestingly, with fixed rates, even though monetary policy is less effective to stabilize the macroeconomy, it seems a good tool to stabilize financial markets.

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# Appendix

## Tables and Figures

Predominant Type of Mortgage Interest Rate			
<b>Australia</b>	Variable	<b>Italy</b>	Mixed
<b>Austria</b>	Fixed	<b>Japan</b>	Mixed
<b>France</b>	Fixed	<b>Spain</b>	Variable
<b>Germany</b>	Fixed	<b>United Kingdom</b>	Variable
<b>Greece</b>	Variable	<b>United States</b>	Fixed

Table A1: Predominant Type of Mortgage Interest Rate. Source: ECB (2003), IMF

## Model Derivations

### Steady-State Relationships

Using (9) in the steady state we obtain  $R = 1/\beta$ . From (5) and (6) we have that  $\bar{R}^* = \bar{R} = R = 1/\beta$ .

From the first order conditions for housing we can obtain the steady-state consumption-to-housing ratio for both constrained and unconstrained consumers:

$$\frac{C^u}{qH^u} = \frac{1}{j}(1 - \beta), \quad (37)$$

$$\frac{C^c}{qH^c} = \frac{1}{j} \left( 1 - \tilde{\beta} - k(\beta - \tilde{\beta}) \right) = \frac{1}{j}\Phi, \quad (38)$$

where  $\Phi \equiv \left( 1 - \tilde{\beta} - k(\beta - \tilde{\beta}) \right)$ . From (19) and (27) we obtain the constrained and unconstrained consumption-to-output ratio in the steady state:

$$\frac{C^c}{Y} = \frac{1 - \gamma}{X} \left( \frac{\Phi}{\Phi + jk(1 - \beta)} \right), \quad (39)$$

$$\frac{C^u}{Y} = 1 - \frac{C^c}{Y}, \quad (40)$$

where  $X = \varepsilon/(\varepsilon - 1)$

The housing-to-output ratio for constrained and unconstrained consumers:

$$\frac{qH^c}{Y} = \frac{(1-\gamma)j}{X} \left( \frac{1}{\Phi + jk(1-\beta)} \right), \quad (41)$$

$$\frac{qH^u}{Y} = \frac{Xj(\Phi + jk(1-\beta)) - j(1-\gamma)\Phi}{X(\Phi + jk(1-\beta))(1-\beta)}. \quad (42)$$

## Log-Linearized Model

The model can be reduced to the following linearized system in which all lower-case variables with a hat denote percent changes from the steady state and steady-state levels are denoted by dropping the time index:

### Financial intermediary

$$\widehat{r}_\tau^* = \frac{(1-\beta)}{\beta} E_\tau \sum_{i=\tau+1}^{\infty} \beta^{i-\tau} \widehat{r}_{i-1}, \quad (43)$$

$$\widehat{r}_t = \widehat{r}_{t-1} \Rightarrow \widehat{r}_t = \widehat{r} = 0. \quad (44)$$

Equation (43) is the log-linearized fixed interest rate in each period  $\tau$ . Using this result we can obtain the log-linearized aggregate fixed interest rate, which is zero in deviations from the steady state (equation (44)), given the initial condition of being at the steady state in the absence of shocks.

### Aggregate Demand

$$\widehat{y}_t = \frac{C^u}{Y} \widehat{c}_t^u + \frac{C^c}{Y} \widehat{c}_t^c, \quad (45)$$

$$\widehat{c}_t^u = E_t \widehat{c}_{t+1}^u - (\widehat{r}_t - E_t \widehat{\pi}_{t+1}), \quad (46)$$

$$\begin{aligned} \widehat{c}_t^c &= \left( \frac{\Phi + jk(1-\beta)}{\Phi} \right) (\widehat{y}_t - \widehat{x}_t) - \frac{j}{\Phi} (\widehat{h}_t^c - \widehat{h}_{t-1}^c) \\ &+ \frac{kj}{\Phi} (\beta \widehat{b}_t^c - \widehat{b}_{t-1}^c) - kj(\alpha \widehat{r}_{t-1} - \widehat{\pi}_t), \end{aligned} \quad (47)$$

$$\widehat{b}_t^c = E_t \widehat{q}_{t+1} + \widehat{h}_t^c - (\alpha \widehat{r}_t - E_t \widehat{\pi}_{t+1}). \quad (48)$$

Equation (45) is the log-linearized goods market clearing condition. Equation (46) is the Euler equation for unconstrained consumption. Equation (47) is the budget constraint for constrained individuals, which determines constrained consumption. Equation (48) is the log-linearized collateral constraint.

### Housing Equations

$$\frac{H^u}{Y} \widehat{h}_t^u + \frac{H^c}{Y} \widehat{h}_t^c = 0, \quad (49)$$

$$\widehat{h}_t^u = \frac{1}{1-\beta} (\widehat{c}_t^u - \widehat{q}_t) - \frac{\beta}{1-\beta} E_t (\widehat{c}_{t+1}^u - \widehat{q}_{t+1}), \quad (50)$$

$$\widehat{h}_t^c = \frac{1-k\beta}{\Phi} \widehat{c}_t^c - \frac{1}{\Phi} \widehat{q}_t - \frac{k\beta}{\Phi} (\alpha \widehat{r}_t - E_t \widehat{\pi}_{t+1}) + \frac{\widetilde{\beta}}{\Phi} \widehat{q}_{t+1} - \frac{\widetilde{\beta}(1-k)}{\Phi} E_t \widehat{c}_{t+1}^c. \quad (51)$$

Equation (49) is the log-linearized market clearing condition for housing. Equation (50) is the housing margin for unconstrained consumers. Equation (51) is the analogous expression for constrained consumers.

### Aggregate Supply

$$\widehat{y}_t = -\frac{1}{\eta-1} (\gamma \widehat{c}_t^u + (1-\gamma) \widehat{c}_t^c + \widehat{x}_t), \quad (52)$$

$$\widehat{\pi}_t = \beta E_t \widehat{\pi}_{t+1} - \widetilde{k} \widehat{x}_t + u_{\pi t}. \quad (53)$$

Equation (52) is the production function combined with labor market clearing. Equation (53) is the New Keynesian Phillips curve.

### Monetary Policy

$$\widehat{r}_t = \rho \widehat{r}_{t-1} + (1-\rho) (1 + \phi_\pi) \widehat{\pi}_t + e_t. \quad (54)$$