Macroprudential Policies Interactions

José A. Carrasco-Gallego*

King Juan Carlos University

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Abstract

In this paper, an RBC model with three types of agents, entrepreneurs, borrowers and banks, and a housing market is used to evaluate the interactions of different macroprudential tools under a technology shock, a housing price shock, and a financial shock. Borrowers are constrained in the amount they can borrow. Banks are constrained in the amount they can lend, that is, there is a capital requirement ratio for banks. it is important to analyze the origin of the shock in the economy in order to be able to implement the appropriate macroprudential tool. It is not recommendable to apply automatically a macroprudential tool without a very careful analysis of the shock that the economy is experimenting In the case of a technology shock the best option is a combination of CCB and LTV ratio as macroprudential tools. If the economy experiences a house price shock, if the macroprudential authority applies the CCB, the shock may be exacerbated. Timing seems also important when the economy faces a financial shock. In this case, the authority may implement a combination of macroprudential tools at the beginning and, then, release all of them.

Keywords: Macroprudential policy, loan-to-value, banking regulation, banking supervision, countercyclical capital buffer, Basel III, credit, technology shock, house price shock, finacial shock

JEL Classification: E32, E44, E58

*King Juan Carlos University, Madrid (Spain). E-mail: jose.carrasco@urjc.es. This paper was presented in the UPO Research seminar sessions. The author wish to thank Matteo Iacoviello and Pablo Revilla. I am responsible for all errors.

"During periods that are assessed as very exuberant, for example, it may be most prudent not only to constrain the build-up of leverage in the private sector – by for instance activating LTV or DTI caps – but also to target banks more directly with higher countercyclical capital requirements". Bank for International Settlements (2012).

1 Introduction

Macroprudential policy tools have been in use in quite a few economies well before the Great Recession. Nevertheless, their broader practice is more recent and the establishment of macroprudential policy frameworks has been impelled by the financial crisis. Today, the vast majority of the countries have implemented some macroprudential tool. The main objective of macroprudential policy is to prevent excessive credit growth and systemic risk.[1] To achieve this objective, the authorities in charge of the implementation of macroprudential policy have an interesting range of tools. IMF (2011) enumerates 23 macroprudential instruments.[2]

Loan-to-value (LTV) ratios aim primarily to increase the resilience of borrowers to asset price and can thereby indirectly increase the resilience of lenders. They are the most widely used macroprudential tools with close to one hundred countries by mid-2016, according to IMF-FS-BIS (2016). From an empirical point of view, Cerutti et al. (2016) find that LTV ratio policies are especially effective in reducing systemic risk and they are more useful in the boom phases of the cycle than in the bust ones. Therefore, it is important to address the interactions of such a popular instrument with other macroprudential tools to understand the possible results for the economy.

The recently in charged macroprudential authorities have been implementing regulatory tools focusing on the housing sector as key element for the stability of the financial system. They are the most widely used macroprudential tools with close to one hundred countries by mid-2016, according to IMF-FS-BIS (2016). Loan-to-value (LTV) ratios aim primarily to increase the resilience of borrowers to asset price and can thereby indirectly increase the resilience of lenders. Therefore, it is important to

[1] See IMF (2011).

[2] IMF (2011) Table 1, page 23, includes time-varying Loan-To-Value (LTV) caps, Countercyclical capital buffers (CCB), Debt-To-Income caps, Loan-To-Income caps, time-varying limits in currency mismatch or exposure, time-varying limits on loan-to-deposit ratio, time-varying caps and limits on credit or credit growth, dynamic provisioning, stressed VaR to build additional capital buffer against market risk, rescaling risk-weights by incorporating, recessionary conditions in the probability of default assumptions, powers to break up financial firms on systemic risk concerns, capital charge on derivative payables, deposit insurance risk premiums sensitive to systemic risk, restrictions on permissible activities, through-the-cycle valuation of margins or haircuts for repos, levy on non-core liabilities, countercyclical change in risk weights for exposure to certain sectors, time-varying systemic liquidity surcharges, systemic capital surcharges, systemic liquidity surcharges, levy on non-core liabilities, higher capital charges for trades not cleared through central counterparty clearing houses.

address the interactions of such a popular instrument with other macroprudential tools to understand the possible results for the economy.

The Basel Committee on Banking Supervision (BCBS) at the Bank for International Settlements (BIS) boosted a new agreement on banking regulation in 2010, known as the Basel III Accord. The goal of Basel III is to increase the resilience of the system and to prevent the occurrence of a financial crisis in the future. Among other measures, this Accord presents a new macroprudential element in the form of a countercyclical capital buffer (CCB) up to 2.5% of capital, which asks banks to hold more capital in good times to prepare for inevitable slumps in the economy. In this way, Basel III tries to achieve the broader macroprudential goal of reducing systemic risk, which in turns protects the banking sector from periods of excessive credit growth. CCB are applied in more than 30 countries (IMF-FS-BIS, 2016) but their implementation will increase a lot in the next years due to the calendar of adoption of the Basel III regulatory framework. These standards will become effective by 2019 in the BCBS jurisdictions. The BCBS comprises 45 members from 28 jurisdictions, but its standards are accepted and adopted by many more countries. According to the last report on the adoption of the Basel regulatory framework, April 2017, the CCB will become fully effective on 1 January 2019.[3]

Therefore, there exist new economic regulations which have set some macroprudential tools that are intended to reduce the effects of the business cycles acting on different actors of the economy. It is important to address the macroeconomic effects and the interactions of the two main macroprudential instruments: the CCB for banks and a rule on the LTV for households. Interactions between these two macroprudential instruments are expected to happen, and it is imperative to understand the economic implications that can provoke. Furthermore, the economic consequences could be different for diverse types of agents and distinct types of shocks. The objective of this paper is to analyse the interaction between these two macroprudential instruments and to ensure the appropriate macroprudential instrument mix facing different shocks (technology, housing, and financial) and the welfare of three types of agents (entrepreneurs, borrowers, and banks).

To achieve this research objective, I use a dynamic stochastic general equilibrium (DSGE) model which features a housing market. The advantage of using this kind of models is that, since they are general equilibrium, they can account for the interactions of all the relevant variables in the economy. They are dynamic, and therefore the effects of different shocks can be studied. They rely on deep parameters and are, thus, free from the Lucas critique, allowing to analyze counterfactuals and do

[3] BCBS (2017).

policy evaluation. And finally, since they are microfounded, they are suitable for welfare analysis. In particular, I construct a Real Business Cycle model (RBC)[4] with an economy composed of banks, borrowers and entrepreneurs. Banks act as financial intermediaries between both types of consumers. This microfounded general equilibrium model allows exploring all the interrelations that appear between the real economy and the credit market.

In this setting, there are three types of distortions: price rigidities, credit frictions and loan frictions. The first distortion appears because of the presence of sticky prices and monopolistic competition, typical in new Keynesian models in which monetary policy has real effects on the economy. entrepreneurs, the owners of the firms, may prefer policies that reduce this price stickiness distortion. Second, credit frictions are present because borrowers need collateral to take credit. Borrowers may prefer a scenario in which the pervasive effect of the collateral constraint is softened. They operate in a second-best situation. They consume according to the borrowing constraint as opposed to entrepreneurs that follow a Euler equation for consumption. Borrowers cannot smooth consumption by themselves, but a more stable financial system would provide them with a setting in which their consumption pattern is smoother. In other words, if the financial system is very unstable and the asset prices (house prices in this framework) are very volatile, borrowers' consumption will also be very volatile since it depends on the value of the collateral. Third, loan frictions are found because banks, by Basel regulation, must have a CRR; they are constrained in the amount they can loan. Banks may prefer policies that ease their capital constraint since capital requirement ratios distort their ability to generate profits and thus to consume. In this model, an increase in the capital requirement ratio implies a lower leverage ratio, since higher CCB diminishes the percentage of deposits that banks can convert into loans and, therefore, reduces the capacity of banks of making profits.

Furthermore, there are two policy authorities: the central bank and the macroprudential regulator. The central bank aims at minimizing the variability of output and inflation to reduce the distortion introduced by nominal rigidities and monopolistic competition, using the interest rate as an instrument. The macroprudential authority can use two macroprudential instruments. One is LTV ratio, and the other is the CCB proposed by Basel III. The macroprudential LTV tool I propose is to introduce a Taylor-type rule that automatically increases loan-to-values when there is a credit boom, therefore limiting the expansion of credit. 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.

[4]Since this paper does not focus on monetary policy, prices are fully flexible here.

I also propose a macroprudential rule for the CCB of Basel III responding to deviation of credit from the steady state.

The results of the papers shows that the implementation of the countercyclical capital buffer can create higher distortions in the economy. It is necessary to analyse carefully the origin of the shock because different shocks produce diverse results when there are different macroprudential tools in the economy. In the case of a technological shock, the macroprudential authority would choose to implement both macroprudential tools together to make an smoother path to the steady state for all variables. However, it is better to choose the loan-to-value ratio with a house price shock.

The rest of the paper continues as follows. Section 1.1 makes a review of the literature. Section 2 presents the modelling framework. Section 3 displays simulations. Section 4 concludes.

1.1 Related Literature

From the point of view of the macroprudential policy based on the LTV ratio, we can find other examples of LTV ratio rules in the literature. Funke and Paetz (2012) use a nonlinear rule for the LTV ratio and find that it can help reduce the transmission of house price cycles to the real economy. Lambertini et al. (2013) allow for the implementation of both interest rate and LTV ratio policies in a model with news shocks.

This paper is related to the strand of research that, following Iacoviello (2005), introduce a rule on the LTV using DSGE models, such as Kannan et al. (2012) or Rubio and Carrasco-Gallego (2014). Antipa et al. (2010) use a DSGE model to show that macroprudential policies would have been effective in smoothing the past credit cycle and in reducing the intensity of the recession.

On the other hand, this work is related with the literature which emphasizes the externalities associated with bank lending and credit and in particular through the price of collateral. For instance, Lorenzoni (2008) and Bianchi (2011) highlight that when individual financial institutions borrow, they may not take into account the possibility that their action could depress collateral values and hence tighten the borrowing constraints throughout the system. In this spirit, the macroprudential tool that I propose for the countercyclical capital buffer of Basel III can maintain financial stability by explicitly accounting for the externalities arising from the behavior of individual institutions as well as the structure of the financial system. This tool may face the ex-ante externalities that lead to an excessive build-up of systemic risk, and the ex-post externalities that can generate inefficient failures of institutions in a crisis. As well, Aikman et al. (2010) and Aikman et al. (2012) consider that banks may have incentives to undertake excessive lending due to strategic complementarities (reputational concerns, for instance) when other banks are profitable and are expanding lending. Therefore, an increase in our countercyclical capital buffer during a credit boom would improve resilience directly by enhancing the loss-absorbing capacity of the system because it would tighten the constraint on financial institutions, such that they cannot increase their risk-weighted assets beyond a certain multiple of equity capital. This policy action could in some circumstances, as Giese et al. (2013) describe, raise the funding costs of financial institutions. When higher funding costs translate into higher lending rates, credit growth would slow down. In addition to increasing banks' capacity to absorb losses, stricter capital requirements might therefore help moderate an unsustainable credit boom, thereby reducing the probability of a crisis

The seminal contribution by Kiyotaki and Moore (1997) stress that collateralized borrowing hinges on market values, yet such market values are endogenous to the economy and out of control by creditors and debtors. In that line of research, the recent work of Pintus et al. (2015) point out that the market value of collateral generates an externality that serves to amplify and propagate business cycle shocks.

Other academics have analyzed the capital buffer with a DSGE framework and proposed some rules. For instance, Kannan et al. (2012) assume that policy-makers can affect the market lending rate by imposing additional capital requirements or additional provisioning when credit growth is above its steady-state value. Angelini et al. (2014) introduce a time-varying capital ratio that adjusts the requirements only in response to movements in the loans-to-output ratio. Drehmann et al. (2010) also point out that the deviations of credit from its long-term trend are very good indicators of the increase in systemic risk, which is the macroprudential attention.

A number of other studies have also found that increasing capital requirements may reduce credit supply (Kishan and Opiela, 2000; Gambacorta and Mistrulli, 2004). In the same line, Akram (2014) finds that the proposed increases in capital requirements under Basel III are found to have significant effects especially on house prices and credit. Our results are related to Drehmann and Gambacorta (2011) which show a simulation that indicates that the countercyclical buffer scheme might reduce credit growth during credit booms and decrease the credit contraction once the buffer is released. This would help to achieve higher banking sector resilience to shocks. Nevertheless, their procedure is subject to the Lucas critique: had the scheme been in place, banks' lending decisions would probably have been different. However, my approach is robust to this critique because is based on a DSGE model.

There also exists some controversy around this regulation that has been pointed out by the literature. In particular, some concerns have been raised about the impact of Basel III reforms on the dynamism of financial markets and, in turn, on investment and economic growth. The reasoning is that Basel III regulation could produce a decline in the amount of credit and impact negatively in the whole economy. Critics of Basel III consider that there is a real danger that this reform will limit the availability of credit and reduce economic activity. Repullo and Saurina (2012) show that a mechanical application of Basel III regulation would tend to reduce capital requirements when GDP growth is high and increase them when GDP growth is low. Then, if banks increase capital requirements during crises, credit will be reduced and the economic growth will be even lower; with a lower growth, welfare will decrease. This is the so-called risk of procyclicality, that is, Basel III could cause a deeper recession in bad times and a higher boom in good ones. Furthermore, it could have an adverse impact on growth plans of the industry, as pointed out by Kant and Jain (2013). If capital requirement ratios increase, households and industries cannot borrow as much, and their plans for recovery would be affected, having an impact on the whole economy. Some authors have attempted to evaluate the effects of capital ratios such as Angeloni and Faia (2013) and Repullo and Suárez (2013). They compare the procyclicality of Basel II and Basel I, the previous frameworks. They find that Basel II is more procyclical than Basel I.

2 Model Setup

The economy is structured with patient and impatient households, a final goods firm and banks. Patient and impatient households are entrepreneurs and borrowers, respectively. Both types of households work and consume housing and consumption goods. The representative firm converts household labor into the final good. Banks intermediate funds between both types of households. There are two macroprudential instruments, the LTV ratio and the CCB. Therefore, borrowers are credit constrained with respect to how much they can borrow from banks, and financial intermediaries are credit constrained in how much they can borrow from entrepreneurs. This setup is DSGE, as it characterizes an extension of a simple Real Business Cycle (RBC) model with collateral constraints, as in Kiyotaki and Moore (1997). The stochastic nature of this model derives from the shocks, which are the source of business cycle fluctuations.

2.1 Entrepreneurs

Patient households choose consumption, housing and labor hours to maximize their utility function:

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

where $\beta_s \in (0,1)$ is the discount factor for entrepreneurs, 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, for them. $1/(\eta - 1)$ is the labor supply elasticity, $\eta > 0$. $j > 0$ constitutes the relative weight of housing in the utility function. Subject to the budget constraint:

$$C_{s,t} + D_t + q_t (H_{s,t} - H_{s,t-1}) = R_{s,t-1} D_{t-1} + W_{s,t} N_{s,t}, \tag{1}$$

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

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

$$\frac{q_t}{C_{s,t}} = \frac{j}{H_{s,t}} + \beta_s E_t \left(\frac{q_{t+1}}{C_{s,t+1}} \right) \tag{3}$$

$$W_{s,t} = (N_{s,t})^{\eta - 1} C_{s,t} \tag{4}$$

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

2.2 Borrowers

Impatient households face following problem:

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

where $\beta_b \in (0,1)$ is the discount factor for borrowers, and $C_{b,t}$, $H_{b,t}$ and $N_{b,t}$ are consumption at time t, the housing stock and working hours, respectively, for them, subject to the budget constraint and the collateral constraint:

$$C_{b,t} + R_{b,t}B_{t-1} + q_t\left(H_{b,t} - H_{b,t-1}\right) = B_t + W_{b,t}N_{b,t}, \tag{5}$$

$$B_t \leq E_t\left(\frac{1}{R_{b,t+1}}k_t q_{t+1} H_{b,t}\right), \tag{6}$$

where B_t denotes bank loans and $R_{b,t}$ is the gross interest rate to be paid by borrowers for their loans, and $W_{b,t}$ is the wage rate for borrowers. k_t can be interpreted as a loan-to-value ratio. The borrowing constraint limits borrowing to the present discounted value of their housing holdings, that is, they use housing as collateral.[5] The first order conditions are as follows:

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

$$\frac{j}{H_{b,t}} = E_t\left(\frac{1}{C_{b,t}}q_t - \beta_b E_t\left(\frac{q_{t+1}}{C_{b,t+1}}\right)\right) - \lambda_{b,t}\frac{1}{R_{b,t+1}}k_t q_{t+1}, \tag{8}$$

$$W_{b,t} = \left(N_{b,t}\right)^{\eta-1} C_{b,t}, \tag{9}$$

where $\lambda_{b,t}$ denotes the multiplier on the borrowing constraint. These first order conditions can be interpreted analogously to the ones of entrepreneurs with the difference that collateral terms appear in them reflecting wealth effects. Through algebra, it can be shown that the Lagrange multiplier is positive in the steady state and thus the collateral constraint holds with equality.[6] This implies that borrowers, contrasting with entrepreneurs, cannot smooth consumption since their consumption comes determined by how much they can borrow.[7] This denotes the first distortion of the model: impatient households do not have free access to financial markets and, consequently, cannot freely smooth consumption.

2.3 Banks

Financial intermediaries solve:

[5] This collateral constraint follows Kiyotaki and Moore (1997) and produces a financial accelerator. Shocks that reduce house prices make consumption by borrowers decrease through the loan-to-value constraint, in the spirit of what happened during the recent financial crisis.

[6] In this model, as in Iacoviello-type models, low uncertainty and small curvature of the utility function are sufficient to guarantee that the borrowing constraint is always binding over the relevant range and therefore there is no negative consumption.

[7] As discussed in Iacoviello (2005), the frequency of borrowing constrained periods depends on the loan-to-value ratio.

$$\max E_0 \sum_{t=0}^{\infty} \beta_f^t \left[\log Div_{f,t}\right],$$

where $\beta_f \in (0,1)$ is the bank discount factor and $Div_{f,t}$ are dividends. Subject to the budget constraint and the collateral constraint:

$$Div_{f,t} + R_{s,t-1}D_{t-1} + B_t = D_t + R_{b,t}B_{t-1}, \tag{10}$$

where the right-hand side measures the sources of funds for the financial intermediary; household deposits and repayments from borrowers on previous loans. The funds can be used to pay back depositors and to extend new loans, or can be used as dividends. Dividends are transformed into consumption by banks. As in Iacoviello (2015), we assume that the financial intermediary, by regulation, is constrained by the amount of assets minus liabilities, as a fraction of assets. That is, there is a capital requirement ratio (CRR). Capital is defined as assets minus liabilities,

$$Cap_t = B_t - D_t \tag{11}$$

so that, the fraction of capital with respect to assets has to be larger than a certain ratio:

$$\frac{B_t - D_t}{B_t} \geq CRR. \tag{12}$$

Simple algebra shows that this relationship can be rewritten as:

$$D_t \leq (1 - CRR)\, B_t, \tag{13}$$

If $\gamma = (1 - CRR)$, then, the capital requirement ratio condition is a standard collateral constraint, as in Rubio and Carrasco-Gallego (2016), so that banks liabilities cannot exceed a fraction of its assets, which can be used as collateral:

$$D_t \leq \gamma B_t, \tag{14}$$

where $\gamma < 1$. The first order conditions for deposits and loans are as follows:

$$\frac{1}{Div_t} = \beta_f E_t \left(\frac{1}{Div_{t+1}} R_{s,t}\right) + \lambda_{f,t}, \tag{15}$$

$$\frac{1}{Div_{t+1}} = \beta_f E_t \left(\frac{1}{Div_{f,}} R_{e,t+1} \right) + \gamma \lambda_{f,t}, \tag{16}$$

where $\lambda_{f,t}$ denotes the multiplier on the bank's borrowing constraint. Financial intermediaries have a discount factor $\beta_f < \beta_s$. This condition ensures that the collateral constraint of the intermediary holds with equality in the steady state, since $\lambda_f = \frac{\beta_s - \beta_f}{\beta_s}$>0. This binding constraint represents the second distortion of the model. Banks need to hold, by regulation, a certain amount of capital. This legal duty defines their dividends and, thus, their consumption. Therefore, like borrowers, they cannot smooth consumption.

2.4 Firms

In the line of Kiyotaki and Moore (1997), Iacoviello (2005) and Iacoviello (2015), output is produced by firms with labor supplied from both agents and maximize profits subject to the production function:

$$\max \Pi_t = Y_t - W_{s,t} N_{s,t} - W_{b,t} N_{b,t},$$

$$Y_t = A_t N_{s,t}^{\alpha} N_{b,t}^{1-\alpha}, \tag{17}$$

where A_t represents a technology parameter and α is the labor income share for entrepreneurs. The problem delivers the standard first-order conditions, which represent the labor-demand equations:

$$W_{s,t} = \frac{\alpha Y_t}{N_{s,t}}, \tag{18}$$

$$W_{b,t} = \frac{(1-\alpha) Y_t}{N_{b,t}}. \tag{19}$$

2.5 Equilibrium

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

$$H_{s,t} + H_{b,t} = 1. \tag{20}$$

The goods market clearing condition is as follows:

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

Labor supply (equations 4 and 9) and labor demand (equations 18 and 19) are equal to each other, so that labor markets also clear. Equilibrium in financial markets is dictated by the regulatory constraint for banks, that is, $D_t = (1 - CRR)\, B_t$.

2.6 Macroprudential Policies

The macroprudential authority can use two instruments to achieve the goal of a more stable financial system. One is the LTV ratio and the other one is the CCB.

2.6.1 Loan-To-Value Ratio

In standard models, the LTV ratio is a fixed parameter that is not affected by economic conditions. However, regulations on LTV ratios have been considered as a way to moderate credit booms. Here, a Taylor-type rule for the LTV ratio that responds to credit growth, in the spirit of the Taylor rules used for monetary policy is implemented.[8] When the LTV ratio is high, the collateral constraint is looser and borrowers will borrow as much as they are allowed to, given that the constraint is binding when tight. Lowering the LTV ratio tightens the constraint and restricts the loans that borrowers can obtain. In this way, the macroprudential regulator's objective of moderating economic booms, which could lead to an excessive growth of credit, can be achieved.

$$k_t = k \left(\frac{B_t}{B_{t-1}} \right)^{-\phi^b}, \tag{22}$$

where k is the steady-state value for the LTV ratio, and $\phi^b \geq 0$ measure the response of the macroprudential instruments to deviations to credit growth.

2.6.2 Countercyclical Capital Buffer

Basel III Accords mark the necessity of an additional countercyclical capital buffer in order to avoid excessive credit growth. The goal of this buffer is the protection of the whole financial system from periods of excessive credit growth. It will operate on avoiding banks from following more than needed

[8] The Taylor rule for monetary policy uses the interest rate as an instrument and responds to inflation and output.

expansionary credit policies during economic expansions or less than needed contractionary times. Thus, the CCB is considered a macroprudential instrument.

The macroprudential authority determines the size of the buffer and must take into account the macroeconomic environment in which banks operate. However, the Basel III accord does not fully specify the criteria to change the capital requirement or under which specific conditions. The main objective, nonetheless, of this buffer in Basel III is to avoid excessive credit growth. Moreover, the Basel Committee on Banking Supervision, in its "Guidance for national authorities operating the countercyclical capital buffer" (2010), recommends considering credit variables to take buffer decisions in both the build-up and release phases. Accordingly, as follows, a rule on the capital requirement ratio that answers to credit growth is suggested.

$$CRR_t = (CRR_{SS}) \left(\frac{B_t}{B_{t-1}} \right)^{\phi_b} \tag{23}$$

If the macroprudential regulator observes that credit is growing, then, by applying this rule, it has to increase the capital requirement ratio to avoid an excess in credit. Therefore, this rule captures the macroprudential approach of Basel III with the intention of anticipating credit growth and avoiding an expansion of it. The regulator uses the capital requirement ratio as an instrument to achieve this goal. The objective is explicitly rooted in the rule since capital requirements respond directly to credit growth.

3 Simulation

3.1 Parameter Values

The discount factor for patient households, β_s, is set to 0.99 to ensure that the annual interest rate is 4% in steady state. The discount factor for the impatient households is set to 0.98.[9] The discount factors for the bankers is set at 0.965 following Iacoviello (2015). This value, in conjunction with the bank leverage parameters, denotes a spread of about 1 percent (on an annualized basis) between lending and deposit rates. In order to obtain a ratio of housing wealth to GDP to be approximately 1.40 in the steady state, the steady-state weight of housing in the utility function, j, consistent with the US data. The parameter associated with labor elasticity $\eta = 2$, implying a value of the labor supply elasticity of 1.[10] For the

[9] Lawrance (1991) estimated discount factors for poor consumers in values between 0.95 and 0.98 at quarterly frequency. The most conservative value is taken.

[10] Microeconomic estimates usually suggest values in the range of 0 and 0.5 (for males). Domeij and Flodén (2006) showed that, in the presence of borrowing constraints, this estimates could have a downward bias of 50%.

parameters controlling leverage, k is set to 0.80[11] and γ to 0.895, which implies a capital requirement ratio of 10.5%,[12] in line with the capital requirement of Basel III.[13] The labor income share for entrepreneurs is set to 0.64, following the estimate in Iacoviello (2005). We assume that technology, A_t, follows an autoregressive process with 0.9 persistence and a normally distributed shock. The response parameter of the macroprudential tools is set to $\phi^b \geq 1.5$ measuring the response of the macroprudential tool to deviations to credit growth.[14] This value is identical for both macroprudential tools to appropriately compare the effects of both macroprudential tools. Table 1 shows a summary of the parameter values used:

Table 1: Parameter Values

β_s	.99	Discount Factor for Entrepreneurs
β_b	.98	Discount Factor for Borrowers
β_f	.965	Discount Factor for Banks
j	.1	Weight of Housing in Utility Function
η	2	Parameter associated with labor elasticity
k	.80	Loan-to-value ratio
CRR	.105	Capital Requirement ratio
α	.64	Labor income share for entrepreneurs
ρ_A	.9	Technology persistence
ϕ^b	1.5	Response parameter of the macroprudential tools

3.2 Dynamics

[11] The same value as the model explained in ECB (2016).

[12] Clerc et al. (2014) find, using a DSGE model, the probability of default for banks for capital requirement ratios higher than 10%, in the range of Basel III regulation, is negligible .

[13] Basel I, signed in 1988, was the first accord on the issue. Basel I primarily focused on credit risk: banks with international presence were required to hold capital equal to 8 % of the risk-weighted assets. Basel II, initially published in June 2004, was intended to create an international standard for banking regulators to control how much capital banks need to put aside to guard against the types of financial and operational risks banks and the whole economy face. The BCBS issued a new agreement in 2010, known as the Basel III Accord, to increase the resilience of the system and to prevent the occurrence of a financial crisis in the future. This new accord introduces a mandatory capital conservation buffer of 2.5% designed to enforce corrective action when a bank's capital ratio deteriorates. Then, although the minimum total capital requirement remains at the current 8% level, yet the required total capital increases up to 10.5% when combined with the conservation buffer. Furthermore, it also adds the CCB as a macroprudential element.

[14] The value of 1.5 has been choosen similar to the typical value of the response parameter to inflation in the Taylor rule for monetary policy.

In this section, the impulse responses of the baseline model to illustrate its dynamics to three shocks are simulated.[15] For each shock (a technological shock, a house price shock, and a financial shock), there are four different types of policies to study: no macroprudential policy in place (named as No Macropru in the graphs); a macroprudential tool based on the countercyclical capital buffer (CCB in the graphs); a macroprudential tool based on the loan-to-value ratio (LTV in the graphs); and, finally, a policy that uses booth macroprudential tools at the same time (CCB+LTV in the graphs).

3.2.1 Technological shock

Figure 1 presents the impulse responses to a 1 percent shock to technology.[16] The positive technological shock impacts output. Output is affected in the same way in all four polices, therefore, the differences between the impulse response functions of the rest of the variables are based on how each policy moderates the transmission of the shock to the other variables. It seems that the smoother behavior appears when the implemented policies are CCB+LTV or LTV. The reason is that since borrowers borrow as much as they can and the price of the collateral, the house, is more affected with the CCB policy, borrowing is more affected by the higher house price and the wedge that the CCB provokes in the spread. This stronger wedge on the spread also affects bankers´ dividends.

In terms of credit (i.e. borrowing), the shock is much more moderated when the authority applies CCB+LTV policy closely followed by LTV policy, and, in the distance, CCB policy. The effect of the shock is smoother when there is an LTV policy in place or, immediately, CCB+LTV, a bit further No-macropru policy and the less effective for house prices is CCB policy. Deposits are more influenced with No-macropru policy and, nearly, with CCB policy; having a smoother behavior with CCB+LTV policy and, closely, LTV policy. The spread increases more when there is only CCB policy than with No-macropru policy or the other policies, but it comes quicker to the steady state. Borrowers ‘consumption for behaves a bit smoother with CCB policy than with the rest, but the opposite is true in terms of consumption for entrepreneurs. Dividends are much higher with CCB policy than with the others

[15] The model is solved using the standard approach in the literature, namely, linearizing the structural equations around the deterministic steady state. In this case, this RBC model takes the mathematical form of a system of nonlinear stochastic equations. Except in a very few cases, there is no analytical solution and it is needed to obtain approximated solutions. Global approximation methods are available when the state space is not too large, while the most usual approach is local approximation around the deterministic steady state. The deterministic steady state, used in this solution, is defined as the equilibrium position of the system in absence of shocks: it is the point in the state space where agents decide to stay when there is no shock in the current period and they do not expect any shocks in the future. One of the shortcomings of this approach is that the deterministic steady state ignores agents' attitude towards risk because uncertainty is removed from the deterministic version of the model.

[16] Simulations to positive and negative shocks are symmetric.

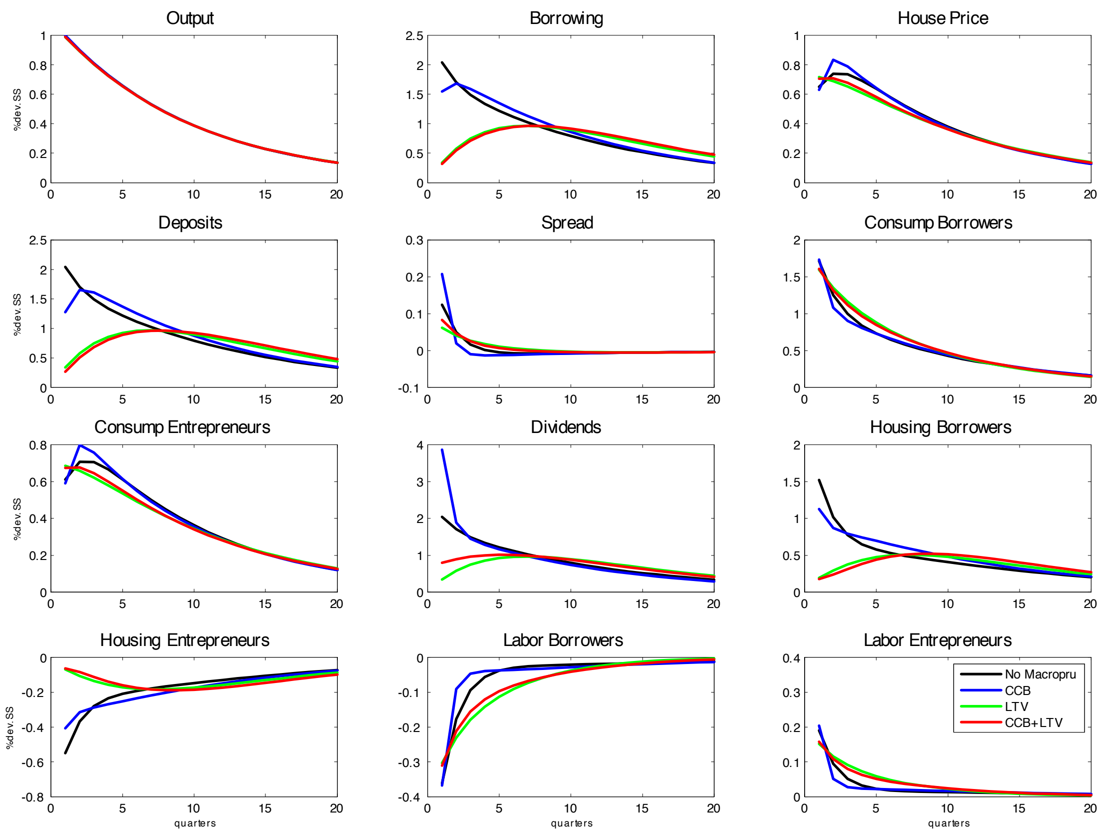

Figure 1: Impulse response functions. Technology shock

because of the behavior of the spread. The house market presents a smoother behavior with CCB+LTV and LTV policies than with CCB and No-Macropru policies. Borrowers have to increase the labor hours much quicker with the CCB policy in place because they have to repay higher debts in this case: house prices are greater in this case and also the amount borrowed. Entrepreneurs have saved more, increase in the deposits, with the No-Macropru and CCB policies, and this allows them to reduce labor hours quicker and to increase consumption in the following periods.

3.2.2 House Price shock

Figure 2 displays the effects of a shock to the house price. The shock is less strong when the macroprudential authority implements the LTV policy, followed by CCB+LTV policy. The CCB policy exacerbates the shock because this is more robust than with the No-Macropru policy. The reason comes from the fact that the LTV policy is implemented in the heart of the housing price shock and this contributes to reduce the impact. However, the CCB policy causes a higher wedge in the spread and higher effect on output with no intervention in the house price. The differences in the responses to the shock of the policies are transmitted to the rest of the variables. Output, spread, and dividends evolve smoother with LTV policy, followed by the CCB+LTV policy, and, further, No-Macropru policy and, finally, CCB policy. Borrowers can increase consumption and reduce labor more with CCB policy in place because the house price is higher and they can borrow more against the collateral. However, they have to reduce consumption and increase labor quickly because they have to repay higher debts. The opposite is true for entrepreneurs but at a lower scale.

Credit is smoother when the macroprudential authority implements CCB+LTV or LTV policies. However, CCB policy makes credit smoother in the first quarter but it is less smooth than No-Macropru policy thereafter.

In terms of the optimal implementation of the rule, we observe that the regulator should attach relatively more weight to the output and the house price parameters in the rule, rather than to the credit growth parameter. The reason is that these variables serve as an anticipated indicator of credit growth and, therefore, help the regulator achieve its macroprudential goal; when the regulator observes credit growth itself, it may be too late to avoid it.

3.2.3 Financial shock

Figure 3 shows the effects of a negative financial shock. I use as a proxy for this shock a shock to the capital. Therefore, now I include a shock ε_{Ct} that follows an autoregressive process with 0.9 persistence and a normally distributed shock in the definition of capital:

$$Cap_t = B_t - D_t - \varepsilon_{Ct} \tag{24}$$

The negative financial shock affects deposits. CCB+LTV policy reduces the shock in this variable and so does it LTV policy. CCB policy reduces in a first stage the shock but, after a while, its behavior is worse than No-Macropru policy. The drop in the deposits causes a fall in borrowing and in house prices. However, due to the smoother behavior of deposits and borrowing with CCB+LTV and LTV policies, house prices recover faster with these two policies. Output also increases more with these policies in

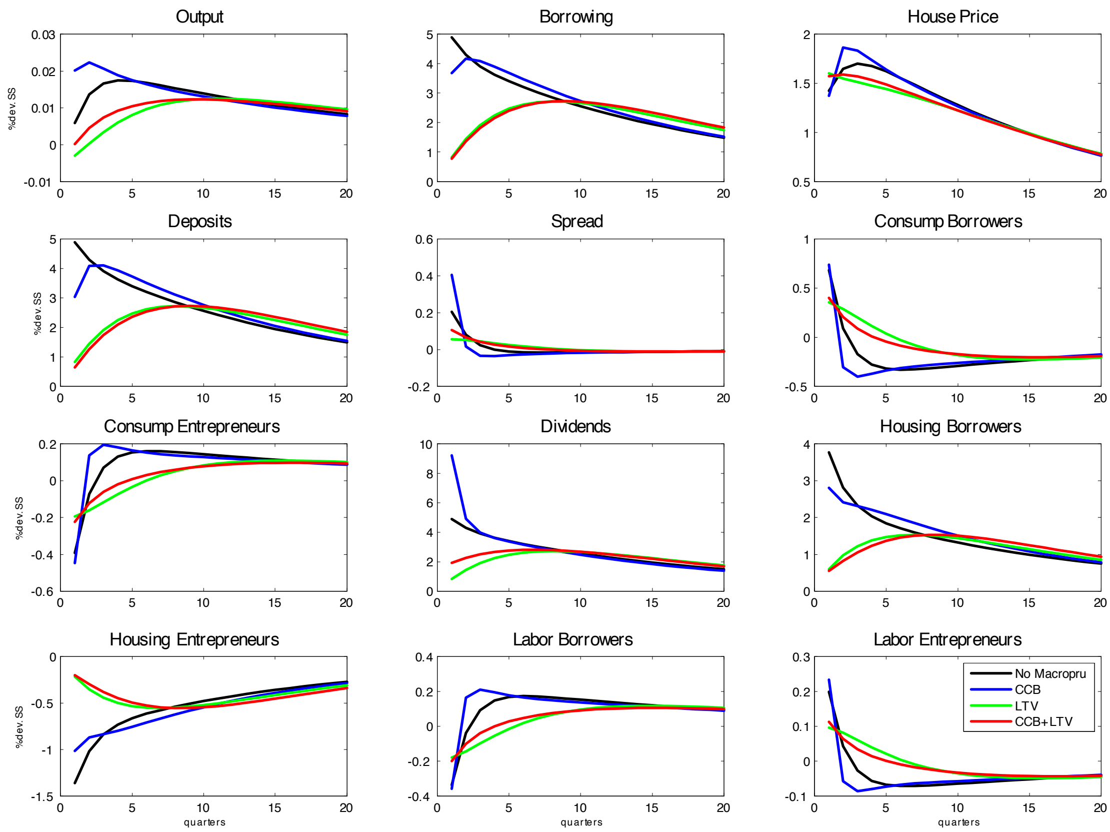

Figure 2: Impulse respose functions. House price shock.

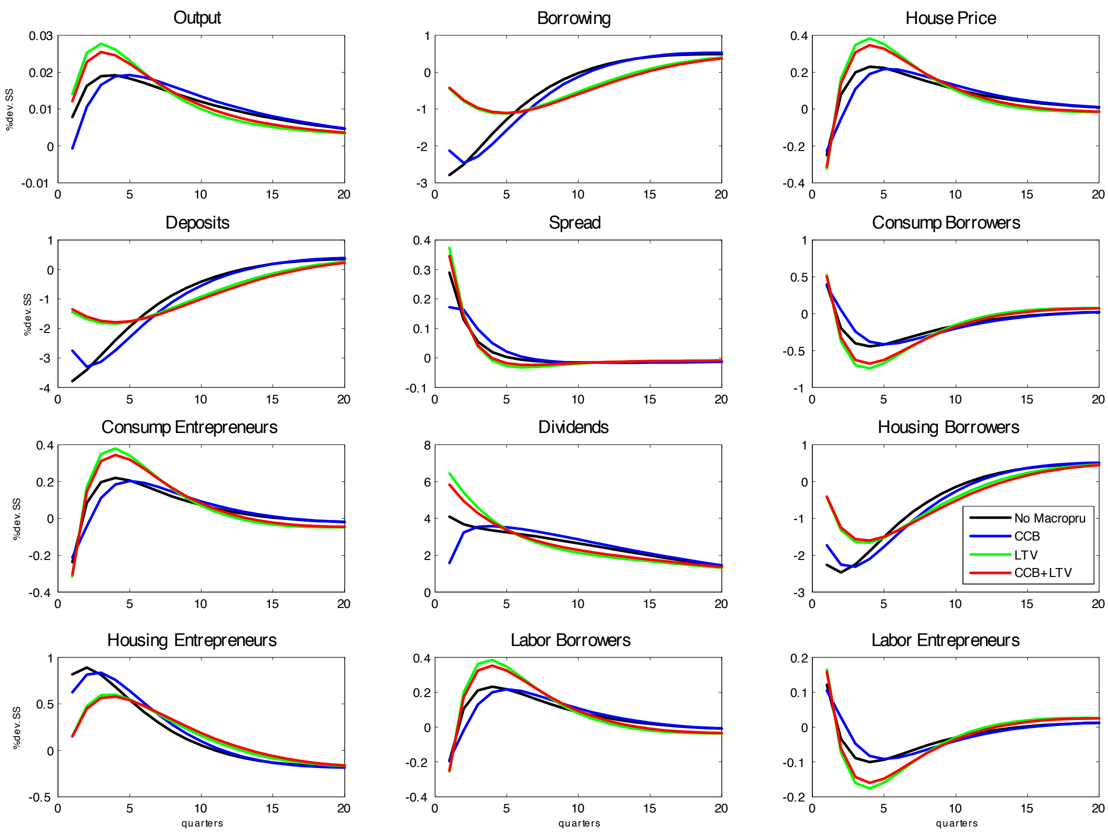

Figure 3: Impulse response functions. Financial shock

place. Dividends and spread increase more thank to the better behavior of borrowing with these two policies. Entrepreneurs suffer the negative shock reducing its consumption and working more time. They use their savings for buying houses and, once the house price recovers, they sell the houses, recover their consumption and reduce their working hours. The opposite is true for borrowers, with a different scale.

The objective of the macroprudential authority smoothing credit growth is more effectively accomplished with CCB+LTV or LTV policies at the beginning of the shock. However, due to the house price boom suffered by the economy with these policies, credit is better contained with No-Macropru or CCB policies.

This is because the credit is more expensive in this case: the spread is more than double than with no macroprudential policy. Therefore, banks are charging more for even lower borrowing. Borrowers use the collateral, the house, to consume more. In this case, at the beginning of the shock, they can consume more against a higher value of the collateral, but when they have to repay the debts, they have to reduce drastically the consumption and the house price reduces as well. In this case, entrepreneurs sell the housing at a higher price and can increase their consumption after a first fall. This effect is also present in the case of the two macroprudential tools in place, with a mix of the best behavior with the LTV ratio and the worst of the CCB.

The macroprudential authority would choose the LTV alone because all variables, including output, are more stable with this tool. For banks, they prefer the CCB because they can get higher dividends thanks to the higher spread.

4 Concluding Remarks

In this paper, an RBC model with three types of agents, entrepreneurs, borrowers and banks, and a housing market is used to evaluate the interactions of different macroprudential tools under a technology shock, a housing price shock, and a financial shock. Borrowers are constrained in the amount they can borrow. Banks are constrained in the amount they can lend, that is, there is a capital requirement ratio for banks.

The macroprudential authority can use four types of policies to achieve the objective of reducing the credit growth when facing the different shocks: one policy is based on the CCB as a tool; another one is to stablish a macroprudential tool founded on the LTV ratio; a third type of policy is using together both tools; and the fourth policy is the absent of macroprudential policy. When there is a macroprudential tool in place, it responds to increase in the credit growth with a Taylor-type rule, similar to the one used in monetary policy.

First, the model is used to evaluate how the economy responds a shock to the technology. In this case, the best option for the macroprudential authority to smooth the credit growth is to implement a policy based on a policy that combines both macroprudential tools, CCB+LTV. A very close second best is to implement just the LTV-based macroprudential policy.

Second, when the economy faces a shock to the house price, the macroprudential authority should chose the combination of both macroprudential tools, followed by just the LTV policy, to reduce credit growth. If the macroprudential authority implements a policy based on the CCB it may exacerbate the housing shock.

Finally, if there is a financial shock, the best option for the macroprudential authority would be to implement a combination of CCB+LTV or just LTV right after the shock. However, in a year-time, the policy should be changed to no-macroprudential policy or with a policy with no LTV macroprudential tool to reduce the credit growth.

Then, it is important to analyze the origin of the shock in the economy in order to be able to implement the appropriate macroprudential policy. It is not recommendable to apply automatically a macroprudential tool without a very careful analysis of the shock that the economy is experimenting because, in some case, macroprudential policy may exacerbate the shock if is applied the wrong macroprudential tool.

Appendix

Steady-State of the main model

$$C_s + D = R_s D + W_s N_s, \tag{25}$$

$$R_s = \frac{1}{\beta_s} \tag{26}$$

$$\frac{qH_s}{C_s} = \frac{j}{(1-\beta_s)} \tag{27}$$

$$W_s = (N_s)^{\eta - 1} C_s \tag{28}$$

$$C_b = \frac{\beta_s - 1}{\beta_s} B + W_b N_b, \tag{29}$$

$$B = \beta_s k q H_b, \tag{30}$$

$$\lambda_b = (\beta_s - \beta_b), \tag{31}$$

$$\frac{1}{C_b}(q - (\beta_s - \beta_b)\beta_s k q - \beta_b q) = \frac{j}{H_b}, \tag{32}$$

$$W_b = (N_b)^{\eta - 1} C_b, \tag{33}$$

$$C_f + B_t = \frac{\beta_s - 1}{\beta_s} D + R_b B, \tag{34}$$

$$\frac{D}{B} = \gamma, \tag{35}$$

$$\lambda_f = (\beta_s - \beta_f), \tag{36}$$

$$\frac{1 - \gamma(\beta_s - \beta_f)}{\beta_f} = R_b,$$

$$Y = AN_s^{\alpha} N_b^{1-\alpha}, \tag{37}$$

$$W_s = \alpha A \left(\frac{N_s}{N_b} \right)^{\alpha - 1}, \tag{38}$$

$$W_b = A \left(1 - \alpha\right) \left(\frac{N_s}{N_b} \right)^{\alpha}. \tag{39}$$

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