

Article

Real Estate, Economic Stability and the New Macro-Financial Policies

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Abstract: The influence of real estate on finance and the whole economy has captured significant attention, especially since the aftermath of the Great Recession, because of the potential of this sector to destabilize markets. This paper explores the other way around: housing markets' capacity to stabilize the economy through different macroprudential policies facing several types of shocks to achieve financial stability as a driver of sustainability. Specifically, a dynamic stochastic general equilibrium model is used to evaluate the effectiveness to stabilize the economy of different macroprudential tools based on the loan-to-value ratio for real estate, on the countercyclical capital buffer for the financial sector and a combination of both tools, facing a housing price shock, a technology shock and a financial shock. The model presents three types of agents (borrowers, entrepreneurs and banks) in an economy with a real estate market, a financial sector, a labor market and a production sector. The government can use different macroprudential policies to stabilize the economy, leaning against the wind of several shocks to achieve economic and financial sustainability. The assessment of the effectiveness of each policy shows that, in the case of a housing sector shock and a technology shock, the more effective policy is the one based on a countercyclical rule on the loan-to-value ratio for the real estate sector as a macroprudential tool. Furthermore, with a house price shock, if the macroprudential authority applies a macroprudential policy based on the countercyclical capital buffer, the shock may be exacerbated. Additionally, when there is a financial shock, the macroprudential authority may face a trade-off between several macro-financial policies depending on its objective. Therefore, it is not recommendable to automatically apply a macroprudential policy without a meticulous analysis of the nature of the shock that the economy is experimenting with and how different policies can stabilize or destabilize the different markets and, therefore, reach higher or lower sustainability.

Keywords: real estate finance; macroprudential policy; loan-to-value; financial regulation; banking supervision; countercyclical capital buffer; Basel III; credit; technology shock; house price shock; financial shock; economic stability

JEL Classification: E32; E44; E58



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“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.” [1]

1. Introduction

Since the crisis of 2008, one of the main challenges for finance is sustainability. The relation between sustainability and finance is increasingly recognized and it goes both ways. The influence of sustainability to finance comes from the financial system's potential risks as environmental issues may damage the economy and the financial system. This impact has been recognized for a long time, for instance [2], primarily through the effect of negative externalities. On the other hand, the financial system's lack of stability may harm sustainability though it could be less evident at a glance. However, several authors have

already shown this direction of the causality. Reference [3] pointed out that the financial sector in the economy plays a crucial role in implementing sustainable development goals. Reference [4] held that effectively operating financial markets ensure efficient capital transfer in the economy, sinking financial risk and guaranteeing stable financing of the real economy and, through these, sustainable growth. Reference [5] proved that better resilience to financial crises should also reduce resource depletion and rise overall sustainability. More recently, Reference [6] verified the hypothesis that there is a strong interaction between a stable financial system and negative externalities and sustainable development. This rising and tangible interaction between finance and sustainability appears, particularly after that crisis [7].

Furthermore, the literature linking sustainability and finance shows that finance is a driver of sustainability. Though, to accomplish sustainability through finance, it is crucial to re-erect the financial system to achieve sustainable development. During the Great Recession, the conventional financial archetype failed, mainly due to the incapacity to stabilize the financial system and avoid contagion to the rest of the economy's sectors. Later, the notion and characterization of a stable financial system have evolved. Although the definition, interpretation and measure of financial stability are very diverse in the literature (see, for instance, Reference [6] for a review), the European Central Bank (ECB) defines financial stability "as a condition in which the financial system—which comprises financial intermediaries, markets and market infrastructures—is capable of withstanding shocks and the unraveling of financial imbalances."

Additionally, the ECB considers that macroprudential policy's overarching goal is to preserve financial stability [8]. Therefore, there are in place this new macroprudential regulation that has set some macro-financial tools that are intended to reduce the effects of the business cycles performing on different actors of the economy and stabilize the financial sector and achieve financial sustainability.

The goal of this paper is to assess the effectiveness of the macroprudential policy facing several types of shocks to ensure the financial system's stability as a driver of sustainability.

Macro-financial policies based on macroprudential tools have been used in 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 countries have implemented some macroprudential tools. The main objective of the macroprudential policy is to prevent excessive credit growth and systemic risk to avoid any destabilization of the economy [9]. As a way to achieve this objective, the authorities in charge of the implementation of macroprudential policy have an interesting range of tools. Reference [9] enumerates 23 macroprudential instruments: 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.

The recently in charged macroprudential authorities are implementing regulatory macro-financial tools focusing on the real estate sector as critical elements for achieving the stability of the financial system. These housing sector-specific tools are the most widely used macroprudential ones, with close to one hundred countries by mid-2016, according to Reference [10]. 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 essential to address the interactions of such a popular instrument with other macroprudential tools to understand the possible results for the economy.

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 Reference [10]. These tools, according to Reference [11], are ubiquitous in particular in Asia, Europe and the Middle East. From an empirical point of view, Reference [12] find that LTV ratio policies are especially useful in reducing systemic risk. They are more useful in the boom phases of the cycle than in the bust ones. Therefore, it is vital to address the interactions of such a popular instrument with other macroprudential tools to understand the possible results for the economy. Reference [13] also points out that LTV changes have significant economic effects.

Besides, 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. Basel III's goal is to increase the resilience of the system and 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, protecting the banking sector from periods of excessive credit growth. CCB is applied in more than 30 countries [14] but their implementation would increase significantly in the following years due to the calendar of adopting the Basel III regulatory framework. These standards became 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 assuming the Basel regulatory framework, July 2020, the CCB has been adopted by 26 of its jurisdictions [15].

Therefore, new economic regulations have set some macroprudential tools that are intended to reduce the effects of the business cycles performing on different actors of the economy and stabilize the financial sector and achieve financial sustainability. It is essential to address the macroeconomic impact and the interactions of the two main macroprudential instruments: a rule on the LTV for households acting on the real estate sector and the CCB for banks. Interactions between these two macroprudential instruments are expected to happen and it is imperative to understand the economic implications that they can provoke. Furthermore, the economic consequences could be different for diverse types of agents and distinct kinds of shocks.

Specifically, this paper aims to evaluate the effectiveness of several macroprudential policy mixes facing three kinds of shocks (technology, housing and financial) to guarantee the economy's stability. 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 model 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. Thus, they rely on deep parameters and are free from the Lucas critique, allowing us to analyze counterfactuals and do policy evaluation. Moreover, since they are micro-founded, they are suitable for welfare analysis. In particular, a DSGE model is applied with an economy composed of banks, borrowers and entrepreneurs. Banks act as financial intermediaries between both types of households. Since this paper does not focus on monetary policy, prices are fully flexible here. This micro-founded general equilibrium model allows exploring all the interrelations that appear between the real economy and the credit market.

In this setting, there are two types of distortions: credit frictions and loan frictions. The first distortion appears 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 an 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 volatile and the asset prices (house prices in this framework) are very volatile, borrowers' consumption will also be very unstable since it depends on the value of the collateral. Second, 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 banks' capacity to make profits.

Furthermore, there is a macroprudential regulator. The macroprudential authority can use two macroprudential instruments. One is the LTV ratio and the other is the CCB proposed by Basel III. The macroprudential LTV tool I suggest is introducing 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; consequently, it seems sensible to apply this kind of rule to macroprudential supervision. A macroprudential rule for the CCB of Basel III, responding to the deviation of credit from the steady-state, is proposed, as well.

The remainder of the paper is organized as follows: Section 1.1 makes a review of the literature. Section 2 presents the modeling framework. Section 3 analyzes the different shocks. Section 4 concludes.

1.1. Related Literature

Nowadays, the state of knowledge of the economic effects of macroprudential policy on macroeconomic results is limited. This situation is similar to where monetary policy started initially with imperfect theoretical fundamentals, somewhat stylized models and frequently insufficient data [15]. For these reasons, there is a considerable need to analyze macroprudential policy effectiveness from the theoretical and empirical sides to have a proper idea of the best policy actions to take in each case or facing different shocks. This paper comes to help on the theoretical side.

Further analyses support the understanding, from the empirical side, of the effects of macroprudential policies using novel data sets. It is very laudable the effort of the IMF to build up an improving database. This work has been very fruitful with recent papers like Reference [13], which exploits the integrated Macroprudential Policy (iMaPP) database and References [16,17]. Reference [13] found significant LTV ratio effects on real credit to households and weaker effects on house prices. Their results are in line with other empirical works such as References [18–21]. There are, as well, some empirical papers that support the use of the CCB-based macroprudential policies for smoothing the credit cycle, such as References [22,23]; its usefulness to reduce credit crunches during recessions, like [24] and the countercyclical tool's necessity [25]. These empirical papers point in the same direction as the hypothesis defended in this theoretical one: the housing sector can be useful by applying the right macroprudential policies to stabilize the financial system and the economy.

This paper is likewise related to previous DSGE works applied to the analysis of macroprudential policy. As mentioned before, DSGE models permit endogenous answers of the economy to policy decisions [26] in general equilibrium. Though DSGE models have been disapproved for providing only limited and stylized evidence on adjustments by households or banks to shocks, for neglecting (in most cases) non-linearities and for not capturing tail risks [27], state-of-the-art effort attempts to alleviate these shortcomings and to capture features appropriate in financial crises [28–31]. This paper introduces both LTV and CCB tools in the same model to analyze macroprudential models' effectiveness. Therefore, it is related to those theoretical models which examine the LTV ratio, such as

References [32–37], among others; furthermore, it is related to those that study the CCB as a tool, like References [38–41], to cite some of them.

Another type of economic analysis is carried through input-output (I-O) models. This analytical instrument captures the overall changes in economic activities. See, among others, Reference [42] for studies of I-O models; Reference [43] for considerations of theory and Reference [44] for juxtaposing I-O techniques with time series methods.

This paper contributes to the literature in the following ways. First, state-of-the-art modeling techniques are applied for the assessment of the macroprudential policies. Second, once the model results are deeply analyzed, there is a clear policy awareness: the automatic application of a macroprudential tool when the economy is shocked is not always the best option. If the wrong macroprudential instrument is implemented, the shock may be exacerbated. In those cases, it is a better option not to apply a macroprudential policy than apply the wrong one. Therefore, it is essential to cautiously examine the source of shock because various disturbances produce mixed results when various macroprudential tools are in the economy. In this examination, the results support the idea that if the origin of the shock is technological, the more efficient macroprudential tool is the one based on the LTV ratio in the housing sector.

In contrast, the macroprudential policy founded on the CCB may provoke instability in the financial and housing sectors. When the disturbance comes from the real estate sector, the more efficient option is the tailored macroprudential tool for this sector, the LTV ratio; the CCB tool may exacerbate the shock in the whole economy. If the shock has a financial nature, the election is more intricate; the first stages of the shock, the more efficient could be a CCB policy and, then, switching to the LTV ratio. This election may present an extra difficulty in timing and, potentially, coordination between different authorities. Then, the real estate sector, by implementing the LTV ratio on it, maybe seen now as leverage to stabilize the financial markets and improve the economy's performance, while in the near past, the housing market was a source of instability.

2. Model Setup

The economy is structured with patient and impatient households, a firm producing final output 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 a Real Business Cycle (RBC) in the family of DSGE models with collateral constraints, as in Reference [45]. The stochastic nature of this model derives from the different 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 entrepreneurs' discount factor, E_0 is the expectation operator and $C_{s,t}$, $H_{s,t}$ and $N_{s,t}$ represents 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. The utility function is subject to the budget constraint:

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

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:

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

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

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

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 the following problem:

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

where $\beta_b \in (0, 1)$ is the discount factor for borrowers; $C_{b,t}$, $H_{b,t}$ and $N_{b,t}$ are consumption, the housing stock and working hours, respectively, at time t for borrowers; j is the weight of housing in the utility function; and $1/(\eta - 1)$ is the aggregate labor-supply elasticity. It is subject to the budget constraint and the collateral constraint:

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

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

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 (LTV) ratio. The borrowing constraint limits borrowing to the present discounted value of their housing holdings, that is, they use housing as collateral. This collateral constraint follows [45] and produces a financial accelerator. The first order conditions are as follows:

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

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

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

where $\lambda_{b,t}$ denotes the multiplier on the borrowing constraint. These first order conditions can be interpreted in a similar way 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. As in similar Iacoviello-type models, in this one, low uncertainty and small curvature of the utility function are sufficient to guarantee the borrowing constraint always binds over the relevant range and, therefore, there is no negative consumption. This implies that borrowers, contrasting with entrepreneurs, cannot smooth consumption since their consumption comes determined by how much they can borrow. The frequency of borrowing constrained periods depends on the LTV ratio, as discussed in Reference [46].

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:

$$\max_{E_0} E_0^{\infty} \sum \beta_f^t [\log \text{Div}_{f,t}],$$

where $\beta_f \in (0, 1)$ is the bank's discount factor and $\text{Div}_{f,t}$ are dividends. Its utility function is subject to the budget constraint and the collateral constraint:

$$\text{Div}_{f,t} + R_{s,t-1} D_{t-1} + B_t = D_t + R_{b,t} B_{t-1}, \quad (10)$$

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 Reference [39], it is assumed 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,

$$\text{Cap}_t = B_t - D_t \quad (11)$$

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

$$\frac{B_t - D_t}{B_t} \geq \text{CRR}. \quad (12)$$

Simple algebra shows that this relationship can be rewritten as:

$$D_t \leq (1 - \text{CRR}) B_t. \quad (13)$$

If $\gamma = (1 - \text{CRR})$, then, the capital requirement ratio condition is a standard collateral constraint, as in Reference [47], so that banks liabilities cannot exceed a fraction of its assets, which can be used as collateral:

$$D_t \leq \gamma B_t, \quad (14)$$

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

$$\frac{1}{\text{Div}_t} = \beta_f E_t \left(\frac{1}{\text{Div}_{t+1}} R_{s,t} \right) + \lambda_{f,t} \quad (15)$$

$$\frac{1}{\text{Div}_{t+1}} = \beta_f E_t \left(\frac{1}{\text{Div}_{f,t+1}} R_{e,t+1} \right) + \gamma \lambda_{f,t}, \quad (16)$$

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 bank 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. Financial intermediaries 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 References [6–47], output is produced by firms with labor supplied from both agents and maximize profits subject to the production function:

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

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

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:

$$W_{s,t} = \frac{\alpha Y_t}{N_{s,t}} \quad (18)$$

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

2.5. Equilibrium

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

$$H_{s,t} + H_{b,t} = 1 \quad (20)$$

The goods market clearing condition is:

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

Labor supply (equations T and T1) and labor demand (equations T2 and T3) 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, $D_t = (1 - \text{CRR}) B_t$.

2.6. Macprudential Policies

The macroprudential authority can use two instruments to achieve the goal of a more stable financial system. One is based on the real estate sector, the LTV ratio and the other one focuses on the banking sector, the CCB.

2.6.1. Loan-To-Value Ratio

In standard models, the LTV ratio remains a fixed parameter which is not affected by changes in economic variables. Nevertheless, regulations on LTV ratios have been considered as an approach to moderate credit booms. In this paper, 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 on the housing sector to reduce financial instability. The interest rate is employed in the Taylor rule for monetary policy as an instrument that responds to inflation and output. The collateral constraint, when the LTV ratio is high, is looser; borrowers will borrow as much as they are allowed to, given that the constraint is binding when tight. Lowering the LTV ratio constricts the constraint and limits the loans that borrowers can obtain. In this way, the macroprudential regulator's objective of moderating economic booms, which could lead to excessive growth of credit, to allow for lower financial instability can be accomplished.

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

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

2.6.2. Countercyclical Capital Buffer

Basel III Accords spot the requirement of an additional countercyclical capital buffer to avoid excessive credit growth. The objective of this buffer is the protection of the whole financial system from periods of excessive credit growth. It will function on avoiding banks from following more than needed expansionary credit policies during economic increases or less than needed during contractionary periods. Thus, the CCB is considered a macroprudential instrument.

The size of the CCB is regulated by the macroprudential authority. It must take into account the macroeconomic environment in which banks operate. Nonetheless, the Basel III accord does not fully stipulate the criteria to change the buffer or under which exact conditions. The main goal, however, of this requirement in Basel III is to elude excessive credit expansion. Besides, the Basel Committee on Banking Supervision (Basel Committee on Banking Supervision (2010). “Guidance for national authorities operating the countercyclical capital buffer”) recommends considering credit variables to take buffer decisions in both the build-up and release phases. Therefore, as follows, a rule on the capital requirement ratio that reacts to credit growth is proposed.

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

Should the macroprudential authority realizes credit is expanding, then, by applying this rule, it must increase the capital requirement ratio to avoid an excess in credit. Consequently, this rule mimics the macroprudential line of Basel III Accords intending to anticipate credit growth and circumvent a progression of it. The regulator employs the capital requirement ratio as an instrument to achieve this objective. This goal is clearly entrenched in the rule since capital requirements respond straight to credit expansion.

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. [48] estimated discount factors for poor consumers in values between 0.95 and 0.98 at quarterly frequency. The most conservative value is taken. Following Reference [39], the discount factors for the bankers is set at 0.965. 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. The steady-state weight of housing in the utility function, j , is set to obtain a ratio of housing wealth to GDP to be approximately 1.40 in the steady state, consistent with the US data. The parameter associated with labor elasticity $\eta = 2$, implying a value of the labor supply elasticity of 1. Microeconomic estimates typically recommend values in the range of 0 and 0.5 (for males). In the presence of borrowing constraints, Reference [49] shows that, this estimates could have a downward bias of 50%. For the parameters controlling leverage, k is set to 0.80. The same value as the model explained in ECB (2016). and γ to 0.895, which implies a capital requirement ratio of 10.5%, Reference [50] found, 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 in line with the capital requirement of Basel III. 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. The labor income share for entrepreneurs is set to 0.64, following the estimate in Reference [39]. 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 $\varphi^b \geq 1.5$ measuring the response of the macroprudential tool to deviations to credit growth. The value of 1.5 has been chosen similar to the typical

value of the response parameter to inflation in the Taylor rule for monetary policy. This value is identical for both macroprudential tools to appropriately compare the effects of both macroprudential tools. See Appendix A for the steady-state of the main model. Table 1 shows a summary of the parameter values used:

Table 1. Parameter Values.

$\beta_{\{s\}}$	0.99	Discount Factor for Entrepreneurs
$\beta_{\{b\}}$	0.98	Discount Factor for Borrowers
$\beta_{\{f\}}$	0.965	Discount Factor for Banks
j	0.1	Weight of Housing in Utility Function
η	2	Parameter associated with labor elasticity
k	0.80	Loan-to-value ratio
CRR	0.105	Capital Requirement ratio
α	0.64	Labor income share for entrepreneurs
$\rho_{\{A\}}$	0.9	Technology persistence
$\varphi^{\{b\}}$	1.5	Response parameter of the macroprudential tools

3.2. Dynamics

In this section, we analyze the effectiveness of the macroprudential policies through the dynamics of the variables of the different markets with their evolution to the three shocks using the impulse responses of the baseline model. The model is resolved using the standard approach in the literature, precisely, 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 sporadic cases, there is no analytical solution and it is required to obtain approximated solutions. Global approximation approaches are available when the state space is not too large, while the most usual method is local approximation around the deterministic steady state. The deterministic steady state, applied in this solution, is defined as the equilibrium position of the system in the absence of shocks: it is the point in the state space where agents choose 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 overlooks agents' attitudes towards risk because uncertainty is detached from the model's deterministic version. However, as stated before, Reference [50] shows the probability of default for capital requirement ratios higher than 10%, in the range of Basel III regulation, is negligible. In this model, the steady-state is 10.5%. For each shock (technological shock, real estate shock and a financial shock), there are four different types of policies to study: a macroprudential policy on the real estate sector using the loan-to-value ratio (LTV in the graphs) as the tool; another macroprudential police based on the countercyclical capital buffer (CCB in the graphs) on the banking sector; a policy with a combination of both tools at the same time (CCB + LTV in the graphs); and, finally, no macroprudential policy in place (named as No Macropru in the graphs).

3.2.1. Technological Shock

A positive technological shock's impulse response functions are represented in Figure 1. This shock impacts output. Higher production implies higher labor demand. A higher income involves a higher consumption, especially for the impatient households while the patient ones increase the deposits and higher demand for houses, also for the impatient agents, with higher house prices. Borrowers can borrow more against a higher value of the collateral, the property. Deposits also increase. The spread for banks rises and this impacts positively in the dividends. Therefore, the shock effects directly on the real economy and, then, it is transmitted through the rest of the markets. In the financial market, we observe

higher credit (borrowing), deposits and spread. In the real estate market, an increase in house prices is noted, due to a higher demand for houses.

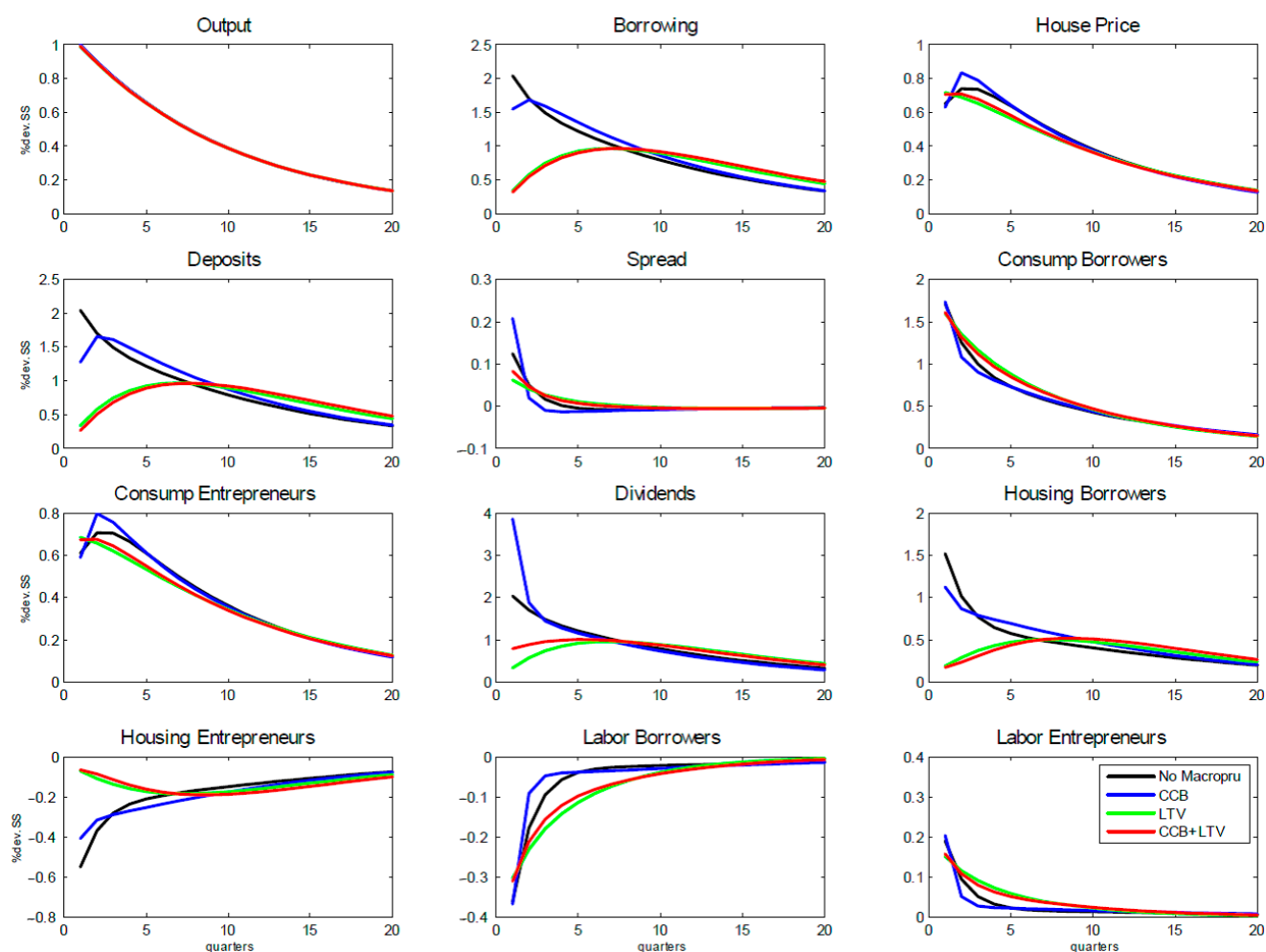


Figure 1. Impulse response functions. Technology shock.

We observe that the output is affected in a very similar way after the technology shock in all the macroprudential policies. This fact allows us to study the differences in the transmission mechanisms of each policy; because the differences between the impulse response functions of the rest of the variables are based only on how each policy moderates or not the transmission of the shock to the other variables. When there is no macroprudential policy in place (No Macroprudential, black line in Figure 1), we see an increase in the consumption of both types of households. The price of the house is also positively affected. Furthermore, after the shock, there is an additional increase in the house price. However, surprisingly, the higher increase in the house price appears when the macroprudential policy in place is based on the CCB (blue line in Figure 1), even more than with no macroprudential policy at all. In this case, the policy exacerbates the house price and this affects the financial market, with even higher credit, spread and dividends for banks. Nevertheless, when the macroprudential policy in place is based exclusively on the real estate (LTV ratio in green in Figure 1), all variables follow a smoother behavior, including those of the financial market. The policy founded on a combination of both tools (CCB + LTV, the red line in the Figures) also follows a smooth pattern.

The different dynamics of the variables under diverse policy regimes will affect the stability of the markets. In Table 2, the variabilities (standard deviations) are shown for a technology shock. In the production sector, the results are similar, however, in the other

sector, the differences are significant. In the finance market, we observe that credit, the variable of interest for the macroprudential authority, shows the highest stability (lowest variability) when the policy is based on the LTV directly influencing the real estate sector. The same is true for the rest of the variables of interest in the financial sector, such as deposits and spread. On the other hand, the highest financial instability is provoked by a macroprudential policy based on the CCB exclusively, in such a way that it is better to have no macroprudential policy than this one. In the housing sector, we find the same patron: the best policy for the stability of the real estate market is the one based on the LTV ratio; while the worse is the policy based on the CCB.

Table 2. Variabilities. Technology Shock.

.	No-Macropu	CCB	LTV	CB+LTV
Output	2.29	2.29	2.28	2.28
Credit	4.52	4.57	3.51	3.57
House Price	2.04	2.09	1.93	1.95
Deposits	4.52	4.53	3.51	3.57
Spread	0.14	0.21	0.08	0.10
Consumption Borrowers	3.01	2.93	3.20	3.15
Consumption Entrepreneurs	1.94	1.99	1.83	1.85
Dividends	4.52	5.51	3.51	3.69
Housing Borrowers	2.62	2.56	1.86	1.93
Housing Entrepreneurs	0.95	0.93	0.67	0.70
Labor Borrowers	0.43	0.40	0.48	0.46
Labor Entrepreneurs	0.23	0.22	0.25	0.24

Therefore, facing a technology shock, the more efficient policy is based exclusively on the LTV as a macroprudential tool. Nevertheless, if the macroprudential authority answers the shock with a policy built on the CCB, a perverse effect will appear: the instability of the financial and housing markets will increase and the sustainability would worsen.

3.2.2. House Price Shock

In this case, shown in Figure 2, the house price shock has its origin in an increase in the weight of housing in the utility function for borrowers. This higher price allows borrowers to borrow more (they are going to borrow as much as they can against the collateral, the house) and, then, consume more. Higher demand for credits rises the spread and so does the dividends. Both borrowers' consumption and dividends impulse output again and this would cause another income effect for all variables and agents.

The real estate market receives the first impact of the shock. However, since the LTV ratio with its macroprudential goal is installed in the core of this market, the shock is moderated since the beginning when the LTV macroprudential tool is in place. This smoother behavior of the housing for borrowers is transmitted more softly to the house price and the rest of the variables of the economy. The real economy, the labor market and the financial market exhibit smoother patrons when the LTV ratio is used by the macroprudential authority. However, there is a slight difference between the policy founded on the LTV ratio only (the green line in Figure 2) and the combined one (the red line). The initial shock (Housing Borrowers) is more moderated with the CCB+LTV policy than with the LTV alone. Then, the CCB would help to control the shock. However, during the transmission of the shock to other markets, the presence of the CCB makes things more difficult. We observe this in the house price evolution and then, in the rest of the variables.

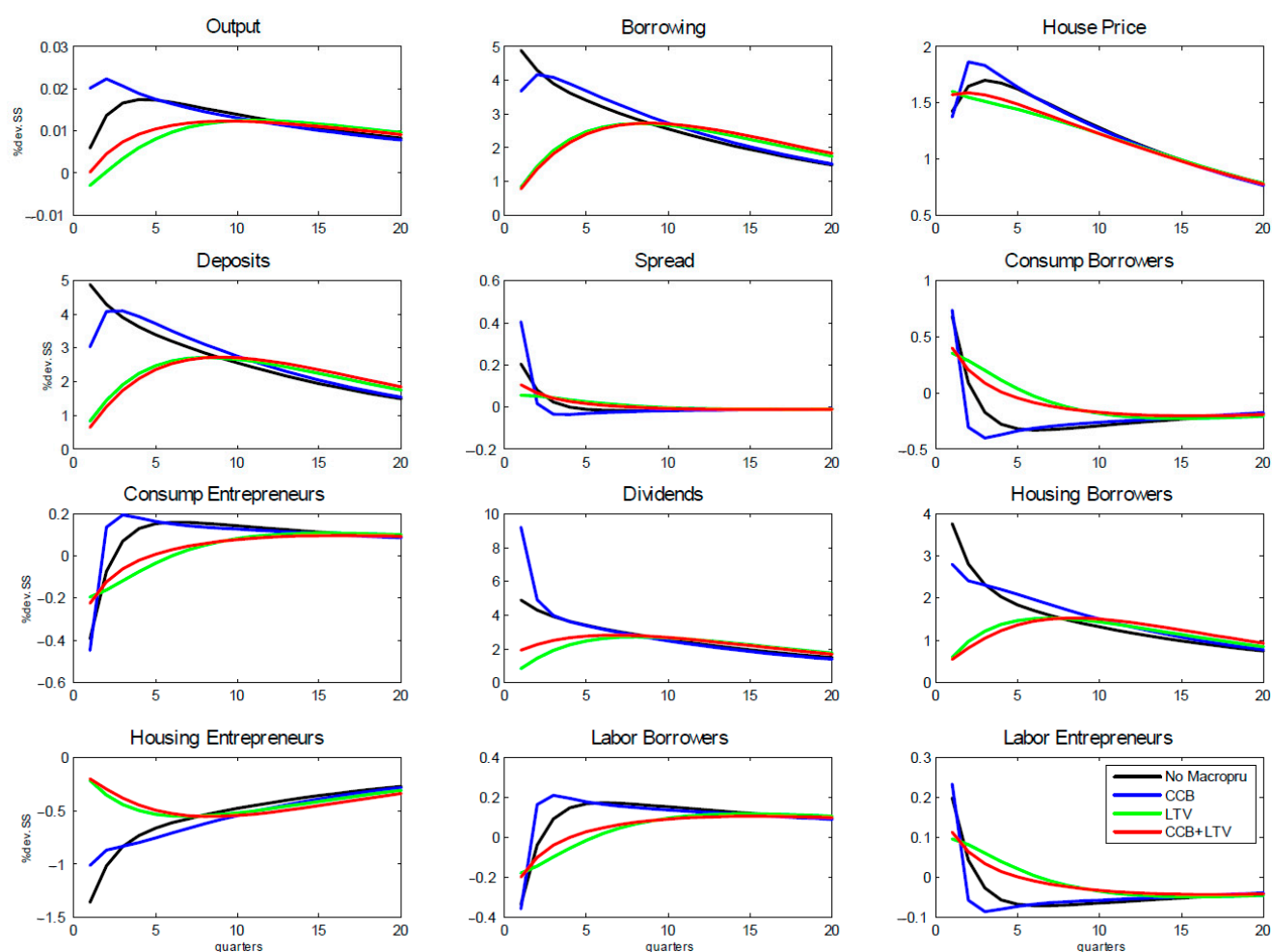


Figure 2. Impulse response functions. House price shock.

The worst macroprudential policy facing this shock is the one based only on the CCB. The reason is that, after a first increase in the house price, the CCB cannot control it properly. On the contrary, the first periods the CCB macroprudential policy exacerbates the house price. A higher house price allows borrowers to borrow even more against the value of 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 on a lower scale. Then, the shifts in all variables (blue line) are even more severe with CCB in place. Then, this macroprudential policy is even counterproductive for the stability of all the markets (output, financial, labor and housing markets).

Table 3 confirms the previous conclusions. Output, financial and real estate markets are more stable when the macroprudential policy is exclusively grounded on the LTV. This is the more efficient policy facing a housing sector shock that could lead to higher sustainability. On the other side, the CCB tool makes markets more unstable, even more than with no policy and reduces economic sustainability.

3.2.3. Financial Shock

Figure 3 shows the effects of a negative financial shock that impacts damaging banks' capital. A shock ε_{Ct} that follows an autoregressive process with 0.9 persistence and normally distributed in the definition of capital is utilized: $Cap_t = B_t - D_t - \varepsilon_{Ct}$. Specifically, the shock affects negatively to deposits and borrowing. Lower credit reduces the demand for houses from borrowers and, thus, the house price drops. Then, the first

impact of the shock is received by the financial market and, then it spreads to the housing market and the rest of the economy.

Table 3. Variabilities. House Price Shock.

	No-Macropru	CCB	LTV	CB+LTV
Output	0.06	0.07	0.05	0.05
Credit	13.48	13.64	11.35	11.52
House Price	6.19	6.28	5.96	6.01
Deposits	13.48	13.57	11.35	11.52
Spread	0.23	0.41	0.11	0.14
Consumption Borrowers	1.42	1.49	1.13	1.06

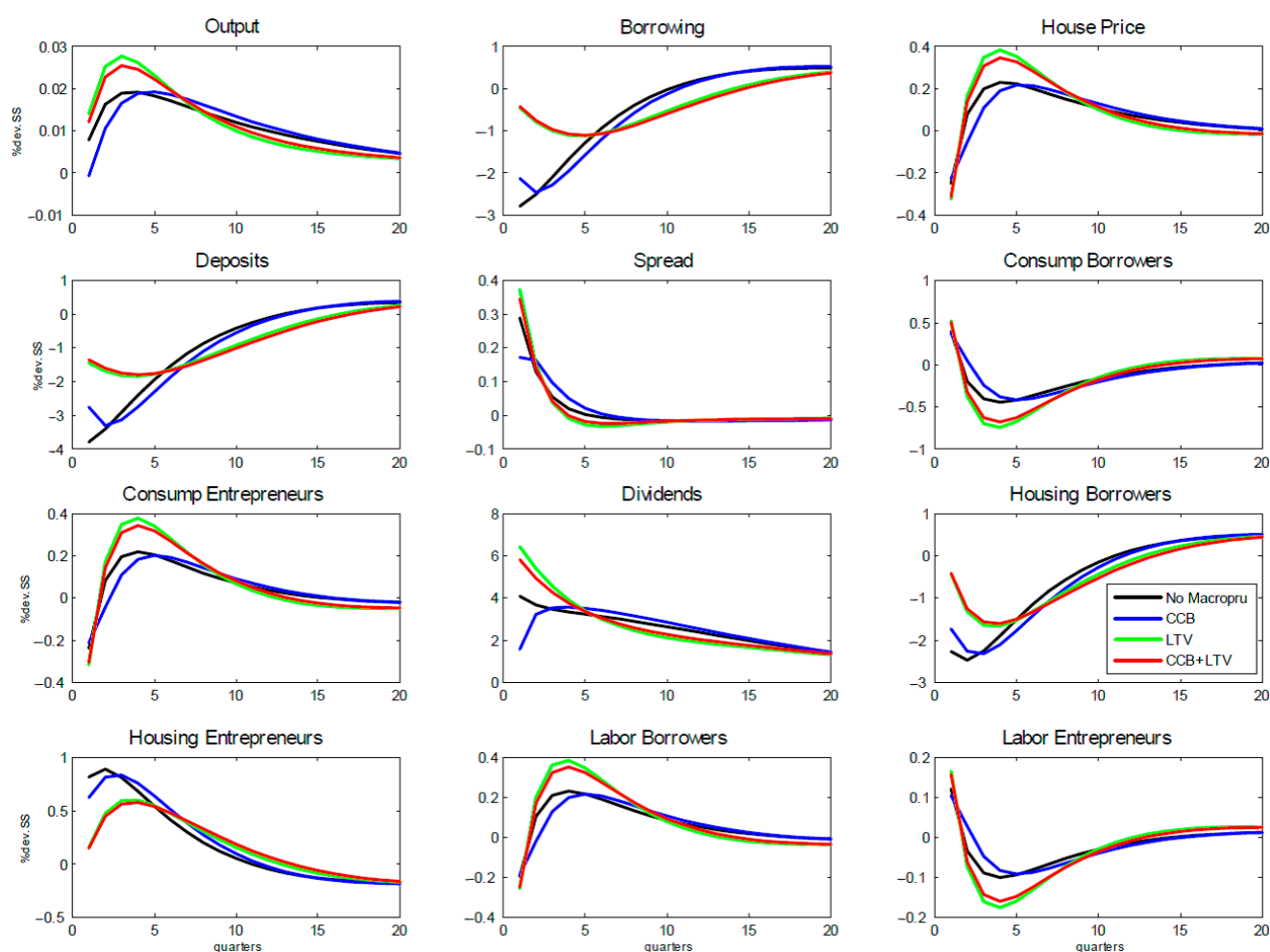


Figure 3. Impulse response functions. Financial shock.

In this case, there is no clear answer about what is the best policy to implement facing a financial shock. The policy based on the LTV ratio and the mixed policy control in a better way the disturbance in some variables of the financial sector and the housing market. While the CCB moderates the shock for the output and other financial variables. Furthermore, the transmission mechanisms change the control of each policy on different markets.

If we focus on the dynamics, a macroprudential policy based on the CCB reduces the influence of the shock in most of the variables in the first periods. But then, the dynamics

evolve not so properly with this policy in place and its behavior becomes even worse than the No-Macropru policy. The drop in the deposits causes a fall in borrowing and 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 place. Dividends and spread increase more thanks 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. It seems that a macroprudential policy with a tool affecting directly to the real estate sector, through the LTV ratio, drives the economy to the stability in a better way, after the early stages.

In terms of variabilities, Table 4 shows that the more efficient policy to reduce credit variability is the one based on the LTV ratio as the macroprudential tool. Though, in this case, this is not true for the house price. The house price presents the lowest variability when the macroprudential authority implements the CCB. The strong reduction of credit that the LTV ratio implies, forces to an increase in the house price provoking higher instability in the real estate market.

Table 4. Variabilities. Financial Shock.

.	No-Macropru	CCB	LTV	CB+LTV
Output	0.06	0.06	0.07	0.06
Credit	5.34	5.41	3.40	3.44
House Price	0.60	0.58	0.86	0.81
Deposits	7.16	7.18	5.19	5.22
Spread	0.33	0.27	0.41	0.38
Consumption Borrowers	1.07	1.04	1.63	1.54
Consumption Entrepreneurs	0.54	0.51	0.84	0.79
Dividends	12.54	12.49	13.83	13.47
Housing Borrowers	5.32	5.40	0.21	4.20
Housing Entrepreneurs	1.92	1.95	1.52	1.52
Labor Borrowers	0.56	0.54	0.84	0.79
Labor Entrepreneurs	0.25	0.24	0.40	0.37

If the macroprudential authority's objective is smoothing the credit growth, this goal is more effectively accomplished with the LTV policy, facing a financial shock. However, it comes with a destabilization of the housing market. Thus, there is a trade-off in this case and it depends on the focus of the macroprudential authority. If the institution only looks to the credit's variability, it is, precisely, the right policy; but if it also looks to the housing sector, the election must be more judiciously studied. If possible, the recommendation would be to use the LTV policy in the first stages and later change to the CCB policy. This mixed presents the difficulty of the right timing to switch between policies.

4. Concluding Remarks

This paper aims to evaluate the effectiveness of several macroprudential policy mixes fronting three varieties of shocks (technology, housing and financial) to assure the economy's stability. To verify the hypothesis that the housing sector can be used as leverage to stabilize the financial system and the economy, a DSGE model assesses the macroprudential tools' effectiveness facing those three shocks. This state-of-the-art model considers three types of agents (entrepreneurs, borrowers and banks) and a housing market 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 has the mandate to stabilize the economy to reach financial and economic sustainability. It can use four types of policies to achieve its objective when facing different shocks: one policy is based on a countercyclical LTV ratio as a macroprudential tool; another one establishes a macroprudential tool founded on the CCB; the third type of macro-financial policy utilizes both tools together; and, the fourth option is the absence of the implementation of any macroprudential tool. The macroprudential authority implements these policies to respond to an increase in the credit growth with countercyclical Taylor-type rules for the CCB and the LTV ratio, similar to the one used in monetary policy.

Previous studies have explicitly evaluated only one macroprudential policy, as pointed out in the literature review section. The focus of those assessments has been preferably the LTV ratio or the CCB. Here, both tools are appraised together, facing at the same time four different shocks. The model allows understanding the economy's dynamics and the election of the most effective policy to face each shock. The conclusions of this analysis are to follow.

First, the model is used to evaluate how the economy responds to a technological shock. In this case, the more efficient option for the macroprudential authority to smooth the credit growth is to implement a policy-based exclusively on the LTV ratio as a macroprudential tool. Furthermore, if the macroprudential authority answers the technology shock with a policy built on the CCB, a perverse effect would appear, provoking instability in the financial sector and the real estate market, reaching lower sustainability in the economy.

Second, when the economy faces a shock to the house price, the more efficient policy is founded exclusively on the LTV ratio. When the macroprudential authority implements this tool, output, financial and real estate markets are more stable and the system's sustainability is higher. On the other side, the CCB-based macroprudential policy makes markets more unstable and unsustainable, even further than with no macroprudential policy in place.

Third, if there exists a financial shock, the election is more complex. In case the macroprudential authority only attempts to reduce credit growth, the more effective policy is founded on the LTV ratio. However, there is a trade-off when using this policy because it would destabilize the housing sector by exacerbating the house price. If the authority also looks at the real estate market, the election should use the LTV policy in the first periods and then change to the CCB policy. This mixed policy shows the extra trouble of reading the shock dynamics to choose the right time to shift between macroprudential tools.

Therefore, there is no automatic macroprudential answer when a disturbance appears in the economy. Not all the macroprudential policies are going to improve per se sustainability and smooth the business cycle. It depends on the origin of the shock. It is then vital to analyze the origin of the shock in the economy to implement the appropriate macroprudential policy. It is not recommendable to apply a macroprudential tool routinely without a meticulous analysis of the shock that the economy is experimenting with.

In some cases, the macroprudential policy may exacerbate the shock if the wrong macroprudential tool is applied, with worse results than no macroprudential policy at all. Nevertheless, evidence supports that a macroprudential tool based on the loan-to-value ratio for real estate can help stabilize the economy and attain the system's sustainability. This paper's findings are supported by the empirical papers reviewed in the related literature section: the housing sector can be useful by applying the right macroprudential policies to stabilize the financial system and the economy. In general terms, the loan-to-value ratio could be seen as the most effective tool to achieve the macroprudential goal facing different shocks.

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Appendix A

Steady-State of the main model

$$C_s + D = R_s D + W_s N_s, \quad (\text{A1})$$

$$R_s = \frac{1}{\beta_s} \quad (\text{A2})$$

$$\frac{qH_s}{C_s} = \frac{j}{(1 - \beta_s)} \quad (\text{A3})$$

$$W_s = (N_s)^{\eta-1} C_s \quad (\text{A4})$$

$$C_b = \frac{\beta_s - 1}{\beta_s} B + W_b N_b, \quad (\text{A5})$$

$$B = \beta_s k q H_b, \quad (\text{A6})$$

$$\lambda_b = (\beta_s - \beta_b), \quad (\text{A7})$$

$$\frac{1}{C_b} (q - (\beta_s - \beta_b) \beta_s k q - \beta_b q) = \frac{j}{H_b}, \quad (\text{A8})$$

$$W_b = (N_b)^{\eta-1} C_b, \quad (\text{A9})$$

$$C_f + B_t = \frac{\beta_s - 1}{\beta_s} D + R_b B, \quad (\text{A10})$$

$$\frac{D}{B} = \gamma, \quad (\text{A11})$$

$$\lambda_f = (\beta_s - \beta_f), \quad (\text{A12})$$

$$\frac{1 - \gamma(\beta_s - \beta_f)}{\beta_f} = R_b, \quad (\text{A13})$$

$$Y = A N_s^\alpha N_b^{1-\alpha}, \quad (\text{A14})$$

$$W_s = \alpha A \left(\frac{N_s}{N_b} \right)^{\alpha-1}, \quad (\text{A15})$$

$$W_b = A(1 - \alpha) \left(\frac{N_s}{N_b} \right)^\alpha. \quad (\text{A16})$$

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