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The new financial regulation in Basel III and monetary policy: A macroprudential approach☆

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ABSTRACT

The aim of this paper is to study the interaction between Basel I, II and III regulations with monetary policy. In order to do that, we use a dynamic stochastic general equilibrium (DSGE) model with a housing market, banks, borrowers, and savers. Results show that monetary policy needs to be more aggressive when the capital requirement ratio (CRR) increases because it is less effective in this case. However, this policy combination brings a more stable economic and financial system. We also analyze the optimal way to implement the countercyclical capital buffer stated by Basel III. We propose that the CRR follows a rule that responds to deviations of credit from its steady state. We find that the optimal implementation of this macroprudential rule together with monetary policy brings extra financial stability with respect to Basel I and II.

"*The regulation proposed by the Basel Committee on Banking Supervision should not be assessed in isolation (. . .) The changes in the financial system caused by the regulation will have to be factored in also by the policy authorities. For central banks, the changes may be far-reaching, ranging from the transmission mechanism of monetary policy to interactions with several aspects of the operational frameworks.*" Speech by Mr Lorenzo Bini Smaghi, Member of the Executive Board of the European Central Bank, at the International Banking Conference "Matching Stability and Performance: the Impact of New Regulations on Financial Intermediary Management", Milan, 29 September 2010.

1. Introduction

The recent crisis has taught us that a necessary condition for growth, technological advances, and innovation is to have a stable economic and financial environment. In order to promote economic recovery and stabilize the financial sector, some changes to financial regulation have been proposed. In this context, a very important package of regulations is the so-called Basel III. Basel III is a comprehensive set of reform measures in banking regulation, supervision and risk management. It was developed by the Basel Committee on Banking Supervision (BCBS) at the Bank for International Settlements (BIS), to strengthen the banking sector and achieve financial stability. Furthermore, some of the new

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measures that Basel III introduces are aimed at preventing future crises, creating a sound financial system in which financial problems are not spread to the real economy. Preventive measures acting in this direction are known between researchers and policymakers as macroprudential policies.

However, these changes to financial regulation have to coexist with monetary policy; therefore, the interaction of the policies conducted by central banks with the set of new regulations is a relevant topic of study. In particular, the transmission and the optimal monetary policy may change depending on the regulations that are in place.

The BCBS aims at providing some guidance for banking regulators on what the best practice for banks is. Its standards are accepted worldwide and are generally incorporated in national banking regulations. The subsequent Basel regulations proposed by the BCBS[1] have introduced, among other elements, higher compulsory capital requirement ratios (CRR) for banks. Basel I and II required a minimum total CRR of 8%.[2] Afterwards, Basel III introduced 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, Basel III adds a dynamic macroprudential element in the form of a countercyclical capital buffer up to another 2.5% of capital, which requires banks to hold more capital in good times to prepare for downturns in the economy. In this way, Basel III tries to achieve the broader macroprudential goal of protecting the banking sector from periods of excessive credit growth.[3] Therefore, the macroprudential approach of Basel III has two components: on the one hand, it increases the static CRR permanently and, on the other hand, it adds a dynamic macroprudential buffer which will depend on economic conditions.

However, the way to implement this dynamic macroprudential component of Basel III has not been fully specified by the Committee.[4] The BCBS states the objectives of this additional countercyclical buffer (CB): "The primary aim of the countercyclical capital buffer regime is to use a buffer of capital to achieve the broader macroprudential goal of protecting the banking sector from periods of excess aggregate credit growth that have often been associated with the build-up of system-wide risk" (BCBS, 2010).[5] Nevertheless, it leaves its implementation as an open question, encouraging authorities to apply judgment in the setting of the buffer using the best information available.

The BCBS also claims that the CB is not meant to be used as an instrument to manage economic cycles or asset prices; these are issues that should be addressed by other policies such as monetary policy. Then, the interaction of the Basel regulation with monetary policy is of an extreme relevance.

Therefore, it is very timely to do research on this topic to provide some general guidance to correctly implement this regulation, together with monetary policy. It is also crucial to consider both macroprudential aspects of Basel III, the increase in the static CRR and the countercyclical buffer since, depending on the country, the countercyclical buffer could be more difficult to implement. For instance, in developing or low-income countries, the buffer could be problematic due to lack of data availability. Capacity constraints and enforcement difficulties may make time-varying macroprudential rules more complicated to be implemented. In those countries, the most relevant aspect of the Basel regulation would be the static CRR. In our paper, unlike the rest of the literature on macroprudential policies, we provide an extensive analysis not only to the time-varying CRR but also to the static ones, to see how they affect the economy and the optimal conduct of monetary policy.

Thus, the goal of this paper is to study the effects of the Basel I, II and III regulations on CRR as well as its interactions with monetary policy. We would like to provide some general lines to correctly implement this regulation, together with monetary policy. We aim at disentangling the effects of increasing CRR as well as the effects of introducing a dynamic macroprudential countercyclical buffer on the economy. Ultimately, our objective is to design an optimal policy mix that includes monetary parameters, the CRR, and the macroprudential CB to best achieve the goals of economic and financial stability.

In order to do that, we use a dynamic stochastic general equilibrium (DSGE) model which features a housing market. The modelling framework consists of an economy composed by banks, borrowers and savers. Banks act as financial intermediaries between both types of consumers. This microfounded general equilibrium model allows us to explore 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. Savers, 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 savers that follow an Euler equation for consumption. Borrowers cannot smooth consumption by themselves, but a more stable financial system would provide them a setting in which their consumption pattern is smoother.[6] 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.[7]

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 the CB proposed by Basel III, with the CRR as an instrument, to achieve a more stable financial system. However, we will show that some trade-offs between agents may appear because of the different effects of each policy on rigidities.

[1] Basel I, signed in 1988; Basel II, published in 2004; and Basel III, agreed in 2010.

[2] We are aware that Pilar I of Basel II significantly increases the risk sensitivity of the capital rule, with respect to Basel I, and considers different approaches to compute the minimum CRR. However, for the goal of this paper, we only take into account the quantitative level of the CRR, not the qualitative implications.

[3] The reform package is a major overhaul of Basel I and II. Basel III includes a comprehensive set of rules encompassing tighter definitions of capital, a framework for capital conservation and countercyclical buffers, improved risk capture, a non-risk-based leverage ratio, and a novel regime for liquidity risk. In this paper, we are interested in the capital requirement ratio and the countercyclical buffer as a macroprudential tool.

[4] The BCBS proposes a 'common reference guide' that should form the starting point of the discussion.

[5] BCBS (2010). Guidance for national authorities operating the countercyclical capital buffer, BIS document.

[6] 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 be also very volatile since it depends on the value of the collateral.

[7] In this model, an increase in the capital requirement ratio implies a lower leverage ratio, since higher CRR diminishes the percentage of deposits that banks can convert into loans and, therefore, reduces the capacity of banks of making profits.

Using this framework, we address several key research questions. First, we analyze how the different values of the CRR, including those of Basel I, II and III, affect the different agents and the whole society, for given monetary policy. We find that increasing the CRR has positive second-order effect for borrowers but negative for savers and banks. However, given that CRR regulations are not microfounded here, we adopt a positive approach along the paper. Second-order values should not be taken as normative. That is, we take the presence of the macroprudential regulator as given and study the effects of the regulation on the economy and its interaction with monetary policy.

Second, we then examine the interaction between monetary policy and the Basel regulation. In this spirit, we consider how the optimal monetary policy changes with different values of the CRR. We observe that the higher the CRR, the more aggressive monetary policy needs to be in order to compensate for being less effective in this case.

Third, we find an optimal implementation of the CB, the instrument that Basel III provides to the macroprudential authority, which delivers a more stable financial system, acting together with a monetary authority that cares of macroeconomic stability. We suggest that the CB follows a rule that increases capital requirements when credit deviates from its steady state and lowers it when the situation is the opposite.[8] Once we have established the rule, we look for its optimal reaction parameters, together with those of monetary policy.[9] Results show that the monetary and the macroprudential authorities acting together can deliver higher macroeconomic and financial stability. We calculate consumption equivalent changes derived from a second-order approximation of the model. We find that, although there may be winners and losers when applying the macroprudential policy, there exists a system of transfers à la Kaldor-Hicks which can be implemented to obtain a Pareto-superior outcome to overcome this trade-off.

In terms of dynamics, our paper shows that Basel regulations also affect the transmission of monetary policy. In particular, using the optimal parameters, we find that the higher capital requirements introduced by Basel III mitigate expansionary monetary policy shocks. And so does the optimal implementation of the CB, since the CRR goes up to avoid credit increases.[10] We also explore the effects of a negative shock to bank capital. We find that, under Basel III with the CB, the CRR would decrease to compensate for the loss in capital, palliating the negative effects of the shock.

The rest of the paper continues as follows. Section 1.1 makes a review of the related literature. Section 2 presents the model. Section 3 analyzes the implications of the new regulation on the different agents, for given monetary policy. Section 4 explains the interaction between the CRR and monetary policy. Section 5 studies the optimal way to implement the CB, together with monetary policy. Finally, Section 6 concludes.

1.1. Related literature

Our approach fits into the flourishing literature interested in analyzing macroprudential policies that deliver a more stable financial system, on the limelight after the crisis. The experience with this kind of policies is still scarce. However, although there is consensus about the need of these policies, the effects of them are still not absolutely understood. Thus, given the novelty of this perspective and the uncertainty about its effects, the studies on the topic are also quite recent.

The analysis that we carry out, though, focuses on quantifying the effects of macroprudential policies in a very specific context: the Basel III regulation. We provide some guidance to optimally implement this new set of banking regulation for a wide range of countries. Therefore, unlike other papers in the macroprudential literature, we contribute finding results both for the macroprudential effects of the permanent increase in the CRR of Basel III as well as for the dynamic counter-cyclical buffer that it introduces.[11]

Borio (2003) was one of the pioneers on the subject. He distinguishes between microprudential regulation, which seeks to enhance the safety and soundness of individual financial institutions, as opposed to the macroprudential view, which focuses on welfare of the financial system as a whole. Following this work, Acharya (2009) points out the necessity of regulatory mechanisms that mitigate aggregate risk, in order to avoid future crises. The literature has proposed several instruments to be implemented as a macroprudential tool. A complete description of them appears in Bank of England (2009, 2011). We contribute to this literature by focusing on the macroprudential tool of Basel III, namely the countercyclical buffer and studying its effects for both the financial system and the macroeconomy, decomposing the channels between different agents.[12]

A key aspect of Basel III regulation is focused on limits on capital requirements. One of the lines of study of the literature about Basel measures focuses on the welfare effects of the new banking rules. There is 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. A number of studies have found that increasing capital requirements may reduce credit supply (Kishan and Opiela, 2000; Gambacorta and Mistrulli, 2004). 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 reform will limit the availability of credit and reduce economic activity. We contribute to the discussion by seeing the effects of Basel III under a negative bank capital shock. We find that the countercyclical buffer would help mitigate the negative effects of the shock. Our results also show that the countercyclical buffer increases both macroeconomic and financial stability.

On the other hand, Tchana Tchana (2012) introduces the new banking regulation in an overlapping-generations model and finds that the overall effect of optimal regulation on social welfare is positive when productivity shocks are sufficiently high and economic agents are sufficiently risk-averse. Repullo and Saurina (2012) model the business cycle as a Markov process with two states

[8] This follows Janet Yellen's advice: "Financial institutions may be required to build capital buffers in good times, which they can run down in bad times, thereby limiting credit growth during booms and mitigating credit contraction in downturns" Yellen, 2010.

[9] Drehmann et al. (2010) points out that the deviations of credit from its long-term trend are very good indicators of the increase in systemic risk.

[10] Any change in the CRR will have an effect on supplied lending. This is due to the fact that the model does not consider different types of capital nor assets; and the constraints are always binding (borrowers are borrowing as much as they can and banks hold capital requirement at the minimum regulatory levels). Therefore, the increase in the CRR will always increase the capital and reduce lending.

[11] As stated in the introduction, the static CRR may be the focus of macroprudential policies in developing and low-income countries because of their possible capacity constraints and enforcement difficulties.

[12] Some recent papers have examined Basel III liquidity risk measures, including liquidity coverage ratio and net stable funding ratio. For instance, the empirical approach of Hong et al. (2014), based on the theoretical model of Allen et al. (2009), differentiate between idiosyncratic and systemic liquidity risks. Since the new liquidity ratios of Basel III target an individual bank's liquidity risk management, their effects are largely contained in the idiosyncratic channel. By comparing the contributions of idiosyncratic and systemic liquidity risks, they assess the effectiveness of the new liquidity risk standards in reducing bank failures. However, these measures are out of the scope of our paper. Our model is a stylized macro model in which assets and liabilities are homogenous and this distinction cannot be made.

(expansion and recession), and consider that for sufficiently large values of the social cost of bank failure, the reforms introduced by Basel III are in the right direction. Although we take a positive approach, we contribute to this line of study with a second order analysis of different CRR for a given monetary policy. We find that with higher CRR there are some distributional effects in favour of borrowers and against savers and banks.

Other academics have focused their efforts in analyzing the countercyclical buffer of Basel III. For instance, Drehmann and Gambacorta (2011) study the CB and show a simulation that indicates that the CB 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's critique: had the scheme been in place, banks' lending decisions would probably have been different. Our approach is robust to this critique because it is based on a DSGE model, and, therefore, contributes significantly to support the idea that if the regulator increases CRR, the credit supply would decrease.

There are a number of papers on the optimality of capital adequacy requirements (see, e.g., Hellmann et al., 2000; Allen and Gale, 2000, 2004). Gerali et al. (2010), induce the existence of buffers by postulating that the deviation from some ad hoc target capital ratio involves a quadratic cost forcing the building up of buffers when cyclically sensitive variables, such as bank profits and credit growth, are high (see Committee of European Banking Supervisors (CEBS, 2009; BCBS, 2010). Repullo and Suarez (2013), which study optimal bank capital regulation over the cycle and compare it to regulations that resemble Basel I, II, and III, find that countercyclical buffers help to mitigate the procyclical effects of regulations such as Basel II. Repullo and Saurina (2012) critique the design of the countercyclical buffer of Basel III because, when GDP growth is low, it may end up exacerbating the inherent procyclicality of risk-sensitive bank capital regulation. Adding to the discussion, we propose a Taylor-type rule responding to credit deviations from the steady state for the CB, which is countercyclical.

Using the proposed Taylor-type rule for the CB, we contribute to this line of research analyzing the changes in consumption equivalents for several agents in the economy and stating for which of them the Basel regulation could imply a positive or negative change. We find that capital requirements have a negative effect for banks while positive for borrowers. We also find that, even the regulation by itself is not positive for savers, it can be when the macroprudential and monetary policies interact in an optimal way. Using another approach, Angeloni and Faia (2013) consider that the best combination of policy rules for welfare includes mildly anticyclical capital ratios (as in Basel III) and a response of monetary policy to asset prices or bank leverage. We contribute by explicitly calculating, in a general equilibrium model, the optimal parameters of monetary policy, with a standard Taylor rule, and the macroprudential CB based on credit deviation from its steady state, and the effects on the three types of agents (borrowers, savers and banks). Our approach is different in the sense that we take the regulation for granted.

Our paper is connected as well with the literature that uses a DSGE model to study the effects of a macroprudential rule acting together with monetary policy. For instance, Borio and Shim (2007) emphasize the complementary role of macroprudential policy to monetary policy and its supportive role as a built-in stabilizer. Also, N'Diaye (2009) shows that monetary policy can be supported by countercyclical prudential regulation and that it can help the monetary authorities to achieve their output and inflation targets with smaller changes in interest rates. In addition, 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. In our paper, we contribute to this topic. We clearly find that higher capital requirements interfere with monetary policy goals. Higher capital requirements imply a less stronger financial accelerator; monetary policy needs to be more aggressive to compensate for that and obtain similar macroeconomic volatilities. Furthermore, the financial system is more stable.

Additionally, our model is part of a new generation of models that attempt to incorporate banks in the analysis. The arrival of the financial crisis led to realize that the mainstream dynamic model, even Bernanke et al. (1999), does not include specific banks and no specific role for bank capital. New models include Gertler and Karadi (2011), Meh and Moran (2010), Gertler and Kiyotaki (2010), or Iacoviello (2015). Their strategy, and ours, can be summarized as consistent on adding a second layer of financially constrained agents which are the banks. Similarly to our case, Angelini et al. (2014a,b) uses a DSGE model with a banking sector à la Gerali et al. (2010). They show interactions between the capital requirement ratio that responds to output growth (while we model countercyclical capital buffers in line with the current regulatory framework responding to credit), and monetary policy. They find that no regime, cooperative or non-cooperative between macroprudential and monetary authorities, makes all agents, borrowers or savers, better off. Our results show that this is the case for banks. However, we could find a system of transfers à la Kaldor-Hicks that generates a Pareto-superior outcome.

2. Model setup

The modelling framework is a DSGE model with a housing market, following Iacoviello (2015). The economy features patient and impatient households, bankers and a final goods firm. Households work and consume both consumption goods and housing. Patient and impatient households are savers and borrowers, respectively. Financial intermediaries intermediate funds between consumers. Bankers are credit constrained in how much they can borrow from savers, and borrowers are credit constrained with respect to how much they can borrow from bankers. The representative firm converts household labor into the final good. The central bank follows a Taylor rule for the setting of interest rates. The countercyclical capital buffer of Basel III is represented by a Taylor-type rule for the setting of the capital requirement ratio.

DSGE models are often used for policy evaluation and have become popular in the macroprudential literature, since they count with some important advantages. First, they can be compared with a benchmark in which there is only monetary policy and, then, obtain some insights on the introduction of additional policies. Second, they include many sources of shocks that can be used to check for different economic trajectories. Moreover, they rely on general equilibrium analysis and are suitable for simulations to study the impact of new policy instruments. Also, calibrated parameters can be altered to test for alternative policy scenarios. And finally, since DSGE models are microfounded, they are suitable to study the second order-approximation of the utility function of each agent.[13]

We have employed, for the purpose of this paper, a DSGE model with housing and credit. Basel regulations mainly refer to restrictions in credit markets. Therefore, we need to use a model that realistically reflects the behavior of credit, house prices, and the macroeconomy. Our model is based on the basic features of Iacoviello (2005) which shows through an empirical VAR analysis that this kind of model matches the evidence. To this basic setting, we add a banking sector, as in Iacoviello (2015), which is crucial to discuss about the CRR regulation in the Basel accords. Thus, the

[13] See Brázdik et al. (2011) for further discussion.

proposed model contains the necessary ingredients to face the research questions and it is supported by the empirical evidence.

2.1. Savers

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

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

where $\beta_s \in (0, 1)$ is the patient discount factor, E_0 is the expectation operator and $C_{s,t}$, $H_{s,t}$ and $N_{s,t}$ represent consumption at time t, the housing stock and working hours, respectively. $1/(\eta - 1)$ is the labor supply elasticity, $\eta > 0$. $j > 0$ constitutes the relative weight of housing in the utility function. Subject to the budget constraint:

$$C_{s,t} + d_t + q_t (H_{s,t} - H_{s,t-1}) = \frac{R_{s,t-1} d_{t-1}}{\pi_t} + w_{s,t} N_{s,t} + \frac{X_t - 1}{X_t} Y_t, \quad (1)$$

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 real wage rate. The last term refers to firms profits, which are rebated back to the saver, being X_t the firm's markup and Y_t the output. The first order conditions for this optimization problem are as follows:

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

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

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

Eq. (2) is the Euler equation, the intertemporal condition for consumption. Eq. (3) represents the intertemporal condition for housing, in which, at the margin, benefits for consuming housing equate costs in terms of consumption. Eq. (4) is the labor-supply condition.

2.2. Borrowers

Borrowers solve:

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

where $\beta_b \in (0, 1)$ is impatient discount factor, subject to the budget constraint and the collateral constraint:

$$C_{b,t} + \frac{R_{b,t} b_{t-1}}{\pi_{t+1}} + q_t (H_{b,t} - H_{b,t-1}) = b_t + w_{b,t} N_{b,t}, \quad (5)$$

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

where b_t denotes bank loans and $R_{b,t}$ is the gross interest rate. k can be interpreted as a loan-to-value ratio. The borrowing constraint limits borrowing to the present discounted value of their housing holdings. The first order conditions are as follows:

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

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

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

where $\lambda_{b,t}$ denotes the multiplier on the borrowing constraint.[14] These first order conditions can be interpreted analogously to the ones of savers.

2.3. Financial intermediaries

Financial intermediaries solve the following problem:

$$\max E_0 \sum_{t=0}^{\infty} \beta_f^t [\log \mathrm{div}_{f,t}],$$

where $\beta_f \in (0, 1)$ is the financial intermediary discount factor, subject to the budget constraint and the collateral constraint and $\mathrm{div}_{f,t}$ are dividends, which we assume are fully consumed by bankers every period, so that $\mathrm{div}_{f,t} = C_{f,t}$:

$$\mathrm{div}_{f,t} + \frac{R_{s,t-1} d_{t-1}}{\pi_t} + b_t = d_t + \frac{R_{b,t} b_{t-1}}{\pi_t}, \quad (10)$$

where the right-hand side measures the sources of funds for the financial intermediary, household deposits and repayments from borrowers on previous loans. These funds can be used to pay back depositors and to extend new loans, or can be used for their own consumption. As in Iacoviello (2015), we assume that the bank, by regulation, is constrained by the amount of assets minus liabilities. That is, there is a capital requirement ratio. We define capital as assets minus liabilities:

$$Cap_t = b_t - d_t. \quad (11)$$

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

$$\frac{b_t - d_t}{b_t} \geq CRR. \quad (12)$$

Simple algebra shows that this relationship can be rewritten as:

$$d_t \leq (1 - CRR) b_t. \quad (13)$$

If we define $\gamma = (1 - CRR)$, we can reinterpret the capital requirement ratio condition as a standard collateral constraint, so that banks liabilities cannot exceed a fraction of its assets, which can be used as collateral:[15]

$$d_t \leq \gamma b_t, \quad (14)$$

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

$$\frac{1}{\mathrm{div}_{f,t}} = \beta_f E_t \left(\frac{1}{\mathrm{div}_{f,t+1} \pi_{t+1}} R_{s,t} \right) + \lambda_{f,t}, \quad (15)$$

$$\frac{1}{\mathrm{div}_{f,t}} = \beta_f E_t \left(\frac{1}{\mathrm{div}_{f,t+1} \pi_{t+1}} R_{b,t+1} \right) + \gamma \lambda_{f,t}, \quad (16)$$

where $\lambda_{f,t}$ denotes the multiplier on the financial intermediary's borrowing constraint.[16]

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[14] Through simple algebra it can be shown that the Lagrange multiplier is positive in the steady state and thus the collateral constraint holds with equality.

[15] Clerc et al. (2014) find, using a DSGE model, that the probability of default for banks is negligible for capital requirement ratios higher than 10%. Basel III imposes a capital requirement ratio of 10.5%, therefore, we assume that, taking into account the goal of the paper, in our model we do not have to include default risk for banks.

[16] 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 $\lambda_f = ((\beta_s - \beta_f)/\beta_s) > 0$.

2.4. Final goods producers

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

$$Y_t = \left[\int_0^1 Y_t(z)^{(\varepsilon-1)/\varepsilon} dz\right]^{\varepsilon/(\varepsilon-1)}, \tag{17}$$

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

$$Y_t(z) = \left(\frac{P_t(z)}{P_t}\right)^{-\varepsilon} Y_t. \tag{18}$$

The price index is then given by:

$$P_t = \left[\int_0^1 P_t(z)^{1-\varepsilon} dz\right]^{1/(\varepsilon-1)}. \tag{19}$$

2.5. Intermediate goods producers

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

$$Y_t(z) = A_t N_{s,t}(z)^{\alpha} N_{b,t}(z)^{(1-\alpha)}, \tag{20}$$

where $\alpha \in [0, 1]$ measures the relative size of each group in terms of labor.[17] This Cobb-Douglas production function implies that labor efforts of constrained and unconstrained consumers are not perfect substitutes. This specification is analytically tractable and allows for closed form solutions for the steady state of the model. This assumption can be economically justified by the fact that savers are the managers of the firms and their wage is higher than the one of the borrowers.[18]

A_t represents technology and it follows the following autoregressive process:

$$\log(A_t) = \rho_A \log(A_{t-1}) + u_{At}, \tag{21}$$

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

Labor demand is determined by:

$$w_{s,t} = \frac{1}{X_t}\alpha \frac{Y_t}{N_{s,t}}, \tag{22}$$

$$w_{b,t} = \frac{1}{X_t}(1-\alpha)\frac{Y_t}{N_{b,t}}, \tag{23}$$

where X_t is the markup, or the inverse of marginal cost.[19]

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

$$\sum_{k=0}^{\infty} (\theta\beta)^k E_t \left\{ \Lambda_{t,k} \left[\frac{P_t^*(z)}{P_{t+k}} - \frac{\varepsilon/(\varepsilon-1)}{X_{t+k}} \right] Y_{t+k}^*(z) \right\} = 0. \tag{24}$$

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

The aggregate price level is then given by:

$$P_t = \left[\theta P_{t-1}^{1-\varepsilon} + (1-\theta)(P_t^*)^{1-\varepsilon}\right]^{1/(1-\varepsilon)}. \tag{25}$$

Using (24) and (25), and log-linearizing, we can obtain a standard forward-looking New Keynesian Phillips curve $\hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} - \psi \hat{x}_t + u_{\pi t}$, that relates inflation positively to future inflation and negatively to the markup ($\psi \equiv (1-\theta)(1-\beta\theta)/\theta$). $u_{\pi t}$ is a normally distributed cost-push shock.[20]

2.6. Equilibrium

The total supply of housing is fixed and it is normalized to unity, therefore house prices will be determined by demand. The market clearing conditions are as follows:

$$Y_t = C_{s,t} + C_{b,t} + C_{f,t}, \tag{26}$$

$$H_{s,t} + H_{b,t} = 1. \tag{27}$$

Labor supply (Eqs. (4) and (9)) and labor demand (Eqs. (22) and (23)) 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, $D_t = (1 - CRR)b_t$.

2.7. Monetary policy and the countercyclical buffer

In the standard new Keynesian model, the central bank aims at minimizing the variability of output and inflation to reduce the distortion introduced by nominal rigidities and monopolistic competition. However, in models with collateral constraints, the design of optimal policies involves a number of issues not considered in standard sticky-price models. In models with constrained individuals, there are three types of distortions: price rigidities, credit frictions and loan frictions. This creates conflicts and trade-offs between borrowers, savers, and banks. Savers may prefer policies that reduce the price stickiness distortion. However, borrowers may prefer a scenario in which the pervasive effect of the collateral constraint is softened. Borrowers operate in a second-best situation. They consume according to the borrowing constraint as opposed to savers that follow an Euler equation for consumption. Borrowers cannot smooth consumption by themselves, but a more stable financial system would provide them a setting in which their consumption pattern is smoother. In turn, banks may prefer policies that ease their capital constraint, since capital requirement ratios distort their ability to leverage and increase their dividends.

In the standard sticky-price model, the Taylor rule of the central bank is consistent with a loss function that includes the variability of inflation and output. In order to rationalize the objectives of the countercyclical buffer in Basel III, we follow Angelini et al. (2014a,b) in which they assume that the loss function in the economy also contains financial variables, namely borrowing variability, as a proxy for financial stability. Then, there would be a loss function for the economy that would include not only the variability of output and inflation but also the variability of borrowing: $L = \sigma_\pi^2 + \lambda_y \sigma_y^2 + \sigma_b^2$ where σ_π^2, σ_y^2 and σ_b^2 are the variances of inflation, output and borrowing. $\lambda_y \geq 0$, represents the relative weight of the central bank to the stabilization of output.[21] The last term would represent the objective of the countercyclical capital buffer in Basel III regulation (Basel III^{CB}).

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

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

[19] Symmetry across firms allows us to write the demands without the index z..

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

[21] This loss function would be consistent with the studies that make a second-order approximation of the utility of individuals and find that it differs from the standard case by including financial variables.

2.7.1. Monetary policy

For monetary policy, we consider a Taylor rule which responds to inflation and output growth:

$$R_{s,t} = (R_{s,t-1})^{\rho}\left((\pi_t)^{(1+\phi_\pi^R)}(Y_t/Y_{t-1})^{\phi_y^R}(1/\beta_s)\right)^{1-\rho}\varepsilon_{Rt}, \tag{28}$$

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

2.7.2. A rule for the countercyclical capital buffer

Here, following the Basel III guidelines, for the countercyclical buffer, we propose a Taylor-type rule that includes deviations of credit from its steady state, in order to explicitly promote stability and reduce systemic risk. This rule is analogous to the rule for monetary policy, but using the CRR as an instrument. It implies that the capital requirement ratio fluctuates around a steady state value, corresponding to the Basel III requirement for capital (10.5%), and it increases when credit grows above its steady state. The implementation of this rule would include the capital buffer stated in Basel III^{CB}. Then, the optimal implementation of Basel III^{CB} would be the value of the reaction parameter that minimizes second-order losses:

$$CRR_t = (CRR_{SS})\left(\frac{b_t}{b}\right)^{\phi_b} \tag{29}$$

This rule states that, whenever regulators observe that credit deviates is above its steady-state value, they automatically increase the capital requirement ratio to avoid an excess in credit.

2.8. Second-order approximation

Even though the paper takes a positive approach, we numerically evaluate the second-order effects implied by the regulations for the different agents of the model. Thus, we solve the model using a second-order approximation to the structural equations for given policy and then evaluating the utility associated to each individual. As in Mendicino and Pescatori (2007), we take this latter approach to be able to evaluate the effects for the three types of agents separately.[22] The individual second order effects for savers, borrowers, and the financial intermediary, respectively, is as follows:

$$W_{s,t} \equiv E_t \sum_{m=0}^{\infty} \beta_s^m \left[\log C_{s,t+m} + j\log H_{s,t+m} - \frac{(N_{s,t+m})^{\eta}}{\eta}\right], \tag{30}$$

$$W_{b,t} \equiv E_t \sum_{m=0}^{\infty} \beta_b^m \left[\log C_{b,t+m} + j\log H_{b,t+m} - \frac{(N_{b,t+m})^{\eta}}{\eta}\right], \tag{31}$$

$$W_{f,t} \equiv E_t \sum_{m=0}^{\infty} \beta_f^m [\log C_{f,t+m}]. \tag{32}$$

2.9. Parameter values

The discount factor for savers, β_s, is set to 0.99 so that the annual interest rate is 4% in steady state.[23] The discount factor for the borrowers is set to 0.98.[24] We set the discount factors for the bankers at 0.965 which, for a bank leverage parameter of 10% implies a spread of about 1 percent (on an annualized basis) between lending and deposit rates.[25] The steady-state weight of housing in the utility function, j, is set to 0.1 in order for the ratio of housing wealth to GDP to be approximately 1.40 in the steady state, consistent with the US data.[26] We set $\eta = 2$, implying a value of the labor supply elasticity of 1.[27] For the parameters controlling leverage, we set k, in line with the US data.[28] γ is the parameter governing the CRR, which will set according to the Basel regulation that we are considering (CRR of 8% for Basel I,II and 10.5% for Basel III). The labor income share for savers 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.[29] Table 1 presents a summary of the parameter values used:

Table 1
Parameter values.

β_s	.99	Discount factor for savers
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	.90	Loan-to-value ratio
α	.64	Labor income share for savers
ρ_A	.9	Technology persistence
BI,II *CRR*	.08	CRR for Basel I, II
BIII *CRR*	.105	CRR for Basel III
BIII CRR_{SS}	.105	Steady State CRR for Basel III^{CB}

3. Second-order effects and the CRR, for given monetary policy

In this section, we analyze second order effects for different capital requirement ratios, including the ones stated in Basel I, II, and III. Throughout the section, we keep monetary policy fixed. Even though the paper takes a positive approach, this evaluation permits us understand how macroeconomic and financial stability operate through the different channels in the model.

Fig. 1 presents the second-order approximation of each agent's utility function for different values of the CRR, given monetary

[22] We used the software Dynare to obtain a solution for the equilibrium implied by a given policy by solving a second-order approximation to the constraints, as in Schmitt-Grohe and Uribe (2004). See Monacelli (2006) for an example of the Ramsey approach in a model with heterogeneous consumers.

[23] Since the seminal paper by Kydland and Prescott (1982), the literature on DSGE models considers a calibrated value of the discount factor of 0.99, to pick up the value of the interest rate in the steady state. It is considered that a reasonable value is 1% in a quarterly model (4% annualized).

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

[25] For discount factors, it is only needed for the solution of the model that both borrowers and banks are more impatient than savers. Lowering discount factors for any agent would make them more impatient and therefore their marginal propensity to consume would increase. Sensitivity of their consumption with respect to shocks would be higher. However, changes in the discount factors within a realistic range represent negigible difference.

[26] Increasing the weight of housing in the utility function would in turn make this variable more sensitive to shocks. However, it is realistically calibrated in line with Iacoviello (2005) and Iacoviello and Neri (2010). Unless it is unrealistically increased, differences are negligible.

[27] Lowering η and make it approach to 1, would make the utility function become linear in leisure, which is arguable. The value we have used make it closer to realistic values widely used in macro models with collateral constraints, closer to the value estimated by Iacoviello and Neri (2010). In fact, microeconomic estimates usually suggest values in the range of 0 and 0.5 (for males). Domeij and Flodén (2006) show that in the presence of borrowing constraints this estimates could have a downward bias of 50%.

[28] See Iacoviello (2015).

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

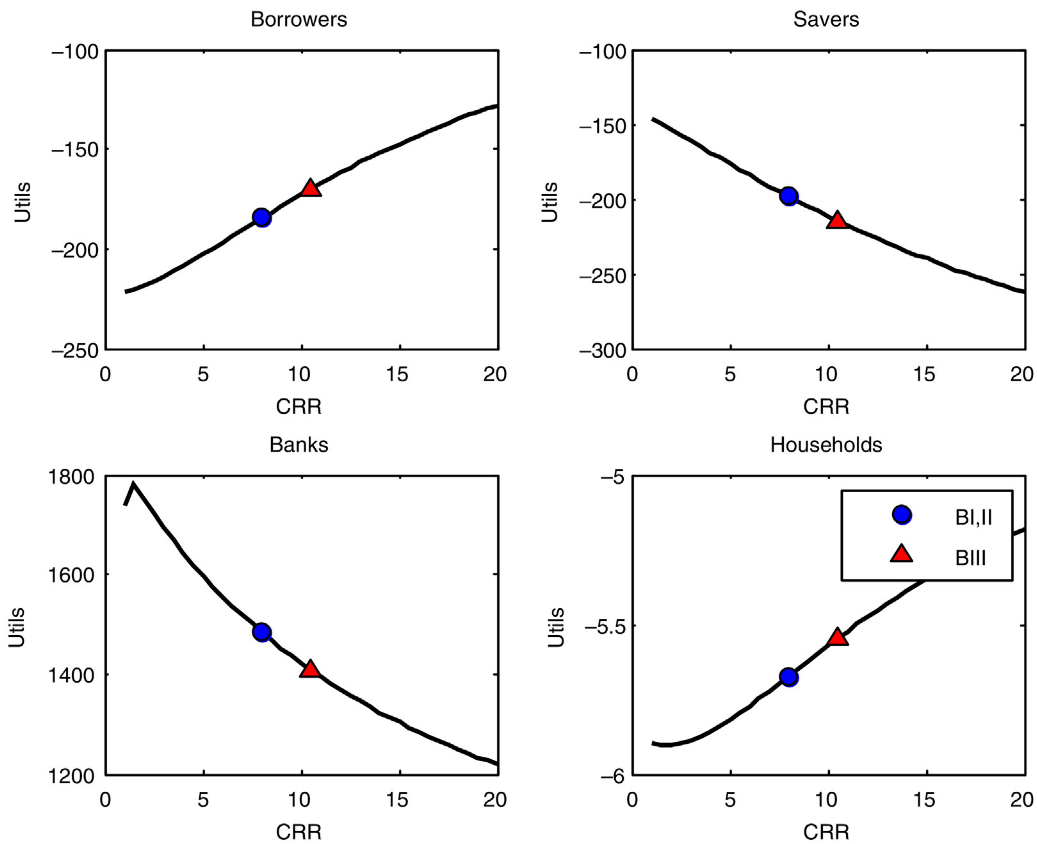

Fig. 1. Second-order effects for different CRR for borrowers, savers, banks and households (given baseline monetary policy).

policy.[30] This figure displays how each agent of the economy separately is affected, and also the household aggregate.[31] The blue circle represents the values corresponding to the Basel I and II CRR, whereas the red triangle corresponds to the Basel III CRR. Notice that results are presented in utils.

In this model, the second-order effects of the three agents are driven by different forces. This creates conflicts and trade-offs between them. Savers, who own the firms, care about the sticky-price distortion, therefore, inflation affects them negatively. Furthermore, inflation makes their savings less valuable. Borrowers are collateral constrained in the amount they can borrow. Since their collateral constraint is binding, they always borrow the maximum amount they can, making it difficult for them to smooth consumption. Therefore, even though higher capital requirements produce a negative level effect in their borrowing, situations that reduce the collateral distortion and help them smooth consumption are beneficial for them. More financially stable scenarios would do it, creating a second order positive effect. Moreover, inflation is beneficial for them, since their debt repayments are lower in real terms. In turn, banks are constrained in the amount they can lend since they are required to hold a certain amount of capital by regulation. This capital requirement distorts its intertemporal consumption decision (see Eq. (16)). Therefore, easing their constraint reduces this distortion for banks.

The top two panels of Fig. 1 show the trade-off that appears between borrowers and savers. A higher CRR implies a more stable financial system, since banks are constrained in the amount they can lend. Borrowers do not follow an Euler equation for consumption, like savers do; they are not able to follow a smooth path of consumption. Their consumption is, however, determined by the amount they can borrow, which in turn depends on the amount banks can lend. Therefore, even though as a level effect they can borrow less, increasing the capital requirement ratio has a positive second-order effect for borrowers. This happens at the expense of savers, who are not financially constrained.

Furthermore, higher CRR makes monetary policy less effective to stabilize inflation, since the financial accelerator is weaker. This means that the higher the CRR the less stabilizing monetary policy and the higher inflation volatility is. Savers suffer from the sticky-price distortion and their savings are worth less. Borrowers see their debt repayments decreasing in real terms.

Nevertheless, in the model, we have a third agent, the financial intermediary. The left bottom panel shows how banks have negative second-order effects with the increase in the CRR, because this tightens their constraint and affects negatively their intertemporal consumption decisions.

4. Optimal monetary policy for different CRR

The above section was assuming that monetary policy was taken as given, that is, that a different CRR did not affect the behavior of the central bank. However, this does not need to be the case. It seems plausible that the optimal conduct of monetary policy changes when the CRR increases. Then, in this subsection, we analyze how the optimized parameters of the Taylor rule for monetary

[30] We consider a benchmark case in which the coefficient for interest-rate smoothing is 0.8, which represents an empirically plausible value, and the reaction parameters for inflation and output are 0.5, as in the original paper by Taylor.

[31] Following Mendicino and Pescatori (2007), Rubio (2011), and Brzoza-Brzezina et al. (2013), we aggregate taking into consideration the discount factor of each individual.

Table 2
Optimal monetary policy and variabilities under different CRR.

CRR	$1+\phi_\pi^{R*}$	ϕ_y^{R*}	σ_π^2	σ_y^2	σ_b^2
1%	10.7	3.1	0.14	1.97	2.70
2%	11	3.6	0.16	1.95	2.43
5%	10.9	3.6	0.16	1.95	2.26
8% (BI, II)	**17.6**	**5.8**	0.16	1.95	2.00
10%	20.7	6.6	0.16	1.96	1.91
10.5% (BIII)	**20.7**	**6.6**	0.16	1.96	1.89
15%	20.5	6.6	0.16	1.96	1.74
20%	20.7	6.6	0.16	1.96	1.61

policy change for different values of the CRR. We define the optimized reaction parameters as those that minimize second-order losses for households.[32] The table shows the specific values corresponding to Basel I, II and Basel III, so that we can compare between these two regimes.[33]

Table 2 displays optimal monetary policy under different values of the CRR. We have presented CRR values for Basel I,II and Basel III, on bold, and six other CRR, just for informational purposes. Results show that now monetary policy can optimally react and stabilize inflation. As we pointed out, when the CRR increases, the financial accelerator is weaker. Therefore, in order to obtain the same impact on macroeconomic volatilities, monetary policy needs to be more aggressive. We find that especially for the inflation reaction parameter, this is the case. If we look at the macroeconomic and financial volatilities (4th, 5th and 6th columns of the table), we observe that the macroeconomic volatility is very similar for the different values of the CRR but the financial volatility decreases, meaning that a higher CRR enhances financial stability and can thus be interpreted as a macroprudential policy. [34]

5. Optimal implementation of the countercyclical buffer

So far, we have only considered the compulsory capital requirements of Basel I, II and III. However, Basel III has a dynamic macroprudential component, a countercyclical capital buffer that should also be taken into account. In this section, we make this countercyclical capital buffer interact with monetary policy and we analyze the optimal implementation of both policies together.

5.1. Optimal policy parameters

Table 3 presents results on the optimal implementation of Basel III^{CB} when it is interacting with monetary policy. We find the optimized values of both rules, monetary policy and Basel III^{CB}.[35] Notice that, in this section, we present consumption equivalent units

Table 3
Optimal monetary policy and CB, consumption equivalent changes and variabilities.

	Basel I, II	Basel III	Basel III^{CB}
ϕ_b^*	–	–	2.4
$1+\phi_\pi^{R*}$	17.6	20.7	49
ϕ_y^{R*}	5.8	6.6	7.4
Consumption equivalents (CE)	–	0.045	0.057
Borrowers CE	–	0.012	2.385
Savers CE	–	0.033	0.077
Banks CE	–	−0.669	−0.999
σ_π^2	0.16	0.16	0.08
σ_y^2	1.95	1.96	2.1
σ_b^2	2.00	1.89	0.82

derived from the second-order evaluation of the model to see the effect of moving to the Basel III regulation.

Considering consumption equivalent changes, we infer that the transition from Basel I, II to Basel III, without its dynamic macroprudential component is Pareto improving for households. This is due to the fact that optimal policies aid to reach a more stable financial system, as the variability of borrowing is lower, which helps borrowers to smooth consumption, and a lower inflation volatility, which benefits savers. However, for banks, a higher CRR reduces their leverage and their capacity to make dividends.

Interestingly, we observe that monetary policy increases its aggressiveness when moving to Basel III and Basel III^{CB}. This higher aggressiveness results in enhanced macroeconomic stability. We also see that introducing the countercyclical capital buffer increases financial stability even more and it also helps to reduce inflation volatility.[36]

Then, looking at consumption equivalent changes, implementing Basel III^{CB} is only Pareto improving for households. Banks suffer from a negative consumption equivalent change, though. However, if the consumption equivalent change of winning agents, i.e. households, were large enough, there could be room for Pareto-superior outcomes.

In order to do that, we apply the concept of Kaldor–Hicks efficiency, also known as Kaldor–Hicks criterion.[37] Under this criterion, an outcome is considered to be more efficient if a Pareto-superior outcome can be reached by arranging sufficient compensation from those that are made better-off to those that are made worse-off so that all would end up no worse-off than before. The Kaldor–Hicks criterion does not require the compensation actually being paid, merely that the possibility for compensation exists, and thus need not leave each at least as well off.

We see that in Table 3, this is the case. Introducing the Basel III^{CB} does not provide a positive consumption equivalent change for banks. Albeit, we can find a system of transfers in which borrowers and savers would compensate the banks with at least the amount they are losing, so that they are at least indifferent between having the new regulation or not.

5.2. Impulse responses

Impulse responses help illustrate the dynamic of the results. Fig. 2 presents impulse responses for an expansionary monetary

[32] Beck et al. (2014) estimate that, on average, the financial industry accounts for about 5% of a country's GDP, based on a sample of 77 countries for the period 1980–2007. Several other authors have recently used similar measures of value added of the financial sector, including Philippon (2008), Philippon and Reshef (2012), and Cecchetti and Kharroubi (2012). Therefore, for simplicity, we consider that the regulator only considers household welfare.

[33] We have not reported results for more extreme values of the CRR because the model does not converge for CRR higher than 39%.

[34] The measure that we take as a proxy for financial stability is the variability of credit. The collateral constraint is introducing a distortion in the economy that motivates the presence of macroprudential policies. Macroprudential policies make the variability of credit decrease and therefore help palliate the second-order perverse effects of the collateral constraint, by creating a more stable financial system. The measure chosen is in line with the discussion provided by Angelini et al. (2014a,b).

[35] We have considered both the cases in which monetary policy and the authority taking care of implementing Basel III^{CB}, act both in a coordinated and in a non-coordinated way. We have found that results do not differ for both cases. Therefore, we have reported them as a single case.

[36] We have performed a robustness check exercise including the credit to GDP with respect to their steady states in the countercyclical buffer rule. With this new specification, we have obtained very similar values, namely 2.3 for ϕ_b^*, 45 for $1+\phi_\pi^{R*}$ and 7.8 for ϕ_y^{R*}.

[37] See Scitovsky (1941).

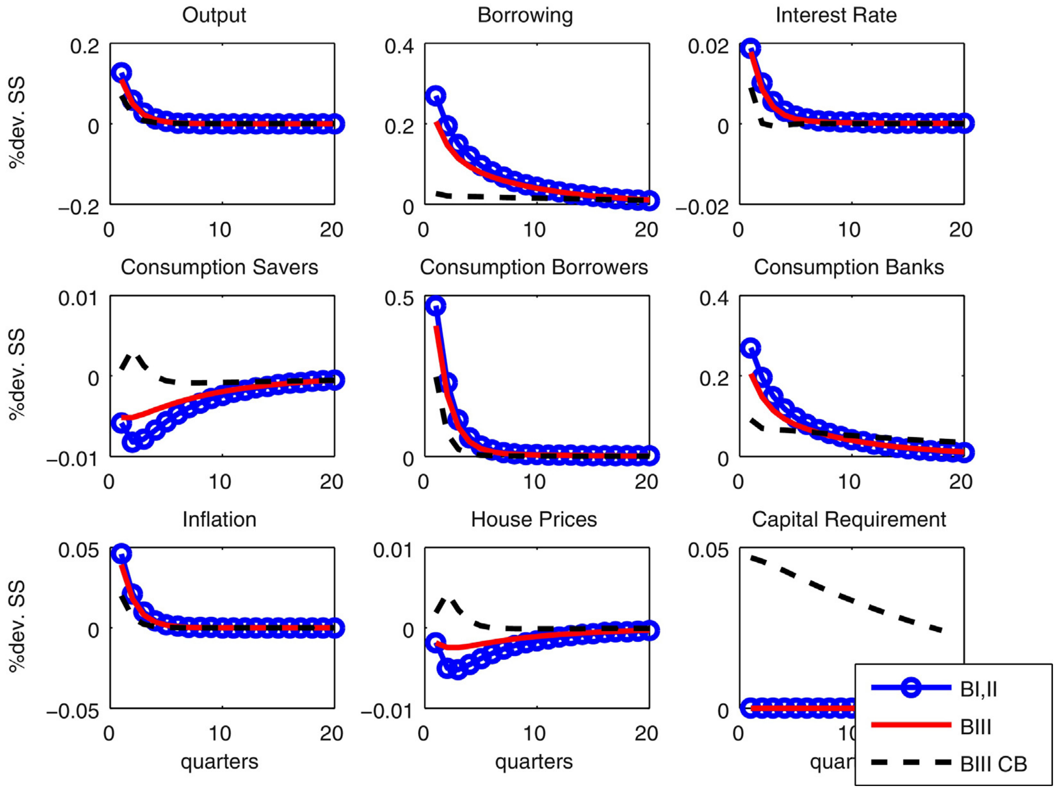

Fig. 2. Impulse responses to a positive monetary shock. BI, II versus BIII and BIII^{CB}. Optimized monetary and CB parameters.

policy shock for the optimized values found in Table 3. Impulses responses show the three cases analyzed: Basel I, II, Basel III and Basel III^{CB}.

What we observe in the figure is that, even if the shock is expansionary, the strong inflation coefficients in the Taylor rule, make the nominal policy rate actually increase so that inflation is contained. However, the real interest rate is still negative and output is increasing. As far as the real interest rate is negative, the expansion makes borrowing increase. Nevertheless, it increases by more in the case of Basel I, II because the capital requirement ratio is not as high as under Basel III and Basel III^{CB}. Then, increasing the capital requirement ratio reduces borrowing. In terms of the response of house prices, we see that they decrease, following the increase in the nominal interest rate. House prices are an asset price and they move inversely with the nominal interest rate. However, borrowing still increases due to the decrease in real rates. The behavior of house prices is mainly coming from the strong response of monetary policy to inflation.

When we allow for the countercyclical buffer to operate, borrowing increases only slightly. The regulator, that observes that borrowing is increasing with respect to its steady state uses its instrument to avoid this situation. Then, the capital requirement ratio increases above its steady state and helps containing credit.

Therefore, we can conclude from the graph that increasing the static capital requirement ratio, that is, going from an 8% in Basel I, II to a 10.5% in Basel III, dampens the effects of expansionary monetary policy shocks. Furthermore, introducing the countercyclical capital buffer mitigates them even more. The channel comes mainly through borrowing; higher capital requirements reduce the capacity of consumers to borrow.

In order to gain some more insight about the dynamics of the model, we also present Fig. 3. In this figure, we consider a shock to bank capital, which could serve as a proxy to a financial shock. Thus, we modify equation (11) to include this shock as follows:

$$Cap_t = b_t - d_t - \varepsilon_{Ct}, \tag{33}$$

where ε_{Ct} follows an an autoregressive process with 0.9 persistence and a normally distributed shock.[38]

Fig. 3 shows how a variation in the tightness of the bankers' borrowing constraint can affect equilibrium dynamics. This negative shock causes a reduction in bank capital and then, given the constraint imposed by Basel regulations, the bank needs to adjust its balance sheet to still meet the requirements. Since borrowing has exogenously fallen, the bank can reduce its deposits or raise new capital reducing its dividends. However, given that the bank is relatively more impatient, this last option is impractical and, in fact, it increases its consumption. This increase is larger in the case of a less tight regulation, as in Basel I and II. As a consequence, both lending and deposits are reduced. Again, the reduction is larger for Basel I and II and this is why savers' consumption increases by more in this case. The increase in consumption by banks and savers produces a positive demand effect that boosts output and inflation. The increase in inflation, in turn, makes the interest rate increase, depressing house prices. The combination of the increase in the interest rate and the fall in house prices makes borrowing decrease further.

However, when the countercyclical capital buffer is in place, the capital requirement ratio reacts to compensate the exogenous fall in capital. In the presence of this negative financial shock, the regulation becomes temporarily looser and the capital requirement ratio decreases. This clearly mitigates the negative effects of the shock on the financial sector.

[38] We follow Iacoviello (2015) for the specification of the shock.

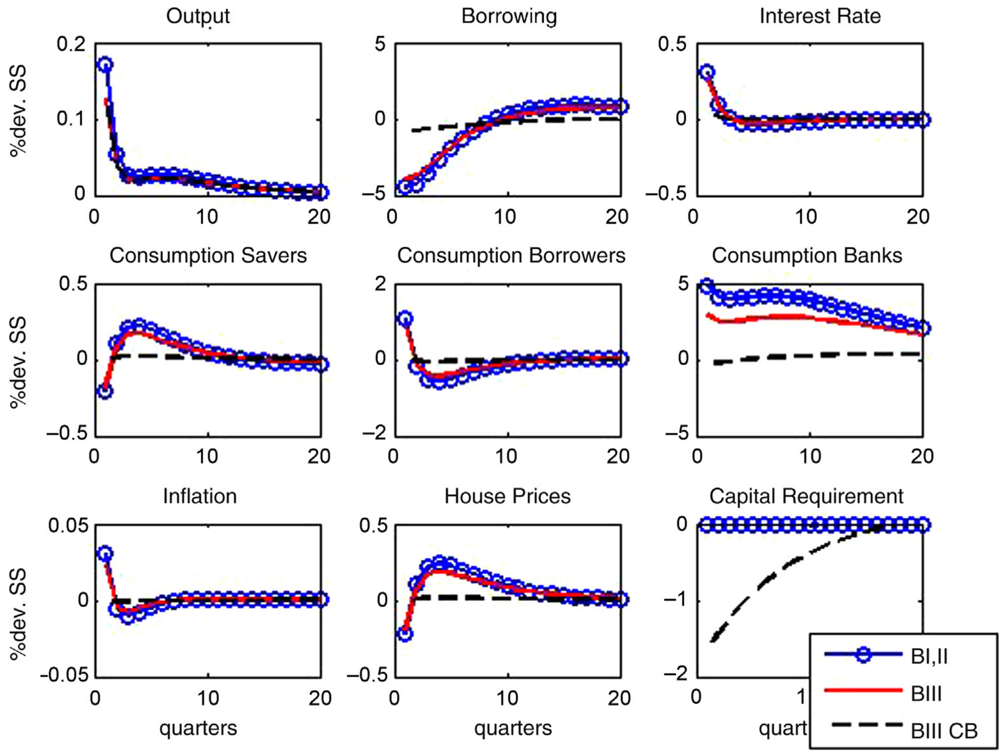

Fig. 3. Impulse responses to a negative shock to bank capital. BI, II versus BIII and BIII^{CB}. Optimized monetary and CB parameters.

6. Concluding remarks

In this paper, we use a DSGE model with housing to compute the effects of Basel I, II, and III regulations and its interactions with monetary policy. The model features three types of agents: savers, borrowers and banks. The two latter are financially constrained. Banks are constrained by Basel minimum requirements ratios because they are forced to hold a certain amount of capital in order to extend loans. Borrowers are constrained because they need collateral to obtain credit. In our model, there are two policy authorities: the central bank, in charge of monetary policy, and the macroprudential authority, taking care of macroprudential policies. The objective of the first one is to achieve macroeconomic stability (inflation and output), through the interest rate. The goal of the second one is to attain financial stability, using the capital requirement ratio of Basel regulations.

Within this framework, we calculate the second-order effects for each agent of increasing the capital requirement, for a given monetary policy. This analysis shows that the effects of Basel regulations are not evenly distributed. We find that while borrowers have positive second-order effects from this measure because it increases financial stability, they are negative for savers and banks.

Then, we analyze the interaction of the higher capital requirements in Basel I, II, and III regulations with monetary policy. We show that the optimal monetary policy becomes more aggressive the higher the capital requirement is, in order to compensate for a less strong financial accelerator. We find that a higher capital requirement increases financial stability without compromising macroeconomic stability.

Finally, we study the countercyclical capital buffer proposed by Basel III, interacting with monetary policy. We approximate this regulation by a rule in which the capital requirement responds to deviations of credit from its steady state. We show that the transition from Basel I, II to Basel III, without its dynamic macroprudential component increases financial stability. Adding the capital buffer improves the financial stability by more and it helps to reduce inflation volatility.

When we analyze the dynamics of the model under the optimized values, we find that higher CRR and the macroprudential CB dampen the effects of expansionary shocks through a credit restraint. If we consider a negative bank capital shock, the CB helps mitigate its effects by reducing the CRR.

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