The Interaction between the Basel Regulations and Monetary Policy: Fostering Economic and Financial Stability

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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. First, we find that higher capital requirement ratios (CRR), implied by the Basel regulations, increase the welfare of borrowers at the expense of savers and banks. Second, results show that monetary policy needs to be more aggressive when the CRR increases because the money multiplier decreases. However, this policy combination brings a more stable economic and financial system. Finally, we 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 credit growth. We find that, for households, the optimal implementation of this rule together with monetary policy represents a welfare improvement with respect to Basel I and II and brings extra financial stability.

Keywords: Basel I, Basel II, Basel III, Countercyclical capital buffer, Macroprudential, capital requirement ratio, credit

JEL Classification: E32, E44, E58

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"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 and scientific 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 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 policy-makers 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. 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. However, Basel I was soon widely viewed as outmoded because the world had evolved as financial corporations, financial innovation and risk management had developed. Therefore, a more comprehensive set of guidelines, known as Basel II were introduced. 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. Nevertheless, since the beginning of the international financial crisis in 2008, central banks all over the world worked on figuring out its reasons and the points of weakness in Basel II accord that was supposed to prevent the occurrence of such a crisis. Hence, the BCBS issued a new agreement in 2010 known as the Basel III Accord concerning the minimum requirements for capital adequacy to face the financial crisis. Basel III introduces an additional capital buffer (the capital conservation buffer) designed to enforce corrective action when a bank’s capital ratio deteriorates. It also adds a macroprudential element in the form of a countercyclical buffer (CB), which requires banks to hold more capital in good times to prepare for downturns in the economy.

Then, the subsequent Basel regulations have introduced higher compulsory capital requirement ratios (CRR) adding to them, finally with Basel III, a countercyclical buffer (CB). However, the way to implement this macroprudential component of Basel III has not been specified by the Committee. The BCBS clearly states the objectives of this additional buffer: "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). 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 states 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.

The aim of this paper is to study the welfare effects of the Basel I, II and III regulations as well as its interactions with monetary policy. Ultimately, our objective is to design an optimal policy mix that includes monetary parameters and a 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. Banks, by regulation, are constrained

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by the amount of assets minus liabilities. That is, there is a CRR. Following the guidelines of Basel III, we also assume that there exists a macroprudential CB that responds to credit growth. This microfounded general equilibrium model allows us to explore all the interrelations that appear between the real economy and the credit market. Furthermore, such a model can deal with welfare-related questions. We consider welfare for the three agents separately and make the analysis for two cases: considering welfare for households, as it is common in the literature, and also including the welfare for banks.

Using this setting, we can address several key research questions. First, we can analyze how the different values of the CRR, including those of Basel I, II and III, affect welfare. We find that increasing the CRR is beneficial for borrowers but welfare decreasing for savers and banks. Then, the Basel regulation seems to bring winners and losers to the economy.

Second, we can analyze 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 a lower money multiplier.

Then, we aim at finding the implementation if the CB that delivers more stable financial system, acting together with a monetary authority that looks at macroeconomic stability. We suggest that the CB follows a rule that increases capital requirements when there is excessive credit growth and diminishes it when the situation is the opposite.\(^2\) Once we have established the rule, we look for its optimal reaction parameters, together with those of monetary policy. We find that, especially when policy-makers maximize households welfare, we obtain higher macroeconomic and financial stability.

Finally, we find that there exists a system of transfers à la Kaldor-Hicks which can be implemented to obtain a Pareto-superior outcome to overcome the trade-off between winners and losers.

The rest of the paper continues as follows. Section 1.1 makes a review of the literature. Section 2 presents the modeling framework. Section 3 presents the modelling of monetary policy and the countercyclical buffer. Sections 4 and 5 explain the welfare measure and the parameter values, respectively. Section 6 studies welfare and the implications for monetary policy of the Basel regulation. Section 7 analyzes the optimal implementation of the Basel III CB. Finally, section 8 concludes.

\(^2\) 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).
1.1 Related Literature

The interest in macroprudential policies and regulations that deliver a more stable financial system is a recent topic, on the limelight after the crisis. Furthermore, 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 literature on the topic, although flourishing is also quite recent.

Borio (2003) was one of the pioneers on the topic. He distinguished 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) and (2011).

Basel III regulation is based on limits on capital requirements. Borio (2011) states that several aspects of Basel III reflect a macroprudential approach to financial regulation. However, 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. 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. Repullo and Saurina (2012) shows that a mechanical application of Basel III regulation would tend to reduce capital requirements when GDP growth is high and increase them when GDP growth is low. We contribute to this line of research analyzing welfare for several agents in the economy and stating for which groups Basel regulation could imply lower welfare. As in Van den Heuvel (2008) we find that capital requirements have a large welfare cost for banks.

This paper is also connected with the literature that uses a DSGE model to study the effects of a macroprudential rule acting together with the monetary policy. Among them, for instance, Borio and Shim (2007) emphasizes 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) uses 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. These papers show that a macroprudential instrument to moderate the credit cycle could potentially reduce output fluctuations. Following this line, we study how optimal monetary policy is affected by the Basel regulation.

This 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, Gertler, and Gilchrist (1999), does not include specific banks and no specific role for bank capital. New models include Gertler and Karadi (2009), Meh and Moran (2010) and Gertler and Kiyotaki (2010). Their strategy, and ours, can be summarized as consistent on adding a second layer of financially constrained agents which are the banks. Angelini et al. (2012) 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 growth), 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 result show that this is also the case. However, we find a system of transfers à la Kaldor-Hicks that finds a Pareto-superior outcome for certain cases.

2 Model Setup

The modelling framework is a DSGE model with a housing market, following Iacoviello (2014). 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.

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:

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

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 first order conditions for this optimization problem are as follows:

\[
\frac{1}{C_{s,t}} = \beta_s E_t \left( \frac{R_{s,t}}{\pi_{t+1}C_{s,t+1}} \right)
\]

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

\[
w_{s,t} = (N_{s,t})^{\eta-1}C_{s,t}
\]

Equation (2) is the Euler equation, the intertemporal condition for consumption. 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

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:

\[
C_{b,t} + \frac{R_{b,t}b_{t-1}}{\pi_{t+1}} + q_t (H_{b,t} - H_{b,t-1}) = b_t + w_{b,t}N_{b,t},
\]
\[ b_t \leq E_t \left( \frac{1}{R_{b,t+1}} k_{t+1} h_{b,t} \pi_{t+1} \right), \]  

(6)

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

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

(7)

\[ \frac{j}{H_{b,t}} = E_t \left( \frac{1}{C_{b,t} q_t - \beta_b E_t \left( \frac{q_{t+1}}{C_{b,t+1}} \right)} \right) - \lambda_{b,t} E_t \left( \frac{1}{R_{b,t+1}} k_{t+1} \pi_{t+1} \right), \]  

(8)

\[ w_{b,t} = (N_{b,t})^{n-1} C_{b,t}, \]  

(9)

where \( \lambda_{b,t} \) denotes the multiplier on the borrowing constraint.\(^3\) These first order conditions can be interpreted analogously to the ones of savers.

### 2.3 Financial Intermediaries

Financial intermediaries solve the following problem:

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

where \( \beta_f \in (0, 1) \) is the financial intermediary discount factor, subject to the budget constraint and the collateral constraint:

\[
C_{f,t} + \frac{R_{s,t-1} d_{t-1}}{\pi_t} + b_t = d_t + \frac{R_{b,t} b_{t-1}}{\pi_t},
\]

(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 (2014), we assume that the bank, by regulation, is constrained by the amount of assets less liabilities. That is, there is a capital requirement ratio. We define capital as assets minus liabilities, so that, the fraction of

\(^3\)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.
capital with respect to assets has to be larger than a certain ratio:

\[ \frac{b_t - d_t}{b_t} \geq CRR. \tag{11} \]

Simple algebra shows that this relationship can be rewritten as:

\[ d_t \leq (1 - CRR) b_t, \tag{12} \]

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:

\[ d_t \leq \gamma b_t, \tag{13} \]

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

\[ \frac{1}{C_{f,t}} = \beta_f E_t \left( \frac{1}{C_{f,t+1} \pi_{t+1}} R_t \right) + \lambda_{f,t}, \tag{14} \]

\[ \frac{1}{C_{f,t}} = \beta_f E_t \left( \frac{1}{C_{f,t+1} \pi_{t+1}} R_{b,t+1} \right) + \gamma \lambda_{f,t}, \tag{15} \]

where \( \lambda_{f,t} \) denotes the multiplier on the financial intermediary’s borrowing constraint.\(^4\)

### 2.3.1 Final Goods Producers

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

\[ Y_t = \left[ \int_0^1 Y_t(z) \frac{1}{z} \frac{dz}{\varepsilon - 1} \right]^{\frac{\varepsilon}{\varepsilon - 1}}, \tag{16} \]

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 \( z \):

\[ Y_t(z) = \left( \frac{P_t}{P_t(z)} \right)^{-\varepsilon} Y_t. \tag{17} \]

\(^4\)Financial intermediaries have a discount factor \( \beta_f < \beta_s \). This condition ensures that the collateral constraint of the intermediary holds with equality in the steady state, since \( \lambda_f = \frac{\beta_s - \beta_f}{\beta_s} > 0 \)
The price index is then given by:

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

(18)

### 2.3.2 Intermediate Goods Producers

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

\[ Y_t(z) = A_t N_{s,t}(z)^{\alpha} N_{b,t}(z)^{(1-\alpha)}, \]  

(19)

where \( \alpha \in [0,1] \) measures the relative size of each group in terms of labor.\(^5\) 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.\(^6\)

\(A_t\) represents technology and it follows the following autoregressive process:

\[ \log (A_t) = \rho_A \log (A_{t-1}) + u_{At}, \]  

(20)

where \( \rho_A \) 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:

\[ w_{s,t} = \frac{1}{X_t} \frac{\alpha}{N_{s,t}} Y_t, \]  

(21)

\[ w_{b,t} = \frac{1}{X_t} (1 - \alpha) \frac{Y_t}{N_{b,t}}, \]  

(22)

where \( X_t \) is the markup, or the inverse of marginal cost.\(^7\)

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

\(^{5}\)Notice that the absolute size of each group is one.

\(^{6}\)It could also be interpreted as the savers being older than the borrowers, therefore more experienced.

\(^{7}\)Symmetry across firms allows us to write the demands without the index \( z \).
able to change the sale price in every period. The optimal reset price \( P_t^* (z) \) solves:

\[
\sum_{k=0}^{\infty} (\theta \beta)^k E_t \left\{ \Lambda_{t,k} \left[ \frac{P_t^*(z)}{P_{t+k}} - \frac{\varepsilon}{(\varepsilon - 1)} \right] \right\} Y_{t+k}^* (z) = 0.
\] (23)

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

The aggregate price level is then given by:

\[
P_t = \left[ \theta P_{t-1}^{1-\varepsilon} + (1 - \theta) (P_t^*)^{1-\varepsilon} \right]^{1/(1-\varepsilon)}.
\] (24)

Using (23) and (24), and log-linearizing, we can obtain a standard forward-looking New Keynesian Phillips curve \( \pi_t = \beta E_t \pi_{t+1} - \psi \hat{\pi}_t + u_{\pi t} \), 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.\(^8\)

### 2.4 Equilibrium

The total supply of housing is fixed and it is normalized to unity. The market clearing conditions are as follows:

\[
Y_t = C_{s,t} + C_{b,t} + C_{f,t},
\] (25)

\[
H_{s,t} + H_{b,t} = 1.
\] (26)

### 3 Modelling 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, welfare analysis and the design of optimal policies involves a number of issues not considered in standard sticky-price models. In models with constrained individuals, there are two types of distortions: price rigidities and credit 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

\(^8\)Variables with a hat denote percent deviations from the steady state.
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 smooth consumption.

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. (2012) 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: \[ L = \sigma^2_\pi + \lambda_y\sigma^2_y + \sigma^2_b \] where \( \sigma^2_\pi, \sigma^2_y \) and \( \sigma^2_b \) 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.\(^9\) The last term would represent the objective of the countercyclical capital buffer in Basel III regulation (Basel III\(^{CB} \)).

### 3.1 Monetary Policy

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

\[
R_t = (R_{t-1})^\rho \left( (\pi_t)^{(1+\phi^R_\pi)} (Y_t/Y_{t-1})^{\phi^R_y} R \right)^{1-\rho} \varepsilon_{Rt},
\]

where \( 0 \leq \rho \leq 1 \) is the parameter associated with interest-rate inertia, \( \phi^R_\pi \geq 0 \) and \( \phi^R_y \geq 0 \) measure the response of interest rates to current inflation and output growth, respectively. \( \varepsilon_{Rt} \) is a white noise shock with zero mean and variance \( \sigma^2_\varepsilon \).

### 3.2 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 credit growth 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. This rule implies that the capital requirement ratio fluctuates around a steady state value, corresponding to the Basel III minimum requirement for capital (10.5%) and increases when credit is growing. The implementation of this rule would include the capital buffer stated in Basel III\(^{CB} \). Then, the optimal implementation of

\(^9\)This loss function would be consistent with 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.
Basel III$^{CB}$ would be the value of the reaction parameter that maximizes welfare:

$$CRR_t = (CRR_{SS}) \left( \frac{b_t}{b_{t-1}} \right)^{\phi_b}$$  \hspace{1cm} (28)

This rule states that whenever the regulator observe that credit is growing, they automatically increase the capital requirement ratio to avoid an excess in credit.

4 Welfare Measure

To assess the normative implications of the different policies, we numerically evaluate the welfare derived in each case. As discussed in Benigno and Woodford (2008), the two approaches that have recently been used for welfare analysis in DSGE models include either characterizing the optimal Ramsey policy, or solving the model using a second-order approximation to the structural equations for given policy and then evaluating welfare using this solution. As in Mendicino and Pescatori (2007), we take this latter approach to be able to evaluate the welfare of the three types of agents separately.$^{10}$ The individual welfare for savers, borrowers, and the financial intermediary, respectively, as follows:

$$W_{s,t} \equiv E_t \sum_{m=0}^{\infty} \beta_s^m \left[ \log C_{s,t+m} + j \log H_{s,t+m} - \frac{(N_{s,t+m})^\eta}{\eta} \right],$$  \hspace{1cm} (29)

$$W_{b,t} \equiv E_t \sum_{m=0}^{\infty} \beta_b^m \left[ \log C_{b,t+m} + j \log H_{b,t+m} - \frac{(N_{b,t+m})^\eta}{\eta} \right],$$  \hspace{1cm} (30)

$$W_{f,t} \equiv E_t \sum_{m=0}^{\infty} \beta_f^m \left[ \log C_{f,t+m} \right].$$  \hspace{1cm} (31)

Following Mendicino and Pescatori (2007), we aggregate as a weighted sum of the individual welfare for the different types of households. Each agent’s welfare is weighted by her discount factor, respectively, so that the all the groups receive the same level of utility from a constant consumption stream.

There is a discussion in the literature of whether the relevant welfare to take into consideration is the one of households, as in the majority of analyses, or whether it should also include banks. Therefore, in this study, we present results for both situations and compare them.

$^{10}$We used the software Dynare to obtain a solution for the equilibrium implied by a given policy by solving a second-order approximation to the constraints, then evaluating welfare under the policy using this approximate solution, as in Schmitt-Grohe and Uribe (2004). See Monacelli (2006) for an example of the Ramsey approach in a model with heterogeneous consumers.
Then, we can define households welfare as:

\[ W_{h,t} = (1 - \beta_s) W_{s,t} + (1 - \beta_b) W_{b,t}, \]  

and total welfare as:

\[ W_t = (1 - \beta_s) W_{s,t} + (1 - \beta_b) W_{b,t} + (1 - \beta_f) W_{f,t}. \]  

5 Parameter Values

The discount factor for savers, \( \beta_s \), is set to 0.99 so that the annual interest rate is 4% in steady state. The discount factor for the borrowers is set to 0.98.\(^{11}\) As in Iacoviello (2014), 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. The steady-state weight of housing in the utility function, \( j \), is set to 0.1 in order for the ratio of housing wealth to GDP to be approximately 1.40 in the steady state, consistent with the US data. We set \( \eta = 2 \), implying a value of the labor supply elasticity of 1.\(^{12}\) For the parameters controlling leverage, we set \( k \), in line with the US data.\(^{13}\) \( \gamma \) 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).

For impulse responses, we consider two types of shocks, a technology shock and a monetary policy shock. We assume that technology, \( A_t \), follows an autoregressive process with 0.9 persistence and a normally distributed shock.\(^{14}\) Table 1 presents a summary of the parameter values used:

\(^{11}\)Lawrance (1991) estimated discount factors for poor consumers at between 0.95 and 0.98 at quarterly frequency. We take the most conservative value.

\(^{12}\)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%.

\(^{13}\)See Iacoviello (2011).

\(^{14}\)The persistence of the shocks is consistent with the estimates in Iacoviello and Neri (2010).
### Table 1: Parameter Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_s$</td>
<td>.99</td>
<td>Discount Factor for Savers</td>
</tr>
<tr>
<td>$\beta_b$</td>
<td>.98</td>
<td>Discount Factor for Borrowers</td>
</tr>
<tr>
<td>$\beta_f$</td>
<td>.965</td>
<td>Discount Factor for Banks</td>
</tr>
<tr>
<td>$j$</td>
<td>.1</td>
<td>Weight of Housing in Utility Function</td>
</tr>
<tr>
<td>$\eta$</td>
<td>2</td>
<td>Parameter associated with labor elasticity</td>
</tr>
<tr>
<td>$k$</td>
<td>.90</td>
<td>Loan-to-value ratio</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>.64</td>
<td>Labor income share for Savers</td>
</tr>
<tr>
<td>$\rho_A$</td>
<td>.9</td>
<td>Technology persistence</td>
</tr>
<tr>
<td>$\rho_j$</td>
<td>.95</td>
<td>House price persistence</td>
</tr>
<tr>
<td>BI,II CRR</td>
<td>.8</td>
<td>CRR for Basel I, II</td>
</tr>
<tr>
<td>BIII CRR</td>
<td>.105</td>
<td>CRR for Basel III</td>
</tr>
<tr>
<td>BIII CRR$_{SS}$</td>
<td>.105</td>
<td>Steady State CRR for Basel III$^{CB}$</td>
</tr>
</tbody>
</table>

6 From Basel I, II to Basel III

In this section, we study how monetary policy interacts with different values of the CRR. In order to gain some insight, we illustrate first how welfare is affected by different values of the CRR, for given monetary policy. Then, we analyze how the optimal monetary policy responds to changes in the CRR.

As in standard models, we consider aggregate welfare as the weighted sum of borrowers and savers welfare. However, for completeness, and since we have a third agent in the model, that is, banks, we also present results considering total welfare as the weighted sum of the three agents.

6.1 Welfare and the CRR, for given Monetary Policy

Figure 1 presents welfare for different values of the CRR, given monetary policy. This figure displays how welfare is affected by this parameter for each agent of the economy separately, for households and for the three agents together. The blue circle represent 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 welfare units, since the purpose of this figure is to illustrate the issue from an ordinal point of view.

Remember that in this model, the welfare of the three agents is driven by different forces. This creates

---

15 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.
conflicts and trade-offs between them. Savers, who own the firms, care about the sticky-price distortion, therefore inflation affects them negatively. 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. Situations that reduce the collateral distortion and help them smooth consumption are beneficial for them. More financially stable scenarios would do it. 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 equation 15). Therefore, easing their constraint increases welfare for banks.

The top left panel of figure 1 shows the trade-off that appears between borrowers and savers welfare. A higher CRR implies a more stable financial system, since banks are constrained in the amount they can lend. Since 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, increasing the capital requirement ratio is welfare enhancing for borrowers. This happens however at the expense of savers, who are not financially constrained.

If we look at the bottom left panel, we can see the evolution of the aggregate welfare by households. There we observe that households as a whole benefit from the increase in the CRR. Thus, the transition from Basel I, II to Basel III is beneficial.
However, in the model, we have a third agent, the financial intermediary. The right top panel shows how banks lose in terms of welfare with the increase in the CRR, because this tightens their constraint and affects negatively their intertemporal consumption decisions. If we aggregate welfare by the three agents, welfare is mainly driven by banks, so that the whole society is worse off by increasing the CRR.

This welfare analysis shows that the effects of the Basel regulation are not evenly distributed. A stricter regulation makes borrowers be the winners, at the expense of bankers and savers, who are the losers.

6.2 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 policy change for different values of the CRR. We define the optimized reaction parameters as those that maximize welfare. The table shows the specific values corresponding to Basel I, II and Basel III, so that we can compare between these two regimes.

Table 2 presents optimal monetary policy under different values of the CRR when the goal of the central bank is to maximize households welfare by choosing the appropriate parameters of the Taylor rule. When the CRR increases, the money mutiplier (or in turn the financial accelerator) is smaller. Therefore, in order to obtain the same impact, 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 (5th, 6th and 7th 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.
Table 2: Optimal Monetary Policy under different CRR, Max Household Welfare

<table>
<thead>
<tr>
<th>CRR</th>
<th>$1 + \phi_y^R$</th>
<th>$\phi_y^R$</th>
<th>Household Welfare</th>
<th>$\sigma^2_\pi$</th>
<th>$\sigma^2_y$</th>
<th>$\sigma^2_\phi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>10.7</td>
<td>3.1</td>
<td>-3.83</td>
<td>0.14</td>
<td>1.97</td>
<td>2.70</td>
</tr>
<tr>
<td>2%</td>
<td>11</td>
<td>3.6</td>
<td>-3.966</td>
<td>0.16</td>
<td>1.95</td>
<td>2.43</td>
</tr>
<tr>
<td>5%</td>
<td>10.9</td>
<td>3.6</td>
<td>-4.137</td>
<td>0.16</td>
<td>1.95</td>
<td>2.26</td>
</tr>
<tr>
<td>8% (BI, II)</td>
<td>17.6</td>
<td>5.8</td>
<td>-4.0988</td>
<td>0.16</td>
<td>1.95</td>
<td>2.00</td>
</tr>
<tr>
<td>10%</td>
<td>20.7</td>
<td>6.6</td>
<td>-4.0617</td>
<td>0.16</td>
<td>1.96</td>
<td>1.91</td>
</tr>
<tr>
<td>10.5% (BIII)</td>
<td>20.7</td>
<td>6.6</td>
<td>-4.0539</td>
<td>0.16</td>
<td>1.96</td>
<td>1.89</td>
</tr>
<tr>
<td>15%</td>
<td>20.5</td>
<td>6.6</td>
<td>-3.9624</td>
<td>0.16</td>
<td>1.96</td>
<td>1.74</td>
</tr>
<tr>
<td>20%</td>
<td>20.7</td>
<td>6.6</td>
<td>-3.8492</td>
<td>0.16</td>
<td>1.96</td>
<td>1.61</td>
</tr>
</tbody>
</table>

Table 3 presents results assuming that the central bank maximizes total welfare, including the welfare of the banks.\(^{16}\) In this case, as we saw, total welfare is driven by the welfare of the financial intermediary. Therefore, the sticky-price distortion that affects savers loses importance. This is why the optimal reaction parameter of inflation is much lower here than in the previous case. The central bank focuses more on stabilizing output. Following the same line of analysis, we observe that monetary policy is more aggressive the higher the CRR is, to compensate for the smaller money multiplier. However, in this case, we see that monetary policy does not do a good job in stabilizing the economy. Especially with a low CRR, both the macroeconomic and the financial volatilities are very high.

Table 3: Optimal Monetary Policy under different CRR, Max Total Welfare

<table>
<thead>
<tr>
<th>CRR</th>
<th>$1 + \phi_y^R$</th>
<th>$\phi_y^R$</th>
<th>Total Welfare</th>
<th>$\sigma^2_\pi$</th>
<th>$\sigma^2_y$</th>
<th>$\sigma^2_\phi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>1.1</td>
<td>3.6</td>
<td>6.7293</td>
<td>87.17</td>
<td>113.22</td>
<td>1185.96</td>
</tr>
<tr>
<td>2%</td>
<td>1.1</td>
<td>3.8</td>
<td>7.0282</td>
<td>94.67</td>
<td>116.40</td>
<td>1423.88</td>
</tr>
<tr>
<td>5%</td>
<td>1.1</td>
<td>4.4</td>
<td>20.348</td>
<td>128.73</td>
<td>132.71</td>
<td>2093.99</td>
</tr>
<tr>
<td>8% (BI, II)</td>
<td>1.1</td>
<td>6.1</td>
<td>.51127</td>
<td>105.61</td>
<td>75.92</td>
<td>2046.28</td>
</tr>
<tr>
<td>10%</td>
<td>1.1</td>
<td>6.6</td>
<td>.21227</td>
<td>23.92</td>
<td>15.41</td>
<td>427.97</td>
</tr>
<tr>
<td>10.5% (BIII)</td>
<td>1.1</td>
<td>6.6</td>
<td>.15112</td>
<td>20.55</td>
<td>13.15</td>
<td>356.13</td>
</tr>
<tr>
<td>15%</td>
<td>1.1</td>
<td>7.6</td>
<td>.027295</td>
<td>9.9</td>
<td>5.2</td>
<td>146.41</td>
</tr>
<tr>
<td>20%</td>
<td>1.1</td>
<td>8.6</td>
<td>.010948</td>
<td>7.1</td>
<td>3.2</td>
<td>89.29</td>
</tr>
</tbody>
</table>

\(^{16}\)Note that welfare values have been rescaled just for illustrative purposes. The ordinality of the measure has not been affected.
7 Optimal Implementation of the Countercyclical Buffer

So far we have only consider the compulsory capital requirements of Basel I, II and III. However, Basel III has a macroprudential component, a countercyclical capital buffer that should also be considered. In this section we study first, how this buffer, that follows the rule in equation 28, affects welfare, for given monetary policy. We take as benchmark the compulsory CRR in Basel III and the optimal monetary policy parameters that we found in the previous section for this case. Then, we make this countercyclical capital buffer interact with monetary policy and we find the optimal implementation of both policies together.

7.1 Welfare

Here, we find welfare gains/losses from introducing the Basel III macroprudential component, leaving monetary policy fixed at the optimal values that we found in the previous section. We calculate welfare gains for different values of the reaction parameter of the CB rule. We present results in consumption equivalents, that is, how much each agent would be willing to pay, in terms of consumption units, to be in a more favorable situation. We take Basel III with no capital buffer as the benchmark.

Figure 2 displays results considering the optimal monetary policy parameters that we found when the central bank maximizes welfare of households. We see that, in this case, introducing the macroprudential component is just beneficial for savers, the rest of agents in the economy lose with the new measure. This is because the central bank has mainly taken into account the welfare from savers, when optimizing monetary policy and has not given the chance re-optimize with the new measure.

Figure 3 shows results when we take as benchmark the optimal monetary policy that considers total welfare maximization including banks. In this case, results are reversed for borrowers and savers. Here, the central bank is not fighting aggressively against inflation, which benefits borrowers. A high inflation environment lowers debt repayments for borrowers. Furthermore, introducing the countercyclical buffer increases financial stability, which also benefits borrowers. Aggregating households welfare, we see that the countercyclical buffer is on average beneficial for consumers. However, the banks are also the losers in this situation. The new measure is welfare decreasing for them.
Figure 2: Welfare gains of introducing the countercyclical buffer in Basel III for given monetary policy. Benchmark: Optimal values of monetary policy for Basel III, maximize household welfare.

7.2 Interaction between the Countercyclical Buffer and Monetary Policy

In the previous subsection, we have studied the welfare gains of applying a countercyclical capital buffer to Basel III. However, monetary policy was kept fixed and that created losses for some agents. Here, we re-optimized monetary policy together with the CB to see if this can improve the situation of agents.

Table 4 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$^{CB}$, that maximize welfare.$^{17}$ In this table we are considering that the relevant welfare is the one from households. We see that the transition from Basel I, II to Basel III, without its macroprudential component is Pareto improving. Contrary to the figures in which we showed that, keeping monetary policy fixed, there were winners and losers (figures 2 and 3), the appropriate re-optimization of monetary policy can make savers and borrowers better off. However, for the case of Basel III including its countercyclical buffer, even if the set of households improve with respect to Basel I and II, savers are worse off. However, we see that introducing the countercyclical capital buffer increases financial stability.

$^{17}$We have considered both the cases in which monetary policy and the authority taking care of implementing Basel III$^{MP}$, 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.
Figure 3: Welfare gains of introducing the countercyclical buffer in Basel III for given monetary policy. Benchmark: Optimal values of monetary policy for Basel III, maximize total welfare.

| Table 4: Optimal Monetary Policy and Basel III$^{CB}$, Max Household Welfare |
|------------------|----------------|----------------|
|                  | Basel I, II   | Basel III     | Basel III$^{CB}$ |
| $\phi_b^{k^x}$   | -             | -             | 0.1              |
| $1 + \phi_b^{R^x}$ | 17.6          | 20.7          | 51               |
| $\phi_y^{R^x}$   | 5.8           | 6.6           | 15.5             |
| Households Welfare Gain | -            | 0.045         | 0.057            |
| Borrowers Welfare Gain  | -            | 0.012         | 0.068            |
| Savers Welfare Gain    | -            | 0.033         | -0.011           |
| $\sigma_\pi^2$      | 0.16          | 0.16          | 0.15             |
| $\sigma_y^2$       | 1.95          | 1.96          | 1.96             |
| $\sigma_b^2$       | 2.00          | 1.89          | 1.82             |

In Table 5 we repeat the analysis but taking total welfare, that is including banks, for the maximization problem. In this case, we see again that when banks are included into the picture, the central bank does not react strongly against inflation because the savers’ welfare has less weight here. We see that, in this case, moving from Basel I, II to Basel III, both with and without the countercyclical buffer component is not beneficial for society. Although borrowers experiment a welfare gain with the measure, banks are worse off because they are more constrained. In aggregate terms, the loss by banks dominates.
Table 5: Optimal Monetary Policy and Basel III\textsuperscript{CB}, Max Total Welfare

<table>
<thead>
<tr>
<th></th>
<th>Basel I, II</th>
<th>Basel III</th>
<th>Basel III\textsuperscript{CB}</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi_{b}^{k*}$</td>
<td>-</td>
<td>-</td>
<td>0.1</td>
</tr>
<tr>
<td>$1 + \phi_{a}^{R*}$</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>$\phi_{y}^{R*}$</td>
<td>6.1</td>
<td>6.6</td>
<td>6.6</td>
</tr>
<tr>
<td>Social Welfare Gain</td>
<td>-</td>
<td>-0.302</td>
<td>-0.311</td>
</tr>
<tr>
<td>Borrowers Welfare Gain</td>
<td>-</td>
<td>0.066</td>
<td>0.069</td>
</tr>
<tr>
<td>Savers Welfare Gain</td>
<td>-</td>
<td>-0.008</td>
<td>-0.009</td>
</tr>
<tr>
<td>Banks Welfare Gain</td>
<td>-</td>
<td>-0.410</td>
<td>-0.418</td>
</tr>
<tr>
<td>$\sigma^{2}_{x}$</td>
<td>105.61</td>
<td>20.55</td>
<td>22.96</td>
</tr>
<tr>
<td>$\sigma^{2}_{y}$</td>
<td>75.92</td>
<td>13.15</td>
<td>14.76</td>
</tr>
<tr>
<td>$\sigma^{2}_{b}$</td>
<td>2046.28</td>
<td>356.13</td>
<td>410.01</td>
</tr>
</tbody>
</table>

Impulse responses in the Appendix help illustrate these results. Figures A1-4 present impulse responses for technology and monetary policy shocks for the optimized values found in Tables 4 and 5. We see that in those situations in which borrowing increases, in the case of Basel III\textsuperscript{CB}, the capital requirement ratio also increases, and the opposite with decreases in borrowing. We also observe that, especially for the case in which we take into consideration the welfare of banks, the effects of shocks is mitigated with Basel III regulation, implying a more stable macroeconomic and financial scenario.

7.3 Pareto-superior Outcomes

We have seen that for the cases analyzed, implementing Basel III\textsuperscript{CB} is not Pareto improving, there are winners and losers. However, if the welfare gain of winning agents 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.\textsuperscript{18} Under this criterion, an outcome is considered 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.

\textsuperscript{18}See Scitovsky (1941).
We see that in Table 4, this is the case. Introducing the Basel III\(^{CB}\) is not beneficial for savers. However, we can find a system of transfers in which the borrowers would compensate the savers with at least the amount they are losing, so that they are at least indifferent between having the CB or not. Then, the new outcome would be desirable for the society and there would be no agent that would lose with the introduction of the new policy. Then, we can re-do Table 4 and, after the compensations are made, the final result is the following:

| Table 6: Optimal MP and Basel III\(^{CB}\), Max Household Welfare (Kaldor-Hicks Improvement) |
|--------------------------------------------------|--------|--------|--------|
| C.B. \(k_b\) | Basel I, II | Basel III | Basel III\(^{CB}\) |
| 1 + \(\phi^R_s\) | 17.6 | 20.7 | 51 |
| \(\phi^R_y\) | 5.8 | 6.6 | 15.5 |
| Households Welfare Gain | - | 0.045 | 0.057 |
| Borrowers Welfare Gain | - | 0.012 | 0.057 |
| Savers Welfare Gain | - | 0.033 | 0 |
| \(\sigma^2_{\pi}\) | 0.16 | 0.16 | 0.15 |
| \(\sigma^2_{\bar{y}}\) | 1.95 | 1.96 | 1.96 |
| \(\sigma^2_b\) | 2.00 | 1.89 | 1.82 |

Nevertheless, for Table 5, there is no room for improvement, the welfare loss by the banks and savers together with the introduction of Basel III is so large that there is no way for borrowers to compensate them.

8 Concluding Remarks

In this paper, we use a DSGE model with housing to assess the welfare effects of the Basel regulation 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 in the sense that they are required to hold a certain amount of capital in order to extend loans.

Within this framework, we study the effects on welfare of increasing the capital requirement ratio in the spirit of the Basel regulation. We find that while borrowers benefit from this measure, because it increases financial stability, savers and banks are worse off.
Then, we analyze the interaction of the Basel I, II, and III regulations with monetary policy. For this purpose, we consider two cases: one in which optimal policies maximize the welfare of households, excluding banks, and a second one in which they maximize total welfare. We find that the optimal monetary policy always becomes more aggressive the higher the capital requirement is, in order to compensate for a lower money multiplier. Moreover, when policy-makers care about households' welfare, monetary policy reacts more strongly against inflation than in the case in which we include total welfare, in order to reduce the sticky-price distortion and benefit savers. In all cases we find that a higher capital requirement increases financial stability.

Finally, we study the countercyclical capital buffer proposed by Basel III. We approximate this regulation by a rule in which the capital requirement responds to credit growth. We find that, if we consider households' welfare, the introduction of this countercyclical capital buffer increases welfare in the economy. Even though savers are worse off, they can be compensated by borrowers à la Kaldor-Hicks, so that it represents a Pareto-superior outcome. However, for banks, this measure is unambiguously welfare worsening.
Appendix

Figure A1: Impulse responses to a technology shock. BI, II versus BIII and BIII$^{CB}$. Optimized parameters. Maximize household welfare.

Figure A2: Impulse responses to a monetary policy shock (decrease in the interest rate). BI, II versus BIII and BIII$^{CB}$. Optimized parameters. Maximize household welfare.
Figure A3: Impulse responses to a technology shock. BI, II versus BIII and BIII$^CB$. Optimized parameters. Maximize total welfare.

Figure A4: Impulse responses to a monetary policy shock (decrease in the interest rate). BI, II versus BIII and BIII$^CB$. Optimized parameters. Maximize total welfare.
References


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