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Effects of Releasing Capital Requirements: A DSGE Approach

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Abstract: This paper simulates a macroprudential policy of reduction in capital requirements, in line with the measures promoted by macroprudential authorities to face the effects of the recent pandemic crisis on real economy. We do that in an otherwise standard DSGE model augmented with a housing sector and a macroprudential regulator. Results show that a regulatory intervention aiming at reducing capital requirements entails a deep and prolonged recession, worsening financial and macroeconomic stability. Overall, it follows that the effects could be opposite to those desired. Two channels lead to this outcome: the financial channel of interest rates on deposits and loans, and the real estate channel of housing prices.

JEL classification: E44, E58, D6
Keywords: Macroprudential Policy; Capital Requirement Ratio; Pandemic Crisis; Welfare Effects

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"Unlike in the 2008 financial crisis, banks are not the source of the problem this time. But we need to ensure that they can be part of the solution"
Andrea Enria, Chair of the ECB Supervisory Board (27 March 2020)

1 Introduction

The new Coronavirus hit the economic system provoking an undefined shock for its impact on public health and global economy. The main economic consequences can be summarized as "stock-market crashes, surging financial volatility, decreases in nominal interest rates, and contractions of real economic activity" (Barro et al., 2020). Over the first phase of the pandemic, when the whole world was in quarantine, many companies faced default (insolvency) risks, fall in foreign and domestic demand, and difficulty of provision of inputs. Restrictions imposed on transport among countries had slowed global economic activities down. The panic spread out among consumers and firms. Resulting needs in liquidity caused a solvency crisis that affected manufacturing system, making, therefore, the recession sharper and longer.

In this difficult and uncertain context, policy makers actions aimed to mitigate the impact of the pandemics on real economy through extraordinary monetary, fiscal and macroprudential policies. In particular, macroprudential policies, introduced in the aftermath of the 2007 global financial crisis to cope with the emergence of possible systemic risks in the financial system, have been implemented to support banks to lend more to the borrowers harmed by the current pandemic. The Basel Committee's Oversight body, the Group of Central Bank Governors and Heads of Supervision (GHOS), adopted prudential actions to contrast the negative effects of the pandemic outbreak on real economy and banking system. In particular, the postponement of the new Basel III Reform (Basel IV Framework) to January 1st, 2023 and the temporary reduction in Basel III capital requirements (Bank for International Settlements, 2020; Levrick et al., 2020) have been put into effect. As well, the European Central Bank (ECB) announced a set of temporary measures to ensure that supervised banks are able to finance real economy in a situation like the very recent financial distress (ECB, April 2020). Importantly, "the ECB reminds banks under its supervision that, in these difficult times, all capital buffers may be used to withstand potential stress, in line with the initial intentions of the international standard setter on the usability of the buffers" (ECB, press release of 12 March 2020). Capital buffers are defined as follows[1]:

- Capital Conservation Buffer (CCoB, henceforth). It is "a capital buffer of up to 2.5% of a bank's total exposures to avoid breaches of minimum capital requirements during periods of stress when losses are incurred".

- Countercyclical Capital Buffer (CCyB, henceforth). It is "a capital buffer intended to ensure that credit institutions accumulate sufficient capital during periods of excessive credit growth to be able to absorb losses during periods of stress and it amounts to 0-2.5% of total risk exposure amount".

- Systemic Risk Buffer (SRB). It is "a capital buffer applied to the financial sector, in order to prevent and mitigate long-term non-cyclical systemic or macroprudential risks".

These buffers were introduced by Basel III regulations, proposed in 2010 by the Basel Committee on Banking Supervision (BCBS), in addition to the minimum total capital of 8% required by Basel II (Basel Committee on Banking Supervision, 2010). The combination between the CCoB and the required minimum total capital of 8% denotes the Capital Requirement Ratio (CRR, hereafter).

In light of the above mentioned macroprudential announcements, analyzing the effects of concessions released by the ECB over the first lockdown period in Europe (March 2020) turns out to be quite important from the policy maker's perspective, since authorities should be aware of the actual consequences of their announcements. This is what we do in this paper. We simulate a transition experiment of permanent reduction in the CCyB associated with a reduction in the CRR in a Dynamic Stochastic General Equilibrium (DSGE) model with housing sector à la Iacoviello (2015) and macroprudential policies (Rubio and Carrasco-Gallego, 2016). The paper addresses two questions: what are the long- and short-run macroeconomic effects of a reduction in capital requirements? how costly is a reduction in capital requirements in terms of welfare? The answer to the first question is that the slackening of macroprudential policies, like the one implemented over the COVID-19 pandemic, may result detrimental to the real economy in the long run since it produces a deep recession.

[1] Capital buffers' definitions are available on the ECB website. For further details: https://www.bankingsupervision.europa.eu/home/glossary/html/glossc.en.html#774; last access September 28, 2021.

Indeed, the increase in savers' consumption is not sufficient to compensate for the reduction in dividends and borrowers' consumption, and the net effect is a decrease in the aggregate demand. On the other hand, in the short run, output expands only for one quarter, thanks to the initial stimulus to the borrowers' consumption that compensate for the drop both in savers' consumption and dividends. The answer to the second question is that reducing capital requirements is welfare improving, at least for borrowers and savers. For banks, instead, the policy is welfare costly. Indeed, their capital decreases, and thus, they have to cope with higher costs, facing lower earnings. In other words, the release in capital buffers pushes down dividends (that is banks' consumption). This, in turn, mainly influences the aggregate demand dynamics. Therefore, reducing capital requirements entails a financial crisis that translates into recession, consistently with the empirically observed procyclicality of the financial system. Specifically, in our model, the spread of the recession on the real economy takes place through both the financial channel of interest rates on deposits and loans, and the real estate channel of the housing prices. In conclusion, our simulations warn us that lower capital buffers could produce real effects opposite to those desired.

Moreover, we investigate the role of monetary policy to eventually mitigate the recessive effects of more relaxed macroprudential policies. Our analysis is akin to those of the strand of literature concerning the interaction between monetary and macroprudential policy, and the cumulative, neutral, or conflicting impacts on price stability. In this regard, some authors seek the optimal combination of the policy parameters that maximizes welfare (Monacelli, 2008; Angelini et al., 2011; Kannan et al., 2012; De Paoli and Paustian, 2013; Rubio and Carrasco-Gallego, 2015, 2016). However, our focus is quite different because we are mainly interested in studying whether alternative monetary policy rules could help the economy to soften the recession generated by the partial use of bank capital buffers. To do that, starting from our reference paper by Rubio and Carrasco-Gallego (2016), who find the optimal implementation of Basel III and its interaction with monetary policy, we design different policy experiments in order to assess the effects of monetary policy and macroprudential policy, and their interdependencies (in line with Sinclair and Sun, 2014; Beau et al., 2012; Christensen and Meh, 2011; and Bailliu et al., 2015). Specifically, we perform a batch of robustness checks taking into account three different monetary policy rules: the first responds to inflation and output gap without interest rate smoothing; the second responds to inflation, output gap, and credit growth (Alpanda and Zubairy, 2017), and the last responds to inflation, output gap, and housing prices growth (Rubio and Carrasco-Gallego, 2015). The last two countercyclical monetary rules include the response to financial variables as a macroprudential tool, constraining the financial accelerator related to borrowers and, therefore, credit. Even employing different monetary policy rules, our results qualitatively hold. This allows us to confirm that releasing capital requirements worsens financial stability, regardless of monetary policy. Indeed, long-run recessionary effects persist but, at the same time, short-run positive effects worsen compared to those of our baseline model, in which the output reaches a higher expansionary peak in the short run.

This paper contributes to the flourishing literature on bank capital regulations interested in analyzing macroprudential policies. Angelini et al. (2014a) and Gozzi et al. (2020) suggest that higher capital requirements can help in achieving a more stable economy. Instead, the only use of monetary policy to enhance financial stability can generate costs in terms of increased inflation variability. Sato (2020) considers the credit-to-GDP ratio as the macroprudential tool to implement countercyclical capital requirements. He finds that the dynamics of the aggregate supply of funds is more softened when banks can use more capital buffers against fluctuations in earnings on loans. On the contrary, Lozej et al. (2018) investigate the performance of several countercyclical capital buffer rules based on credit gap and real house prices. They demonstrate that these rules fail to attenuate the response of the economy to shocks that cause an acyclical credit gap response. Moreover, they show that these macroprudential rules amplify their negative effects when shocks trigger a countercyclical credit gap response. Baron (2020) argues that "higher capital requirements may reduce banks' risk-taking incentives and help banks better withstand adverse shocks". Pariès et al. (2011) show that an immediate implementation of higher capital requirements causes a drop in real GDP, but these negative effects are rapidly reabsorbed in the medium-long run.

The rest of the paper is organized as follows. Section 2 describes the model setup, and section 3 shows the calibration. Results are reported in section 4, in which we explain long- and short-run effects of the reduction in capital requirements. Then, we present the welfare effects. Robustness checks on monetary policy are shown in section 5. Section 6 concludes.

2 Methods and Data

We develop a DSGE model with housing market and macroprudential policy à la Rubio and Carrasco-Gallego (2016). The economy is populated by households, banks, firms, and two authorities, the central bank and the macroprudential regulator.

Households work and consume both consumption goods and housing. They are differentiated in savers and borrowers. The former, who are patient agents, deposit their savings in banks. Instead, borrowers are impatient and borrow from banks. Therefore, banks intermediate funds among households. Specifically, financial intermediaries are credit constrained in borrowing from savers. Instead, impatient agents are credit constrained in borrowing from banks. The representative firm converts household labor into the final good. Central bank follows a Taylor rule in setting interest rate, and macroprudential authority follows a Taylor-type rule in setting capital requirement ratio.

2.1 Savers

The representative patient household chooses consumption $(C_{S,t})$, housing shares ($H_{S,t}$), and working hours ($N_{S,t}$). In particular, savers' utility function is increasing in consumption and housing share, while it is decreasing in working 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. $\frac{1}{\eta-1}$ is the labor supply elasticity, where $\eta > 0$. $j > 0$ is the relative weight of housing in the utility function.

Their budget constraint is:

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

where d_t are bank deposits, $R_{S,t}$ is the gross return from deposits, q_t is the housing price in units of consumption, and $w_{S,t}$ is the real wage rate. X_t is the markup of the firm, Y_t is the output, and $\frac{X_t - 1}{X_t} Y_t$ represents firms' profits, which are paid back to savers. First order conditions to the problem are:

$$\frac{1}{C_{S,t}} = \beta_S E_t \left(\frac{R_{S,t}}{\pi_{t+1} C_{S,t+1}} \right) \qquad (2)$$

$$\frac{q_t}{C_{S,t}} = \frac{j}{H_{S,t}} + \beta_S E_t \left(\frac{q_{t+1}}{C_{S,t+1}} \right) \qquad (3)$$

$$w_{S,t} = (N_{S,t})^{\eta-1} C_{S,t}, \qquad (4)$$

where the first equation is the intertemporal condition for consumption (Euler equation), the second is the intertemporal condition for housing, and the last equation is the labor-supply condition.

2.2 Borrowers

The representative impatient household chooses consumption $(C_{S,t})$, housing shares $(H_{S,t})$, and working hours $(N_{S,t})$. Borrowers' utility function is increasing in consumption and housing share, while it is decreasing in working hours:

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

where $\beta_B \in (0,1)$ is the impatient discount factor.

Their budget constraint is:

$$C_{B,t} + \frac{R_{B,t-1} b_{t-1}}{\pi_t} + q_t (H_{B,t} - H_{B,t-1}) = b_t + w_{B,t} N_{B,t}, \tag{5}$$

and the collateral constraint is:

$$b_t \leq E_t \left(\frac{1}{R_{B,t}} \kappa q_{t+1} H_{B,t} \pi_{t+1} \right), \tag{6}$$

where b_t denotes bank loans, $R_{B,t}$ is the gross interest rate, and κ is the loan-to-value ratio. This borrowing constraint states that borrowing is limited to the present discounted value of their housing holdings. First order conditions are the following:

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

$$\frac{j}{H_{B,t}} = \frac{q_t}{C_{B,t}} - \beta_B E_t \left(\frac{q_{t+1}}{C_{B,t+1}} \right) - \lambda_{B,t} E_t \left(\frac{1}{R_{B,t}} \kappa q_{t+1} \pi_{t+1} \right) \tag{8}$$

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

where $\lambda_{B,t}$ is the multiplier on the borrowing constraint. These equations stay for the Euler equation, the intertemporal condition for housing, and the labor-supply condition, respectively.

2.3 Banks

Banks maximize dividends $(div_{f,t})$, that are fully consumed by bankers, so that $C_{f,t} = div_{f,t}$. In particular, their utility is a convex function of dividends, that can be thought as the residual income of banks after savers have been repaid and loans have been issued (Iacoviello, 2015). Their maximization problem is the following:

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

where $\beta_f \in (0,1)$ is the bankers discount factor.

Their budget constraint is:

$$div_{f,t}+\frac{R_{S,t-1}d_{t-1}}{\pi_t}+b_t=d_t+\frac{R_{B,t-1}b_{t-1}}{\pi_t}, \quad (10)$$

where $d_t+\frac{R_{B,t-1}b_{t-1}}{\pi_t}$ represents deposits by households and repayments from borrowers on previous loans, as sources of funds for the banks. Banks would use these funds for paying back depositors and extending new loans, or for banks' consumption.

Banks are constrained by the amount of assets minus liabilities2: this introduces the Capital Requirement Ratio (CRR), according to the Basel regulation.

The fraction of capital (b_t-d_t) with respect to assets, b_t, has to be larger than a certain ratio. The collateral constraint is defined as:

$$\frac{b_t-d_t}{b_t}\geq CRR, \quad (11)$$

that is

$$d_t\leq(1-CRR)b_t. \quad (12)$$

If we define $\gamma=(1-CRR)$, where $\gamma\leq1$, we can say that banks liabilities cannot exceed a fraction of its assets, which can be used as collateral:

$$d_t\leq\gamma b_t. \quad (13)$$

First order conditions for deposits and loans are, respectively, as follows:

$$\frac{1}{div_{f,t}}=\beta_f E_t\left(\frac{R_{S,t}}{div_{f,t+1}\pi_{t+1}}\right)+\lambda_{f,t} \quad (14)$$

$$\frac{1}{div_{f,t}}=\beta_f E_t\left(\frac{R_{B,t}}{div_{f,t+1}\pi_{t+1}}\right)+\gamma\lambda_{f,t}, \quad (15)$$

where $\lambda_{f,t}$ is the multiplier on the bankers' borrowing constraint.

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,

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

[2] Deposits represent bank liabilities, while loans represent bank assets.

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:

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

The price index is then given by:

$$P_t=\left[\int_0^1 P_t\,(z)^{1-\varepsilon}dz\right]^{\frac{1}{(\varepsilon-1)}}. \tag{18}$$

2.5 Intermediate Goods Producers

The intermediate goods market is monopolistically competitive. These goods are produced according to the production function:

$$Y_t(z)=N_{S,t}(z)^{\alpha}N_{B,t}(z)^{(1-\alpha)}, \tag{19}$$

where $\alpha\in[0,1]$ measures the relative size of each group in terms of labor.

Labor demands are determined by:

$$w_{S,t}=\frac{1}{X_t}\alpha\frac{Y_t}{N_{S,t}} \tag{20}$$

$$w_{B,t}=\frac{1}{X_t}(1-\alpha)\frac{Y_t}{N_{B,t}}, \tag{21}$$

where X_t is the markup, or the inverse of marginal cost. The price-setting problem for the intermediate good producers is a standard Calvo-Yun setting. In each period an intermediate good producer sells its good at price $P_t(z)$ and faces a constant probability, $1-\theta\in[0,1]$, of being able to change the sale price. The optimal reset price $P_t^*(z)$ solves:

$$\sum_{k=0}^{\infty}(\theta\beta)^k E_t\left\{\Lambda_{t,k}\left[\frac{P_t^*(z)}{P_{t+k}}-\frac{\frac{\varepsilon}{(\varepsilon-1)}}{X_{t+k}}\right]Y_{t+k}^*(z)\right\}=0, \tag{22}$$

where $\frac{\varepsilon}{\varepsilon-1}$ is the steady-state markup.

The aggregate price level is given by:

$$P_t=\left[\theta P_{t-1}^{1-\varepsilon}+(1-\theta)\left(P_t^*\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}. \tag{23}$$

2.6 Equilibrium

Market clearing conditions are:

$$Y_t=C_{S,t}+C_{B,t}+C_{f,t}, \tag{24}$$

$$H_{S,t}+H_{B,t}=1, \tag{25}$$

$$D_t=(1-CRR)b_t. \quad (26)$$

The first equation represents equilibrium in the goods market, and the second refers to the total supply of housing, which is fixed and normalized to unity. The last equation represents equilibrium in the financial market. Finally, according to the Walras law, labor market also clears.

2.7 Monetary Policy

The Taylor rule is built to respond to inflation and output growth:

$$R_{S,t}=\left(R_{S,t-1}\right)^{\rho}\left((\pi_t)^{\left(1+\phi_\pi^R\right)}\left(\frac{Y_t}{Y_{t-1}}\right)^{\left(\phi_Y^R\right)}\left(\frac{1}{\beta_S}\right)\right)^{1-\rho}, \quad (27)$$

where $0\leq\rho\leq1$ is the interest rate inertia, and $\phi^R{}_\pi\geq0$ and $\phi^R{}_Y\geq0$ measure the response of the interest rate to current inflation and output growth, respectively.

2.8 Macroprudential Policy

The macroprudential rule shows that the CRR is related to its steady-state value and to deviations of credit from its steady state, according to the Basel III guidelines. It means that CRR increases when credit grows above its steady-state level, as follows:

$$CRR_t=(CRR_{SS})\left(\frac{b_t}{b}\right)^{\phi_b}, \quad (28)$$

where ϕ_b is the CCyB parameter.

3 The experiment

The experiment simulates a permanent partial release of two capital buffers: the Countercyclical Capital Buffer (CCyB) and the Capital Conservation Buffer (CCoB). Specifically, in order to model the decrease in capital requirements, we assume a release of 0.1% of the CCyB associated with a release of 0.5% of CCoB. We remind that CCoB is part of the Capital Requirement Ratio (CRR). Thus, the exercise entails a transition from one steady-state level of CRR equal to 10.5% as in Basel III regulations, to another steady-state CRR level of 10%. To these different values of CRR, we associate different levels of CCyB equal to 2.4% and 2.3%, respectively.

4 Calibration

We use baseline calibration of structural parameters following Rubio and Carrasco-Gallego (2016), consistently with the US data[3]. The discount factor, β, is set to 0.99, 0.98 and 0.965 for savers, borrowers and banks, respectively. The steady-state weight of housing in the utility function, j, is calibrated at 0.1 to match the steady-state housing wealth-to-GDP ratio, which equals 1.40. The parameter η is fixed at 2, in order to calibrate labor supply elasticity value to 1. The loan-to-value ratio parameter, κ, is fixed at 0.9, as in Iacoviello (2015). The labor income share for savers, α, is set to 0.64, and the price elasticity of demand, ε, is calibrated at 21, so that X is equal to 1.05 in steady state, as in Iacoviello (2005).
In order to simulate a partial release of 0.5% of CCoB, we set the initial steady-state value of CRR* equal to 10.5%, consistently with the Basel III regulations, and the second steady-state value of CRR** equal to 10%. To these values of CRR, we associate two different steady-state levels of CCyB equal to 2.4% and 2.3%, respectively. Eventually, γ is defined endogenously and changes according to the CRR steady-state values. The responses of interest rate to current inflation and output growth ($\phi^R{}_\pi$, $\phi^R{}_Y$) change from the first to the second scenario, as described in the Table A.1 in the Appendix. Note that the different values of CCyB and of monetary policy parameters are estimated by Rubio and Carrasco-Gallego (2016) as optimal[4].

5 Results

In order to assess the different impacts of releasing capital requirements, we analyze the long- and short-run macroeconomic effects on real economy and, then, we perform a welfare analysis. We numerically solve the nonlinear model in DYNARE[5] using perfect foresight. All transition dynamics are expressed as percentage deviations from the initial steady-state level.

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3 Table A.1 summarizing parameter values and their description is presented in the Appendix.

4 These parameters are those minimizing second-order losses for households when monetary and macroprudential policies act together. The authors 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.

5 Dynare is a software platform for handling a wide class of economic models, in particular Dynamic Stochastic General Equilibrium (DSGE) models. For more details, see https://www.dynare.org/; last access September 28, 2021.

5.1 Long-run Effects

Table 1 reports steady-state percentage variations in the key macroeconomic variables. By releasing bank collateral constraint, the reduction in capital requirements allows banks to lend more, stimulating loans. This, in turn, causes that borrowers benefit of larger liquidity that is used to invest in housing rather than to consume more. In other words, they reallocate their resources from consumption to housing, enjoying a larger collateral to borrow. On the other hand, savers expect that the interest rate on deposits returns to the previous steady-state level in the long run. Thus, they decide to deposit more. In addition, they invest less in housing given the higher price, in order to have more liquidity to spend on future consumption.

Savers and borrowers' behavior impacts on bank consumption. Indeed, the long-run positive variation in deposits, which is larger than the long-run positive variation in loans, causes a reduction in bank capital. Moreover, the reduction in capital requirements also influences the behavior of nominal interest rate on both deposits and loans: while the former returns to the previous steady-state level, the latter decreases entailing lower revenues for banks in the long run. Eventually, dividends reduce.

Overall, the increase in savers' consumption is not sufficient to compensate the reduction in dividends and borrowers' consumption. The net effect is a decrease in aggregate demand, pushing down output.

Table 1. Steady-state Percentage Variations

Variable	Value	Variable	Value	Variable	Value
ΔY^{**}	-0.0151	ΔR_S^{**}	0	ΔR_B^{**}	-0.0129
ΔC_S^{**}	0.0255	ΔC_B^{**}	-0.0033	Δdiv^{**}	-3.9307
ΔH_S^{**}	-0.2150	ΔH_B^{**}	0.6172	Δq^{**}	0.2410
Δd^{**}	1.4363	Δb^{**}	0.8728	ΔCRR^{**}	-4.7619
ΔN_S^{**}	-0.0203	ΔN_B^{**}	-0.0059		

5.2 Short-run Effects of Capital Requirements Reduction

The next step in our analysis is a discussion of short-run effects of capital requirements reduction. Figure 1 shows the transition dynamics of both real and financial variables from the old to the new steady state.

Reducing capital requirements immediately impacts on loans that increase because banks can lend more. On the other hand, the lower interest rate also stimulates loans demand by borrowers.

As a result, they are incentivized to consume more and demand more housing to increase their collateral (Figure 2). Patient and forward-looking households increase their savings because of a higher interest rate on deposits. However, they expect that, in the future, their savings will be less profitable; therefore, they postpone their consumption when the interest rate on deposits will come back to the previous steady-state level. In this scenario, also banks are harmed. Indeed, consistently with the long-run results, since loans arise less than deposits, bank capital reduces. Thus, banks tighten their borrowing constraint. Moreover, interest rate on deposits increases, and interest rate on loans reduces. In other words, banks have to cope with higher costs, facing lower earnings. This, in turn, entails a reduction in dividends, which represent banks' consumption.

Figure 1. Short-run Transition Dynamics for Real and Financial Variables

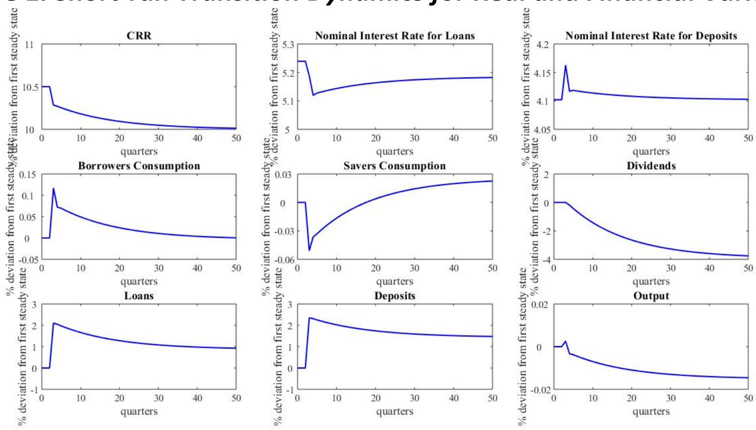
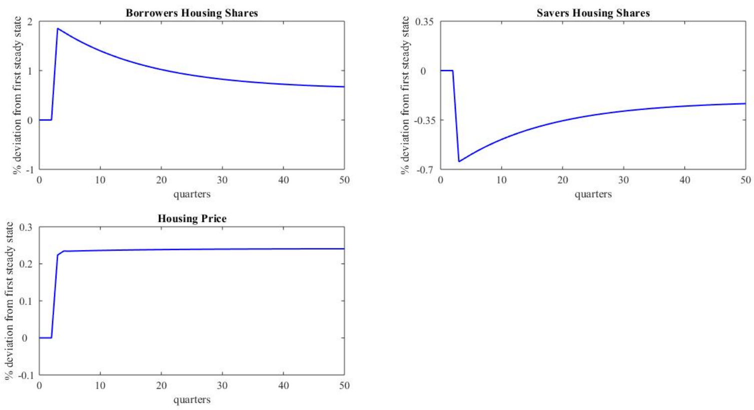


Figure 2. Short-run Transition Dynamics for Real Estate Variables



Overall, the capital requirements reduction entails an output expansion for only one quarter, caused by an increase in borrowers' consumption that compensates for the drop in both savers' consumption and dividends. From the next quarter, output starts decreasing due to the fall of borrowers' consumption, to reach the long-run steady-state level.

Figure 2 focuses on real estate market dynamics. As well as the long run, borrowers enjoy the benefit of having more liquidity to demand more housing, in order to provide a larger collateral to the banks. The higher investment in housing shares by borrowers prevails with respect to the lower housing share investment by savers, and this causes an increase in housing prices.

5.3 Welfare Effects of Reducing Capital Requirements

We now perform a welfare analysis to assess how costly the slackening of capital buffers is in terms of welfare.

The intertemporal welfare function in recursive form is:

$$V_t^i = \log C_{i,t} + j\log H_{i,t} - \left(\frac{(N_{i,t})^{\eta}}{\eta}\right) + \beta E_t V_{t+1}^i; \tag{29}$$

we define

$$V_{old}^i = \left(\frac{1}{1-\beta}\right)\left[\log C_{i,old}(1-\lambda^i) + j\log H_{i,old} - \left(\frac{(N_{i,old})^{\eta}}{\eta}\right)\right]; \tag{30}$$

$$i = s,b,f,$$

as the steady-state value of V_t^i when the macroprudential authority does not implement the reduction in capital requirements, and V_0 as the steady-state value of V_t^i when the release of capital requirements is implemented. Since utility function is not cardinal, we need to find a measure that can represent welfare costs (or gains) of the CRR reduction. To do that, we calculate the welfare-based ratio by using Consumption Equivalent Measure (CEM, henceforth) as in Ascari and Ropele (2012), who investigate welfare effects of disinflationary policies.

CEM is defined as the constant fraction of consumption that households should give away in order to permanently reduce the CRR:

$$\left(\frac{1}{1-\beta}\right)\left[\log C_{i,old}(1-\lambda^i) + j\log H_{i,old} - \left(\frac{(N_{i,old})^{\eta}}{\eta}\right)\right] = V_0^i, \tag{31}$$

$$\lambda^i = 1 - \exp\left[(1-\beta^i)(V_0^i - V_{old}^i)\right]. \tag{32}$$

Then, we compute the Welfare-based Ratio (WR^i, henceforth) as the ratio between CEM and the difference between old and new CRR values:

$$WR^i = \left(\frac{\lambda^i}{CRR_{old}^* - CRR_{new}^*}\right). \tag{33}$$

Releasing CRR is welfare improving when the welfare-based ratio is negative, and we read negative values as welfare gains.

Table 2 reports percentage values of WRs for savers, borrowers, and banks. Results show that the reduction in capital requirements has a different impact on economic agents. It turns out to be welfare improving for savers and borrowers, but not for banks. This is consistent with the steady-state variations analyzed in the Section 4.1.

Table 2. Welfare-Based Sacrifice Ratios*

	WR^i
Savers	-0.0049
Borrowers	-0.2700
Banks	3.6243

**Values are in percentage terms*

Impatient agents benefit from lower capital buffers because they can borrow more and invest more in housing shares. The positive variation in housing demand in the long run prevails with respect to the negative variation in borrowers' consumption, in terms of utility. Moreover, they work less, so the labor disutility decreases. This, in turn, causes that the reduction in CCyB associated with a reduction in CRR is welfare improving for borrowers. On the other hand, patient agents consume more and work less in the long run. Thus, savers' utility increases even though they invest less in housing shares. Banks welfare strongly worsens because of large negative variation in dividends in the long run.

6 Robustness

In order to investigate whether a different monetary policy can mitigate the negative effects generated by a release in capital requirements, we perform the transition experiment of permanent reduction in the CCyB associated with a reduction in the CRR under alternative policy regimes and, then, we compare results with those described in Section 4 (baseline model, henceforth). Therefore, being equal the macroprudential policy, we study how the model economy reacts according to three monetary policy rules:

1. When central bank responds to inflation and output gap without interest rate smoothing (Policy experiment I).
2. When central bank responds to inflation, output gap, and credit growth (Policy experiment II).
3. When central bank responds to inflation, output gap, and house prices (Policy experiment III).

Analyzing welfare implications, baseline case results are confirmed under each policy experiment[6]. This means that, even with a different monetary policy, lower capital requirements are still welfare improving for borrowers and savers, and welfare costly for banks. This is consistent with the long-run behavior of variables, that holds both qualitatively and quantitatively compared to the baseline model. In the following subsections, we show short-term effects on the main economic variables implementing the aforementioned three different policy experiments.

6.1 Policy Experiment I: Central Bank Responds to Inflation and Output Gap

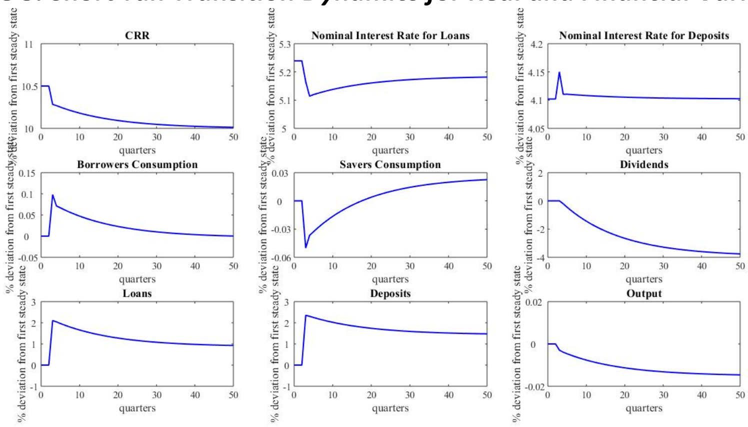
The first regime of monetary policy follows a simple Taylor rule in which the central bank adjusts nominal interest rate in response to changes in fundamentals. With respect to the baseline model, this rule assumes the absence of the interest rate smoothing:

$$\frac{R_{S,t}}{R_S} = \left(\frac{\pi_t}{\pi}\right)^{\phi_\pi^R} \left(\frac{Y_t}{Y}\right)^{\phi_Y^R} . \tag{34}$$

Simulating the model, we find out that qualitative results of baseline analysis are confirmed in this policy experiment for most of the variables, but not for output. Differently from the baseline case in which output expands for only one quarter, in this regime, output starts falling immediately: this short-run dynamics is mainly driven by a smaller positive variation in borrowers' consumption that does not compensate for savers' consumption reduction (Figure 3). Hence, the absence of interest rate inertia implicates a lower level of consumption.

6 In the sensitivity analyses, we kept all the parameters the same as in our baseline experiment. In addition, we performed a robustness check for each of the three monetary policy regimes also considering a standard calibration for the Taylor rule. Thus, we fixed the response of interest rate to current inflation and output growth equal to 1.5 and 0.5, respectively, and we set interest rate inertia parameter equal to zero. Results are qualitatively the same as those displayed further: however, with a less aggressive monetary policy, the amplitude of short- and long-run effects of the reduction in capital requirements is larger. Also welfare analysis results qualitatively hold.

Figure 3. Short-run Transition Dynamics for Real and Financial Variables



In other words, it would be preferable, for the private sector, a monetary policy rule that pursues interest rate smoothing objective and that depends not only upon current conditions, but also upon past conditions. Indeed, in this case, agents will form rational expectations knowing that the subsequent policy will be affected by past shocks (Woodford, 2003). In the end, central bank should consider a history dependent monetary policy rule as in the baseline model because it helps the economy to reach a higher level of consumption in the short run, stimulating the aggregate demand.

6.2 Policy Experiment II: Central Bank Responds to Inflation, Output Gap and Credit Growth

Following Alpanda and Zubairy (2017), we consider an alternative policy rule that adjusts the policy rate in response to a measure of financial vulnerability in addition to the standard variables. Specifically, we consider an interest rate rule that responds also to credit growth as follows:

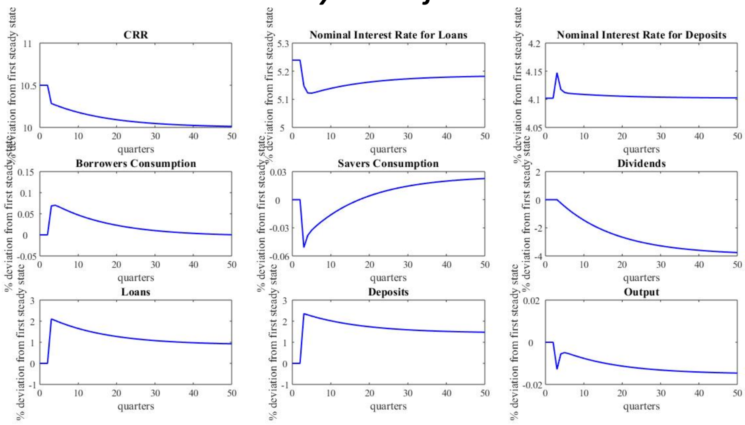
$$R_{S,t}=\left(R_{S,t-1}\right)^{\rho}\left(\pi_t^{\left(1+\phi_\pi^R\right)}\left(\frac{Y_t}{Y}\right)^{\phi_\pi^R}\left(\frac{b_t}{b_{t-1}}\right)^{\phi_b^R}\left(\frac{1}{\beta_S}\right)\right)^{1-\rho}, \qquad (35)$$

where the long-term response coefficient ϕ_b^R is positive for borrowers[7].

As shown in Figure 4 and as for Policy experiment I, also for this policy regime results qualitatively hold in the short run for all variables except for output. When the regulator and the monetary authority both act to restrain the increase in loans, policy interest rate responds less than when each is operating on its own (Christensen and Meh, 2011).

7 The coefficient ϕ_b^R is set to 0.1 as in Alpanda and Zubairy (2017). It is positive for borrowers since their consumption and housing shares are more correlated with loans.

Figure 4. Short-run Transition Dynamics for Real and Financial Variables



In other words, adding credit growth response in the Taylor Rule reduces the volatility of interest rate, even though the policy rule is more aggressive. The reduction in capital requirements immediately impacts on loans that increase slightly more, even if the nominal interest rate decreases less than in our baseline model. Surprisingly, deposits slightly arise as well, despite of their lower interest rate. This happens because savers, who are forward-looking agents, expect the stronger reaction from the central bank. Therefore, they make decisions according to these expectations. As a consequence, savers' consumption decreases. This drop, together with the one in dividends, prevails over the increase in borrowers' consumption in the short run. This, in turn, reduces immediately the output. In other words, along with Kannan et al. (2012), the intimidation of a very severe intervention by monetary authority could be more incisive than its actual implementation. As a result, in the presence of a macroprudential rule, central bank does not have to be aggressive in adjusting the interest rate in response to credit. In fact, consistently with Christensen and Meh (2011), a "lower output and inflation volatility could be obtained by leaving the bulk of the response to credit to the regulatory authority". In other words, we can conclude that adding credit growth to the monetary policy rule entails a lack of improvement in stability. It follows that a Taylor rule that responds only to output gap and inflation - like the one implemented in the baseline case - is sufficient to enhance macroeconomic and financial stability[8].

[8] Kannan et al. (2012), quite the opposite, conclude that "the improvement in stability from adding nominal credit to the monetary policy rule and employing the macroprudential instrument could simply indicate that, under the baseline Taylor rule, the reaction to the output gap and inflation is insufficient".

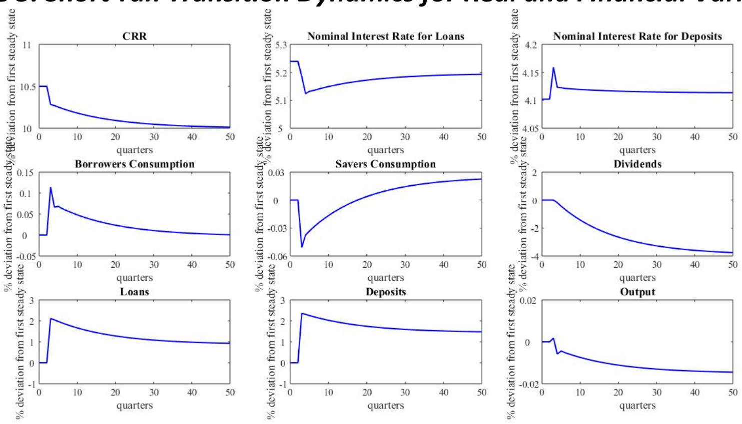
6.3 Policy Experiment III: Central bank Responds to Inflation, Output Gap and House Prices

Following Rubio and Carrasco-Gallego (2015), we consider a generalized Taylor rule that responds to inflation, output, and house prices. Central bank implements a macroprudential policy in which interest rate increases whenever house prices raise. In this way, the authority restricts credit booms in the economy [9]. In other words, considering the case of an extended Taylor rule for monetary policy that responds to house prices as well, we will include also financial stability among the objectives of central bank:

$$R_{S,t}=\left(R_{S,t-1}\right)^{\rho}\left(\pi_t^{\left(1+\phi_\pi^R\right)}\left(\frac{Y_t}{Y}\right)^{\phi_\pi^R}\left(\frac{q_t}{q}\right)^{\phi_q^R}\left(\frac{1}{\beta_S}\right)\right)^{1-\rho}. \quad (36)$$

Figure 5 shows that results qualitatively hold for all variables, but the amplitude of short-run adjustments is smaller with respect to the baseline policy rule.

Figure 5. Short-run Transition Dynamics for Real and FInancial Variables



This, implies that, in the short term, the expansionary spike of output caused by the reduction in capital requirements is slightly mitigated. In other words, although long-term effects hold both qualitatively and quantitatively, we find that short-term dynamics do not improve compared to those of our main results. Considering that and according to Rubio and Carrasco-Gallego (2015), we assert that it is preferable to leave the goal of financial system stabilization to the macroprudential authority. Therefore, a monetary policy should respond only to inflation and output instead of being countercyclical vis-a-vis house prices. Furthermore, as for the Policy

[9] House prices can be considered as an indicator of excessive credit growth.

experiment II, also in this case, considering a monetary policy that is macroprudential itself could be redundant if there is already a macroprudential regulator.

7 Conclusions

The aim of our paper is to examine real and welfare effects of a reduction in capital requirements, through a permanent reduction in the Countercyclical Capital Buffer associated with a reduction in Capital Requirement Ratio. Our results show that a release in capital buffers reduces banks' profits, triggering a deep and prolonged recession. In a context of a crisis in which real economy has already been contracted by a negative shock, these effects could be amplified and the recession could become deeper. In other words, the partial release in capital requirements - like the one announced by macroprudential authorities to contrast the pandemic outbreak - worsens financial stability, and it does not stimulate aggregate demand in terms of consumption. As a result, this macroprudential measure could generate consequences opposite to those desired.

As shown in the robustness section, recessionary effects generated by the slackening of macroprudential policies occur also with alternative monetary policy rules. This is confirmed even with an augmented Taylor Rule, which represents a proxy for the macroprudential instrument, taking into account financial variables variations.

Since monetary policy is not able to mitigate recessionary effects generated by a reduction in capital requirements, it would be interesting to investigate on the outcomes of an active fiscal policy that uses automatic stabilizers. Instead, from the banking regulation point of view, it would be interesting to verify if this mechanism of CRR reduction could work with an additional constraint, i.e., on deposits. Moreover, it would be useful to analyze the effects of softening of borrowers' collateral constraint by increasing the loan-to-value ratio. We leave these extensions for future research.

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Appendix

Table A.1. Parameter Values

Parameter	Value	Description
βs	0.99	Discount factor for savers
βb	0.98	Discount factor for borrowers
βf	0.965	Discount factors for banks
j	0.10	Weight of housing
η	2	Parameter associated with labor elasticity
κ	0.9	Loan-to-value ratio
α	0.64	Labor income share for savers
ε	21	Price elasticity of demand
ρ	0.8	Coefficient for interest rate smoothing
CRR*	10.5%	CRR (old target)
CRR**	10%	CRR (new target)
ϕ_b^*	2.4%	CCyB (old target)
ϕ_b^{**}	2.3%	CCyB (new target)
γ*	0.895	(1-CRR*)
γ**	0.9	(1-CRR**)
ϕ_π^{R*}	48	Inflation stabilization (old target)
ϕ_π^{R**}	7.4	Inflation stabilization (new target)
ϕ_Y^{R*}	44	Output stabilization (old target)
ϕ_Y^{R**}	7.8	Output stabilization (new target)