Countercyclical Capital and Reserve Requirements in a Small Open Economy

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Abstract

This paper analyses the interaction between macroprudential instruments in a small open economy through a dynamic stochastic general equilibrium (DSGE) that incorporates both financial and nominal frictions. Our model features a rich, yet parsimonious banking sector that allows us to study the distinct channels through which different policy instruments operate, particularly focusing on interest rate spreads and the composition of bank balance sheets. By considering various objectives for the monetary authority, we explore optimal policy rules involving countercyclical capital and reserve requirements. Our results suggest that adjusting reserve and capital requirements in response to economic conditions yields significant benefits, especially when financial stability is included as an objective of the central bank. In contrast to capital requirements, an increase in reserve requirements leads to higher inflation and has an ambiguous effect on output. Finally, under a financial stability objective with a clear separation of tasks, reserve requirements respond slightly more effectively to exogenous economic shocks than capital requirements.

Keywords: Macroprudential Policy, Capital Requirements, Reserve Requirements
JEL Codes: E30, E32, G18, F41

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1 Introduction

The onset of the Global Financial Crisis (GFC) highlighted the importance of macroprudential policies in safeguarding financial stability by targeting specific sources of financial imbalances, overcoming a traditional monetary policy limitation. Despite their relevance, there is still no consensus on the appropriate mix of macroprudential policy instruments, especially regarding their simultaneous roles in macroeconomic and financial stabilization. On top of that, knowledge on the effectiveness of macroprudential policies still lags behind that of monetary policy, which constrains our insights into the interaction of these instruments (Claessens and Valencia, 2013).

This paper studies the interaction and effectiveness of two macroprudential policy tools used extensively across central banks and financial regulators: reserve requirements and countercyclical capital requirements. Particularly, reserve requirements have long been used to stabilize the cycle, though in recent years they have been employed primarily by emerging economies (Cordella et al., 2014). In contrast, the application of countercyclical capital requirements is more recent and more common in advanced economies (see Figure 1).

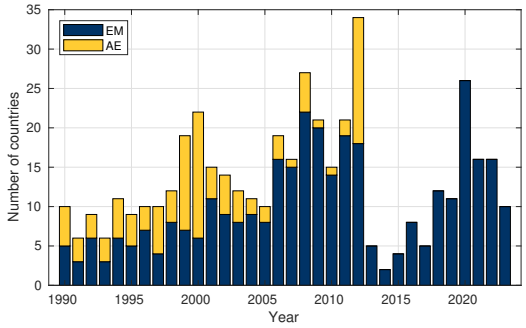
The fact that in many economies both instruments either respond to the cycle or have a cyclical stabilization objective, opens the door to interesting research questions: do countercyclical capital and reserve requirements complement each other? How do they interact with traditional monetary policy instruments? To answer them, we abstract from other objectives related to these policies and treat them as only oriented to stabilize macroeconomic and financial aggregates. We evaluate their effectiveness using a dynamic stochastic general equilibrium (DSGE) model for a small open economy with nominal rigidities, financial frictions, a banking sector, and a central bank. We calibrate the model and estimate optimal policy rules under different configurations of anchor variables and central bank objectives.

This study contributes to our understanding of a dual macroprudential policy mix in a small open economy general equilibrium setting. Our modeling of the banking sector is particularly convenient since it includes a rich yet parsimonious structure that allows us to analyze the channels through which policy instruments operate, particularly through interest rate spreads and balance sheet composition. Moreover, it also provides insights on the design of optimal monetary policy rules by including macroprudential policies as stabilization tools, focusing on how these instruments complement or substitute each other depending on the central bank's objectives.

Our findings suggest that under a price stability objective, the gains from allowing for adapting reserve and capital requirements to economic conditions are substantial when the economy faces nominal and financial frictions. When financial stability is included as a central bank objective, macroprudential policies become more relevant and can help mitigate output volatility in addition to credit fluctuations.

Moreover, we identify key differences between the effects of reserve requirements and capital requirements on other variables. Surprisingly, an increase in reserve requirements is associated with higher inflation, while tighter capital requirements lead to a drop in inflation. This result may be explained by the different channels through which reserve and capital requirements operate. An increase in reserve requirements influences banks' deposits, reducing deposit rates and incentivize consumption. In contrast, an increase in capital requirements impacts negatively banks' lending

(a) Reserve Requirements tightening and/or loosening (number of countries)



(b) Countercyclical Capital Requirements tightening and/or loosening (number of countries)

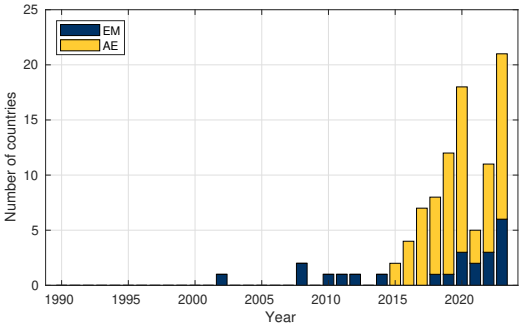


Figure 1: Usage of macroprudential instruments

Note: The classification of countries is based on IMF's World Economic Outlook 2018. Panel (a) considers reserve requirements (domestic or foreign currency) for macroprudential purposes (it might include those for monetary policy, as distinguishing those for macroprudential or monetary policy purposes is often not clear-cut). Panel (b) considers a requirement for banks to maintain a countercyclical capital buffer. Implementations at 0% are not considered as a tightening. ***Source:*** IMF's iMaPP database 2024.

and investment. The overall impact on output is similar in magnitude, but more ambiguous in the case of reserve requirements, as it depends on the degree of price stickiness in the economy.

In terms of achieving the central bank's objectives, both instruments seem to perform similarly, and the benefits of complementing each other are not significant. However, in the scenario of a financial stability objective and strict separation of tasks, reserve requirements provide a slightly better response to the exogenous shocks in the economy than capital requirements.

Related Literature. Our work relates mainly to three strands of the literature. First, we contribute to the literature about countercyclical bank capital requirements. These requirements can prove useful when facing certain financial frictions, as for example the moral hazard problem between bankers and depositors, developed by Gertler and Karadi (2011). Standard capital requirements introduce important feedback loops between the real and financial sides of the economy (Gerali et al., 2010). On the one hand, during expansions, bank earnings tend to rise and so does capital accumulation, leading to an increase in loans (and a more dramatic expansion). As macroeconomic conditions deteriorate, banks' profits and hence capital might be negatively impacted —depending on the nature of the shock that hits the economy, banks might respond by reducing the outstanding loans to the private sector, thus exacerbating the original contraction. In a recent study, Lozej et al. (2018) evaluate different countercyclical capital buffer rules in a small open economy where monetary policy is completely shut off. Ferreira et al. (2015) focus on the anchor variable for the capital buffer using a DSGE model estimated for Brazil. They find that credit growth is the variable that performs best. Paries et al. (2022) find that, in the short run, GDP declines due to higher bank capital requirements. However, when monetary policy reacts strongly to inflation deviations from the target, the impact of higher capital requirements is significantly reduced.

Second, our work speaks to the theoretical effects of reserve requirements from a macroprudential perspective[1]. Studies such as Glocker and Towbin (2012) considered required reserves as an

[1]See for example Prada-Sarmiento (2008), Bianchi (2011), Kashyap and Stein (2012), Mimir et al. (2013), Alper et al. (2014), and Guzman and Roldos (2014).

additional policy instrument and variations in loans as an additional target into an open-economy model with nominal rigidities and financial frictions. Their results imply that reserve requirements favor the price stability objective only if financial frictions are nontrivial and are more effective if there is a financial stability objective and debt is denominated in foreign currency. Areosa et al. (2013) find a similar result by augmenting the model of Gertler and Karadi (2011) to include a compulsory reserve requirement ratio. They estimate a new-Keynesian DSGE model for the Brazilian economy, with financial intermediaries facing endogenous balance sheet constraints. The authors conclude that the effect of a monetary policy shock on the interest rate is much stronger than the one on the reserve requirement, despite both shocks yielding similar dynamics in the macroeconomic aggregates. Bustamante and Hamann (2015) also resorted to a DSGE model to shed light on the effectiveness of reserve requirements in mitigating business cycle fluctuations. Using a framework with risk-averse financial intermediaries and heterogeneous agents facing uninsurable idiosyncratic risks, they find that reserve requirements help reduce consumption volatility only if banks are sufficiently risk-averse.

Most of the papers that incorporate macroprudential policies in general equilibrium models focus on the interaction between these tools and traditional monetary policy (e.g., Angelini et al., 2011; Agénor et al., 2013; Kannan et al., 2012; Quint and Rabanal, 2013; Suh, 2012; Cecchetti and Kohler, 2012; Carvalho and Castro, 2017; Van der Ghote, 2021; Carrillo et al., 2021; Bianchi and Coulibaly, 2022). Nevertheless, there have been recent efforts to study the interaction between different macroprudential tools, as in Frache et al. (2017). The authors assess the effectiveness of two macroprudential tools: countercyclical capital buffers and dynamic provisions[2], using a DSGE model estimated with data for Uruguay. Carvalho et al. (2014), on the other hand, try to understand the transmission mechanism of capital and reserve requirements under traditional and matter-of-fact financial frictions in Brazil, and find that both instruments have important quantitative effects. However, they do not evaluate countercyclical capital requirements[3] and consider only a closed economy, ignoring external financial and trade shocks that are important drivers in the business cycle of emerging economies.

The rest of this paper is organized as follows. Section 2 describes the model and calibration. Section 3 provides a first glance at how discretionary changes to macroprudential instruments affect the banking sector and the economy. Section 4 discusses the main results and provides an application, while Section 5 concludes.

2 The Model

The model is largely based on the work by Glocker and Towbin (2012), who incorporate reserve requirements to a relatively standard small open economy model with investment, sticky prices, and a financial accelerator mechanism. In order to accurately capture the dynamics of the banking sector, we introduce banking capital and balance sheet constraints into the model following Gerali

[2]The underlying principle behind dynamic provisioning is that loan loss provisions should be set in line with estimates of long-run, or through-the-cycle expected losses, breaking pro-cyclicality and creating countercyclical provision buffers (Mahapatra (2012)).

[3]They only consider Basel I and Basel II-type of requirements, which are not sensitive to the business-cycle. In particular, bank minimum capital requirements are modeled as an AR(1) process with a very high persistence.

et al. (2010). As it will be discussed later, this provides an additional financial friction, and further scope for macroprudential policy. The model is solved by log-linearization around the steady-state[4].

Household savings have to be intermediated through banks in order to reach firms. Banks make loans to entrepreneurs to finance their capital stock. They are subject to reserve and capital requirements set by the government[5]. Households consume a bundle of home and foreign goods and have access to an internationally traded bond to invest in.

2.1 The Banking Sector

Banks attract funding from households and lend to entrepreneurs. For ease of exposition, we analyze the tasks of lending and funding separately and consider lending units and deposit units. This separation is convenient especially to evaluate the effectiveness of our two macroprudential tools: deposit units will be subject to reserve requirements, while lending units will face capital requirements. Households' savings are remunerated at the deposit rate, while deposit units lend to lending units at the (risk-free) interbank rate. Lending units make risky loans to entrepreneurs[6].

2.1.1 Deposit Units

Deposit units collect deposits from households and lend a fraction to lending units on the interbank market and keep the rest as reserves with the central bank. They operate in perfectly competitive input and output markets, and their profits accrue to the banking sector's accumulation of bank capital.

The representative deposit unit collects deposits D_t from households and pays a gross deposit interest rate i_t^D. Next, the bank has two possibilities to use the deposits. It allocates a fraction $1-\varsigma_t$ of deposits to lending in the interbank market and earns a gross return equal to $i_t^I B$. The remaining fraction of funds are defined as reserves, $Res_t = \varsigma_t D_t$, and they are placed into an account at the central bank, which is remunerated at the reserve rate i_t^R. The bank optimally chooses the composition of its assets, taking into account the minimum reserve requirement ratio ς^{MP} imposed by the monetary authority. The balance sheet of the deposit unit reads

$$Res_t + D_t^{IB} = D_t, \tag{1}$$

where $D_t^{IB} = (1-\varsigma)D_t$ is interbank lending. Deposit units face convex costs in holding reserves G_t^{ς}:

$$G_t^{\varsigma} = \psi_1(\varsigma_t - \varsigma_t^{MP}) + \frac{\psi_2}{2}(\varsigma_t - \varsigma_t^{MP})^2, \tag{2}$$

where ψ_1 and ψ_2 are cost function parameters. The first linear term determines steady-state deviations from the required reserve ratio. Holding excess reserves may generate some benefits, for example, because it reduces the costs of liquidity management. In addition, the central bank

[4]The log-linearized equations of the model can be found in the Appendix 1.

[5]We assume that there are no other means of external finance. Possibilities to circumvent banks would obviously weaken the effects of reserve and capital requirements.

[6]Note that an alternative would be to consider banking units that both collect savings and lend to firms. The opportunity cost of attracting an additional unit of deposit would then correspond to the interbank rate.

may impose a fee for not fulfilling the reserve requirement. Both motivations imply that $\psi_1 < 0$. On the other hand, the quadratic term with $\psi_2 > 0$ guides the dynamics around the steady state. Glocker and Towbin (2012) discuss several motivations for such convex costs. First, the benefits from holding excess reserves may decline because of decreasing returns to scale. Second, the central bank may punish large negative deviations from its target with a larger penalty rate and phase out the remuneration of excess reserves at the same time.

The problem that the deposit unit faces is to maximize its profits, taking i_t^{IB}, i_t^D, and i_t^R as given, and subject to equation (2):

$$\max_{\{\varsigma_t, D_t\}} \Pi_t^S = \left[(1-\varsigma_t)i_t^{IB} + \varsigma i_t^R - i_t^D - G_t^{\varsigma}\right] D_t. \tag{3}$$

The first-order conditions of the optimization problem are:

$$-(i_t^{IB} - i_t^R) - \psi_1 = \psi_2(\varsigma_t - \varsigma_t^{MP}) \tag{4}$$

$$i_t^D = (1-\varsigma_t)i_t^{IB} + \varsigma_t i_t^R - G_t^{\varsigma}. \tag{5}$$

The bank's actual reserve ratio, ς_t, is determined by equation (4). It is decreasing in the spread between the interbank rate and the reserve rate and increasing in the required reserve ratio ς_t^{MP}. On the other hand, equation (5) shows that the deposit rate is a weighted average of the rates received from lending and reserve holdings, net of operating costs. Deposit units face opportunity costs by investing part of their assets in reserves, which is captured by the interest rate differential $i_t^{IB} - i_t^R \geq 0$. Therefore, it is possible to think of reserve requirements as a tax on the banking system. An increase in the monetary authority's target value of reserve requirements increases the opportunity costs. As a consequence, the spread between deposit and interbank rates rises[7].

2.1.2 Lending Units

Lending units do not interact with households. They finance themselves through the interbank market and with banking capital. They do not hold any deposits from households. Given this, they are not subject to reserve requirements, but to capital requirements.

Lending units operate in perfectly competitive input and output markets. They supply loans to entrepreneurs at the lending rate (i_t^L). The interaction between lending units and entrepreneurs are modeled through the financial contract as in Bernanke et al. (1998).

A key feature of our model is that lending units obey the following balance sheet identity:

$$L_t = D_t^{IB} + K_t^b, \tag{6}$$

stating that each lending unit can finance loans L_t using either fund from deposit units D_t^{IB} –at the cost of the interbank rate– or bank capital K_t^b. As in Gerali et al (2010), the two sources of funding are perfect substitutes from the point of view of the balance sheet. Lending units face costs related to the capital position of the bank. In particular, lending units pay a quadratic cost

[7] In order to solve the model, we will make some assumptions about how the central bank conducts monetary policy, which will lead to the reserve supply to adjust endogenously.

whenever the capital-to-assets ratio K_t^b/L_t moves away from a target value v^b, set by the financial regulator:

$$\Upsilon_t = \frac{\kappa}{2}\left(\frac{K_t^b}{L_t} - v^b\right)^2 K_t^b, \tag{7}$$

with $\kappa > 0$. Bank capital is accumulated each period out of retained earnings according to

$$K_t^b = (1-\delta^b)K_{t-1}^b + \Pi_{t-1}, \tag{8}$$

where $\Pi_t = \Pi_t^L + \Pi_t^D$ are the profits generated by the baking sector by adding profits from the lending units and the deposit units, respectively. δ^b measures resources spent in managing bank capital. This equation assumes that all profits are retained in the banking sector, so any potential dividends that could be accrued to the households (or other agents in the model) are zero. Given this law of motion, bank capital is not a choice variable for the bank.

On the lending unit's side, there are two financial frictions present: the financial accelerator, and the capital costs and dynamics. Therefore, it is helpful to separate the maximization process of the bank in two steps, to capture the different interest rate spreads that arise from the frictions. First, assume that there is no financial accelerator mechanism, so the problem for the lending unit is just to choose loans and funds from deposit units so as to maximize profits:

$$\max_{\{L_t, D_t^{IB}\}} \Pi_t^L = i_t^F L_t - i_t^{IB} D_t^{IB} - \frac{\kappa}{2}\left(\frac{K_t^b}{L_t} - v^b\right)^2 K_t^b, \tag{9}$$

subject to the balance sheet in equation (6), where i_t^F denote the lending rate in the absence of the financial accelerator, i.e. the risk-free lending rate. The first-order conditions deliver a condition linking the spread between friction-less rates on loans and on deposits to the degree of leverage, i.e.

$$i_t^F = i_t^{IB} - \kappa\left(\frac{K_t^b}{L_t} - v^b\right)\left(\frac{K_t^b}{L_t}\right)^2. \tag{10}$$

Equation (10) shows that the spread is inversely related to the overall capital-to-assets ratio of banks: in particular, when banks are scarcely capitalized and leverage increases, margins become wider. On the one hand, the higher the leverage, the wider (i.e. more positive) the spread between the risk-free loan rate and the interbank rate, the more the bank wants to lend, increasing profits per unit of capital (or return on equity). On the other hand, as leverage increases further, the deviation from v^b becomes more costly, reducing bank profits.

2.1.3 Equilibrium in the Financial Sector

Since all deposit units face the same interbank and reserve interest rates, as well as the same reserve requirement ratio, all of them will set the same deposit rate i_t^D and reserve rate ς_t. The same applies to the lending units. Based on these equilibrium conditions, the following consolidated

financial sector balance sheet emerges:

$$L_t = (1 - \varsigma_t)D_t + K_t^b. \tag{11}$$

Now, to understand how monetary policy works in the model, note that equation (4) can be written as follows:

$$\varsigma_t = \varsigma_t^{MP} - \left(\frac{i_t^R - i_t^{IB} - \psi_1}{\psi_2} \right). \tag{12}$$

Denote Δ_t as the spread between the interbank rate and the rate paid on reserve balances: $\Delta_t \equiv i_t^{IB} - i_t^R$. Following Glocker and Towbin (2012), we assume that the central bank maintains Δ_t equal to a constant $\Delta \geq 0$, which from equation (4) again, pins down the difference between effective reserves and required reserves to a constant

$$\varsigma_t - \varsigma_t^{MP} = -\left(\frac{\Delta - \psi_1}{\psi_2} \right) \equiv \Omega \geq 0. \tag{13}$$

Now, while the spread between the rate on reserves and the interbank rate is constant, the spread between the rate paid on deposits and the interbank rate is determined by the zero-profit condition for deposit-taking banks:

$$i_t^D = (1 - \varsigma_t)i_t^{IB} + \varsigma_t i_t^R - G^\varsigma = i_t^{IB} - \varsigma_t^{MP} - G^\varsigma, \tag{14}$$

where G^ς is the cost of holding reserves from equation (2), that is now also constant given Δ and Ω. From (14), it is easy to see that changes in the reserve requirements will have a direct negative impact on the deposit interest rates.

To conclude this subsection, since households do not hold cash, aggregate nominal reserves $\varsigma_t P_t D_t$ correspond to the monetary base in our model. Taking into account reserve remuneration, real seignorage revenue T_t^S is

$$T_t^S = \varsigma_t D_t - \frac{i_{t-1}^R}{\pi_t} \varsigma_{t-1} D_{t-1}.$$

All seignorage revenue is redistributed as a lump-sum transfer to households. The rest of the model follows the exact same structure as in Glocker and Towbin (2012), except for the entrepreneurs and the Government sector.

2.2 The Household Sector

There is a continuum of households. In a given period households derive utility from consumption C_t and disutility from working (h_t). Their instant utility function is $u(C_t, h_t) = \ln C_t - \Psi \frac{h_t^{1+\phi}}{1+\phi}$. Consumption is a Cobb-Douglas bundle of home C_t^H and foreign C_t^F goods: $C_t \propto (C_t^H)^\gamma (C_t^F)^{1-\gamma}$. The resulting price index reads $(P_t^H)^\gamma (P_t^F)^{1-\gamma}$. Households can invest their savings in real deposits D_t and foreign nominal bonds B_t, evaluated at the nominal exchange rate S_t. Because of limited

capital mobility, acquiring foreign bonds entails a small holding cost[8] $\frac{\psi_B}{2}\left(\frac{S_t}{P_t}B_t\right)^2$. By supplying labor, households receive labor income $W_t h_t$. In addition, they receive gross interest payments on their deposits $i^D_{t-1}D_{t-1}$, interest payments on foreign bonds $i^*_{t-1}S_tB_{t-1}$, dividends from deposit units Π^S_t and intermediate goods producers Π^R_t, and lump-sum transfers T_t from the government. The budget constraint reads

$$\begin{aligned} P_tC_t + P_tD_t + S_tB_t = i^D_{t-1}P_{t-1}D_{t-1} + i^*_{t-1}S_tB_{t-1} + P_tW_th_t + \\ + P_t\sum_{j\in(S,R)}\Pi^j_t + P_tT_t + \frac{\psi_B}{2}P_t\left(\frac{S_t}{P_t}B_t\right)^2. \end{aligned} \tag{15}$$

Households discount instant utility with β. They maximize their expected lifetime utility function subject to the budget constraint, which leads to the familiar optimality conditions:

$$1 = E_t\Lambda_{t,t+1}\frac{i^D_t}{\pi_{t+1}} \tag{16}$$

$$1 - \psi_B\frac{S_t}{P_t}B_t = E_t\left[\Lambda_{t,t+1}\frac{i^*_t}{\pi_{t+1}}\frac{S_{t+1}}{S_t}\right] \tag{17}$$

$$W_t = \Psi h^\phi_t C_t, \tag{18}$$

where the stochastic discount factor is given by $\Lambda_{t,t+1} = \beta^k\frac{C_t}{C_{t+k}}$ and $\pi_t = P_t/P_{t-1}$ is the gross inflation rate.

2.3 Capital Goods Producers

Capital goods producers build the capital stock, which is sold to entrepreneurs. They purchase the previously installed capital stock net of depreciation from entrepreneurs and combine it with investment goods to produce the capital stock for the next period. Investment goods have the same composition as final consumption goods. Capital is subject to quadratic adjustment costs according to $\frac{\chi}{2}\left(\frac{I_t}{K_{t-1}} - \delta\right)^2 K_{t-1}$, where δ is the depreciation rate of capital. The parameter χ captures the sensitivity of changes in the price of capital to fluctuations in the investment to capital ratio.

The market price of capital is denoted by Q_t. The optimization problem is to maximize the present discounted value of dividends by choosing the level of new investment I_t. Since the optimization problem is completely static, it reduces to

$$\max_{I_t}\left[(Q_t - 1)I_t - \frac{\chi}{2}\left(\frac{I_t}{K_{t-1}} - \delta\right)^2 K_{t-1}\right]. \tag{19}$$

The maximization problem yields the following capital supply curve: $Q_t = 1 + \chi\left(\frac{I_t}{K_{t-1}} - \delta\right)$. Finally, the aggregate capital stock evolves according to the following law of motion $K_t = (1 - \delta)K_{t-1} + I_t$.

[8] The assumption ensures stationarity in small open-economy models (Schmitt- Grohé and Uribe 2003).

2.4 Entrepreneurs

Entrepreneurs are the critical link between intermediate goods producers and capital goods producers. They purchase capital from the capital goods producers at the beginning of the period and resell at the end of the period. They rent it to intermediate goods producers at rental rate z_t. The structure of this part of the model is the same as in Bernanke et al. (1998), so we will not go into details.

Entrepreneurs finance their capital purchases out of their net worth N_t and with bank loans from bank lending units. For this setting, we consider only the case where the loan from the lending unit is denominated in domestic currency $Q_t K_t = N_t + L_t$. The interaction between entrepreneurs and bank lending units is characterized by an agency problem: entrepreneurs' projects face idiosyncratic shocks that are not publicly observable and they have an incentive to underreport their earnings. Lenders can verify the idiosyncratic shock at a cost. The optimal financial contract delivers the following key equation that links the spread between the aggregate expected real return on capital $E_t r^K_{t+1}$ and the risk-free lending to the entrepreneurs' leverage:

$$Q_t K_t = f\left(\frac{E_t r^K_{t+1}}{i^F_t / E_t \pi_{t+1}}\right) N_t, \text{ with } f'(\cdot) > 0. \tag{20}$$

Contrary to the standard model in Glocker and Towbin (2012), the risk-free rate is not the interbank rate, but it is given by equation (10). Given this, equation (20) shows that the external finance premium is

$$\frac{E_t r^K_{t+1}}{\left(i^{IB}_t - \kappa\left(\frac{K^b_t}{L_t} - v^b\right)\left(\frac{K^b_t}{L_t}\right)^2\right)/E_t \pi_{t+1}},$$

and increases with the share of debt in total financing. The entrepreneur's real return on capital is given by

$$r^K_t = \frac{z_t + Q_t(1-\delta)}{Q_{t-1}}, \tag{21}$$

where z_t is the real rental cost of capital.[9]

With probability $1-\nu$, entrepreneurs leave the market and consume their net worth. They are replaced by new entrepreneurs who receive a small transfer $\bar{g}$ from the departing entrepreneurs. Aggregate net worth is given by the following expression:

$$N_t = \nu V_t + (1-\nu)\bar{g}, \tag{22}$$

where V_t denotes the net worth of surviving entrepreneurs. Different from Bernanke et al. (1998), but in line with Gertler et al. (2007), we assume that the lending rate is fixed in nominal terms in the respective currency. Since we are only considering deposits in domestic currency, the net

[9] Equation (21) takes into account that in a model with investment adjustment costs and incomplete capital depreciation, one has to differentiate between the entrepreneur's return on capital (r^K_t) and the rental rate on capital (z_t). The return on capital depends on the rental rate as well as on the depreciation rate of capital, adjusted for asset price valuation effects (i.e., variations in Q_t/Q_{t-1}).

worth of surviving entrepreneurs is

$$V_t = (1-\tilde{\mu}) r_t^K Q_{t-1} K_{t-1} - i_{t-1}^L \frac{P_{t-1}}{P_t} L_{t-1}, \tag{23}$$

where the term $\tilde{\mu}$ reflects the dead-weight cost associated with imperfect capital markets (see Bernanke et al. (1998) for further details) and i_t^L is the state-contingent nominal lending rate specified in the optimal financial contract (see Appendix 1). Combining equations (22) and (23) yields a dynamic equation for aggregate net worth.

Movements in net worth stem from unanticipated changes in returns and borrowing costs. Changes in Q_t are likely to provide the main source of fluctuations in r_t^K, which stresses that changes in asset prices play a key role in the financial accelerator. On the liabilities side, unexpected movements in the price level affect ex-post borrowing costs. For instance, unexpected inflation increases entrepreneurs' net worth.

2.5 Intermediate Goods Producers

Intermediate goods producers buy labor input from households and rent capital from entrepreneurs. They produce differentiated intermediate goods and operate in competitive input and monopolistically competitive output markets. The production function of intermediate goods producer $i \in [0,1]$ is

$$y_t(i) = \xi_t^A K_{t-1}(i)^{\alpha} h_t(i)^{1-\alpha}, \tag{24}$$

where ξ_t^A is an aggregate technology term and follows an AR(1) process. Cost minimization implies $\frac{h_t(i) W_t}{z_t K_{t-1}(i)} = \frac{1-\alpha}{\alpha}$ and marginal costs are given by

$$mc_t \propto \frac{W_t^{1-\alpha} z_t^{\alpha}}{\xi_t^A}. \tag{25}$$

2.6 Final Goods Producers

Final goods producers buy differentiated intermediate domestic goods from intermediate goods producers and transform them into one unit of final domestic good. They resell these transformed goods to households as consumption goods and to capital goods producers as investment goods. The final good is produced using a constant elasticity of substitution (CES) production function with elasticity of substitution ϵ to aggregate a continuum of intermediate goods indexed by $Y_t = \left(\int_0^1 y_t(i)^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}$. Final domestic goods producers operate in competitive output markets and maximize each period the following stream of profits $P_t^H Y_t - \int_0^1 p_t^H(i) y_t(i) di$, where $p_t^H(i)$ is the price of intermediate good i. The demand for each intermediate input good is $y_t(i) = (p_t(i)/Y_t)^{-\epsilon} Y_t$ and the aggregate price level satisfies $P_t^H = \left(\int_0^1 p_t^H(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}$.

We assume that Calvo-type price staggering (Calvo (1983)) applies to the price-setting behavior of intermediate goods producers. The probability that a firm cannot reoptimize its price for k periods is given by θ^k. Profit maximization by an intermediate goods producer who is allowed to reoptimize his price at time t chooses a target price p_t^* to maximize the following stream of future

profits:

$$\max_{\{p_t^*\}_{t\in\mathbb{Z}}} E_t\left[\sum_{k=0}^{\infty}\theta^k\Lambda_{t,t+k}\Pi^R_{t+k|t}(i)\right], \tag{26}$$

where profits are given by $\Pi^R_t(i)=\frac{p_t^*}{P_t}y_t(i)-mc_{t+k|t}(i)y_{t+k|t}(i)$. The first-order condition is

$$E_t\left[\sum_{k=0}^{\infty}\theta^k\Lambda_{t,t+k}y_{t+k|t}(i)\left(\frac{p_t^*}{P_{t+k}}-\frac{\epsilon}{\epsilon-1}mc_{t+k|t}(i)\right)\right]=0. \tag{27}$$

Final import goods are provided in competitive markets and the foreign currency price is normalized to one: $P_t^F=S_t$.

2.7 Equilibrium in the Goods Market

The economy-wide resource constraint is given by

$$Y_t=\gamma\frac{P_t}{P_t^H}(C_t+I_t+G_t)+\frac{S_t}{P_t^H}X_t+\gamma\frac{P_t}{P_t^H}\Psi_t.$$

Foreigners buy an exogenous amount X_t (expressed in foreign currency) of domestic goods and $\Psi_t=K_{t-1}(\frac{\chi}{2}(\frac{I_t}{K_{t-1}}-\delta)^2+\tilde{\mu}r_t^KQ_{t-1}+G_t^{\varsigma}(\cdot)+\frac{\psi_B}{2}(\frac{S_t}{P_t}B_t)^2$ captures adjustment costs. The balance of payment identity is

$$S_tB_t=P_t^HY_t-P_t(C_t+I_t+G_t)(1+i^*_{t-1})S_tB_{t-1}+P_t\Psi_t.$$

2.8 Government

The Central Bank has two dimensions: the central bank's objective and the implementation of the policy. In terms of objectives, we will consider two exogenously given loss functions. In the first case, the monetary authority's loss function includes only the traditional objectives of output and price stability. The price stability loss function L_t^{PS} reads

$$L^{PS}=E(\hat{\pi}_t^2+\lambda_Y(\hat{Y}_t)^2), \tag{28}$$

where $\hat{Y}_t$ is the log-deviation of output from its steady-state value and λ_Y reflects the policymakers' subjective weight of output stability relative to price stability. Moreover, we also consider the case where the central bank cares about financial stability, measured as the deviations from the stock of loans, yielding a loss function as follows:

$$L^{FS}=E(\hat{\pi}_t^2+\lambda_Y(\hat{Y}_t)^2+\lambda_L(\hat{L}_t)^2), \tag{29}$$

where $\hat{L}_t$ is the log-deviation of loans from their steady-state value and λ_L reflects the policymakers' subjective weight of loan stability relative to price stability.

As mentioned in the Introduction, it is reasonable to think that Central Banks may want to avoid abrupt fluctuations in credit, mainly because of the risk of a financial crisis. Studies from

the Bank for International Settlements have pointed out that deviation of credit from its trend can predict financial crisis (Borio and Drehmann (2009), Borio et al. (2002)). Note, however, that we do not include a role for countercyclical capital buffers, for example, as there is no risk of a financial crisis.

In terms of instruments, we consider three: the interbank interest rate (i_t^{IB}), capital requirements (v_t^b), and reserve requirements (ς_t^{MP}). In practice, these instruments are used in many different ways by central banks and financial regulators. For example countries that use both reserve requirements and interest rates as policy tools include Brazil, Colombia, Peru, Turkey, and others. On the other hand, there are many different anchor variables for setting the level of the countercyclical regulatory capital requirements for banks. Drehmann et al. (2010) conclude that the best leading indicator is credit-to-GDP gap, whereas the best coincident indicator is banking spread. Still, the Basel Committee suggests the use of credit-to-GDP gap as an anchor variable for both periods. However, Repullo and Saurina Salas (2011) argue that the use of such variable may exacerbate procyclicality inherent in the financial system and recommend the use of output growth.

Having said that, we will consider several policy rules based on combinations of these instruments, that minimize the two loss functions proposed before. In particular, the general setting we consider is the following:

$$\hat{i}_t^{IB} = \phi_{\pi,i}\hat{\pi}_t + \phi_{Y,i}\hat{Y}_t + \phi_{L,i}\hat{L}_t \tag{30}$$

$$\hat{\varsigma}_t^{MP} = \phi_{\pi,\varsigma}\hat{\pi}_t + \phi_{Y,\varsigma}\hat{Y}_t + \phi_{L,\varsigma}\hat{L}_t \tag{31}$$

$$\hat{v}_t^b = \phi_{\pi,v}\hat{\pi}_t + \phi_{Y,v}\hat{Y}_t + \phi_{L,v}\hat{L}_t. \tag{32}$$

In this paper we are interested in the interaction between the macroprudential instruments, using monetary policy as a complement. There is a consensus in the literature about the effectiveness of macroprudential policy to amplify the effect of monetary policy (under certain conditions), but little has been said about the sustainability of different macroprudential instruments. For this reason, we will consider a simple Taylor-rule for the interest rate, meaning $\phi_{L,i} = 0$, so that credit deviations are mitigated directly by capital or reserve requirements, leaving monetary policy focus on inflation and output. In another specification, we will also consider the case of an even simpler rule, where the interest rate only reacts to changes in inflation, to test the effectiveness of macroprudential instruments. As for capital requirements, we will only consider output and loans as potential anchor variables, as it is not usual to target inflation with this instrument. Moreover, we will set $\phi_{\pi,\varsigma} = 0$ in all our specifications, as our main focus is the effectiveness of reserve requirements as a macroprudential tool, and not as an unconventional monetary policy instrument.

2.9 Shocks and Calibration

The economy's dynamics is driven by five shocks: a cost-push shock (ξ_t^{CP}), a technology (or productivity) shock (ξ_t^A), a government spending shock (G_t), a foreign interest rate shock (i_t^*), and a foreign export demand shock (X_t). As usual, all shocks follow AR(1) processes, and the persistence and variances for each of them are shown in the Appendix 2 (Table 4). The values

therein are taken from an estimated DSGE model as described in Christoffel et al. (2008). Most of the rest of the parameters are standard (see Table 3 in Appendix 2).

Several parameters are not calibrated directly but specified such that they match model-specific variables to their empirical counterparts in a standard small-open-economy as in Glocker and Towbin (2012). We use the case of Peru to set the steady-state value of ς_t^{MP} to 0.09 (average of the last 8 years, in local currency), and the effective reserve ratio (ς_t) to 0.1. This is in line with banks wanting to comply with the requirement, as reputational and operational costs would be severe. The other coefficients are calibrated such that they imply an interest rate differential between the interbank rate (i_t^{IB}) and the interest rate on reserves (i_t^R) in the steady state of 150 basis points on a quarterly basis, as in Glocker and Towbin (2012). The steady-state leverage ratio of entrepreneurs is two. We choose the other parameters of the financial contract to generate a steady-state external finance premium of 50 basis points and an elasticity to leverage of $\eta = 0.05$ as in Christensen and Dib (2008) (standard in the literature).

Regarding the parameters on the lending units, we follow Gerali et al. (2010) for parameters such as the sensitivity to bank capital cost (κ), the debt-to-loans ratio, bank capital depreciation, and the target capital-to-loans ratio (v^b). Based on this, we set the steady-state capital ratio to be 0.11, above the requirement. This is a commonly observed fact in banking: they usually maintain more capital than the minimum that is required by regulation (see Allen and Rai (1996), Peura and Jokivuolle (2004), or Barth et al. (2013)).

3 Discretionary changes to macroprudential instruments

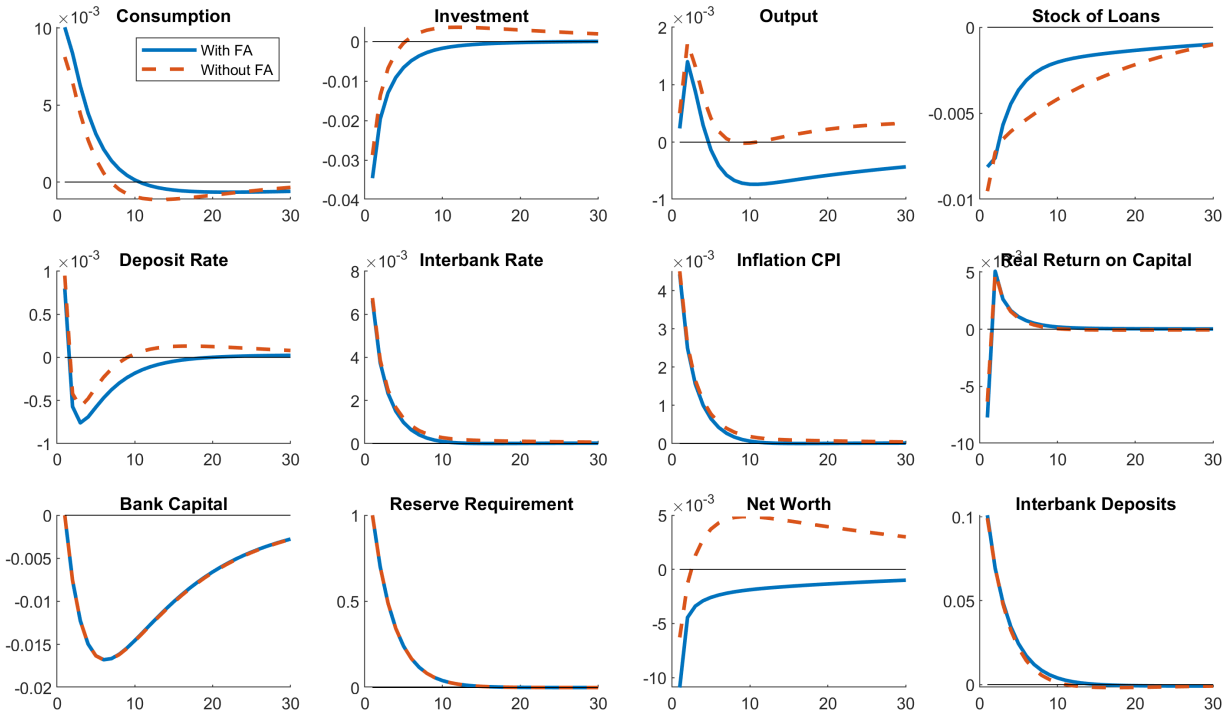
This section provides a set of simulation exercises to shed light on the transmission mechanism and potential effects of reserve and capital requirements on the financial system and the economy. Following Glocker and Towbin (2012) we assume that both variables follow an exogenous AR(1) process with autocorrelation 0.7 and we abstract from a systematic component in requirements' policy.

For this analysis, we will keep monetary policy as simple as possible[10], and will particularly pay attention to the role of the financial accelerator in amplifying (or dampening) the macroprudential shocks. In the case of a change in reserve requirements, two opposite effects are interacting. First, for a given monetary base, higher reserve requirements imply smaller broad money aggregates and we expect an economic contraction. On the other hand, if the rate of reserve remuneration lies below the market interest rate, then requirements also act as a tax on the banking sector, driving a wedge between deposit and lending rates.

In the case of capital requirements, an increase leads to an immediate contraction in credit, for a given spread between wholesale loan and interbank rate. Since banking capital accumulates only through the previous period's profits, the only possible action for the bank is to cut lending, and thus interbank deposits. This will lead, eventually, to an increase in consumption (decrease in deposits), and a decrease in investment. However, this process generates higher profits for the banking units, since the increase in the interest rate spread is stronger compared to the fall in

[10] In particular, we will assume a simple Taylor rule where the coefficient associated with the deviations of inflation, $\phi_{\pi,IB}$, is 1.5, and the other coefficients are zero.

Figure 2: Reserve Requirement Shock and the Financial Accelerator



Note: The figure reports quarterly impulse responses to a 1-std deviation increase in reserve requirements, considering scenarios with and without the financial accelerator mechanism. Monetary policy is specified by an interest rate rule for the interbank interest rate as defined in section 2.8 with $\phi_{\pi,i} = 1.5$ and the other coefficients equal 0. The y-axis denotes the deviation in percent from the steady state.

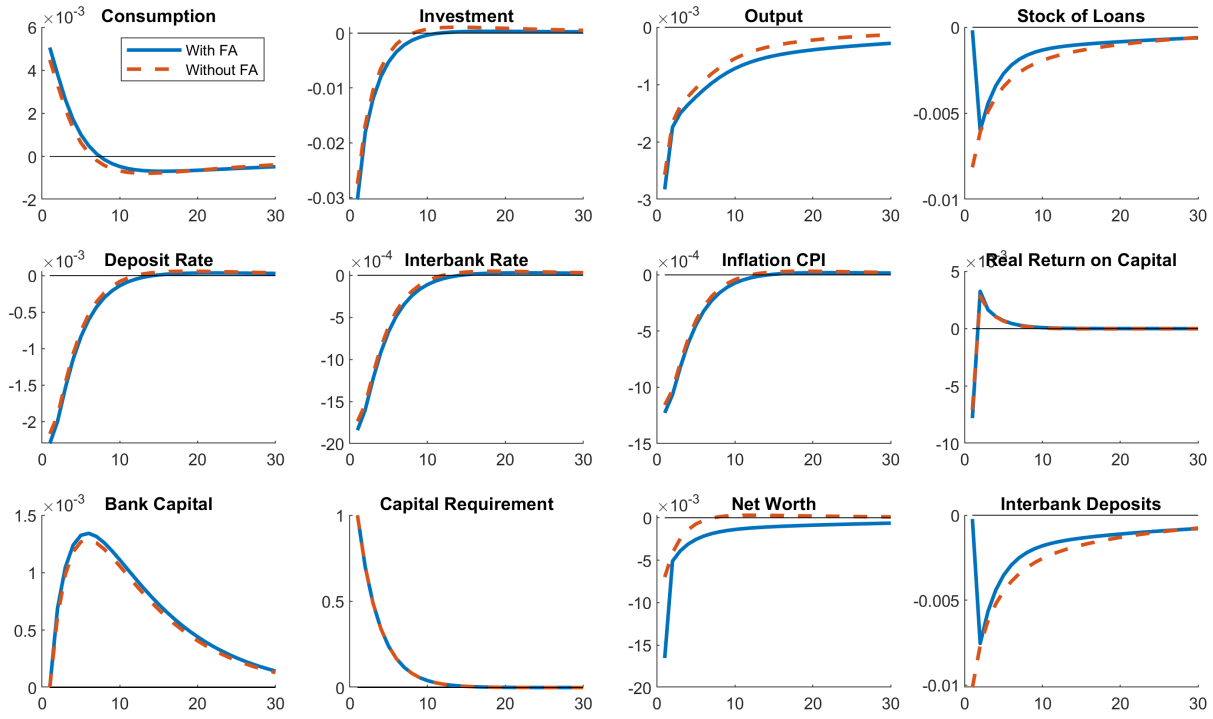
loans and deposits, leading to an increase in the accumulation of capital in the next period.

The effects discussed above might depend both on financial and nominal frictions. Therefore, while analyzing the effects of the macroprudential measures, we will consider scenarios with and without the financial accelerator mechanism, and with various degrees of price stickiness[11]. Figure 2 shows the effects of a one standard deviation discretionary change of reserve requirements. As discussed before, the negative effect on the deposit rate (tax effect) implies an increase in consumption, which combined with an increase in the interbank rate, leads to a decrease in the stock of loans and investment. Additionally, we have that, contrary to a contractionary monetary policy shock, an increase in reserve requirements tightens credit conditions and depreciates the exchange rate simultaneously. Because of the uncovered interest parity, the decline in the deposit rate also leads to an exchange rate depreciation and a rise in exports. Given this, the effect on output is ambiguous: for our particular parametrization, the effect seems to be initially positive, while later becomes contractionary.

The financial accelerator appears to be relevant to the transmission mechanism of reserve requirements. In particular, it strengthens the effect on investment; because of movements in the external finance premium, net worth of entrepreneurs and investment become more sensitive to

[11]For the analysis with different degrees of price stickiness (see Figure 6 and 7 in the Appendix 3)

Figure 3: Capital Requirement Shock and the Financial Accelerator



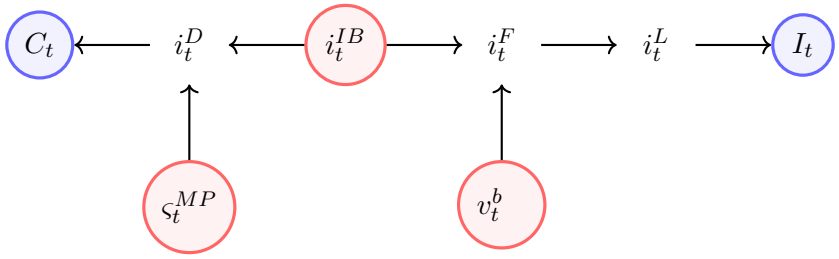
Note: The figure reports quarterly impulse responses to a 1-std deviation increase in capital requirements, considering scenarios with and without the financial accelerator mechanism. Monetary policy is specified by an interest rate rule for the interbank interest rate as defined in section 2.8 with $\phi_{\pi,i} = 1.5$ and the other coefficients equal 0. The y-axis denotes the deviation in percent from the steady state.

fluctuations in the interbank rate. As a final result, the impact on output is more severe than in the baseline case, with a sharper and more persistent decline in economic activity.

Regarding the effects of capital requirements, most of these are in line with the ones from the reserve requirements, both in direction and magnitude (see Figure 3), except with the bank balance sheet variables. An increase in capital requirements leads to a decrease in the stock of loans, which leads to a decrease in investment. The return on capital initially drops but tends to stabilize almost immediately. Although consumption and investment react in opposite ways as in the reserve requirement case, the effect on output is undoubtedly negative. On the other hand, as we discussed previously, an increase in capital requirements needs to be matched by the banks by reducing lending while increasing the accumulation of bank capital through a rise in profits. Thus, bank capital tends to increase, contrary to what we see after an increase in reserve requirements.

Finally, the main difference between the aggregate effect of both macroprudential measures can be seen in the impact on inflation. In the case of capital requirements, inflation tends to decrease, in line with a decrease in output. However, for our calibration, an increase in reserve requirements leads to an increase in inflation, contrary to the popular notion that reserve requirements can be increased to contain inflation. The increase in the tax on banks increases overall production costs, which puts upward pressure on the overall price level. The financial accelerator does not

Figure 4: Transmission Mechanism of Macroprudential Policy



Note: The variables in red represent the monetary and macroprudential instruments at the disposal of the policy-makers. i_t^D, i_t^F, i_t^L are the deposit, risk-free, and state-contingent lending interest rates, respectively. Due to the various frictions inherent in the model, the transmission mechanisms of each instrument may vary, leading to heterogeneous effects on aggregate variables such as consumption and investment.

seem to influence significantly the transmission mechanism of capital requirements, aside from the magnitude of the decrease in lending and interbank borrowing.

Figure 4 captures these insights and provides a visual representation of the different transmission mechanisms behind macroprudential policy. For instance, reserve requirements, by directly influencing the distribution of deposits and reserves in banks' balance sheets, typically exert a more substantial and immediate impact on deposit rates. As a result, households adjust their savings decisions, thereby affecting aggregate consumption. On the other hand, changes in capital requirements directly impact the stock of loans and, consequently, lending interest rates. Entrepreneurs, reliant on bank loans to fund their projects, adjust their investment decisions in response to the changes in borrowing costs. Lastly, the monetary policy rate plays a pivotal role in mediating the interaction between deposit and lending units, exerting a direct influence on both sides. In the absence of financial frictions and nominal rigidities, the distinctions between these transmission mechanisms would dissipate.

4 Optimal Policy rules and applications

In this section we analyze the optimal macroprudential policy rules considering two different objectives and plausible sensitivities in the different instruments. In particular, we seek to find the optimal parameters for the different policy rules described in section 2.8 based on the loss functions provided there. The approach we follow is a grid-search-type optimizing process, with reasonable boundaries for the parameters to be plausible in a policy-making context.

Regarding the parameters of the Taylor-rule, we use the following search intervals. For $\phi_{Y,IB}$ we set it to $[0, 3]$ following[12] Schmitt-Grohé and Uribe (2007). On the other hand, the coefficient associated to inflation, $\phi_{\pi,IB}$, is set to be between $[1.1, 3.5]$ since values between 0 and 1 are not compatible with a rational expectations equilibrium. Note that we will not consider the case where the monetary policy rate reacts directly to loans, since our interest relies on the interaction between the two macroprudential instruments in addressing financial volatility.

For the $\phi_{\pi,\varsigma}$ and $\phi_{\pi,v}$ parameters associated with the reserve requirements and the capital

[12] Although the authors apply this criteria to a welfare-based analysis, the same mechanism applies.

Table 1: Optimal Policy Rules under a Price Stability Objective

	Policy A(I)			Policy A(II)			Policy A(III)		
	i^{IB}	ς^{MP}	v^b	i^{IB}	ς^{MP}	v^b	i^{IB}	ς^{MP}	v^b
ϕ_L	—	—	—	—	31.90	—	—	—	31.90
ϕ_Y	1.37	—	—	1.28	—	—	1.30	—	—
ϕ_π	2.86	—	—	3.50	—	—	3.50	—	—
L^{PS}		**5.34**			**4.94**			**4.95**	

Note: The table shows the parameter values for policy A(I), policy A(II) and policy A(III), based on the specifications in equations (30)-(32) for the optimal policy projections under the loss function defined in equation (28).

requirements, we will follow the results[13] from Glocker and Towbin (2012) and set the search interval to $[0, 31.9]$. This is also plausible from a policy-making perspective, since in countries such as Peru, reserve requirements have more than tripled in the aftermath of the global financial crisis. For the case of the parameters $\phi_{Y,\varsigma}$ and $\phi_{Y,v}$ we set the search interval for the capital requirement parameters to $[0, 13]$.

4.1 Price Stability Objective

First, we will consider a traditional central bank that only monitors fluctuations in output and inflation and does not respond to volatility in loans. The optimized coefficients in the policy rule and the value of the resulting loss function (in absolute value) are reported in Table 1, and we denote it as policy AI. The optimal coefficients we get are in line with Glocker and Towbin (2012) and Benes and Kumhof (2015).

Now, consider the case where the central bank is still only focused on the price stability objective, but uses another instrument that reacts to the deviations of the stock of loans. Note that here the central bank responds to loans because they contain information about the state of the economy, not because the containment of loan fluctuations is an end in itself. We denote AII as the policy where the reserve requirement ratio (ς_t^{MP}) is the instrument that reacts to loans. The estimated coefficient $\phi_{L,\varsigma}$ obtained is 31.9, the upper bound of the search interval set. This is not surprising, since we have seen that reserve requirements have a direct impact on variables such as investment, output and the stock of loans (which eventually lead to effects on economic activity). Moreover, in the previous section, we showed that although an increase in reserve requirements seems to cause an increase in inflation, it is not significant in magnitude and thus the usual trade-off between price and output stability should not be an issue. Policy AII represents a reduction in the lost function of almost 8% with respect to the benchmark case. This is not surprising, as the central bank has three instruments for only two objectives.

[13] In their study, the authors consider the difference in levels of the reserve requirements as the policy instrument, thus the coefficients in the policy rules can only be compared when multiplying them by the steady state of the reserve requirements in our calibration (9%).

Table 2: Optimal Policy Rules under a Financial Stability Objective

	Policy B(I)			Policy B(II)			Policy B(III)		
	i^{IB}	ς^{MP}	v^b	i^{IB}	ς^{MP}	v^b	i^{IB}	ς^{MP}	v^b
ϕ_L	—	—	—	—	31.90	—	—	—	31.90
ϕ_Y	0.19	—	—	1.20	—	—	0.40	—	—
ϕ_π	1.10	—	—	3.50	—	—	1.62	—	—
L^{PS}		**7.13**			**5.61**			**6.02**	
	Policy C(I)			Policy C(II)			Policy C(III)		
	i^{IB}	ς^{MP}	v^b	i^{IB}	ς^{MP}	v^b	i^{IB}	ς^{MP}	v^b
ϕ_L	—	31.90	31.90	—	31.90	—	—	—	31.90
ϕ_Y	—	13.00	13.00	—	—	13.00	—	13.00	—
ϕ_π	3.50	—	—	1.10	—	—	3.50	—	—
L^{PS}		**5.33**			**5.96**			**6.17**	

Note: The table shows the parameter values for policy B(I), policy B(II), policy B(III), policy C(I), policy C(II) and policy C(III) based on the specifications in equations (30)-(32) for the optimal policy projections under the loss function defined in equation (29).

Finally, we turn to the case where the central bank uses the capital requirements to respond to deviations in the stock of loans. The estimated coefficient $\phi_{L,v}$ obtained is 31.9, following the same logic as in the reserve requirements' case. We obtain very similar results in terms of minimizing the loss function focused only on output and inflation. These findings suggest that the two macroprudential instruments analyzed are useful even for a central bank that does not have financial stability as an objective. Moreover, they have the same effect when it comes to contributing to price and output stability by reacting to changes in the stock of loans.

4.2 Financial Stability Objective

In this section we consider a case where the central bank explicitly wants to stabilize the fluctuations in loans, as reflected in the loss function L_t^{FS} in section 2.8. The results are displayed in Table 2. The block of specifications denoted by B are similar to the previous setting, but with the only difference of an additional objective in the central bank's loss function. As it was expected, including financial stability into the equation, without having an instrument specifically to target that variable, ends up being costly, as shown with Policy BI. Note that the coefficients related to inflation and output in the original Taylor-rule change with respect to the benchmark with only a price stability objective. This is explained by a potential trade-off between credit and the rest of the variables, and a lack of instruments.

Including any of the macroprudential instruments to target credit directly provides significant gains in terms of minimizing the loss function. In the case of reserve requirements, ς^{MP}, the loss

function is reduced by 21%. Similarly, adding capital requirements, v^b, that depend positively on the deviations of credit provides a 16% decrease in the central bank's loss function. These results are in line with Glocker and Towbin (2012), who find that the use of reserve requirements as a policy tool leads to substantially lower loss function values in the presence of financial frictions.

To conclude, we also analyze the case with a strict separation of tasks, where interest rates react solely to inflation fluctuations, while the macroprudential instruments respond to output and loans. Policy CI shows that using reserve and capital requirements as instruments that depend both on loans and output has a significant impact on the loss function. Nevertheless, such a policy could be difficult and confusing to implement, and besides could lead to excessive volatility in the instruments. More plausible setting are shown as Policy CII and CIII, which exhibit a higher loss function (on average 14% higher) than the one from the overcrowded specification. However, if we compare them to the case with no separation of tasks (BII and BIII), we see that the gains are very similar. Given that CII and CIII are more feasible options, they could be preferred from a policy-making perspective.

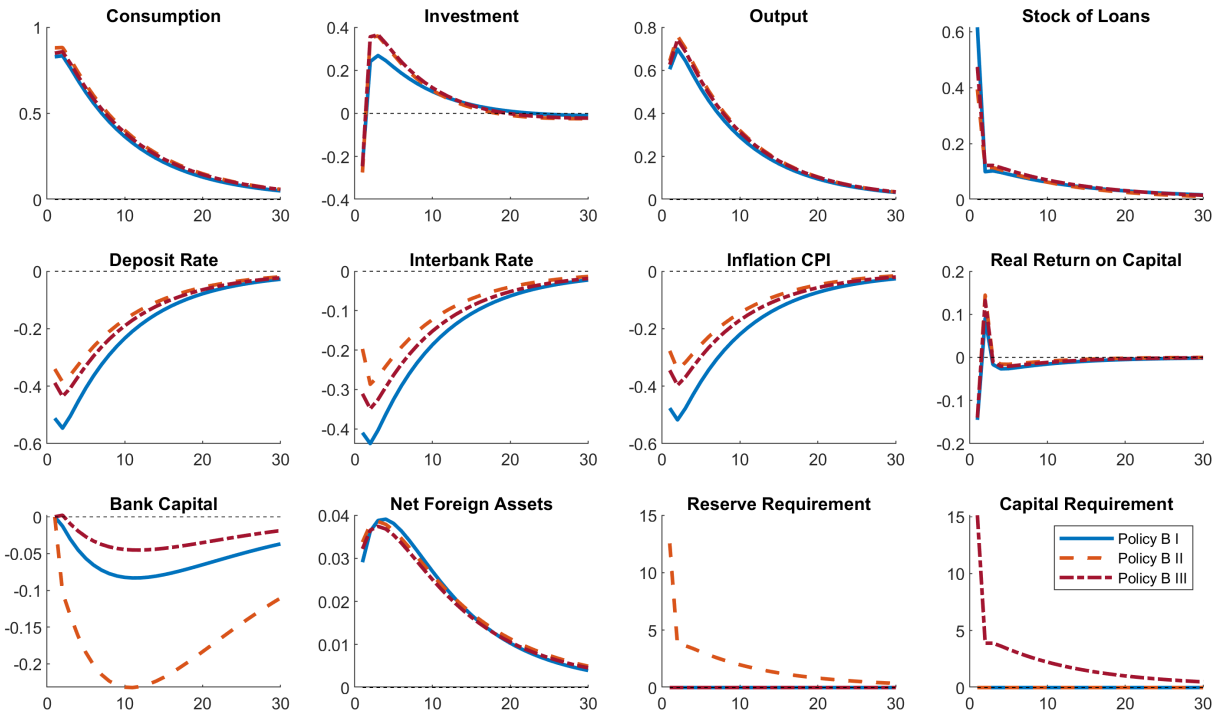
Based on the evidence presented in this section, we can draw some conclusions about the optimal macroprudential rules. First, even under a price stability objective framework, reserve and capital requirements can be beneficial if they are incorporated to a traditional Taylor-rule. Second, if financial stability is included as an objective of the central bank, the effects of macroprudential policies become more important, reducing the target loss function up to 21%. Additionally, they seem to be useful to target output fluctuations, not only credit. Finally, in the scenario of a financial stability objective and strict separation of tasks, reserve requirements provide a slightly better response to the exogenous shocks in the economy than capital requirements.

4.3 Application: technology shock

To illustrate the differences in the optimal policy rules described in the previous subsections, we show here how the economy reacts to a technology shock under these rules, as depicted in Figure 5. The natural transmission channel tells us that the expansionary shock triggers a decline in inflation and an increase in loans. A policy aiming to stabilize inflation would favor a decline in the interbank interest rate in order to keep real rates low. At the same time, with the objective of stabilizing output, interbank interest rates should increase. Hence, even if the central bank does not monitor credit growth, two goals should be implemented with one policy instrument: the interbank rate should increase and decrease at the same time. This becomes more dramatic if we include a financial stability objective such as in policy type B.

Macroprudential instruments, under such a scenario, proved to be helpful in stabilizing credit and some aggregate components of output. Due to the calibration of the optimal rules, the interbank rate reacts almost one-to-one to the decline in inflation. On the other hand, the positive effect on investment is reduced by around 33% if any of the macroprudential instruments is active (policies BII and BIII). The natural increase in loans is also dampened by and increase in capital or reserve requirements, which induce tighter conditions in the credit market. Moreover, an important difference between the two macroprudential instruments, in their effect on bank capital after a technology shock. We can see that the use of capital requirements (BIII) produces less volatility in the bank capital, compared to the cases in which this instrument is inactive (policies BI and

Figure 5: Technology shock under different Policy Rules and a Financial Stability Objective



Note: The figure reports quarterly impulse responses to a 1-std deviation positive technology shock, considering a scenario with a financial accelerator mechanism and different policy rules, as described in the legend. The y-axis denotes the deviation in percent from the steady state.

BII). As mentioned before, this is due to the fact that the increase in the stock of loans induces an increase in the capital requirements, undercutting the negative profits from the banking sector.

5 Conclusions

This paper analyzes the interaction and effectiveness of two macroprudential instruments under different anchor variables and central bank's objectives. We build on a small open-economy model with nominal rigidities, financial frictions, a banking sector that is subject to reserve requirements, and include banking capital and capital requirements.

Under a price stability objective, the gains from adapting reserve and capital requirements to economic conditions are substantial when the economy faces nominal and financial frictions. The more traditional financial accelerator mechanism is complemented by the inherent procyclicality of banking capital accumulation, leaving scope for macroprudential measures.

On the other hand, if financial stability is included as an objective of the central bank, the effects of macroprudential policies become more relevant. These instruments are not only useful to target credit fluctuations but also to stabilize output. Regarding the differences between the two instruments, the most important is that an increase in reserve requirements is associated with higher inflation, while tighter capital requirements lead to a drop in inflation. The overall impact

on output is similar in magnitude, but more ambiguous in the case of reserve requirements, as it depends on the degree of price stickiness in the economy. Nevertheless, in terms of achieving the central bank's objectives, both instruments seem to perform similarly, and the benefits of complementing each other are not significant.

Lastly, in the scenario of a financial stability objective and strict separation of tasks, reserve requirements provide a slightly better response to the exogenous shocks in the economy than capital requirements. However, it is important to notice that the role of capital requirements is not necessarily to stabilize credit growth but to force banks to build buffers that can be used in recessions. This dimension is not captured by the model, as there is no risk of a financial crisis, and it represents an extremely interesting area for future research.

References

Agénor, P.-R., Alper, K., da Silva, L. P. et al. (2013), 'Capital regulation, monetary policy and financial stability', *International Journal of Central Banking* **9**(3), 193–238. 3

Allen, L. and Rai, A. (1996), 'Operational efficiency in banking: An international comparison', *Journal of Banking & Finance* **20**(4), 655–672. 13

Alper, K., Binici, M., Demiralp, S., Kara, H. and Özlü, P. (2014), Reserve requirements, liquidity risk, and credit growth, Technical report, Working Paper. 2

Angelini, P., Neri, S. and Panetta, F. (2011), 'Monetary and macroprudential policies', *Bank of Italy Temi di Discussione (Working Paper) No* **801**. 3

Areosa, W. D., Coelho, C. A. et al. (2013), 'Using a DSGE model to assess the macroeconomic effects of reserve requirements in Brazil', *Banco Central Do Brasil Working Paper Series* **303**, 1–28. 3

Barth, J. R., Lin, C., Ma, Y., Seade, J. and Song, F. M. (2013), 'Do bank regulation, supervision and monitoring enhance or impede bank efficiency?', *Journal of Banking & Finance* **37**(8), 2879–2892. 13

Benes, J. and Kumhof, M. (2015), 'Risky bank lending and countercyclical capital buffers', *Journal of Economic Dynamics and Control* **58**, 58–80. 17

Bernanke, B., Gertler, M. and Gilchrist, S. (1998), The financial accelerator in a quantitative business cycle framework, Technical report, National Bureau of Economic Research. 5, 9, 10

Bianchi, J. (2011), 'Overborrowing and systemic externalities in the business cycle', *American Economic Review* **101**(7), 3400–3426. 2

Bianchi, J. and Coulibaly, L. (2022), Liquidity traps, prudential policies, and international spillovers, Technical report, National Bureau of Economic Research. 3

Borio, C. E. and Drehmann, M. (2009), 'Assessing the risk of banking crises–revisited', *BIS Quarterly Review, March* . 12

Borio, C. et al. (2002), 'Assessing the risk of banking crises', *BIS Quarterly Review* **7**(1), 43–54. 12

Bustamante, C. and Hamann, F. (2015), 'Countercyclical reserve requirements in a heterogeneous-agent and incomplete financial markets economy', *Journal of Macroeconomics* **46**, 55–70. 3

Calvo, G. A. (1983), 'Staggered prices in a utility-maximizing framework', *Journal of monetary Economics* **12**(3), 383–398. 10

Carrillo, J. A., Mendoza, E. G., Nuguer, V. and Roldán-Peña, J. (2021), 'Tight money-tight credit: coordination failure in the conduct of monetary and financial policies', *American Economic Journal: Macroeconomics* **13**(3), 37–73. 3

Carvalho, F. A. and Castro, M. R. (2017), 'Macroprudential policy transmission and interaction with fiscal and monetary policy in an emerging economy: a DSGE model for Brazil', *Macroeconomics and Finance in Emerging Market Economies* **10**(3), 215–259. 3

Carvalho, F. A., Castro, M. R. and Costa, S. (2014), 'Traditional and matter-of-fact financial

frictions in a DSGE model for Brazil: the role of macroprudential instruments and monetary policy'. 3

Cecchetti, S. G. and Kohler, M. (2012), 'When capital adequacy and interest rate policy are substitutes (and when they are not)'. 3

Cerutti, E., Claessens, S. and Laeven, L. (2017), 'The use and effectiveness of macroprudential policies: New evidence', *Journal of financial stability* **28**, 203–224. 36

Christensen, I. and Dib, A. (2008), 'The financial accelerator in an estimated new keynesian model', *Review of Economic Dynamics* **11**(1), 155–178. 13

Christoffel, K. P., Coenen, G. and Warne, A. (2008), 'The new area-wide model of the euro area: a micro-founded open-economy model for forecasting and policy analysis'. 13

Claessens, S. and Valencia, F. (2013), 'The interaction between monetary and macroprudential policies', *Approved By Olivier Blanchard and José Viñals, IMF* . 1

Cordella, T., Federico, P., Vegh, C. and Vuletin, G. (2014), *Reserve requirements in the brave new macroprudential world*, World Bank Publications. 1

Drehmann, M., Borio, C. E., Gambacorta, L., Jimenez, G. and Trucharte, C. (2010), 'Countercyclical capital buffers: exploring options'. 12

Ferreira, L. N., Nakane, M. I. et al. (2015), *Macroprudential Policy in a DSGE Model: anchoring the countercyclical capital buffer*, FEA/USP. 2

Frache, S., García-Cicco, J. and Ponce, J. (2017), 'Countercyclical prudential tools in an estimated DSGE model', *Documento de Trabajo/FCS-DE; 09/17* . 3

Gerali, A., Neri, S., Sessa, L. and Signoretti, F. M. (2010), 'Credit and banking in a DSGE model of the Euro area', *Journal of Money, Credit and Banking* **42**, 107–141. 2, 3, 13

Gertler, M., Gilchrist, S. and Natalucci, F. M. (2007), 'External constraints on monetary policy and the financial accelerator', *Journal of Money, credit and Banking* **39**(2-3), 295–330. 9

Gertler, M. and Karadi, P. (2011), 'A model of unconventional monetary policy', *Journal of monetary Economics* **58**(1), 17–34. 2, 3

Glocker, C. and Towbin, P. (2012), 'Reserve requirements for price and financial stability-when are they effective?', *Banque de France Working Paper* . 2, 3, 7, 9, 13, 17, 19

Guzman, J. P. M. and Roldos, M. J. (2014), *Monetary and macroprudential policies to manage capital flows*, number 14-30, International Monetary Fund. 2

Kannan, P., Rabanal, P. and Scott, A. M. (2012), 'Monetary and macroprudential policy rules in a model with house price booms', *The BE Journal of Macroeconomics* **12**(1). 3

Kashyap, A. K. and Stein, J. C. (2012), 'The optimal conduct of monetary policy with interest on reserves', *American Economic Journal: Macroeconomics* **4**(1), 266–82. 2

Lozej, M., Onorante, L. and Rannenberg, A. (2018), 'Countercyclical capital regulation in a small open economy DSGE model'. 2

Mahapatra, B. (2012), Underlying concepts and principles of dynamic provisioning, *in* 'Keynote address at the Conference on Introduction of dynamic provisioning framework for banks in India, organised by the Centre for Advanced Financial Research and Learning (CAFRAL) Mumbai',

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Mimir, Y., Sunel, E. and Taşkın, T. (2013), 'Required reserves as a credit policy tool', *The BE Journal of Macroeconomics* **13**(1), 823–880. 2

Paries, M. D., Karadi, P., Kok, C. and Nikolov, K. (2022), 'The impact of capital requirements on the macroeconomy: lessons from four macroeconomic models of the euro area', *International Journal of Central Banking* **18**(5), 197–246. 2

Peura, S. and Jokivuolle, E. (2004), 'Simulation based stress tests of banks' regulatory capital adequacy', *Journal of Banking & Finance* **28**(8), 1801–1824. 13

Prada-Sarmiento, J. D. (2008), 'Financial intermediation and monetary policy in a small open economy', *Borradores de Economía; No. 531* . 2

Quint, M. D. and Rabanal, P. (2013), *Monetary and macroprudential policy in an estimated DSGE model of the euro area*, number 13-209, International Monetary Fund. 3

Repullo, R. and Saurina Salas, J. (2011), 'The countercyclical capital buffer of basel III: A critical assessment'. 12

Schmitt-Grohé, S. and Uribe, M. (2007), 'Optimal simple and implementable monetary and fiscal rules', *Journal of monetary Economics* **54**(6), 1702–1725. 16

Suh, H. (2012), 'Macroprudential policy: its effects and relationship to monetary policy'. 3

Van der Ghote, A. (2021), 'Interactions and coordination between monetary and macroprudential policies', *American Economic Journal: Macroeconomics* **13**(1), 1–34. 3

Appendix

Appendix 1: The log-linearized equations

Households

- Consumption-saving decision:

$$E_t\hat{C}_{t+1} - \hat{C}_t = \hat{i}_t^D - E_t\hat{\pi}_{t+1}$$

- Uncovered interest parity condition:

$$\hat{i}_t^D + \psi_B\hat{B}_t = \hat{i}_t^* + E_t\Delta\hat{s}_{t+1}$$

- Labor supply:

$$\hat{w}_t = \phi\hat{h}_t + \hat{C}_t$$

Deposit Units

- Reserve requirements:

$$\hat{i}_t^{IB} = \frac{i^R}{i^{IB}}\hat{i}_t^R - \psi_2(\tilde{\varsigma}_t - \tilde{\varsigma}_t^{MP})$$

- Deposit rate:

$$\hat{i}_t^D = \left((1-\varsigma)\frac{i^{IB}}{i^D} + \varsigma\frac{i^R}{i^D}\right)\hat{i}_t^{IB} - \frac{i^{IB} - i^R}{i^D}\hat{\varsigma}_t^{MP}$$

- Reserves:

$$\hat{R}_t = \tilde{\varsigma}_t + \hat{D}_t$$

Lending Units

- Balance Sheet:

$$\hat{L}_t = \frac{D^{IB}}{L}\hat{D}_t^{IB} + \frac{K^b}{L}\hat{K}_t^b$$

- Bank capital dynamics

$$\hat{K}_t^b = (1-\delta^b)\hat{K}_{t-1}^b + \delta^b\hat{\Pi}_{t-1}$$

- Risk-free interest rate

$$\hat{i}_t^F = \frac{i^{IB}}{i^F}\hat{i}_t^{IB} - \kappa\frac{(K^b/L)^2}{i^F}\left((\frac{3K^b}{L} - 2v^b)(\hat{K}_t^b - \hat{L}_t) - v^b\hat{v}_t^b\right)$$

- Profits

$$\begin{aligned}\hat{\Pi}_t = &\frac{i^L}{\delta^b}\frac{L}{K^b}(\hat{i}_t^L + \hat{L}_t) + \frac{i^R}{\delta^b}\frac{\varsigma D}{K^b}(\hat{i}_t^R + \hat{R}_t) - \frac{i^D}{\delta^b}\frac{D}{K^b}(\hat{i}_t^D + \hat{D}_t)\\ &- \frac{\kappa K^b}{2}\left(\frac{K^b}{L} - v^b\right)^2\left(\kappa\left(\frac{K^b}{L}\right)^2\left(\frac{3K^b}{L} - 2v^b\right)\left(\hat{K}_t^b - \hat{L}_t\right) - v^b\hat{v}_t^b + \hat{K}_t^b\right)\end{aligned}$$

Financial contract

- Leverage and external finance premium:

$$E_t\hat{r}^K_{t+1} - \hat{i}^F_t + E_t\hat{\pi}_{t+1} = \eta(\hat{Q}_t + \hat{K}_t - \hat{N}_t)$$

- Loan rate (nominal and real):

$$\hat{r}^L_t = \hat{Q}_t + \hat{K}_t + E_t\hat{r}^K_{t+1} - \hat{L}_t$$

$$\hat{i}^L_t = \hat{r}^L_t + E_t\hat{\pi}_{t+1}$$

Entrepreneurs

- Balance Sheet:

$$\hat{Q}_t + \hat{K}_t = \epsilon_L\hat{L}_t + (1-\epsilon_L)\hat{N}_t$$

- Net Worth:

$$\hat{N}_t = \nu\hat{N}_{t-1} + (1-\nu)(\hat{Q}_{t-1} + \hat{K}_{t-1}) + \hat{r}^K_t + \nu\frac{\epsilon_L}{1-\epsilon_L}(\hat{r}^K_t - (\hat{i}^L_{t-1} - \pi_t))$$

Intermediate Goods Producers

- Production function:

$$\hat{y}_t = \hat{\xi}^A_t + \alpha\hat{K}_{t-1} + (1-\alpha)\hat{h}_t$$

- Marginal costs:

$$\hat{mc}_t = \alpha\hat{z}_t + (1-\alpha)\hat{W}_t - \hat{\xi}^A_t$$

- Cost minimization:

$$\hat{h}_t + \hat{W}_t = \hat{z}_t + \hat{K}_{t-1}$$

- Price setting:

$$\hat{\pi}^d_t = \beta E_t\hat{\pi}^d_{t+1} + \frac{(1-\theta)(1-\theta\beta)}{\theta}\hat{mc}_t + \hat{\xi}^{CP}_t$$

Capital Goods Producers

- Investment Demand:

$$\hat{Q}_t = \chi(\hat{I}_t - \hat{K}_{t-1})$$

- Price of capital:

$$\hat{r}^K_t + \hat{Q}_{t-1} = \frac{MPK}{r^K}\hat{z}_t + \frac{1-\delta}{r^K}\hat{Q}_t$$

  where MPK is the marginal product of capital.

- Capital dynamics:

$$\hat{K}_t = (1-\delta)\hat{K}_{t-1} + \delta\hat{I}_t$$

Monetary and Macroprudential Policy

- Taylor-rule:

$$\hat{i}_t^{IB} = \phi_{\pi,i}\hat{\pi}_t + \phi_{Y,i}\hat{Y}_t + \phi_{L,i}\hat{L}_t$$

- Reserve requirements:

$$\hat{\varsigma}_t^{MP} = \phi_{\pi,\varsigma}\hat{\pi}_t + \phi_{Y,\varsigma}\hat{Y}_t + \phi_{L,\varsigma}\hat{L}_t$$

- Capital requirements:

$$\hat{v}_t^{b} = \phi_{\pi,v}\hat{\pi}_t + \phi_{Y,v}\hat{Y}_t + \phi_{L,v}\hat{L}_t$$

Market Clearing

- Goods market:

$$\hat{Y}_t = \gamma(c_y\hat{C}_t + i_y\hat{I}_t + g_y\hat{G}_t + (1-\gamma)\hat{\epsilon}_t) + (1-\gamma)(\hat{\epsilon}_t + \hat{X}_t)$$

- Balance of payments

$$\hat{B}_t = \hat{Y}_t - (c_y\hat{C}_t + i_y\hat{I}_t + g_y\hat{G}_t + (1-\gamma)\hat{\epsilon}_t) + i^*\hat{B}_{t-1}$$

- Real exchange rate:

$$\hat{\epsilon}_t - \hat{\epsilon}_{t-1} = \Delta\hat{s}_t - \hat{\pi}_t^d$$

- CPI inflation rate:

$$\hat{\pi}_t = \gamma\hat{\pi}_t^d + (1-\gamma)\Delta\hat{s}_t$$

Appendix 2: Calibration

Table 3: Calibration

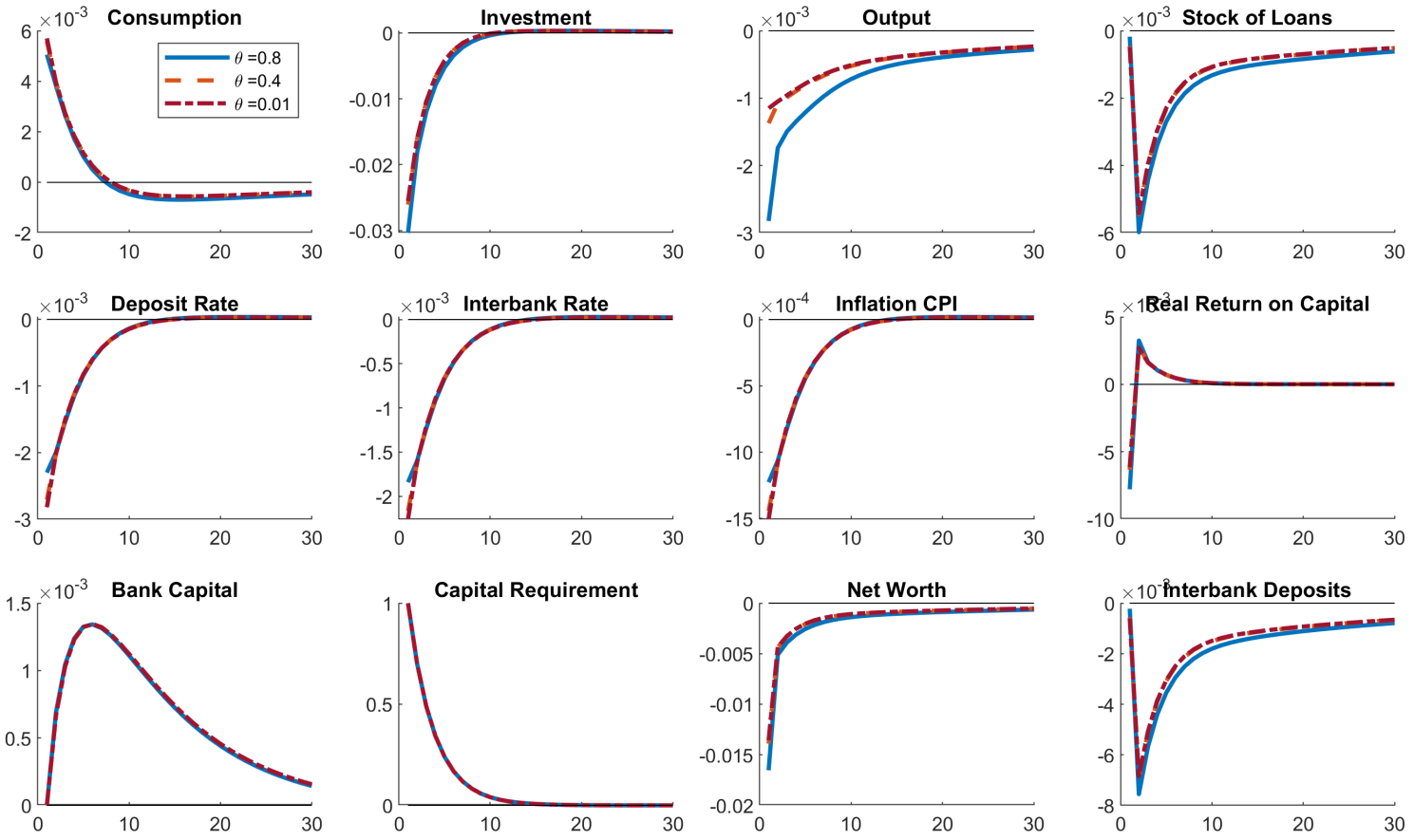
Param.	Value	Description
δ	0.025	Depreciation Rate of Capital
β	0.985	Discount Factor
α	0.33	Capital Share in Production
ϕ	3.00	Inverse of Frisch Labor Supply Elasticity
θ	0.75	Degree of Price Stickiness
ν	0.97	Survival Rate of Entrepreneurs
χ	0.25	Capital Adjustment Costs
η	0.05	Elasticity of External Finance Premium
ψ_B	0.02	Adjustment Costs for Net Foreign Assets
γ	0.75	Share of Domestically Produced Goods
c_y	0.55	Share of Consumption on Output
i_y	0.22	Share of Investment on Output
g_y	0.23	Share of Government Spending on Output
δ^b	0.1049	Bank Capital Depreciation
v^b	0.09	Target Capital-to-Loans Ratio
K^b/L	0.11	Actual Capital-to-Loans Ratio
κ	10	Sensitivity to Bank Capital Cost

Table 4: Calibration of the Shocks

ρ	σ^2	Description
0.89	1.13	Technology Shock
0.40	0.14	Cost-Push Shock
0.86	4.63	Government Expenditures Shock
0.88	0.43	Foreign Interest Rate Shock
0.80	5.01	Export Demand Shock

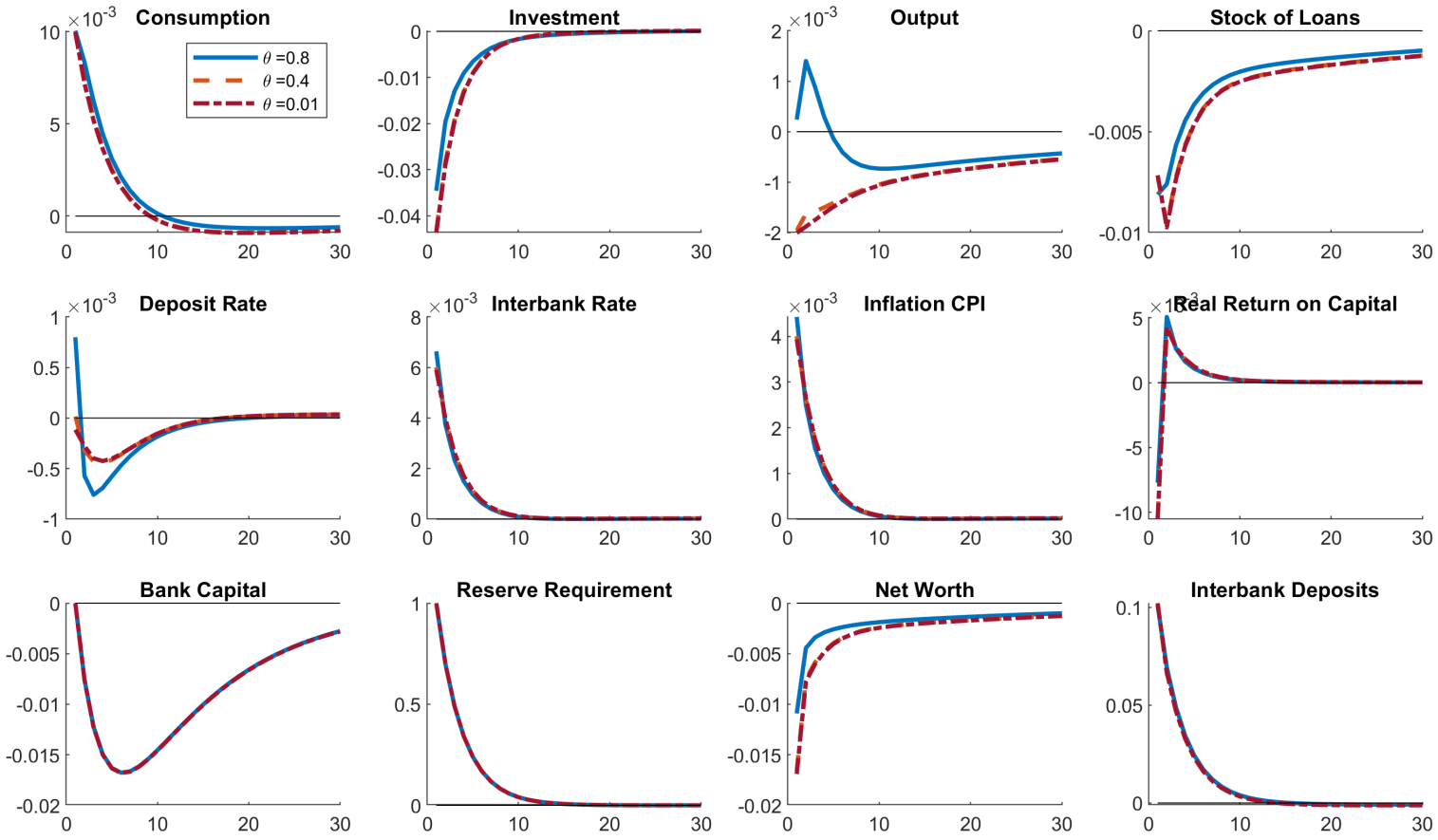
Appendix 3: Impulse Response functions

Figure 6: Capital Requirement Shock and the degree of Price Stickiness



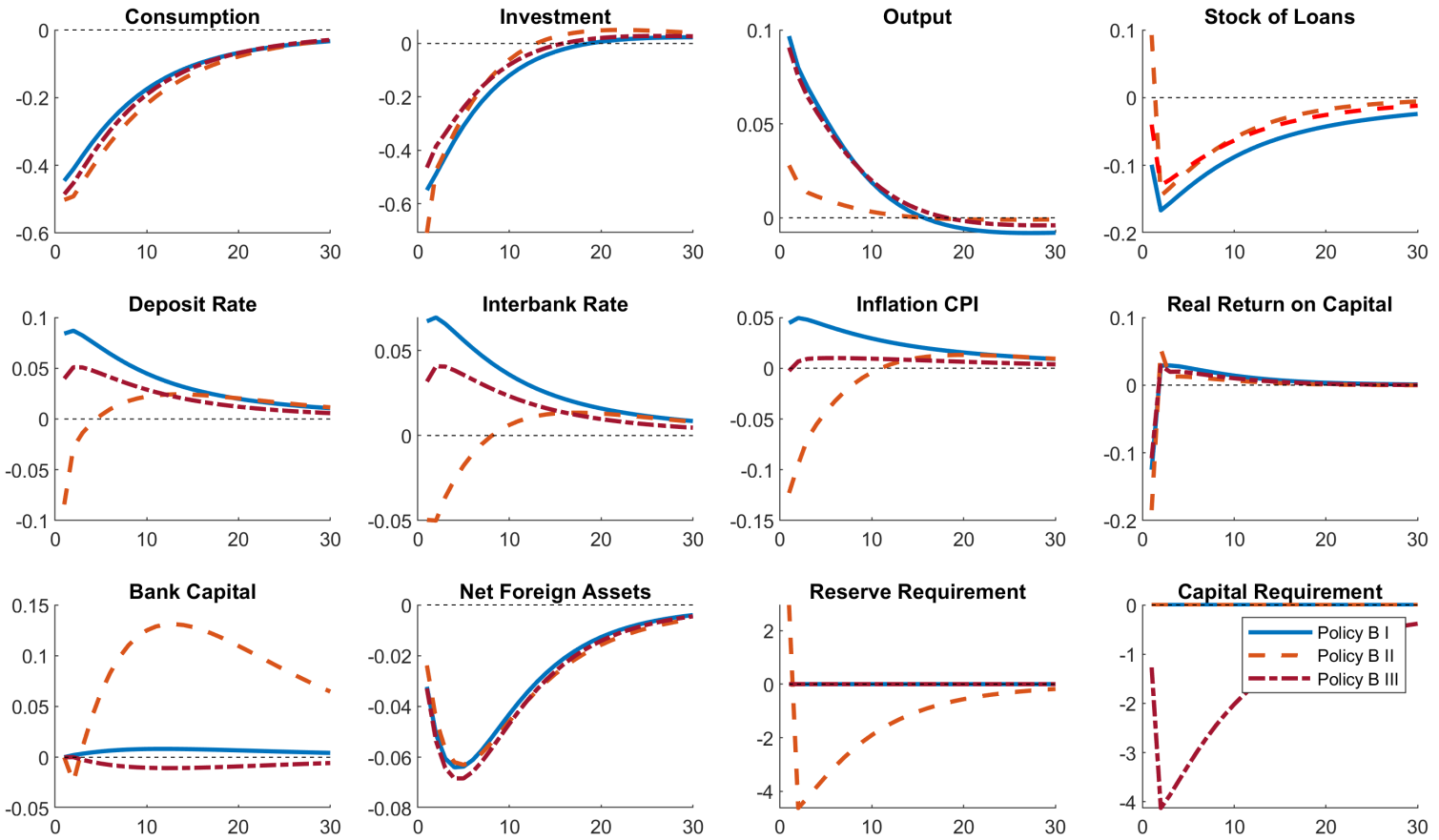
Note: The figure reports quarterly impulse responses to a 1-std deviation increase in capital requirements, considering a scenario with a financial accelerator mechanism and different values of θ. Monetary policy is specified by an interest rate rule for the interbank interest rate as defined in section 2.8 with $\phi_{\pi,i} = 1.5$ and the other coefficients equal 0. The y-axis denotes the deviation in percent from the steady state.

Figure 7: Reserve Requirement Shock and the degree of Price Stickiness



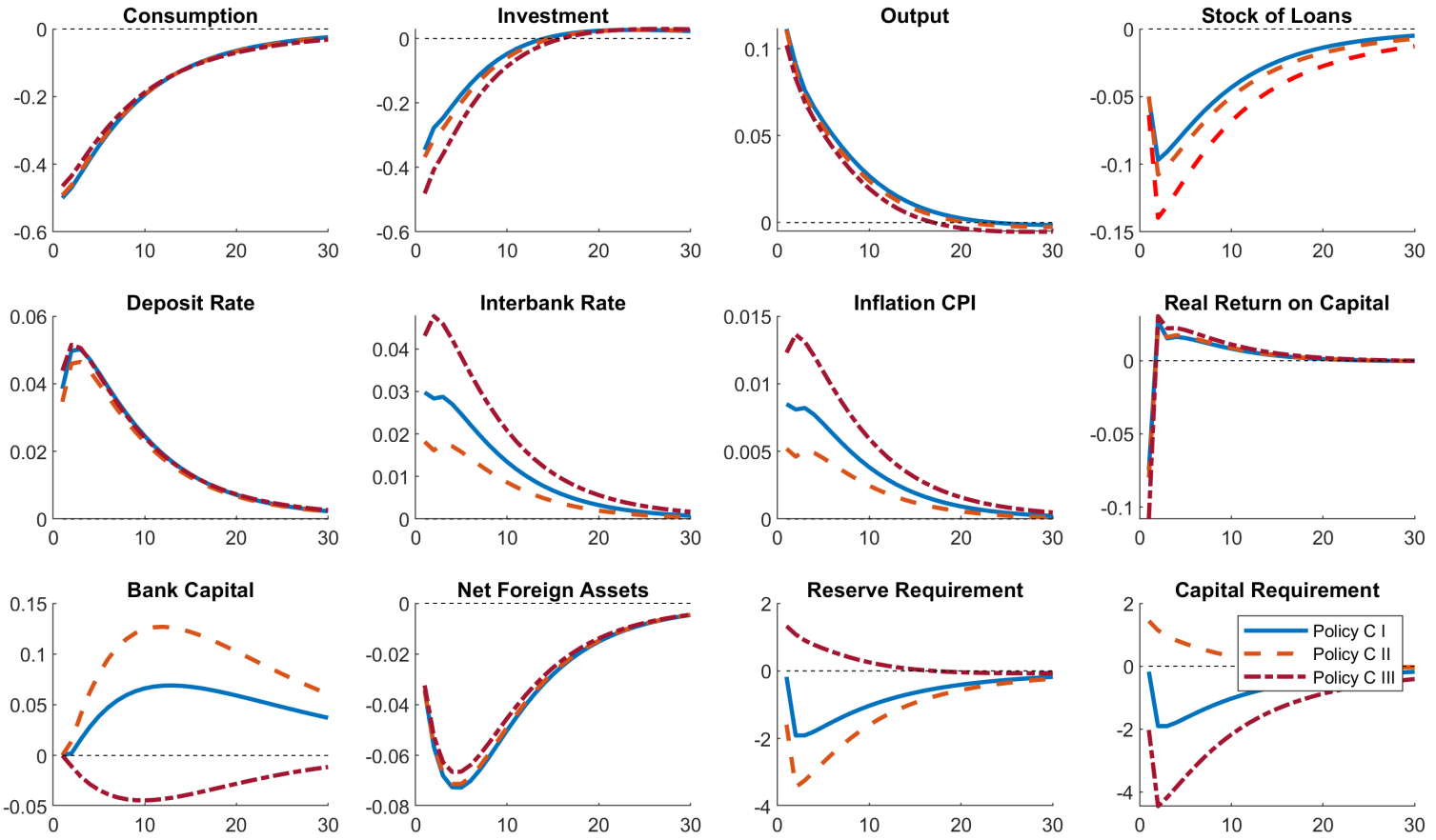
Note: The figure reports quarterly impulse responses to a 1-std deviation increase in reserve requirements, considering a scenario with a financial accelerator mechanism and different values of θ. Monetary policy is specified by an interest rate rule for the interbank interest rate as defined in section 2.8 with $\phi_{\pi,i} = 1.5$ and the other coefficients equal 0. The y-axis denotes the deviation in percent from the steady state.

Figure 8: Government shock under different Policy Rules and a Financial Stability Objective



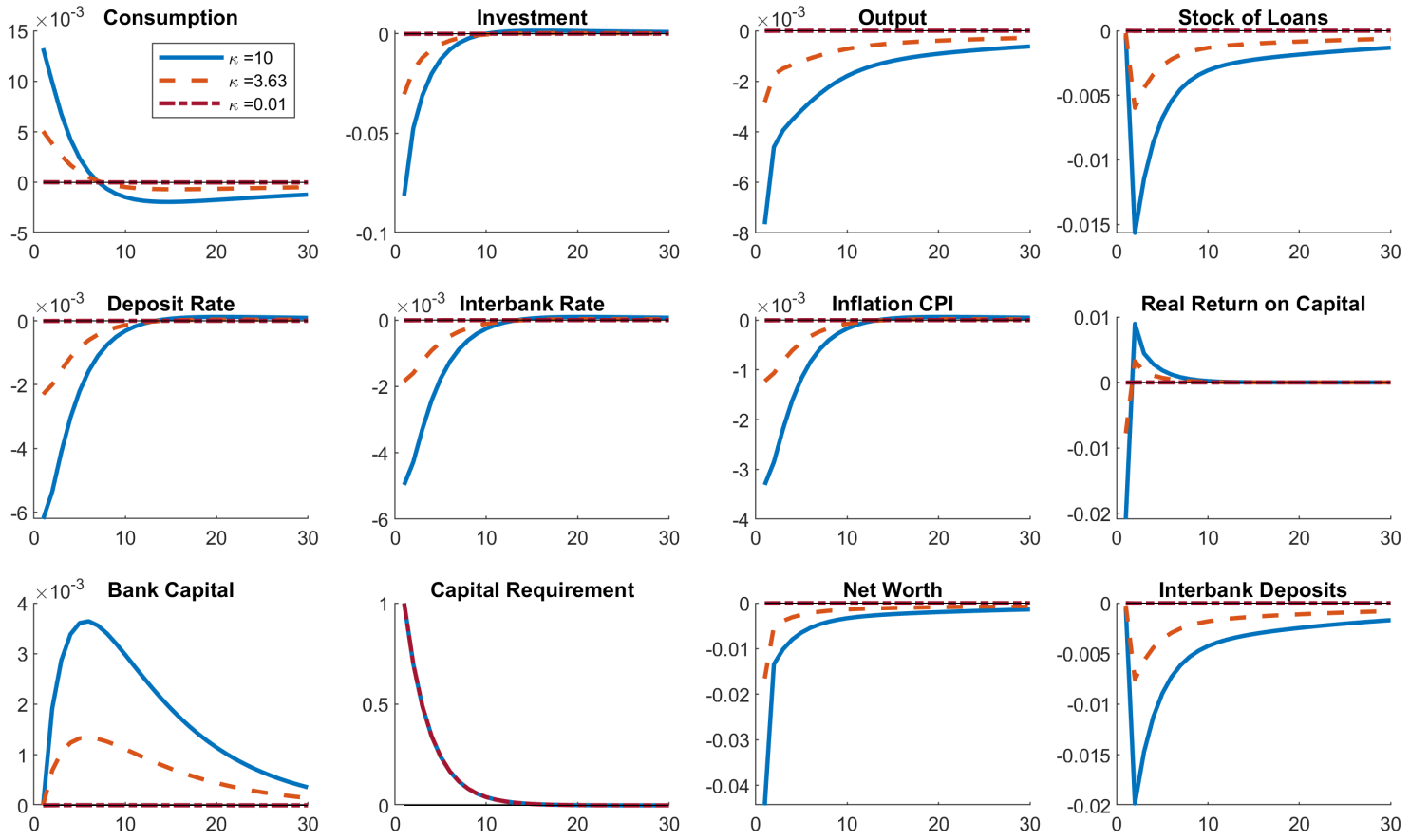
Note: The figure reports quarterly impulse responses to a 1-std deviation increase in government expenditure, considering a scenario with a financial accelerator mechanism and different policy rules, as described in the legend. The y-axis denotes the deviation in percent from the steady state.

Figure 9: Government shock under different Policy Rules and a Financial Stability Objective



Note: The figure reports quarterly impulse responses to a 1-std deviation increase in government expenditure, considering a scenario with a financial accelerator mechanism and different policy rules, as described in the legend. The y-axis denotes the deviation in percent from the steady state.

Figure 10: Capital requirement shock under different degrees of bank capital adjustment cost



The figure reports quarterly impulse responses to a 1-std deviation increase in capital requirements, considering different values for κ, the adjustment cost on bank capital. Monetary policy is specified by an interest rate rule for the interbank interest rate as defined in section 2.8 with $\phi_{\pi,i} = 1.5$ and the other coefficients equal 0. The y-axis denotes the deviation in percent from the steady state.

Appendix 4: List of Countries

Table 5: List of Countries

Country	Category (b)	Code	RR(%)	Last Obs.	CCyB (%)	CCyB?
Australia	High-income	AU	0.5%	Sep. 2024	1.0%	Yes
Austria	High-income	AT	1.0%	Aug. 2024		No
Bahrain	High-income	BH	5.0%	Sep. 2024		No
Belgium	High-income	BE	1.0%	Aug. 2024	1.0%	Yes
Brunei	High-income	BN	6.0%	Sep. 2024		No
Canada	High-income	CA	0.0%	Sep. 2024	0.0%	Yes
Chile	High-income	CL	9.0%	Sep. 2024	0.5%	Yes
Cyprus	High-income	CY	1.0%	Aug. 2024		No
Czech Republic	High-income	CZ	2.0%	Aug. 2024	1.3%	Yes
Denmark	High-income	DK	0.0%	Sep. 2024	2.5%	Yes
Estonia	High-income	EE	1.0%	Aug. 2024		No
Finland	High-income	FI	1.0%	Aug. 2024		No
France	High-income	FR	1.0%	Aug. 2024	1.0%	Yes
Germany	High-income	DE	1.0%	Aug. 2024	0.8%	Yes
Greece	High-income	GR	1.0%	Aug. 2024		No
Hong Kong	High-income	HK	0.0%	Sep. 2024	1.0%	Yes
Iceland	High-income	IS	3.0%	Aug. 2024	2.5%	Yes
Ireland	High-income	IE	1.0%	Aug. 2024	1.5%	Yes
Israel	High-income	IL	6.0%	Sep. 2024		No
Italy	High-income	IT	1.0%	Aug. 2024	0.0%	Yes
Japan	High-income	JP	0.8%	Jul. 2024	0.0%	Yes
Korea	High-income	KR	7.0%	Sep. 2024	1.0%	Yes
Latvia	High-income	LV	1.0%	Aug. 2024		No
Lithuania	High-income	LT	1.0%	Aug. 2024		No
Luxembourg	High-income	LU	1.0%	Aug. 2024	0.5%	Yes
Malta	High-income	MT	1.0%	Aug. 2024	0.0%	Yes
Netherlands	High-income	NL	1.0%	Aug. 2024	2.0%	Yes
Norway	High-income	NO	3.5%	Sep. 2024	2.5%	Yes
Oman	High-income	OM	5.0%	Sep. 2024		No
Poland	High-income	PL	3.5%	Dec. 2017		No
Portugal	High-income	PT	1.0%	Aug. 2024		No
Qatar	High-income	QA	4.5%	Sep. 2024	0.0%	Yes
Saudi Arabia	High-income	SA	7.0%	Sep. 2024	0.0%	Yes
Singapore	High-income	SG	3.0%	Sep. 2024	0.0%	Yes
Slovakia	High-income	SK	1.0%	Jul. 2021	1.5%	Yes
Slovenia	High-income	SI	1.0%	Aug. 2024		No
Spain	High-income	ES	1.0%	Aug. 2024	0.0%	Yes
Sweden	High-income	SE	0.0%	Sep. 2024	2.0%	Yes
Switzerland	High-income	CH	2.5%	Sep. 2024	0.0%	Yes
Taiwan	High-income	TW	4.8%	Aug. 2024		No
United Arab Emirates	High-income	AE	1.0%	Sep. 2024		No
United Kingdom	High-income	GB	0.0%	Sep. 2024	2.0%	Yes
United States	High-income	US	0.0%	Sep. 2024	0.0%	Yes
Algeria	Upper-middle-income	DZ	3.0%	Sep. 2023		No
Argentina	Upper-middle-income	AR	42.0%	May 2024	0.0%	Yes

Country	Category (b)	Code	RR(%)	Last Obs.	CCyB (%)	CCyB?
Azerbaijan	Upper-middle-income	AZ	5.0%	Aug. 2024		No
Belarus	Upper-middle-income	BY	20.0%	Oct. 2024		No
Bosnia	Upper-middle-income	BA	10.0%	Aug. 2024		No
Botswana	Upper-middle-income	BW	2.5%	Feb. 2021		No
Brazil	Upper-middle-income	BR	21.0%	Jul. 2024	0.0%	Yes
Bulgaria	Upper-middle-income	BG	10.0%	Sep. 2024		No
China	Upper-middle-income	CN	6.6%	Sep. 2024	0.0%	Yes
Colombia	Upper-middle-income	CO	8.0%	Sep. 2024		No
Croatia	Upper-middle-income	HR	2.7%	Dec. 2022		No
Ecuador	Upper-middle-income	EC	2.0%	Aug. 2022		No
Hungary	Upper-middle-income	HU	10.0%	Sep. 2024		No
Iran	Upper-middle-income	IR	10.0%	May 2024		No
Kazakhstan	Upper-middle-income	KZ	2.0%	Oct. 2024		No
Kosovo	Upper-middle-income	XK	10.0%	(yearly) 2022		No
Lebanon	Upper-middle-income	LB	25.0%	Aug. 2024		No
Malaysia	Upper-middle-income	MY	2.0%	Aug. 2024		No
Mauritius	Upper-middle-income	MU	9.0%	Sep. 2024		No
Mexico	Upper-middle-income	MX	0.0%	Sep. 2024	0.0%	Yes
Montenegro	Upper-middle-income	ME	5.5%	Aug. 2024		No
North Macedonia	Upper-middle-income	MK	8.0%	Sep. 2024		No
Peru	Upper-middle-income	PE	5.5%	Sep. 2024	2.5%	Yes
Romania	Upper-middle-income	RO	8.0%	Aug. 2024		No
Russia	Upper-middle-income	RU	4.5%	Sep. 2024	0.0%	Yes
Serbia	Upper-middle-income	RS	7.0%	Aug. 2024	0.0%	Yes
South Africa	Upper-middle-income	ZA	2.5%	Sep. 2024	0.0%	Yes
Sri Lanka	Upper-middle-income	LK	4.0%	Jun. 2023		No
Thailand	Upper-middle-income	TH	1.0%	Sep. 2024		No
Turkey	Upper-middle-income	TR	8.0%	Sep. 2024	0.0%	Yes
Venezuela	Upper-middle-income	VE		Aug. 2024		No
Armenia	Lower-middle-income	AM	8.0%	(yearly) 2024	1.5%	Yes
Bangladesh	Lower-middle-income	BD	4.0%	Sep. 2024		No
Bolivia	Lower-middle-income	BO	8.5%	Jul. 2024		No
Cambodia	Lower-middle-income	KH	7.0%	Sep. 2024		No
Egypt	Lower-middle-income	EG	18.0%	Sep. 2024		No
Georgia	Lower-middle-income	GE	5.0%	Aug. 2024		No
India	Lower-middle-income	IN	4.5%	Sep. 2024	0.0%	Yes
Indonesia	Lower-middle-income	ID	9.0%	Sep. 2024	0.0%	Yes
Ivory Coast	Lower-middle-income	CI	3.0%	Dec. 2023		No
Kenya	Lower-middle-income	KE	4.3%	Mar. 2023		No
Kyrgyzstan	Lower-middle-income	KG	9.0%	Sep. 2015		No
Laos	Lower-middle-income	LA	8.0%	Sep. 2024		No
Malawi	Low-income	MW	8.8%	Aug. 2024		No
Moldova	Lower-middle-income	MD	31.0%	May 2024		No
Mongolia	Lower-middle-income	MN	8.0%	Sep. 2024		No
Morocco	Lower-middle-income	MA	0.0%	Sep. 2024		No
Mozambique	Low-income	MZ	39.0%	Oct. 2024		No
Myanmar	Low-income	MM	3.8%	Sep. 2024		No
Nepal	Low-income	NP	4.0%	Sep. 2024		No
Nigeria	Lower-middle-income	NG	45.0%	Aug. 2024		No
Pakistan	Lower-middle-income	PK	5.0%	Sep. 2024	0.0%	Yes

Country	Category (b)	Code	RR(%)	Last Obs.	CCyB (%)	CCyB?
Philippines	Lower-middle-income	PH	9.5%	Sep. 2024	0.0%	Yes
Sudan	Low-income	SD	18.0%	Sep. 2024		No
Tajikistan	Lower-middle-income	TJ	3.0%	Mar. 2024		No
Tunisia	Lower-middle-income	TN	1.0%	Aug. 2024		No
Ukraine	Lower-middle-income	UA	20.0%	Sep. 2024		No
Vietnam	Lower-middle-income	VN	3.0%	Sep. 2024		No
Yemen	Low-income	YE	7.0%	Aug. 2015		No
Zambia	Low-income	ZM	26.0%	Aug. 2024		No

The data on reserve requirements was obtained from the CEIC Data website, a comprehensive resource that provides up-to-date information for numerous countries. We cross-referenced this information with data from the Bank for International Settlements (BIS), which details countries' compliance with countercyclical buffers. Additionally, we incorporated the data from Cerutti et al. (2017) which examines the use of countercyclical buffers across a broader set of countries, despite with updates only through 2017. This multi-source approach ensures a robust analysis of reserve requirements and countercyclical policies globally.