Policy Mandates for Macroeconomic and Financial Stability

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Abstract

The paper examines the performance of alternative institutional policy mandates for achieving macroeconomic and financial stability in a model with financial frictions and fractional reserves. These arrangements involve goal-integrated, goal-distinct, and common-goal mandates for the monetary authority and the financial regulator. In the first case both monetary and macroprudential policies are set optimally, but in the last two cases monetary policy only is set optimally whereas macroprudential policy is implemented through a simple rule linking the required reserve ratio and the credit-to-output ratio. A parameterized version of the model is used to simulate responses to a financial shock. The analysis shows that under the goal-integrated mandate, and for some parameter configurations, it may be optimal to use only the required reserve ratio rather than the refinance rate. In addition, it is also optimal to delegate the financial stability goal solely to the monetary authority, when the financial regulator is equipped only with a simple, credit-based reserve rule to conduct macroprudential regulation. To that end, a broader information set and/or a broader range of instruments may be needed.

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1 Introduction

The global financial crisis prompted a far-reaching debate on the role of monetary and macroprudential policies in achieving macroeconomic and financial stability. A key question in that context has been the extent to which central banks, in addition to pursuing a price stability objective, should also respond to financial imbalances—in the form of either a significant and sustained deviation of asset prices from their longer-term trends or unsustainable credit expansion.

A number of contributions have attempted to examine this issue in formal dynamic stochastic general equilibrium (DSGE) models with financial frictions and an explicit account of financial regulation. Some of these contributions have focused on the trade-offs that may arise when monetary policy rules are designed to lean against the build-up of financial imbalances, compared to the case where standard Taylor-type monetary policy rules are complemented by macroprudential rules designed to achieve financial stability. These contributions include Faia and Monacelli (2007), Akram and Eitrheim (2008), Christensen et al. (2011), Gelain et al. (2012), Agénor et al. (2013), Angelini et al. (2014), Rubio and Carrasco-Gallego (2014), and Svensson (2015). Christensen et al. (2011), Agénor et al. (2013), and Angelini et al. (2014) for instance focused on the interaction between monetary policy and countercyclical capital buffers, whereas Rubio and Carrasco-Gallego (2014) examined the interplay between monetary policy and loan-to-value ratios. Several of these studies found that, in the presence of financial shocks, countercyclical capital requirements may yield a significant gain in terms of macroeconomic stabilization, regardless of the way monetary and capital requirements policies interact. In addition, some also found that when monetary policy "leans against the wind" significant gains can be achieved in terms of either reduced macroeconomic and financial volatility or higher welfare.

Other contributions, however, have argued—based on Tinbergen's effective assignment principle—that monetary policy should remain squarely focused on macroeconomic stability, whereas macroprudential policy should focus solely on financial stability. For Svensson (2015) for instance, monetary policy should almost never be used to contain threats to financial stability and so should not have a financial stability goal; moreover, monetary policy and macroprudential policies should be conducted by separate entities and need not be coordinated.[1] A higher monetary policy interest rate, for instance, may have benefits in terms of lower real debt growth and a lower probability of a financial crisis, but it may have costs in terms of higher unemployment and lower inflation, which may increase the cost of a crisis when the economy is weaker. At the same time, this policy assignment may be suboptimal if the ability of macroprudential regulation to mitigate credit growth is not well established or if the regulatory structure is fragmented—thereby impeding the effective operation of macroprudential tools.[2] A fair assessment therefore is that the debate on whether monetary policy should be used to achieve a financial stability objective, in the context of either separate or joint mandates with a macroprudential regulation, remains largely unsettled.

The purpose of this paper is to contribute to the ongoing debate about the "cost-benefit analysis" of different institutional policy mandates for achieving macroeconomic and financial stability (or, for short, economic stability). It uses a model with banking and financial frictions to analyze how monetary and macroprudential

[1] A similar view is taken by the International Monetary Fund (2015). An often cited example as to why monetary policy should not be used as the primary tool for achieving financial stability is the Riksbank's attempt to use monetary policy to choke off upward pressure on house prices and household debt in Sweden during the period 2010-11, when the policy rate was raised from 0.25 percent to 2 percent in the span of a few months. Svensson (2016) argued that it ultimately generated below-target inflation, higher unemployment and even higher real debt.

[2] Even though recent empirical studies suggests that sector-specific macroprudential tools have proved effective in terms of mitigating financial risks (especially in terms of mitigating pressure on house prices), the evidence is either less compelling or quasi inexistent when it comes to some of the countercyclical tools introduced under the new Basel arrangement (such as countercyclical capital buffers or the net funding ratio) and other tools such as dynamic provisions. See Akinci and Olmstead-Rumsey (2015), Bruno et al. (2015), and Cerutti et al. (2015) for instance.

policies interact to shape macroeconomic outcomes and mitigate financial volatility. We focus on reserve requirements as a macroprudential tool—an instrument that has been used extensively in middle-income countries in recent years, not only as a substitute to monetary policy (during episodes of large capital flows) but also as a tool to manage financial risks.[3] Although reserve requirements have either disappeared or have been set at very low levels in high-income countries, they have been made part of Basel III's liquidity requirement ratio (see Basel Committee on Banking Supervision (2011, 2013)).[4] There has been some discussion recently on whether in these countries reserve requirements should not only be increased permanently but also used—as we discuss in this paper—as a countercyclical rule to mitigate excessive credit growth.

We also analyze three alternative institutional arrangements for achieving macroeconomic and financial stability, with the former defined in terms of the volatility of output and inflation, and the latter in terms of the volatility of the credit-to-output ratio and the bank lending spread. The first arrangement is the *goal-integrated mandate*, where the monetary authority and the financial regulator coexist inside the central bank, whose goal is to minimize a social loss function in terms of two instruments (the policy rate and the required reserve ratio) in order to achieve *jointly* macroeconomic and financial stability. Thus, under this regime we consider not only whether it is optimal for monetary policy to lean against the build-up of financial imbalances but also whether macroprudential regulation can contribute to achieving macroeconomic stability as well. Under the second institutional arrangement, *goal-distinct mandates*, the central bank sets the policy rate (by minimizing its loss function) to achieve macroeconomic stability *only*, whereas the financial regulator

[3] See Agénor et al. (2015) and Agénor and Pereira da Silva (2016) for a detailed discussion of the evidence.

[4] Historically, reserve requirements played a significant role in many of today's high-income countries; see Elliot et al. (2013) for instance for a discussion of the experience of the United States over the period 1948-80.

sets the reserve requirement ratio on the basis of a simple implementable rule based *only* on the behavior of the credit-to-output ratio. Finally, under the third arrangement, *common-goal mandates*, the financial stability goal is given to both the central bank, consisting only of the monetary authority, and to an independent and separate financial regulator. Yet, the central bank is allowed to set the policy rate only (by minimizing its loss function) to achieve both macroeconomic and financial stability, whereas the financial authority sets the required reserve ratio as under the second mandate, that is, using a simple implementable rule. In all three regimes, policymakers have access to their own instrument and set its value according to a specific rule.

The remainder of the paper proceeds as follows. Section 2 presents the model, which is based in part on Agénor et al. (2013) but with an important difference—it introduces a penalty rate in the cost of borrowing from the central bank to account for imperfect substitutability between funding sources for commercial banks (deposits and central bank liquidity), thereby creating a role for changes in reserve requirements as a countercyclical policy. The equilibrium solution of the model and some key features of its steady state and log linearization are discussed in Sections 3 and 4, whereas a parameterization is presented in Section 5. The performance of alternative mandates in response to a financial shock (an increase in the risk of default) is studied in Section 6. In contrast to several existing studies, in which standard and augmented Taylor rules are directly specified, we solve explicitly for the monetary policy rule (as well as the macroprudential rule under the integrated mandate) that minimizes a social loss function. The last section offers some concluding remarks and discusses some possible extensions of the analysis.

2 The Model

We consider a closed economy with nine categories of agents: a final good-producing (FGP) firm, a capital good (CG) producer, employment agencies, a continuum of intermediate good-producing (IGP) firms indexed by $j \in [0, 1]$, a representative household indexed by $i \in [0, 1]$, a commercial bank, the government, a monetary authority and a financial authority.

The FGP firm aggregates imperfectly substitutable intermediate goods into a single final good which is sold in a perfectly competitive market. The CG producer buys I_t of the final good for investment and to produce new capital. Each IGP firm produces an intermediate good using capital rented from the CG producer and homogenous labor provided by the employment agencies. Competitive employment agencies combine specialized labor supplied by households into an homogenous labor input.

Households hold IGP firms and commercial banks, consume the final good, supply specialized labor to employment agencies and supply deposits to the commercial bank.

The commercial bank supplies credit to the CG producer to purchase the final good. The bank's supply of loans is perfectly elastic at the prevailing lending rate. Loans are paid off at the end of the period. All the credit demanded by the commercial bank is supplied by a monetary authority which, along with a financial regulator, is in charge of macroeconomic and financial stability. We consider alternatives scenarios with respect to the goals, the instruments, and the operating procedure the society gives to these authorities.

2.1 Final Good-Producing Firm

The final good producer uses a continuum of imperfectly substitutable intermediate goods Y_{jt}, indexed by $j \in [0, 1]$, to produce the final good Y_t. The production technology for combining intermediate goods to produce the final good is given by:

$$Y_t = \left\{ \int_0^1 Y_{jt}^{(\theta-1)/\theta} dj \right\}^{\theta/(\theta-1)}, \tag{1}$$

where $\theta > 1$ represents the elasticity of substitution.

Given the prices of intermediate goods P_{jt} and the price of the final good P_t, the final good-producing firm chooses the quantities of intermediate goods to maximize its profits. The profit maximization problem of the final good producer is given by:

$$\max_{Y_{jt}} P_t \left\{ \int_0^1 Y_{jt}^{(\theta-1)/\theta} dj \right\}^{\theta/(\theta-1)} - \int_0^1 P_{jt} Y_{jt} dj.$$

The first-order condition with respect to Y_{jt} gives the demand for each intermediate good j:

$$Y_{jt} = (\frac{P_{jt}}{P_t})^{-\theta} Y_t. \tag{2}$$

Substituting (2) in (1) yields the final good price:

$$P_t = (\left\{ \int_0^1 P_{jt}^{1-\theta} dj \right\}^{1/(1-\theta)}. \tag{3}$$

The final good Y_t is used for private and government consumption as well as investment by the CG producer.

2.2 Capital Good Producer

All the capital used in the economy is owned by the CG producer who employs a linear production function to produce capital goods. At the beginning of each period, the capital good producer purchases I_t of the final good from the final good producer. Since payments for these final goods must be made in advance, the CG producer borrows from the commercial bank, $L_t^F = P_t I_t$, where L_t^F denotes loans made to the CG producer for investment. In real terms,

$$l_t^F = I_t. \tag{4}$$

Loans are repaid at the end of the period. The total cost of buying an amount I_t of the final good is $(1 + i_{t-1}^L)P_t I_t$, where i_t^L is the lending rate.

The CG producer combines undepreciated capital from the previous period, with investment to produce new capital goods and rents it to IGP firms at the rate r_t^K.

New capital goods, denoted as K_{t+1}, are given by:

$$K_{t+1} = I_t + (1 - \delta_K)K_t - \frac{\Theta_K}{2}(\frac{K_{t+1}}{K_t} - 1)^2 K_t, \tag{5}$$

where $\delta_K \in (0, 1)$ gives the constant rate of depreciation and $\Theta_K > 0$ measures the magnitude of adjustment costs.

The CG producer chooses the amount of capital stock that will maximize the value of the discounted stream of dividend payments to the household. The optimization problem of the CG producer is given by

$$\max_{K_{t+1}} \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \Lambda_{t+s}(\frac{J_{t+s}^K}{P_{t+s}}), \tag{6}$$

where $\mathbb{E}_t$ is the expectation operator conditional on the information available at period t and

$$J_t^K = r_t^K P_t K_t - q_t(1 + i_{t-1}^L)P_t I_t - (1 - q_t)\,\kappa P_t K_t,$$

is nominal profits and $q_t \in (0, 1)$ is the repayment probability of IGP firms (assumed identical across them) and is given by

$$q_t = \phi(\frac{\kappa K_{t-1}}{P_{t-1} L_{t-1}^F})^{\phi_1}(\frac{Y_{t-1}}{Y})^{\phi_2}\xi_t, \tag{7}$$

where $\kappa \in (0, 1)$ and ξ_t is a financial shock, which follows an $AR(1)$ process of the form

$$\xi_t = \xi_{t-1}^{\rho_\xi} \exp(\varepsilon_t), \tag{8}$$

where $\rho_\xi \in (0, 1)$ and $\varepsilon_t \sim \mathbf{N}(0, \sigma_\varepsilon)$. Thus, the repayment probability depends on the collateral-loan value (lagged one period) and on cyclical output, where Y denotes the steady-state value of Y_t.

Maximizing (6) subject to (5), yields the first-order condition

$$\mathbb{E}_t r^K_{t+1} = q_t(1+i^L_{t-1})E_t\left\{\left[1+\Theta_K(\frac{K_{t+1}}{K_t}-1)\right](\frac{1+i^B_t}{1+\pi_{t+1}})\right\} \tag{9}$$

$$+\mathbb{E}_t\left\{(1-q_{t+1})\,\kappa - q_{t+1}(1+i^L_t)\left\{1-\delta+\frac{\Theta_K}{2}\left[\left(\frac{K_{t+2}}{K_{t+1}}\right)^2-1\right]\right\}\right\}.$$

2.3 Intermediate Good-Producing Firms

Each IGP firm, indexed by $j \in [0,1]$, produces a separate good which is sold on a monopolistically competitive market. To produce these goods, each firm rents capital at the price r^K_t, and combines it with an homogenous labor input bought at the real wage $\omega_t = P_t^{-1}W_t$. The technology faced by IGP firms are given by the Cobb-Douglas production function:

$$Y_{jt} = K^{\alpha}_{jt}N^{1-\alpha}_{jt}, \tag{10}$$

where N_{jt} is household $h = j$ labor hours, K_{jt} is the amount of capital rented by the firm, $\alpha \in (0,1)$ is the elasticity of output with respect to capital.

IGP firms solve a two-stage problem. In the first stage, given input prices and technology, firms integrate capital and labor in a perfectly competitive market in order to minimize real costs. Thus the cost minimization problem for firm j is:

$$\min_{N_{jt},K_{jt}} \omega_t N_{jt} + r^K_t K_{jt}, \tag{11}$$

subject to (10). From the first-order conditions with respect to N_{jt} and K_{jt} we obtain a common capital-labor ratio among producers

$$\frac{K_{j,t}}{N_{j,t}} = \frac{\omega_t}{r^k_t}\frac{\alpha}{1-\alpha}, \tag{12}$$

and thus a common unit real marginal cost

$$mc_{j,t} = \frac{\omega_t^{1-\alpha}(r^K_t)^{\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}. \tag{13}$$

In the second stage, each IGP firm chooses the optimal price at random intervals following the standard Calvo staggered price model and have the opportunity to change their prices with probability $1 - \omega_p$. Thus, a firm j that is allowed to set its price in period t chooses its new price for the random period starting in t, P_t, to maximize, subject to (2), the expected discounted value of current and future real profits

$$\max_{P_{jt}} \mathbb{E}_t \sum_{s=0}^{\infty} \omega_p^s \frac{\beta^s \Lambda_{t+s}}{\Lambda_t} \left\{ (\frac{P_{jt}}{P_{t+s}} - mc_{jt+s}) Y_{jt+s} \right\} \tag{14}$$

where Λ_t is the marginal utility of nominal income. The first-order condition is then

$$\mathbb{E}_t \left\{ \sum_{s=0}^{\infty} \omega_p^s \beta^s \Lambda_{t+s} \tilde{Y}_{t+s} (\tilde{P}_t - \frac{\theta}{\theta - 1} mc_{t+s}) \right\} = 0,$$

where $\tilde{P}_t$ is the optimally chosen price, which is the same for all IGP firms and $\tilde{Y}_{t+s}$ and mc_{t+s} are, respectively, the demand they face and the marginal costs in $t + s$. IGP firms buy labor from employment agencies.

2.4 Employment Agencies

As in Erceg et al. (2000), a large number of competitive employment agencies combine specialized labor type $N_{i,t}$ supplied by each household into a homogenous labor input according to

$$N_t = [\int_0^1 N_{i,t}^{(\theta_\omega - 1)/\theta_\omega} di]^{\theta_\omega / (\theta_\omega - 1)}, \tag{15}$$

where $\theta_\omega > 1$ is the constant elasticity of substitution between different types of labor.

Profit maximization by the perfectly competitive employment agencies implies that the demand for each labor type is

$$N_{i,t} = (\frac{W_{i,t}}{W_t})^{-\theta_\omega} N_t, \tag{16}$$

where $W_{i,t}$ is the wage paid by the employment agencies to the supplier of labor of type i and W_t the aggregate wage paid by IGP firms for the composite labor input N_t and is given by

$$W_t = (\int_0^1 W_{i,t}^{1-\theta_\omega} di)^{1/(1-\theta_\omega)}. \tag{17}$$

2.5 Household

The representative household in the model maximizes utility from consumption, hours worked and real monetary assets. His discounted utility is:

$$U_t = \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \left\{ \frac{C_{t+s}^{1-\sigma^{-1}}}{1-\sigma^{-1}} - \frac{N_{i,t+s}^{1+\gamma}}{1+\gamma} + \eta_x \ln x_{t+s} \right\}, \tag{18}$$

where C_t is consumption, $N_{i,t}$ the share of total time endowment (normalized to unity) spent working, x_t a composite index of real monetary assets, and $\beta \in (0,1)$ the discount factor, $\sigma > 0$ is the intertemporal elasticity of substitution in consumption, $\gamma > 0$ is the inverse of the Frisch elasticity of labor supply, and $\eta_x > 0$.

The composite monetary assets is a combination of real cash balances m_t^H and real bank deposits d_t:

$$x_{ht} = (m_t^H)^\nu d_t^{1-\nu}, \tag{19}$$

where $\nu \in (0,1)$.

Nominal wealth at the end of period t, A_t, is given by

$$A_t = M_t^H + D_t + B_t^H, \tag{20}$$

where $M_t^H = P_t m_t^H$ is nominal cash holdings, $D_t = P_t d_t$ is nominal bank deposits, and $B_t = P_t b_t$ represents holdings of one-period nominal government bonds.

The household enters period t with M_{t-1}^H holdings of cash. It also collects principal plus interest on bank deposits at the rate contracted in $t-1$, $(1+i_{t-1}^D)D_{t-1}$, where i_{t-1}^D is the interest rate on deposits, principal and interest payments on maturing government bonds, $(1+i_{t-1}^B)B_{t-1}^H$, where i_{t-1}^B is the bond rate at $t-1$.

At the beginning of the period, the household chooses the real levels of cash, deposits, and bonds, and supplies labor to IGP firms, for which it receives factor payment $\omega_t N_t$, where $\omega_t = W_t/P_t$ is the economy-wide real wage, with W_t denoting the nominal wage.

The household receives all the profits made by the IGP firms, $J_t^I = \int_0^1 \Pi_{jt}^I dj$, and by the CG producer.[5] In addition, it receives all the profits of the bank, J_t^B. It also pays a lump-sum tax, whose real value is T_t.

The household's real budget constraint is thus

$$C_t + m_t^H + d_t + b_t^H = \omega_t N_t - T_t + (\frac{P_{t-1}}{P_t})m_{t-1}^H + (1+i_{t-1}^D)(\frac{P_{t-1}}{P_t})d_{t-1} \quad (21)$$

$$+(1+i_{t-1}^B)(\frac{P_{t-1}}{P_t})b_{t-1}^H + \frac{J_t^I}{P_t} + \frac{J_t^B}{P_t}.$$

Maximizing the utility function (18), with respect to C_t, b_t^H, m_t^H, and d_t, subject to (19)-(21), and taking i_t^D, i_t^B, P_t, and T_t as given, yields the following first-order conditions:

$$C_t^{-1/\sigma} = \Lambda_t P_t, \quad (22)$$

$$\mathbb{E}_t(\frac{C_t^{-1/\sigma}}{C_{t+1}^{-1/\sigma}}) = \beta \mathbb{E}_t(\frac{1+i_t^B}{1+\pi_{t+1}}), \quad (23)$$

$$m_t^H = \frac{\eta_x \nu C_t^{1/\sigma}(1+i_t^B)}{i_t^B}, \quad (24)$$

$$d_t = \frac{\eta_x (1-\nu) C_t^{1/\sigma}(1+i_t^B)}{i_t^B - i_t^D}, \quad (25)$$

where Λ_t is the marginal utility of nominal income and $1 + \pi_{t+1} = P_{t+1}/P_t$ denotes the gross inflation rate.

Equation (23) represents the Euler equation, (24) shows the demand for real cash balances which is positive to consumption and negative to the opportunity cost of

[5] As noted below, the FGP firm makes zero profits.

holding money; and equation (25) denotes the real demand for deposits which has a positive relationship with consumption and the deposit rate.

As in Erceg et al. (2000), in each period a constant fraction ω_w of workers cannot reoptimize its wage and follows the indexation rule

$$W_{i,t} = (1 + \pi_{t-1}) W_{i,t-1},$$

while the remaining fraction chooses the optimal wage by maximizing

$$\mathbb{E}_t \left\{ \sum_{s=0}^{\infty} \omega_w^s \beta^s \left[-\frac{N_{i,t+s}^{1+\gamma}}{1+\gamma} + \Lambda_{t+s} W_{i,t} N_{i,t+s} \right] \right\},$$

subject to the labor demand function (16). The wage-setting equation for workers renegotiating their salary is given by the following first-order condition:

$$\mathbb{E}_t \left\{ \sum_{s=0}^{\infty} \omega_w^s \beta^s \Lambda_{t+s} N_{t+s} \left[\tilde{W}_t \Pi_{t,t+s}^w - \frac{\theta_\omega}{\theta_\omega - 1} \frac{\tilde{N}_{t+s}^\gamma}{\Lambda_{t+s}} \right] \right\} = 0, \tag{26}$$

where

$$\Pi_{t,t+s}^w = \begin{cases} 1 & \text{for } s = 0 \\ \prod_{k=1}^{s} (P_{t+k}/P_{t+k-1}) & \text{for } s = 1, 2, ... \end{cases}$$

and wages evolve as

$$W_t = \left[(1 - \omega_w) \tilde{W}_t^{\theta_\omega - 1} + \omega_w (\pi_{t-1} W_{t-1})^{\theta_\omega - 1} \right]^{\frac{1}{\theta_\omega - 1}}. \tag{27}$$

2.6 Commercial Bank

Assets of the bank at the beginning of period t consist of loans, L_t^F, and reserve holdings, R_t, whereas its liabilities comprise loans from the central bank, L_t^B, and household deposits, D_t. The bank's balance sheet can be written as:

$$L_t^F + R_t = D_t + L_t^B. \tag{28}$$

Reserves held at the central bank do not pay interest. They are determined by:

$$R_t = \mu_t D_t, \tag{29}$$

where $\mu_t \in (0,1)$ is the required reserve ratio. As discussed next, according to the specific mandate in place μ_t can be either optimally set by the central bank, or set by an independent financial regulator through a simple implementable rule.

We assume that the commercial bank lends in t to the CG producer at $t-1$ interest rates and that the central bank lends in t to the commercial bank at $t-1$ interest rates. Thus, using (28), the bank's optimization problem can be written as

$$\max_{\left\{1+i_t^L, 1+i_t^D\right\}_{s=0}^{\infty}} \mathbb{E}_t \sum_{s=t}^{\infty} \beta^{s-t} \Lambda_s \left\{ q_s \left(1+i_{s-1}^L\right) l_s^F + (1-q_s)\kappa K_s + \mu_s d_s \right. \tag{30}$$

$$\left. - \left(1+i_s^D\right) d_s - \left(1+i_{s-1}^C\right)\left[l_s^F - (1-\mu_s) d_s\right] \right\},$$

where i_t^C is the cost of central bank liquidity, which is taken as given by the commercial bank. The term $q_t(1+i_{t-1}^L)l_t^F$, represents repayment on loans if there is no default, which occurs with probability q_t. The term $(1-q_t)\kappa K_t$ represents what the bank earns in case of default (which occurs with probability $1-q_t$), that is, under limited liability, the "effective" value of collateral pledged by the borrower, κK_t.[6] The term $\mu_t d_t$ represents the reserve requirements held at the central bank and returned to the bank at the end of the period (prior to its closure). The terms $(1+i_t^D)d_t$ and $(1+i_{t-1}^C)[l_t^F - (1-\mu_t)d_t]$ represent repayment of deposits and borrowing from the central bank (principal and interest) by the bank.

Maximizing (30) with respect to $1+i_t^L$ and $1+i_t^D$ yields the first-order conditions

$$1+i_t^L = \frac{1+i_t^C}{q_{t+1|t}\left(1+\eta_L^{-1}\right)}, \tag{31}$$

$$1+i_t^D = \frac{\mu_t}{1+\eta_D^{-1}} + \left(1+i_{t-1}^C\right)\frac{(1-\mu_t)}{1+\eta_D^{-1}}, \tag{32}$$

[6] Note that although revenues depend on whether the borrower repays or not, payments of principal and interest to households and the central bank are *not* contingent on shocks occurring during period t and beyond and on firms defaulting or not. Note also that in case of default the bank can seize only collateral, $\kappa P_t K_t$ (valued at the economy-wide price of the final good, P_t) not realized output (valued at the firm-specific intermediate price, P_{jt}). This is important because it implies that firm j, which takes P_t as given when setting its price, does not internalize the possibility of default.

where η_L and η_D are elasticities and $q_{t+1|t}$ is the expectation of q_{t+1} based on information available at period t.

2.7 Monetary and Financial Authorities

The balance sheet of the monetary authority comprises government bonds, B_t^C, and loans to commercial banks, L_t^B, on the asset side, whereas its liabilities consist of reserves, R_t, and currency supplied to household and firms, M_t^S:

$$B_t^C + L_t^B = R_t + M_t^S. \tag{33}$$

The cost of central bank liquidity is given by the sum of the base policy rate, i_t^R, and a penalty rate which depends on the ratio of borrowing to reserves:

$$i_t^C = i_t^R + z_0(\frac{l_t^B}{\mu_t d_t})^2, \qquad z_0 > 0 \tag{34}$$

Thus, the central bank charges a penalty that increases with the amount borrowed. In addition, this amount is scaled by the bank's required reserves, which represent implicit collateral, as argued for instance in Barnea et al. (2015) and Agénor and Jia (2015).[7] This specification captures in a simple manner imperfect substitutability between funding sources for the bank—a necessary condition for reserve requirements to be effective as a countercyclical instrument.

The monetary authority sterilizes liquidity injections by a percentage factor $\kappa_F \in (0, 1)$:

$$\frac{B_t^C}{B_{t-1}^C} = -(\frac{L_t^B}{L_{t-1}^B})^{\kappa_F} \tag{35}$$

Income received by the monetary authority from bond holdings and lending to commercial banks are subsequently transferred to the government at the end of each period.

[7] Note that here collateral determines not the *amount* that can be borrowed from the central bank but rather the *cost* at which such borrowing occurs.

In this economy, goals, instruments and operating procedure of the monetary and financial authorities depend on the specific policy mandate that they are conferred to by society. We consider three alternative arrangements. Under each arrangement, policymakers have access to their own instrument and set its value according to a specific rule.

Under the first arrangement, the *goal-integrated* mandate, the monetary authority and the financial regulator coexist within the central bank. The central bank minimizes a social loss in terms of two instruments, the base policy (or refinance) rate, i_t^R, and the required reserve ratio, μ_t, while taking into account the behavior of the private sector. The operating procedure consists of forecast targeting.

Formally, the central bank solves the following problem:

$$\min_{\left\{i_{t+s}^R,\mu_{t+s}\right\}_{s=0}^{\infty}} \mathbb{E}_t \left\{ \sum_{s=0}^{\infty} \delta^s \left[f_{\pi_p} \pi_{p,t+s}^2 + f_y y_{t+s}^2 + f_{l^F/y} \left(l_{t+s}^F - y_{t+s} \right)^2 \right.\right. \tag{36}$$

$$\left.\left. + f_{i^L/i^D} \left(i_{t+s}^L - i_{t+s}^D \right)^2 + f_{i^R} \left(i_{t+s}^R - i_{t+s-1}^R \right)^2 + f_{\mu} \left(\mu_{t+s} - \mu_{t+s-1} \right)^2 \right] \right\},$$

where variables are expressed in terms of log-deviations from their steady-state values, subject to the first-order conditions of the private sector.

Solving the problem leads to two optimal rules, one for the refinance rate and the other for the required reserve ratio. These rules are respectively attributed to the monetary authority and to the financial regulator. Under this mandate, both authorities share common macroeconomic and financial stability goals, and have access to the same information set. They differ, however, in that each authority can manipulate only one instrument. Because each authority is given a different instrument and optimal rule, they are independent. Put it differently, neither of the two authorities can affect the optimal rule of the other as they both stem from the social loss function bestowed upon the central bank given by society. Nor can either one affect the setting of the instrument that the other authority controls, as each one has its own instrument. But because they share the same goals and information set, the monetary and financial authorities are not separate.[8]

It is worth noting that the optimal rules devolved to the different authorities share two features: *a*) each instrument reacts optimally to all the available information; and *b*) each instrument is set optimally given the choice of the other instrument. These features are important because they identify the optimal rules as two best reaction functions that are given to two independent subjects. Hence, these optimal rules are naturally interpreted as two strategies which, along with the outcome in terms of macroeconomic and financial stability, determine a Nash equilibrium between the monetary authority and the financial regulator.

Under the second arrangement, the *goal-distinct* mandate, the financial stability goal only is delegated to an independent and separate financial regulator who sets the reserve requirement ratio according to the following simple implementable rule:

$$\frac{1+\mu_t}{1+\mu} = (\frac{1+\mu_{t-1}}{1+\mu})^{\chi_1}(\frac{l_t^F/Y_t}{l^F/Y})^{(1-\chi_1)\chi_2}, \tag{37}$$

which relates μ_t to changes in the credit-to-output ratio. This specification is consistent with the evidence, documented for instance by Schularick and Taylor (2012) and Aikman et al. (2015), showing that excessive credit expansion is a key predictor of financial crises.

The central bank now consists only of the monetary authority and sets the base refinance rate $1 + i_t^R$ to achieve only macroeconomic stability. In this case, the problem for the monetary authority is

$$\min_{\left\{i_{t+s}^R\right\}_{s=0}^{\infty}} \mathbb{E}_t \left\{ \sum_{s=0}^{\infty} \delta^s \left[f_{\pi_p}\pi_{p,t+s}^2 + f_y y_{t+s}^2 + f_{i^R}\left(i_{t+s}^R - i_{t+s-1}^R\right)^2 \right] \right\}, \tag{38}$$

[8] This scenario captures to some extent the actual behavior of the ECB and the FED, where we find both a monetary authority and a financial regulator [**NOT TRUE FOR THE ECB**]. In the case of the FED for instance, some members belong to the board of both authorities. In the policy mandate discussed here, there is some coordination at the higher level of goals, information, and operating procedures, while there is independence at the lower level of rules to follow and instruments.

subject to the first-order conditions of the private sector and the simple implementable rule (37) given to the financial regulator.

Finally, under the third arrangement, the *common-goal* mandate, the financial stability goal is given to both the central bank, consisting only of the monetary authority, and to the independent and separate financial regulator. Yet, the central bank is allowed to set the refinance rate to achieve both macroeconomic and financial stability by minimizing the loss function

$$\min_{\left\{i_{t+s}^R\right\}_{s=0}^{\infty}} \mathbb{E}_t \left\{ \sum_{s=0}^{\infty} \delta^s \left[f_{\pi_p} \pi_{p,t+s}^2 + f_y y_{t+s}^2 + f_{l^F/y} \left(l_{t+s}^F - y_{t+s} \right)^2 \right.\right. \tag{39}$$
$$\left.\left. + f_{i^L/i^D} \left(i_{t+s}^L - i_{t+s}^D \right)^2 + f_{i^R} \left(i_{t+s}^R - i_{t+s-1}^R \right)^2 \right\},$$

subject to the first-order conditions of the private sector and the simple implementable rule (37), whereas the financial authority sets the reserve coefficient requirement as under the second mandate.

To compare how the economy performs in terms of macroeconomic and financial stability in the three alternatives scenarios associated with these mandates, it is convenient to define the social loss in terms of the unconditional variance of the macro, financial, and instrument variables:

$$SL = f_{\pi_p} \sigma_{\pi}^2 + f_y \sigma_y^2 + f_{l^F/y} \sigma_{l^F/y}^2 + f_{i^L/i^D} \sigma_{i^L/i^D}^2 + 0.0001 \sigma_{i^R}^2 + 0.0001 \sigma_{\mu}^2, \tag{40}$$

where a small weight is put on the volatility of the two policy instruments to ensure some degree of smoothing in their manipulation.

2.8 Government

The government purchases the final good, collects taxes, and issues bonds, B_t, which are held by the central bank, B_t^C, and households, B_t^H. The government's budget constraint is given by

$$B_t = (1 + i_{t-1}^B) B_{t-1} + P_t (G_t - T_t) - i_t^R L_t^B - i_{t-1}^B B_{t-1}^C, \tag{41}$$

where $B_t = B_t^C + B_t^H$, G_t denotes government spending, T_t represents real lump-sum tax revenues. The terms $i_t^R L_t^B$ and $i_{t-1}^B B_{t-1}^C$ are included in the budget constraint to account for the fact that the income earned by the central bank from lending to the commercial bank and holding government bonds, respectively, is transferred to the government.

Government purchases represent a fraction $\psi \in (0,1)$ of output of the final good. Thus,

$$G_t = \psi Y_t. \tag{42}$$

3 Equilibrium

In a symmetric equilibrium, all IGP firms are identical. Therefore, $K_{jt} = K_t$, $N_{jt} = N_t$, $Y_{jt} = Y_t$, $P_{jt} = P_t$, for all $j \in [0,1]$. In the steady state, inflation is constant and normalized at zero.

The supply of loans by the commercial bank and supply of deposits by households are perfectly elastic at the prevailing interest rates; as a result, the markets for loans and deposits always clear. The equilibrium condition of the goods markets is

$$Y_t = C_t + G_t + I_t. \tag{43}$$

Assuming that bank loans to the CG producer are only extended in the form of cash, $L_t^F = M_t^F$, the equilibrium condition of the market for cash is denoted by

$$M_t^S = M_t^H + L_t^F, \tag{44}$$

which, using (24), can be solved for the government bond rate.[9]

[9] We eliminate the equilibrium condition of the market for government bonds by Walras' Law.

4 Steady State and Log-Linearization

Appendix A contains the steady-state equations, whereas the log-linearized equations are presented in Appendix B. In brief, in the steady state both the inflation rate and the inflation target are set to zero. The steady-state interest rate on bonds is given by $\tilde{\imath}^B = \tilde{\imath}^C = \beta^{-1} - 1$. The first equality shows that because the interest rate on bonds is the same as the refinance rate, the bank has no incentives to borrow from the central bank to purchase bonds. The steady-state deposit and lending rates are given by

$$1 + \tilde{\imath}^D = \frac{\tilde{\mu} + (1 + \tilde{\imath}^C)(1 - \tilde{\mu})}{1 + \eta_D^{-1}},$$

$$1 + \tilde{\imath}^L = \frac{1 + \tilde{\imath}^C}{\left(1 + \eta_L^{-1}\right) \tilde{q}},$$

and the refinance rate is $\tilde{\imath}^C = \tilde{\imath}^R + z_0(\tilde{l}^B/\tilde{\mu}\tilde{d})^2$. From these equations it is easy to see that $\tilde{\imath}^D < \tilde{\imath}^C$ and $\tilde{\imath}^L \lesseqgtr \tilde{\imath}^C$. In order to have $\tilde{\imath}^L > \tilde{\imath}^C$ (to ensure that the bank has an incentive to borrow from the central bank), it must be assumed that that $1/(1 + \eta_F^{-1})\tilde{q} > 1$. These conditions also imply that $\tilde{\imath}^L > \tilde{\imath}^B$, which ensures that in equilibrium the bank always prefers to lend than hold government bonds. Thus, $\tilde{\imath}^L > \tilde{\imath}^C > \tilde{\imath}^R = \tilde{\imath}^B > \tilde{\imath}^D$; the bank's interest rate spread, $\tilde{\imath}^L - \tilde{\imath}^D$, which enters in the loss functions (36) and (39), is positive in equilibrium. Finally, the steady-state repayment probability is inversely related to the firm's physical assets over its financial liabilities, $\tilde{q} = (\kappa\tilde{K}/\tilde{l}^F)^{\phi_1}$.

5 Parameterization

Table 1 summarizes our parameter values. Starting with employment agencies and households, we set the elasticity of substitution between different type of labors, θ_ω, to 21, as in Altig et al. (2004). The discount factor β is set equal to 0.97 to match a real interest rate of about 3 percent. As in Walsh (2014), the fraction of workers who are not optimizing their wage is equal to 0.75. The inverse of the Frisch elasticity of labor supply is set equal to 3, well within the empirically plausible range. The intertemporal elasticity of substitution is 0.5, in line with the empirical evidence discussed by Braun and Nakajima (2012). The preference parameter for composite monetary assets η_x, is set at a low value of 0.02, to capture the fact that monetary assets bring little utility. Furthermore, the share parameter in the index of money holdings, ν, which corresponds to the relative share of cash in narrow money, is set at 0.2 to capture a significantly higher use of deposits.

Regarding production, he elasticity of demand for intermediate goods, θ, is set at 6, implying a steady-state value of the markup rate equal to 20 percent. In line with Walsh (2014), the fraction of firms who are not optimizing their price is set at 0.65 consistent with previous estimates[10] and implying an average duration between price optimizations of three quarters. The share of capital in output of intermediate goods, α, is set at 0.3, a pretty standard value, and the rate of depreciation of private capital, δ_k, is set equal to 0.03, corresponding to an annual rate of 12.6 percent. The adjustment cost for transforming the final good into investment, Θ_K, is set at 10 to capture significant frictions in that process and in line with Ireland (2001).

The repayment probability coefficient with respect to steady state collateral-loan ratio is set equal to 0.6. The elasticity of the repayment probability with respect to the collateral-loan ratio and cyclical output is set at 0.22, whereas with respect to financial shock is set equal to 0.98. As to the effective collateral-loan ratio, κ, we set it at 0.2. For the parameters characterizing the commercial bank, the loan elasticity to the lending rate is set to -25, whereas the deposit elasticity to the deposit rate is set at 21.5. As to the central bank, the penalty rate coefficient is set to 0.01 to generate reasonable departures for the refinance rate from the interest rate. The steady-state required reserve ratio μ is set at 0.05, whereas the sterilization

[10] See, among others, Lubik and Schorfheide (2006).

factor, κ_F, at 0.2. As to the central bank loss function, the weights on inflation and output gap stabilization are 1 and 0.2, respectively. When either the first or third mandate is at work, the weights on credit-to-output and bank loan-deposit spread stabilization are both set equal to 0.3, otherwise they are zero. As to the social loss function, the weights coincide with the central bank loss function with respect to the variables already considered, while are equal to 0.0001 for both interest rate and reserve requirement volatility. Finally, the share of government spending in output, ψ is set at 0.4, and the degree of persistence in the financial shock is set at 0.95.

Before we consider the numerical experiments, it is worth discussing intuitively what happens if the central bank raises the reserve requirement rate. An increase in μ_t lowers initially the deposit rate (as can be inferred from (32)), thereby reducing the demand for deposits by households. All else equal, borrowing from the central bank increases. With perfect substitution between funding sources ($z_0 = 0$), the drop in deposits is perfectly offset by the increase in central bank borrowing. With $z_0 > 0$, and given that from (29), $R_t = \mu_t D_t$, the net effect on required reserves is in general ambiguous (μ_t increases, whereas D_t falls). If the interest elasticity of deposits is sufficiently high, required reserves fall, and given that L_t^B rises as well, so does the ratio l_t^B/d_t. From (34), borrowing from the central bank becomes more expensive. In turn, the increase in i_t^C tends to raise the deposit rate, which mitigates the initial drop in i_t^D as well as the loan rate. The increase in the loan rate dampens investment, whereas the higher deposit rate induces an increase in household deposits. By implication, even if there is a reduction in the bond rate (a likely outcome) on impact, and an expansion in consumption (as a result of the intertemporal effect), output may still drop if the fall in investment, induced by the higher loan rate, is sufficiently large. Thus, the policy may indeed be countercyclical. At the same time, to the extent that the output gap and inflation fall, the optimal base policy rate i_t^R may also fall; thus, second-round effects may involve lower deposit and loan rates, which may in turn mitigate the initial contractionary effects.

6 Response to Financial Shock

In what follows we study the response of the model to a temporary negative shock to the repayment probability, of the order of one standard deviation. We thus focus on the case where, as a result of adverse conditions in the economy, the risk of default of borrowers has increased.[11]

In order to compare the social loss under the alternative mandates we need a benchmark. Because we are interested in analyzing how both the refinance rate and the required reserve ratio affect economic stability, we want the benchmark to feature the minimum feasible use of these instruments.

Accordingly, we first computed the social loss as described by (40) in each mandate under the assumption that the required reserve ratio is fixed at its steady-state value and the refinance rate reacts to the shock just enough for the economy to get back to the steady state. Table 2 reports the three values of the social loss. We then take as a benchmark the value of the social loss under the first mandate, where the monetary and financial authorities operate under the same roof but independently.[12] Tables 3 to 5 then report the ratio between the social loss associated with the mandate under consideration and the benchmark loss when either only one instrument or both instruments are manipulated. Specifically, moving downward across rows increases the intensity in the use of the refinance rate, and moving rightward across columns increases the intensity in the use of the required reserve ratio. Furthermore, the ratios in bold character correspond to the minimum value per column, whereas the ratios that are underlined correspond to the minimum value per row. Finally, the starred ratio characterizes the minimum per column and row.

[11] This shock could also be viewed as representing a negative shock to collateral values.

[12] In this case the loss is smaller than under the second mandate, and almost the same as under the third mandate.

6.1 Goal-Integrated Mandate

In this scenario, as noted earlier, the monetary authority and the financial regulator operate in the same institutional setting (the central bank) and share the same goals of macroeconomic and financial stability, the same information set, and the same operating procedure of forecast targeting. They are given, however, different instruments and optimal policy rules. For this reason, they can be considered as independent entities at the operational level.

Table 3 shows that there is a U-shaped relation between the loss ratio and the required reserve ratio, and that there tend to be a U-shaped relation also between the loss ratio and the refinance rate.[13] Overall, these results show that if the refinance rate is the only available instrument, then it is good best to use it and the social loss can be reduced down to 88.1 percent of its benchmark value. Yet, if both instruments are available, then it is best to use only the required reserve ratio, because this allows a loss reduction to 68.6 percent of the benchmark. Put differently, the best result, in terms of (relative) social loss, tends to occur when the required reserve ratio is used rather than the refinance rate.

6.2 Goal-Distinct Mandate

Under this mandate the monetary authority and the financial regulator have different goals, information sets, operating procedures, and instruments.

Table 4 shows a general worsening with respect to the previous case. Furthermore, when there is an independent financial regulator that operates through a simple

[13] In Table 3, for the sake of simplicity, but without loss of generality, the policy aggressiveness of the optimal required reserve ratio is defined as the inverse of the loss function weight f_μ scaled by 1E-4. Furthermore, the zero value in the first column corresponds to the initial value of policy aggressiveness. As for the aggressiveness of the optimal interest rate rule, it is defined as the inverse of the loss function weight f_{i^R}, and the initial value corresponds to the case in which the interest rate is just allowed to respond to the shock to ensure that the economy returns to the steady state. For that reason, the initial value is larger than zero.

implementable rule, which only reacts to the credit-to-output ratio, then the lowest loss occurs when only the refinance rate is used as an instrument by the monetary authority. Put differently, these results suggest that a financial regulator equipped with a simple implementable rule should not adjust the required reserve ratio in countercyclical fashion, as it leads to a worse outcome.

6.3 Common-Goal Mandate

Here the monetary authority targets macroeconomic and financial stability but with the refinance rate only, whereas the financial authority manipulates the required reserve ratio to achieve financial stability.

The results are shown in Table 5. When these results are compared with those shown in Table 4, the only difference is that now the social loss can be reduced to 88.2 percent of the benchmark, whereas before the best result was a loss equal to 275.8 percent of the benchmark. Moreover, when we compare Table 5 with Table 3, the outcome is that the former is dominated by the latter. Thus, delegating to the monetary authority responsibility for a financial stability goal as well corroborates the result found under the second mandate; that is, the financial stability objective should not be given to a financial regulator when is equipped with the required reserve ratio only as an instrument and operates it as a simple, credit-based rule. This result suggests that, for macroprudential regulation to be effective, a broader information set and/or a broader range of instruments may be needed.

7 Robustness

TO BE COMPLETED.

8 Concluding Remarks

The purpose of this paper was to examine the performance of alternative institutional policy mandates for achieving macroeconomic and financial stability, in a dynamic stochastic general equilibrium model with financial frictions and fractional reserves. These arrangements involve integrated, independent and separate, and partially dependent and separate, mandates for the monetary authority and the financial regulator. In the first case both monetary and macroprudential policies are set optimally, whereas in the last two cases macroprudential policy is implemented through a simple rule linking the required reserve ratio and the credit-to-output ratio.

A parameterized version of the model was used to simulate responses to a financial shock. The analysis showed that under the integrated mandate, and for some parameter configurations, it may be optimal to use only the required reserve ratio rather than jointly with the refinance rate. However, the results also showed that it may be optimal to delegate the financial stability goal solely to the monetary authority, when the financial regulator is equipped only with a required reserve ratio as an instrument. The results have useful policy implications for the countries (including a number of middle-income countries in Asia and Latin America in recent years) that have used intensively reserve requirements to manage financial risks.

TO BE COMPLETED.

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Table 1
Benchmark Parameterization

Parameter	Value	Description
θ_w	21	Elasticity of substitution, different types of labor
β	0.97	Discount factor
ω_w	0.75	Fraction of workers nonoptimising their wage
γ	3	Inverse of the Frisch elasticity of labor supply
σ	0.5	Elasticity of intertemporal substitution
η_x	0.02	Relative preference for money holdings
ν	0.2	Share parameter in index of money holdings
θ	6.0	Elasticity of demand, intermediate goods
ω_p	0.65	Fraction of firms nonoptimising their price
α	0.3	Share of capital in output, intermediate good
δ_K	0.03	Depreciation rate of capital
Θ_K	10	Adjustment cost parameter, investment
φ	0.6	Repayment prob coef. wrt SS collateral-loan ratio
φ_1	0.22	Elasticity of repayment prob wrt collateral-loan ratio
φ_2	0.22	Elasticity of repayment prob wrt cyclical output
κ	0.2	Effective share of capital pledged as collateral
z	0.01	Penalty rate coefficient
η_L	-25	Loan elasticity to interest rate on loans
η_D	21.5	Deposit elasticity to interest rate on deposits
μ	0.05	Steady-state required reserve ratio
κ_F	0.2	Sterilization factor
f_{π_p}	1	Weight on inflation stabilization
f_y	0.2	Weight on output gap stab (first and third mandate)
$f_{l_{I/y}}$	0.3	Weight on credit-to-GDP stab (first and third mandate)
f_{i^L/i^D}	0.3	Weight on loan-deposit spread stabilization
f_{π_p}	1	Weight on inflation volatility
f_y	0.2	Weight on output gap volatility
$f_{l^F/y}$	0.3	Weight on credit-to-output volatility
f_{i^L/i^D}	0.3	Weight on lending-to-deposit rate spread volatility
f_{i^R}	0.0001	Weight on interest rate volatility
f_μ	0.0001	Weight on required reserve ratio volatility
ψ	0.4	Share of government spending in output
ρ_ξ	0.95	Degree of persistence, financial shock

Table 2. Value of the social loss in the three scenarios assuming minimum use of the instruments.

Mandates for Monetary Authority and Financial Regulator	Social Loss Value
1. Goal integrated: same goals, information set, operating procedure but different instruments.	**0.00047742**
2. Goal-distinct: different goals, information set, operating procedure, and instruments.	**0.00222742**
3. Common-goal: monetary authority has both goals, financial regulator only financial stability; difference in information operating procedure, and instruments.	**0.00047723**

Table 3. Loss ratios under the goal integrated mandates. Monetary authority and financial regulator optimally target both macro and financial stability .

	Aggressiveness of the optimal rule for the required reserves ratio										
Aggressiveness of the optimal interest rate rule	**0**	**0.00002**	**0.00008**	**0.00032**	**0.00128**	**0.00512**	**0.02048**	**0.0819**	**0. 32768**	**1.3107**	**5.2428**
0.2	1.0000	1.0064	1.0382	1.0772	1.0172	0.8558	**0.7380**	**0.6966**	**0.6864**	**0.6855***	**0.6871**
0.4	0.9335	0.9358	0.9539	0.9772	0.9378	0.8336	0.7481	0.7138	0.7051	**0.7046**	0.7064
0.8	0.9052	0.9055	0.9165	0.9303	0.8961	0.8175	0.7543	0.7287	**0.7225**	0.7227	0.7246
0.16	0.8923	0.8915	0.8992	0.9083	0.8755	0.8081	0.7580	0.7400	**0.7371**	0.7381	0.7402
0.32	0.8860	0.8848	0.8909	0.8979	0.8657	0.8035	0.7604	**0.7479**	0.7483	0.7504	0.7526
0.64	0.8829	0.8815	0.8870	0.8933	0.8615	0.8018	0.7624	**0.7532**	0.7564	0.7597	0.7618
0.128	0.8815	0.8800	0.8853	0.8914	0.8600	**0.8016**	0.7641	**0.7568**	0.7618	0.7663	0.7685
0.256	0.8809	0.8795	0.8847	0.8908	**0.8597**	0.8020	0.7655	**0.7593**	0.7653	0.7706	0.7731
1.024	0.8808	0.8793	0.8846	**0.8907**	0.8598	0.8024	0.7665	**0.7609**	0.7675	0.7733	0.7760
2.048	**0.8807**	**0.8792**	**0.8845**	**0.8907**	0.8599	0.8027	0.7671	**0.7618**	0.7687	0.7748	0.7777
4.096	**0.8807**	**0.8792**	**0.8845**	**0.8907**	0.8600	0.8029	0.7675	**0.7624**	0.7694	0.7756	0.7786
8.192	**0.8807**	**0.8792**	**0.8845**	0.8908	0.8601	0.8031	0.7677	**0.7627**	0.7698	0.7760	0.7791

Table 4. Loss ratios under the goal-distinct mandates. The monetary authority optimally targets macro stability while the financial regulator pursues financial stability via a simple implementable rule.

	Aggressiveness of simple implementable financial stability rule for the required reserves ratio $\chi_2 = 1-\chi_1$										
Aggressiveness of optimal interest rate rule	**0.0223**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**	**0.9777**
0.2	**4.6655**	4.6687	4.6755	4.6853	4.6976	4.7116	4.7269	4.7430	4.7596	4.7766	4.7937
0.4	**3.5792**	3.5819	3.5868	3.5930	3.6002	3.6081	3.6166	3.6254	3.6345	3.6436	3.6529
0.8	**3.0964**	3.0989	3.1033	3.1083	3.1137	3.1195	3.1255	3.1315	3.1377	3.1438	3.1500
0.16	**2.8838**	2.8863	2.8906	2.8953	2.9003	2.9054	2.9105	2.9156	2.9207	2.9259	2.9309
0.32	**2.7928**	2.7954	2.7997	2.8045	2.8094	2.8144	2.8193	2.8243	2.8291	2.8340	2.8388
0.64	**2.7599**	2.7624	2.7669	2.7718	2.7769	2.7820	2.7871	2.7921	2.7970	2.8019	2.8068
0.128	**2.7575***	**2.7601**	**2.7646**	**2.7698**	**2.7751**	**2.7805**	**2.7858**	**2.7911**	**2.7963**	**2.8014**	**2.8065**
0.256	**2.7739**	2.7765	2.7812	2.7866	2.7922	2.7979	2.8036	2.8092	2.8148	2.8203	2.8257
1.024	**2.8043**	2.8070	2.8118	2.8173	2.8233	2.8294	2.8355	2.8416	2.8476	2.8536	2.8595
2.048	**2.8460**	2.8487	2.8535	2.8592	2.8654	2.8719	2.8785	2.8851	2.8916	2.8982	2.9046
4.096	**2.8957**	2.8983	2.9031	2.9088	2.9152	2.9220	2.9290	2.9361	2.9432	2.9504	2.9574
8.192	**2.9491**	2.9518	2.9564	2.9621	2.9686	2.9756	2.9829	2.9904	2.9980	3.0056	3.0131

Table 5. Loss ratios under the common-goal mandates. Monetary authority optimally targets both macro and financial stability while financial authority pursues financial stability via simple implementable rule.

	Aggressiveness of simple implementable financial stability rule for the required reserves ratio $\chi_2 = 1-\chi_1$										
Aggressiveness of optimal interest rate rule	**0.0223**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**	**0.9777**
0.2	**0.9996**	1.0001	1.0010	1.0020	1.0031	1.0042	1.0053	1.0064	1.0075	1.0086	1.0095
0.4	**0.9342**	0.9347	0.9357	0.9366	0.9376	0.9387	0.9397	0.9408	0.9418	0.9429	0.9437
0.8	**0.9065**	0.9070	0.9080	0.9089	0.9099	0.9110	0.9120	0.9130	0.9141	0.9151	0.9159
0.16	**0.8938**	0.8944	0.8953	0.8963	0.8973	0.8983	0.8993	0.9003	0.9014	0.9024	0.9032
0.32	**0.8876**	0.8882	0.8891	0.8901	0.8911	0.8921	0.8931	0.8941	0.8952	0.8962	0.8970
0.64	**0.8846**	0.8852	0.8861	0.8871	0.8881	0.8891	0.8901	0.8911	0.8921	0.8932	0.8940
0.128	**0.8832**	0.8838	0.8847	0.8857	0.8867	0.8877	0.8887	0.8897	0.8907	0.8918	0.8926
0.256	**0.8827**	0.8832	0.8842	0.8851	0.8861	0.8871	0.8881	0.8892	0.8902	0.8912	0.8920
1.024	**0.8825**	0.8831	0.8840	0.8850	**0.8859**	0.8870	0.8880	0.8890	0.8900	**0.8910**	**0.8918**
2.048	**0.8824***	**0.8830**	**0.8839**	**0.8849**	**0.8859**	**0.8869**	**0.8879**	**0.8889**	**0.8899**	**0.8910**	**0.8918**
4.096	**0.8824***	**0.8830**	**0.8839**	**0.8849**	**0.8859**	**0.8869**	**0.8879**	**0.8889**	**0.8899**	**0.8910**	**0.8918**
8.192	**0.8824***	**0.8830**	**0.8839**	**0.8849**	**0.8859**	**0.8869**	**0.8879**	**0.8889**	**0.8899**	**0.8910**	**0.8918**