Macroprudential Intervention and (Un)employed Households

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Abstract

This paper studies indirect macroprudential intervention's effects on household welfare in a two-agent New Keynesian setting. I develop a two-agent New Keynesian DSGE model à la Gertler and Karadi (2011) to compare the welfare impacts of different monetary policy regimes in the presence of a tax policy in the banking system. I investigate whether there is a welfare benefit if a standard Taylor rule incorporates financial variables, in particular, the interest rate spread. The results suggest that deviating from the standard Taylor rule to its augmented alternative in an unregulated economy is ineffective regarding welfare improvement. On the other hand, within a regulated economy, the maximized welfare of households is given in the presence of a tax policy and a monetary policy rule reacting to the interest rate spread. However, the results are unclear about the welfare-improving role of monetary policy in terms of economic stabilization within both unregulated and regulated economies.

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1 Introduction

Before the 2008-2009 global financial crisis (GFC), many (but certainly not all) central bankers and academic researchers believed that considerations of financial markets and their relevant imperfections played no role when making decisions about monetary policy. The main argument was that the financial crisis is not *predictable* enough for there to be any point in trying to lean against financial market risks. Moreover, the idea was based on the widely used frictionless New Keynesian model, which assumes that financial markets work flawlessly under the unified interest rate determined by the central bank. In frictionless models, financial markets do not have any role in the propagation of shock, since their resources are optimally distributed to their most productive uses. However, the GFC exposed the weakness of such models in explaining how financial shocks affect macroeconomic stability and household consumption.

There is a sizable body of literature, starting before the crisis, developing macroeconomic models with financial frictions. One strand of the New Keynesian literature incorporates financial intermediaries into the general equilibrium model based on Bernanke et al. (1999). In addition, another stream of literature is based on the seminal work of Kiyotaki and Moore (1997) where there are borrowers and lenders with different rates of time preferences and collateral constraints. The financial sector, particularly the banking system, introduces frictions by requiring collateral from borrowers.

Even though it is widely accepted that financial frictions are salient factors in macroeconomic stability, there is no consensus on whether financial policies must be incorporated into monetary rules or into separate macroprudential policies. On the one hand, a fraction of the literature asserts that the monetary policy rule should consider only inflation and output (see, e.g., Mishkin, 2011). Similarly, studying a simple New Keynesian model, Suh (2014) shows that a monetary policy rule performs weaker in stabilizing credit compared to a separate macroprudential policy rule. On the other hand, extensive literature shows the importance of the monetary policy's response to financial variables (see, among many others, Auclert, 2019; Cúrdia and Woodford, 2016; Lee et al., 2021; Stein, 2012). The key result of this line of research is that financial intermediaries and their relevant frictions can be a source of (in)stability affecting the real economy. This finding highlights the importance of unconventional policies used by central banks. For instance, Curdia and Woodford (2010) extend the standard New

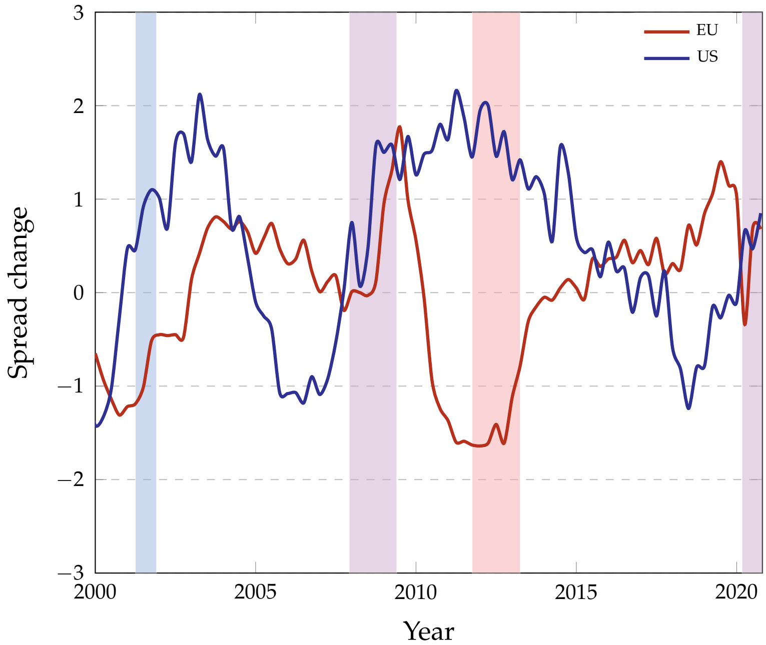
Keynesian model by introducing credit frictions. They show that an augmented Taylor rule improves the economy's reaction to different shocks upon an unadjusted rule in the case of endogenous credit spread. For a comprehensive survey of financial frictions and macroeconomic models, see Brunnermeier et al. (2012). Farhi and Werning (2016) develop a theoretical framework for the interaction between monetary and macroprudential policies. Their results show that financial interventions in the form of taxes generate Pareto improvements. Their findings are in line with the empirical macro literature documenting the necessity of considering financial factors inside monetary policy rules and their interaction with financial policies in pricing and transmitting shocks throughout the economy.[1]

This paper incorporates the banking system into a two-agent New Keynesian model. There are two types of households in the economy: *employed* and *unemployed* households. The former works and deposits its income in the banking system, while the latter can borrow money from the banking system. There is a lump-sum tax on employed households, which is paid back to unemployed households in the form of transfers by the government. This paper closely follows Gertler and Karadi (2011) in modeling the banking system. However, the banking system introduced in this paper differs in two respects. First, the initial wealth of the new banks in each period is transferred from the existing banks. Second, there is no equity outside the banking sector, making net worth accumulation endogenous and dependent only on the interest rate spread. The spread is defined as the difference between the loan rate from banks to unemployed households and the rate of return on deposits made by employed households.

This paper focuses mainly on the interest rate spread movement and its effect on household consumption and welfare. The motivation is based on the countercyclical movements of spread during business cycles that indicate the procyclicality of banks' net worth. Figure 1 shows such movements in the spread in the US and the Eurozone. Shaded regions indicate recessions. The difference between a two-year Treasury constant maturity rate and commercial bank rate on a 24-month loan is the spread in the US market. For the Eurozone, the interest rate spread is the difference between the

[1] Among various studies, Christiano et al. (2003) examine a counterfactual monetary policy in the case of the Great Depression. Combining vector autoregression (VAR) analysis with high-frequency identification (HFI) of the effects of policy surprises on interest rates, Gertler and Kiyotaki (2015) suggest incorporating term premium and credit spread effects in the modeling of monetary policy transmission. For some other empirical studies, see Kashyap et al. (1997), Bruno et al. (2017), Bussière et al. (2021), Gambacorta and Murcia (2017), and Takáts and Temesvary (2021).

Figure 1: Interest Rate Spread Fluctuations



Notes: The interest rate spread in the US and Euro area. The blue line indicates the spread for the US, which is defined as a two-year Treasury constant maturity rate minus the commercial bank rate on a 24-month loan. The red line is the spread for the euro area, defined as the consumption loan rate minus the deposit rate with an agreed maturity of up to 1 year. The blue shaded region indicates NBER recessions, while the red shaded region corresponds to recession in the euro area. The pink shaded area indicates recessions for both the US and Eurozone. The data on loan and deposit rates in the US are taken from Federal Reserve Economic Data (FRED) set by the Federal Reserve Bank of St. Louis (FRED). The Eurozone data are from the European Central Bank. NBER and Eurostat Business Cycle Clock are sources of data on recessions.

consumption loan and deposit rates with an agreed maturity of up to 1 year.

In both cases, there is a significant increase in the spread during recessions, while the interest rate spread, on average, declines when the economy booms. This pattern of movements is crucial for fluctuations in consumption, as recessions affect the households facing borrowing constraints more adversely compared to wealthier agents (employed households in our model), resulting in a decline in poorer (unemployed) households' consumption. In contrast, households on the right tail of the wealth distribution respond differently to technology and monetary policy shocks as they can consume more due to their positive asset holding.

I consider two economies: an unregulated economy with no macroprudential instruments involved and a regulated economy with macroprudential interventions in the form of a tax policy in the banking system. However, my proposed macroprudential tool differs from the usual ones in the literature. I impose a tax only on the loan made by the bank to unemployed households. In addition, this paper abstracts from other financial variables and concentrates only on the interest rate spread. Thus, the tax policy considers only the interest rate spread.[2] The results demonstrate that in the unregulated economy, where there is no macroprudential intervention, there is virtually no welfare improvement when we move from the standard Taylor rule to a monetary policy rule responsive to the spread. If there is any change in welfare, it is negative (i.e., -0.005% in terms of consumption equivalent). However, an augmented Taylor rule performs better in economic stabilization than its counterpart.

In the case of the regulated economy, optimal monetary policy analysis shows a significant welfare improvement if the monetary authority reacts to the interest rate spread. A Taylor rule considering the interest rate spread performs better regarding welfare improvement in the economy in all cases compared to the benchmark policy without considering the spread. Relevant impulse responses also suggest that having an augmented Taylor rule in use results in faster recovery if a monetary policy shock hits the economy. However, the optimal monetary policy rule augmented with the response to the interest rate spread yields a less smooth response to monetary policy shocks with no response to the output gap. On the other hand, our results indicate a larger value for the inflation coefficient than the standard value used in the literature.

The results of this paper offer several insights into the existing literature in the following ways. First, the analysis adds to the literature on financial frictions and their effects on households. I show that in the case of macroprudential interventions in the form of a tax policy on banks' capital, a monetary rule reacting to the spread is associated positively with the level of consumption for households. In addition, the findings indicate the importance of monetary policy's response to the interest rate spread. In line with a large body of studies, e.g., Curdia and Woodford (2010) and Cúrdia and Woodford (2016), the findings confirm a better performance of a policy rule incorporating the interest rate spread relative to the standard Taylor rule in terms of both stabilizing the economy and welfare improvement of households. Finally, this study adds to the literature by introducing a new model consisting of two types of agents and a simplified version of the banking sector, which is flexible enough to allow for studying the impact of various financial frictions and relevant macroprudential interventions on welfare.

[2]For a survey on several other macroprudential instruments, see Galati and Moessner (2013).

Relevant literature. This paper relates to various strands of literature. First, this paper relates to the extensive literature on the interaction between monetary policy and macroprudential policies. I follow a long stream of research that incorporates financial intermediaries into macroeconomic models (Angelini et al., 2011; Angeloni and Faia, 2013; Brzoza-Brzezina et al., 2013, Gerali et al., 2010; Gersbach et al. (2017); Gertler and Kiyotaki, 2015; Levine and Lima, 2015; Paoli and Paustian, 2017; Quint and Rabanal, 2018; Rubio and Carrasco-Gallego, 2014; Smets, 2018; Tayler and Zilberman, 2016; Van der Ghote, 2021). For example, Gersbach et al. (2017) integrate banks into a standard New Keynesian model to investigate the optimal policy rules for monetary and macroprudential policy-makers. The authors show that the central bank should focus exclusively on price stability, and macroprudential policy-makers should react to both output variation and financial instability. Estimating a DSGE model on euro data, Quint and Rabanal (2018) find that macroprudential interventions help stabilize the economy and improve welfare. Similarly, Angeloni and Faia (2013) examine several monetary policy rules and show that adjusted monetary rules that include a response to asset prices or bank leverage outperform the benchmark Taylor rule. In a recent study, Van der Ghote (2021) examines the interaction between monetary and macroprudential policies in an economy with boom-bust cycles. The author demonstrates that the interest rate policies that lean against credit imbalances improve social welfare over the benchmark Taylor rule.

Our paper is closely related to Levine and Lima (2015) from this line of research. The authors develop a DSGE model with banks to assess the importance of macroprudential and monetary policies to improve welfare and stabilize the economy. The authors find that the consideration of a monetary policy leaning against financial instability is welfare-improving and performs better than a conventional monetary rule. However, this paper examines a two-agent New Keynesian model, while their model is a representative agent New Keynesian (RANK) model.

Additionally, this paper is related to the strand of literature that studies optimal monetary policy. This paper particularly focuses on welfare-maximizing optimal policy analysis and abstracts from the other measures used in part of this literature to rank alternative specifications for monetary policy rules. (Cúrdia and Woodford, 2016; Faia and Monacelli, 2007; Fiore and Tristani, 2013; Kollmann, 2008; Leduc and Natal, 2018;

Schmitt-Grohé and Uribe, 2007). For example, in a study close to the scope of this paper, Leduc and Natal (2018) investigate the optimal monetary policy in the presence of macroprudential regulations and find that state-contingent taxes on lending are welfare-improving. They show that monetary policy stabilizes the economy as taxes on lending lower externalities associated with financial accelerators and shocks. As elaborated by Schmitt-Grohé and Uribe (2007) and Kim et al. (2008), the methodological framework used to examine welfare-based optimal monetary rules mainly relies on higher-order approximations of the nonlinear competitive equilibrium.

Finally, this paper contributes marginally to the nonrepresentative agents New Keynesian (N-RANK) literature. Even though there is extensive literature studying financial frictions and monetary policy, to the best of my knowledge, few studies incorporate heterogeneous agents into the New Keynesian model to investigate the issue. This study could be complementary to Lee et al. (2021), in which the authors investigate the impact of financial intermediaries in a heterogeneous agents New Keynesian (HANK) model. In line with the significant share of literature, they find a stabilizing role for macroprudential interventions. However, their results indicate a significant welfare cost of macroprudential regulation, which contrasts with this paper's findings.

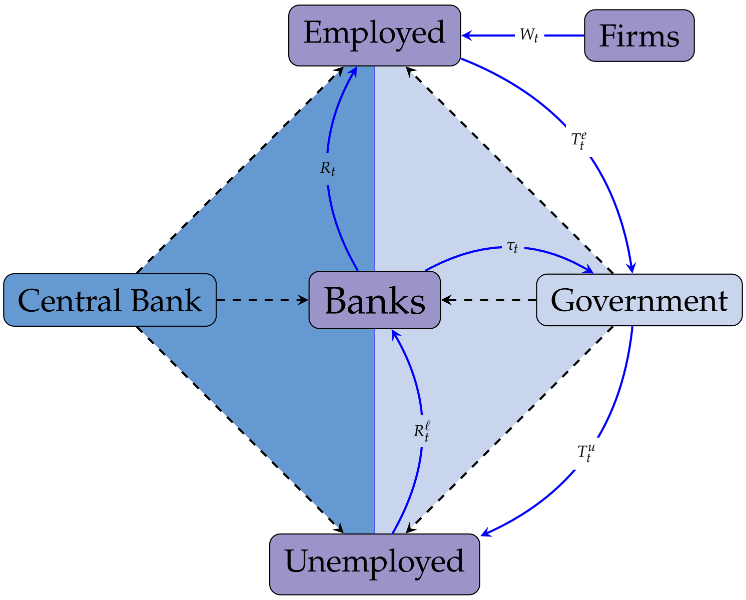
The rest of the paper is organized as follows. The following section presents the model and methodological framework in detail. Section 3 provides details on the calibration strategy and results regarding the optimal policy and welfare experiments. The final section concludes the paper and discusses future avenues for research.

2 Environment

Time is discrete and indexed by $t \geq 0$. The model consists of various blocks. Figure 2 depicts the model economy and its components. On the household side, there are two types of risk-averse agents: *employed* households and *unemployed* households.[3] Consequently, the quantity of labor (hours) supplied by households (H_t^j) can take two values H_t^e and H_t^u. If the household is employed, $H_t^j = H_t^e$, and if the household is unemployed, $H_t^j = H_t^u \equiv \nu$, which means that the household supplies a minimum quantity of labor ν for home production.

[3]One can think of a model with savers and borrowers or parents and children. For example, see Sims et al. (2020) for a recent similar study using the parent-child household block.

Figure 2: Model Economy



Household preferences are separable over consumption and labor. The functional form of utility for both agents is expressed as follows:

$$(1) \quad U(C_t^j, H_t^j) = \log(C_t^j) - \chi \frac{(H_t^j)^{1+1/\eta}}{1+1/\eta},$$

where $j \in \{e, u\}$, χ is a scaling parameter for the disutility of labor, and η is the Frisch elasticity of labor supply. Finally, the households also differ from each other according to their corresponding discount factors. Employed and unemployed households discount their future utilities by β_e and β_u, respectively. Both discount factors are between zero and one, while $\beta_e > \beta_u$.

Employed household. A fraction γ of households are employed. The recursive formulation of the employed household's problem is:

$$(2) \quad V^e(D_t^e) \equiv \max \log(C_t^e) - \chi \frac{(H_t^e)^{1+1/\eta}}{1+1/\eta} + \beta_e \mathbb{E}\left[V^e(D_{t+1}^e)\right],$$

subject to the nominal budget constraint:

$$(3) \quad P_t C_t^e + D_t^e = \overline{W}_t H_t^e + \Xi_t + (1 + R_{t-1}) D_{t-1}^e - T_t^e.$$

Employed households receive nominal wages $\overline{W}_t$ for supplied hours. Ξ_t denotes profits distributed evenly among employed households. Furthermore, D^e_t is the nominal stock of liquid assets, e.g., money deposited into a bank account as an extra source. Depositing in period t gives $1 + R_{t+1}$ in nominal terms in the next period $t + 1$. As in Gertler and Karadi (2011), the rate of return on deposits is identical to that of the government's bonds. Each period, T^e_t is a fixed part of employed households' wealth, which is transferred to unemployed households. All income net of transfers on the right-hand side of the budget constraint is used to finance the real consumption expenditure (C^e_t) together with the deposit made for the next period.

Using the first-order conditions with respect to deposit and envelope theorem conditions, we find the following Euler equation for employed households:

$$\text{(4)} \qquad \frac{1}{C^e_t} = \beta_e \mathbb{E}_t \left[\frac{1 + R_t}{1 + \Pi_{t+1}} \frac{1}{C^e_{t+1}} \right],$$

$$\text{(5)} \qquad 1 = \mathbb{E}_t \Lambda^e_{t,t+1} \frac{1 + R_t}{1 + \Pi_{t+1}},$$

where $\Pi_t = \frac{P_t - P_{t-1}}{P_{t-1}}$ and $\Lambda^e_{t,t+1} = \beta_e \frac{U'(C^e_{t+1})}{U'(C^e_t)}$ is the employed household's stochastic discount factor. Moreover, the optimal choice of labor is given by:

$$\text{(6)} \qquad \frac{\overline{W}_t}{P_t} \equiv W_t = \chi C^e_t (H^e_t)^{\frac{1}{\eta}}.$$

Unemployed household. A fraction $1 - \gamma$ of households are unemployed. Since they are constrained in labor choice and do not receive any labor income, this type of household does not have access to the stock of deposits. Hence, its budget constraint consists of home labor production and government transfers. The unemployed household solves the following dynamic optimization program:

$$\text{(7)} \qquad V^u(L^u_t) \equiv \max \log(C^u_t) - \chi \frac{\nu^{1+1/\eta}}{1 + 1/\eta} + \beta_u \mathbb{E} \left[V^u(L^u_{t+1}) \right],$$

subject to the flow budget constraint:

$$\text{(8)} \qquad P_t C^u_t + (1 + R^\ell_{t-1}) L^u_{t-1} = \nu + L^u_t + T^u_t,$$

where L_t^u is the stock of loan/borrowing held by the unemployed household, which is paid back to banks next period at the rate of R_t^ℓ. T_t^u denotes the transfers that unemployed households receive from employed households and the government every period. The first-order and envelope theorem conditions with respect to consumption and borrowing give the Euler equation as follows:

$$(9) \quad \frac{1}{C_t^u} = \beta_u \mathbb{E}_t \left[\frac{1+R_t^\ell}{1+\Pi_{t+1}} \frac{1}{C_{t+1}^u} \right],$$

$$(10) \quad 1 = \mathbb{E}_t \Lambda_{t,t+1}^u \frac{1+R_t^\ell}{1+\Pi_{t+1}},$$

where $\Lambda_{t,t+1}^u = \beta_u \frac{U'(C_{t+1}^u)}{U'(C_t^u)}$ is the unemployed household's stochastic discount factor. In the case of unemployed households, since they supply a fixed quantity of labor, ν, for home production and do not hold deposits, the only relevant decision is made on the loan/borrowing.

Final good firm. There is a competitive representative final good producer aggregating a continuum of intermediate inputs distributed over a unit interval, through the Dixit-Stiglitz technology::

$$(11) \quad Y_t = \left(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}},$$

where $\varepsilon > 1$ is the elasticity of substitution among intermediate goods. The maximization problem of the final good producer is as follows:

$$(12) \quad \max_{Y_t(i)} \left(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}} \quad \text{s.t.} \quad \int_0^1 P_t(i) Y_t(i) di$$

The first-order condition with respect to $Y_t(i)$ gives the following:

$$\langle Y_t(i) \rangle : \left(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{1}{\varepsilon-1}} Y_t(i)^{-\frac{1}{\varepsilon}} = \frac{P_t(i)}{P_t}$$

Using equation (11), one can rewrite the FOC as follows:

$$(13)\quad Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\varepsilon} Y_t,$$

which indicates the relative demand for the intermediate good i as a function of its relative price $\frac{P_t(i)}{P_t}$ and aggregate production Y_t. Moreover, one can derive the price index as:

$$(14)\quad P_t = \left(\int_0^1 P_t(i)^{1-\varepsilon} di\right)^{\frac{1}{1-\varepsilon}}.$$

Intermediate good firms. Using a linear technology $Y_t(i) = A_t H_t(i)$, each monopolistically competitive intermediate firm i produces intermediate good $Y_t(i)$. A_t is the common productivity shock following an AR(1) process: $\ln A_t = \phi_a \ln A_{t-1} + \epsilon_t^a$. The cost minimization program for each intermediate firm implies that the real marginal cost (MC_t) is equal to $\frac{W_t}{A_t}$. Following Rotemberg (1982), each intermediate firm faces a quadratic cost of price adjustment:

$$(15)\quad \frac{\xi}{2}\left(\frac{P_t(i)}{P_{t-1}(i)} - 1\right)^2 Y_t,$$

where $\xi > 0$ scales the cost of changing prices. The intermediate firm i maximizes the sum of its expected profits discounted by the stochastic discount factor of employed workers:

$$(16)\quad \max_{P_{t+k}(i)} \mathbb{E}_t \sum_{k=0}^{\infty} \Lambda_{t,t+k}^e \Xi_{t+k}(i),$$

where $\Lambda_{t,t+k}^e = \beta_e^k \frac{C_t^e}{C_{t+k}^e}$ is the stochastic discount factor of employed workers who own the intermediate firms. The real profits of intermediate firm i are given by the following:

$$(17)\quad \Xi_t(i) = \overbrace{\left(\frac{P_t(i)}{P_t}\right) Y_t(i)}^{revenue} - \overbrace{W_t H_t(i) - \frac{\xi}{2}\left(\frac{P_t(i)}{P_{t-1}(i)} - 1\right)^2 Y_t}^{cost}$$
$$= \left(\frac{P_t(i)}{P_t}\right)^{1-\varepsilon} Y_t - MC_t(i)\left(\frac{P_t(i)}{P_t}\right)^{-\varepsilon} Y_t - \frac{\xi}{2}\left(\frac{P_t(i)}{P_{t-1}(i)} - 1\right)^2 Y_t.$$

To find the optimal solution for (16), we take FOC with respect to $P_t(i)$, which gives the following:

$$\left[(1-\varepsilon)\left(\frac{P_t(i)}{P_t}\right)^{-\varepsilon}\frac{Y_t}{P_t} + \varepsilon MC_t(i)\left(\frac{P_t(i)}{P_t}\right)^{1-\varepsilon}\frac{Y_t}{P_t} - \xi\left(\frac{P_t(i)}{P_{t-1}(i)} - 1\right)\frac{Y_t}{P_{t-1}(i)}\right]$$
$$+ \xi\beta_e \mathbb{E}_t \frac{C^e_t}{C^e_{t+1}}\frac{P_{t+1}(i)}{P_t(i)^2}\left(\frac{P_{t+1}(i)}{P_t(i)} - 1\right) Y_{t+1} = 0.$$

First, since in equilibrium all firms are identical, then $P_t(i) = P_t$. Next, we multiply both sides of the equation by $\frac{P_t}{Y_t}$. Finally, I define the net inflation rate as $\Pi_t = \frac{P_t - P_{t-1}}{P_{t-1}}$. One can express the nonlinear New Keynesian Phillips Curve (NKPC) as follows:

$$(18)\quad (1-\varepsilon) + \varepsilon MC_t - \xi\Pi_t(1+\Pi_t) + \xi\mathbb{E}_t\left[\Lambda^e_{t,t+1}\frac{Y_{t+1}}{Y_t}\Pi_{t+1}(1+\Pi_{t+1})\right] = 0.$$

The NKPC tracks the inflation dynamics by relating today's inflation to its expected future value and to the output level in the economy.

Banks. The economy is populated by a continuum of homogeneous risk averse banks à la Gertler and Karadi (2011) and Gertler and Kiyotaki (2015). Each bank's balance sheet consists of deposits made by employed households and issued loans by the bank. In other words, at the beginning of each period, banks raise deposits from employed households and then use them to issue loans to unemployed households. The simple balance sheet of a representative bank in period t can be written as:

$$(19)\quad L_t = N_t + D_t,$$

where N_t is the net worth of the representative bank at the end of period t. In addition, L_t and D_t are the total amount of loans and deposits issued by the bank, respectively. The liabilities side thus consists of net worth and household deposits. The net worth of a bank accumulates in the following form:

$$N_{t+1} = (R^{\ell}_{t+1})L_t - (R_{t+1})D_t. \tag{20}$$

Substituting for D_t from Equation (19), one can rewrite the capital accumulation of the bank as:

$$N_{t+1} = (R^{\ell}_{t+1} - R_{t+1})L_t + (R_{t+1})N_t. \tag{21}$$

The net worth of the bank at the end of a period thus equals the net excess return from loans plus the return at the risk-free rate R_t from the previous period. Moreover, banks face an exogenous probability of default $\mu \in [0,1]$ in each period. The probability of surviving for $t-1$ periods and defaulting in period t is $\mu(1-\mu)^{t-1}$. Hence, the representative bank maximizes its expected discounted net wealth:

$$V^b_t = \mathbb{E}_t \sum_{s=1}^{\infty} \mu(1-\mu)^{s-1} \Lambda_{t,t+s} N_{t+s} \tag{22}$$

where $\Lambda_{t,t+s} = \beta^s_e \frac{C^e_t}{C^e_{t+s}} \frac{P_t}{P_{t+s}}$ is the stochastic discount factor based on the utility maximization of the employed households. There is also an incentive constraint (IC) to prevent bankers from diverting funds from households:

$$V^b_t \geq \theta L_t. \tag{IC}$$

As in Gertler and Karadi (2011), (IC) means that in the case of shrinking a fraction θ of funds by the bank, the terminal expected wealth of the bank must be as large as its gain from this operation. Hence, the household is willing to make a deposit in the bank since even if the bank defaults, the household can reclaim its funds.

The representative bank solves its problem by maximizing (22) subject to (21) and (IC). The Bellman equation of the representative bank can be written as:

$$(23) \quad V^b_{t-1}(N_{t-1}, L_{t-1}) = \mathbb{E}_t \Lambda_{t,t+1}\big[\mu N_t + (1-\mu)\max_{L_t} V^b_t(N_t, L_t)\big].$$

First, we guess that the solution is linear in loans and net worth. We express the value function as follows:

$$(24) \quad V^b_t(N_t, L_t) = x_{d,t}N_t + (\overbrace{x_{\ell,t} - x_{d,t}}^{z_{\ell,t}})L_t,$$

where $x_{d,t}$ is the marginal value of deposits and $z_{\ell,t}$ is the excess value of holding loans net of deposits for the bank: $z_{\ell,t} \equiv x_{\ell,t} - x_{d,t}$. Using our guess, we rewrite (IC) as:

$$(25) \quad x_{d,t}N_t + z_{\ell,t}L_t \geq \theta L_t.$$

The second term on the right-hand side of (23) can be solved by the following Lagrangian equation subject to (IC) or equivalently (25):

$$\begin{aligned}(26) \quad \mathcal{L} &= V^b_t(N_t, L_t) + \lambda_t(V^b_t - \theta L_t) \\ &= (1+\lambda_t)(x_{d,t}N_t + z_{\ell,t}L_t) - \lambda_t\theta L_t.\end{aligned}$$

The first-order conditions with respect to L_t and the Lagrange multiplier λ_t give:

$$(27) \quad (1+\lambda_t)z_{\ell,t} - \lambda_t\theta = 0,$$

$$(28) \quad x_{d,t}N_t + z_{\ell,t}L_t - \theta L_t \geq 0.$$

If $\lambda_t > 0$, then (IC) is binding and can be written as:

$$(29) \quad L_t = \frac{x_{d,t}}{\theta - z_{\ell,t}}N_t,$$

where $\frac{x_{d,t}}{\theta - z_{\ell,t}}$ is the bank's leverage ratio. Using the leverage ratio, the value function (24) can be written as:

$$(30) \quad V^b_t = \frac{\theta x_{d,t}}{\theta - z_{\ell,t}}N_t.$$

Using the last expression for the value function and (20), we can rewrite (23) as follows:

$$
\begin{aligned}
V_t^b(N_t, L_t) &= \mathbb{E}_t \Lambda_{t,t+1} \Phi_{t+1} N_{t+1} \\
&= \mathbb{E}_t \Lambda_{t,t+1} \Phi_{t+1} \left[(R_{t+1}^{\ell}) L_t - (R_{t+1}) D_t \right],
\end{aligned} \tag{31}
$$

where $\Phi_t \equiv \mu + (1-\mu)\left(\frac{\theta x_{d,t}}{\theta - z_{\ell,t}}\right)$. One can interpret Φ_t as the shadow price of one extra unit of wealth in the bank's portfolio. Using (31) and (24), we finally can verify the coefficients of our value function:

$$x_{d,t} = \mathbb{E}_t \Lambda_{t,t+1} \Phi_{t+1} (R_{t+1}), \tag{32}$$

$$z_{\ell,t} = \mathbb{E}_t \Lambda_{t,t+1} \Phi_{t+1} (R_{t+1}^{\ell} - R_{t+1}). \tag{33}$$

At the aggregate level, the total net worth is the sum of old surviving banks and the newcomer banks:

$$N_t = N_{o,t} + N_{n,t}, \tag{34}$$

where the first term on the right-hand side is the net worth of existing banks, equal to earnings on loans net of deposit costs conditional on survival probability, μ:

$$N_{o,t} = (1-\mu)(R_t^{\ell} L_{t-1} - R_t D_{t-1}). \tag{35}$$

Employed households transfer a fraction of the value of existing banks, denoted by σ to each new bank. The new bank's net worth is as follows:

$$N_{n,t} = \sigma R_t^{\ell} L_{t-1}. \tag{36}$$

Aggregate net worth thus accumulates according to:

$$N_t = (1 + \sigma - \mu) R_t^{\ell} L_{t-1} - (1-\mu) R_t D_{t-1} \tag{37}$$

Macroprudential intervention. In this part, I introduce a tax on loans as a macroprudential instrument. In this setting, the government imposes taxes on loans issued by the bank and transfers to unemployed households every period. Therefore, the total tax on the employed household includes the tax on the bank's net worth, i.e., the tax on the bank's dividends. The balance sheet of the bank is the same as in (19), and the net worth accumulation now becomes:

$$N_{t+1} = (R^{\ell}_{t+1} - \tau_t)L_t - (R_{t+1})D_t, \tag{38}$$

where the net worth of the bank at the beginning of period $t+1$ equals the returns on loans minus deposit repayments and taxes on the net worth from the previous period. Combining (19) and (38) gives the following:

$$N_{t+1} = \big(R^{\ell}_{t+1} - R_{t+1} - \tau_t\big)L_t + (R_{t+1})N_t. \tag{39}$$

Solving the dynamic optimization of banks in this setting is identical to the model without macroprudential taxation. Following the same procedure, we can write our guess for the value function and its verified coefficients as follows:

$$V^b_t(N_t, L_t) = x_{d,t}N_t + z_{\ell,t}L_t,$$

$$x_{d,t} = \mathbb{E}_t\Lambda_{t,t+1}\Phi_{t+1}(R_{t+1}), \tag{40}$$

$$z_{\ell,t} = \mathbb{E}_t\Lambda_{t,t+1}\Phi_{t+1}\big(R^{\ell}_{t+1} - R_{t+1} - \tau_t\big). \tag{41}$$

The solution procedure is identical to what we have without a macroprudential policy except for the coefficient of loans, $z_{\ell,t}$, in the guessed value function. Now, with taxes imposed on the bank's capital, the banker needs to take into account the effect of taxes on the marginal value of loans. Defining $\aleph_t = (1-\mu)(R^{\ell}_t - \tau_t) + \sigma R^{\ell}_t$, the aggregate net worth accumulation is:

$$N_t = \aleph_t L_{t-1} - (1-\mu)R_t D_{t-1}. \tag{42}$$

Monetary and macroprudential policies. In the baseline setting, the central bank sets the monetary policy in a way that the nominal interest rate reacts to its lagged value, the deviation of inflation from its steady state value, and the variation of output from its potential value:

$$\text{(43)} \quad \ln R_t = \rho_r \ln R_{t-1} + (1-\rho_r)\Big[\ln R + \phi_{r,\pi}(\ln \Pi_t - \ln \Pi) + \phi_{r,y}(\ln Y_t - \ln \bar{Y}_t)\Big] + \epsilon_t^R,$$

where $0 < \rho_r < 1$ is the smoothing term, $\phi_{r,\pi} > 1$ and $\phi_{r,y}$ indicate the degree of responsiveness of the policy to variations in inflation and actual output's deviation from its potential level, respectively, and ϵ_t^R is an exogenous i.i.d. monetary policy shock: $\epsilon_t^R \sim \mathcal{N}(0, \sigma_R^2)$. Variables without time superscripts denote their steady state values.

Alternatively, I define another modification of the interest rate policy rule in which, in addition to inflation and the output gap, the nominal interest rate responds to the expected deviation of the interest rate spread from its steady state level:

$$\text{(44)} \quad \ln R_t = \rho_r \ln R_{t-1} + (1-\rho_r)\Big[\ln R + \phi_{r,\pi}(\ln \Pi_t - \ln \Pi) + \phi_{r,y}(\ln Y_t - \ln \bar{Y}_t) + \phi_{r,\varsigma}\mathbb{E}_t(\ln \varsigma_{t+1} - \ln \varsigma)\Big] + \epsilon_t^R,$$

where $\varsigma_{t+1} = R^{\ell}_{t+1} - R_{t+1}$ is the expected interest rate spread, and ς is the steady state spread.

Furthermore, the government taxes employed households and loans held by banks to transfer them to unemployed households in the form of unemployment benefits T_t^u. Hence, the total taxes and transfers collected by the government can be expressed as follows:

$$\text{(45)} \quad T_t^u = T_t^e + \tau_t L_t,$$

where T_t^e is a lump-sum tax on employed households, and τ_t is the tax rate on loans issued by the banks. The tax rate policy can be interpreted as a countercyclical macro-prudential instrument affecting macroeconomic stability. The tax rate responds to its lagged value and the expected variation in the interest rate spread:

$$\text{(46)} \quad \ln \tau_t = \rho_\tau \ln \tau_{t-1} + (1-\rho_\tau)\Big[\psi_{\tau,\varsigma}\mathbb{E}_t(\ln \varsigma_{t+1} - \ln \varsigma)\Big] + \epsilon_t^\tau,$$

where $0 < \rho_\tau < 1$ is the tax rate's smoothing coefficient, and $\psi_{\pi,\varsigma} < 0$ is the degree of aggressiveness of the tax rate in response to the interest rate spread. This means that by lowering taxes, the macroprudential regulator responds to an increase in the spread with respect to its steady state, which consequently increases lending in the economy. Finally, ϵ_t^τ is an i.i.d. macroprudential policy shock: $\epsilon_t^\tau \sim \mathcal{N}(0, \sigma_\tau^2)$.

Market clearing and equilibrium. A competitive equilibrium consists of sequences of prices $\{P_t, W_t, R_t, R_t^\ell\}_{t=0}^\infty$ and allocations $\{Y_t, C_t^e, C_t^u, H_t, H_t^e, D_t, D_t^e, L_t, L_t^u, N_t\}_{t=0}^\infty$ solving household, firm, and bank optimization problems. Moreover, labor market clearing requires that the demand of labor equals the supply of labor coming from the employed agents:

$$H_t = \int_e H_t^e(j)dj \equiv \gamma H_t^e, \tag{47}$$

where γ is the share of employed households in the economy. Regarding the banking sector, at time t both deposit and loan markets clear:

$$D_t \equiv \int_0^1 D_t^b(i)di = \int_e D_t^e(j)dj, \tag{48}$$

$$L_t \equiv \int_0^1 L_t^b(i)di = \int_u L_t^u(j)dj, \tag{49}$$

where D_t^b and L_t^b are deposits and loans provided by individual banks. Their aggregate values are equal to the total deposits and loans issued by the representative bank. Households hold the aggregate deposits and loans supplied by the banks. Finally, market clearing in the goods market requires that at time t:

$$\left(1 - \frac{\xi}{2}\Pi_t^2\right) Y_t + (1-\gamma)\nu = \gamma C_t^e + (1-\gamma) C_t^u. \tag{50}$$

In sum, the nonlinear equilibrium consists of 23 variables and equations. Details of the competitive equilibrium are available in Appendix A.

3 Quantitative Analysis

In this section, I conduct numerical simulations to investigate the model's performance concerning different specifications, derive the optimal monetary rules, and compare the welfare loss/gain of different policy regimes. The analysis helps understand the effectiveness of macroprudential interventions and monetary policy rules that consider the interest rate spread.

I solve the model using the widely known perturbation method, initially proposed by Judd and Guu (1993) in the economics literature. These methods are based on Taylor's expansions around the steady state point and the implicit function theorem. I use MATrix LABoratory (MATLAB) software to implement the standard perturbation method for solving the model. I further employ a standard minimization procedure to conduct welfare analysis and find optimal policy rules.

Calibration. Table 1 summarizes the values chosen for the parameters in the model. The unit of time is a quarter, and I choose standard values used in the literature. I set $\beta_e = 0.995$ so that the employed household discounts the future at a 2% rate per annum. Hence, the steady state interest rate (R) is 0.005. I target a steady state spread (ς) equal to 2% at an annual frequency. Hence, I set $\beta_u = 0.99$, which means $R^\ell = 0.01$. I assume a zero steady state net inflation rate, $\Pi = 0$. The Frisch elasticity is set to 1, and the labor scaling parameter is 1.4. Home production, ν is set to 0.05. Employed-unemployed fixed transfers and employed-banks fixed transfers are 0.40 and 0.005, respectively. The Bureau of Labor Statistics reports that 64.9 and 63.5 percent of the population worked in 2019 and 2020, respectively. In addition, 65.70 and 64.60 percent of the population worked at some time in 2019 and 2020, respectively. Omitting the post-pandemic data from 2020, I set the share of employed households γ = 0.67, which is considered a relevant value for normal times.

Following the literature, the markup is set to 10 percent, which means the intermediate goods elasticity of substitution equals 11. I assume that the Rotemberg price adjustment cost xi is 42.68. I further assume that banks survive for 20 quarters given the banks' probability of default $\sigma = 0.05$. The fraction of diverted loans θ is set to 0.41 to hit the target interest rate spread of 200 annual basis points. The autoregressive parameter for productivity is set to 0.8, which is commonly used in the literature.

Finally, I set the parameters used in policy rules. I name this group of parameters *ad hoc* parameters since these values' main purpose is to have results to be compared with those obtained from the model with the optimal policy. I consider the most commonly used values in the literature and assign them to corresponding parameters. I assume that the benchmark Taylor rule parameters are $\rho_r = 0.8$, $\phi_{r,\pi} = 1.5$, $\phi_{r,y} = 0.25$, and $\phi_{r,\varsigma} = 0.3$. Moreover, I set the tax policy parameters, ρ_τ and $\psi_{\tau,\varsigma}$, to 0.9 and 0.5, respectively.

Table 1: Parameter values

Parameter	Description	Value
Discount factor, employed	β_e	0.995
Discount factor, unemployed	β_u	0.99
Labor scaling parameter	χ	1.4
Frisch elasticity	η	1
Fraction of employed households	γ	0.67
Home production	ν	0.05
Employed-unemployed fixed transfer	T^e	0.4
Banks fixed transfer	σ	0.005
Fraction of diverted loans	θ	0.41
Banks' probability of default	μ	0.05
Intermediate goods elasticity of substitution	ε	11
Rotemberg price adjustment cost	ξ	42.68
Steady state net inflation rate	Π	0
AR productivity	ρ_a	0.8

3.1 Optimal Policies

I investigate optimal monetary policy rules as the first step in the analysis. To do so, I consider two different economies. The first economy is an *unregulated* economy with no macroprudential interventions or a tax policy on the banking system. The economy in the presence of tax policy on the banking system as a macroprudential instrument, named the *regulated* economy, is the second environment where I conduct the analysis. Furthermore, I define several regimes in each economy. Within the unregulated economy, a benchmark specification is a regime with no macroprudential intervention and a monetary policy rule that follows the standard Taylor rule. I define an alternative regime in which the augmented Taylor rule includes a response to the interest rate spread.

For the regulated economy, I define three alternative policy regimes in addition to a benchmark regime similar to the one in the unregulated economy. The first alternative regime includes a Taylor rule considering the interest rate spread's movements. There is also a simple tax policy that does not react to the spread. The second alternative regime consists of the standard Taylor rule, while a tax policy on the banking system is interpreted as macroprudential intervention reacting to the spread. The third alternative regime in the regulated economy encompasses both the macroprudential instrument and the augmented monetary policy rule considering the spread. Hence, six different regimes are present for the policy evaluation analysis.

Following the approach by Schmitt-Grohé and Uribe (2007), I compute welfare-maximizing optimal monetary policies. Their approach is widely used in the literature since one does not need to know the efficient level of output or other macroeconomic variables in the model. At the same time, optimized policy variables are functions of a number of observable macroeconomic variables. Moreover, this method relies on higher-order approximations, as the previous literature shows that first-order approximations can lead to an inaccurate evaluation of policies' performance in terms of welfare maximization (Kim and Kim, 2003; Kollmann, 2008; Lambertini et al., 2013).

I use perturbation methods to approximate the nonlinear competitive equilibrium around its deterministic steady state up to the second order. I further compute the maximized welfare level by looping over values of parameters used in monetary policy rules. Unlike the unconditional welfare values that need long-horizon simulations, these maximized welfare values are conditional on the theoretical stochastic mean of the welfare delivered by the second-order approximation. Hence, the results are independent of different realizations of technology and monetary policy shocks in the model. I keep all other parameters used in the model constant while searching for the optimized parameters of the monetary policy rule. In this way, I look for only three or four values in every optimization procedure (depending on the Taylor rule's specification).

Table 2 presents the values of coefficients of the optimized monetary policy rules in regulated and unregulated economies. I set the coefficient reacting to inflation as bounded, i.e., $0 < \phi_{r,\pi} < 5$, as the only restriction in the maximization procedure. The first significant result across all policy rules and specifications is the low value of the

Table 2: Optimal parameters (constrained $\phi_{r,\pi}$)

Without regulation	ρ_r	$\phi_{r,\pi}$	$\phi_{r,y}$	$\phi_{r,\varsigma}$
Benchmark	0.099	3.359	0.000	-
Benchmark + ς	0.118	4.998	0.000	0.349
With regulation	ρ_r	$\phi_{r,\pi}$	$\phi_{r,y}$	$\phi_{r,\varsigma}$
Benchmark	0.000	4.895	0.000	-
Benchmark + ς	0.000	3.209	0.088	0.256
Benchmark + macroprudential	0.054	2.323	0.000	-
(Benchmark + ς) + macroprudential	0.000	2.332	0.000	0.292

Notes: This table reports the optimal coefficients of different monetary policy rules when the response to inflation is set bounded ($0 < \phi_{r,\pi} < 5$). There is a benchmark monetary rule in each regulated and unregulated economy that does not react to the spread. The second row shows the results for the alternative rule in the unregulated economy reacting to the interest rate spread. In the case of regulated economy, there are three alternative regimes (rows 4-6). *"Benchmark + ς"* is the monetary regime that reacts to the spread while there is no macroprudential rule concerning the spread. *"Benchmark + macroprudential"* indicates a monetary policy abstracting from the spread while there is a macroprudential instrument reacting to the spread. Finally, *"(Benchmark + ς) + macroprudential"* is a regime where both monetary and macroprudential rules react to the spread.

interest rate rule smoothing variable. In the case of the unregulated economy, the value corresponding to interest rate rule smoothing (ρ_r) ranges from 0.10 to 0.12, while in the regulated economy, the corresponding value is virtually zero. This finding is consistent with those of previous literature. For instance, Schmitt-Grohé and Uribe (2007) show that the welfare gain of interest rate smoothing is negligible.

Next, the results indicate a large level of reaction to inflation fluctuations in all policy regimes. The optimized values ranged from 2.33 to 5. These values are significantly larger than the conventional value used in the literature, i.e., $\phi_{r,\pi} = 1.5$. In the unregulated economy, the policy responding to the spread reacts to inflation movements more strongly than the policy that excludes the response to the fluctuation of the spread around its steady state. In contrast, in the regulated economy, Taylor rules augmented with the response to the interest rate spread react to inflation fluctuations around its steady state more moderately compared to the policy rule in the benchmark regime.

In almost all cases, the optimal reaction to output fluctuations around its potential level is zero. Only the augmented optimal monetary policy responding to the interest rate spread and a simple macroprudential intervention without responding to the interest rate spread within the regulated economy would result in an optimal value of other than zero, i.e., 0.088, for the optimal reaction to output fluctuations.

Table 3: Optimal parameters (unconstrained $\phi_{r,\pi}$)

Without regulation	ρ_r	$\phi_{r,\pi}$	$\phi_{r,y}$	$\phi_{r,\varsigma}$
Benchmark	0.099	3.359	0.000	-
Benchmark + ς	0.000	272.590	0.000	-0.802
With regulation	ρ_r	$\phi_{r,\pi}$	$\phi_{r,y}$	$\phi_{r,\varsigma}$
Benchmark	0.000	4.895	0.000	-
Benchmark + ς	0.000	278.426	0.069	-1.544
Benchmark + macroprudential	0.054	2.323	0.000	-
(Benchmark + ς) + macroprudential	0.000	2.332	0.000	0.292

Notes: This table reports the optimal coefficients of different monetary policy rules when the response to inflation is set unbounded ($-\infty < \phi_{r,\pi} < +\infty$). There is a benchmark monetary rule in each regulated and unregulated economy that does not react to the interest rate spread. The second row shows the results for the alternative rule in the unregulated economy reacting to the spread. In the case of regulated economy, there are three alternative regimes (rows 4-6). *"Benchmark + ς"* is the monetary regime that reacts to the spread while there is no macroprudential rule concerning the spread. *"Benchmark + macroprudential"* indicates a monetary policy abstracting from the spread while there is a macroprudential instrument reacting to the spread. Finally, *"(Benchmark + ς) + macroprudential"* is a regime where both monetary and macroprudential rules react to the spread.

Moreover, the findings highlight the importance of responding to the interest rate spread in the Taylor rule. The optimized values for the corresponding variable in the augmented Taylor rule are between 2.6 and 3.5. However, these results suggest that the monetary policy authority would increase the policy rate in response to an increase in the interest rate spread, which is not consistent with a fraction of the literature supporting a countercyclical reaction to the spread. Curdia and Woodford (2010), for example, suggest that a monetary policy rule should be associated positively with an increase in the credit spread.

On the one hand, monetary authority pushes back the interest rate spread to its steady state value by increasing the policy rate (R), or in other words, the rate of return on deposits. On the other hand, since macroprudential interventions in the form of a tax on banks' capital are present in the economy and consider the expected changes in the spread, such tax policies disincentivize banks from increasing the rate of return on loans (R^{ℓ}). These two forces stabilize the deviations of interest rate spread from its steady state level and consequently the consumption of households located in different ranges of wealth distribution.

In addition to the baseline results presented in this section, I conduct a similar experiment when the coefficient reacting to inflation is unbounded. The results are summarized in Table 3.

The results are almost identical to Table 2, except for two cases in which I find unrealistically large values regarding the optimal reaction to deviations of inflation from its steady state. The first case is the alternative regime within the unregulated economy, which yields a value equal to 273 regarding the optimal reaction to inflation in the Taylor rule. The second case is the monetary policy that reacts to the spread, while the tax policy in the regulated economy does not respond to the interest rate spread fluctuations. In this case, the optimal monetary policy rule yields a value as large as 279 for the corresponding parameter reacting to inflation fluctuations. The large values of the inflation feedback in both cases are associated with negative optimized values for the parameter responsible for reacting to the expected interest rate spread deviations from its steady state value.

The negative values of the optimal interest rate spread parameter in the monetary policy rule imply that in the absence of a macroprudential instrument that reacts to the interest rate spread, the optimal monetary policy would react negatively to an increase in the interest rate spread. This is the opposite of other cases in Tables 2 and 3. However, these results are conditional on an unbounded interval for the inflation feedback parameter resulting in large values of the corresponding variable, which is impractical. Moreover, as we will see later in the paper, the welfare gain from the corresponding optimal policy rules is insignificant. Therefore, these results technically do not affect the welfare experiment results.

3.2 Welfare Performance

I examine welfare improvement across policy regimes in terms of consumption equivalence. First, I take the maximized welfare value obtained from the optimal policy in the benchmark and alternative regimes within unregulated and regulated economies. Next, fixing the benchmark welfare values as in the previous section, I calculate the fraction of consumption that households would be willing to give up if they moved from the benchmark economy to alternative economies. The value obtained is consumption equivalence, which is the amount of consumption that makes the household indifferent between the benchmark and alternative economies. Since consumption in the model is in the form of log utility, it is straightforward to compute consumption equivalence. Suppose that the maximized welfare under the benchmark regime is given by the following:

$$\mathbb{E}_t\left[W_t^b\right] \equiv \mathbb{E}_t\left[\sum_{t=0}^{\infty} \beta^t U(C_t^b, H_t^b)\right].$$

Consumption equivalence (*ce*) is the value satisfying the following equation

$$\mathbb{E}_t\left[\sum_{t=0}^{\infty} \beta^t U(C_t^b(1+ce), H_t^b)\right] = \mathbb{E}_t\left[\sum_{t=0}^{\infty} \beta^t U(C_t^a, H_t^a)\right],$$

where the right-hand side of the equation denotes the maximized welfare within the alternative regime. In the case of log utility, solving for *ce* yields

$$ce = \exp\Big((1-\beta)\big(\mathbb{E}_t\left[W_t^a\right] - \mathbb{E}_t\left[W_t^b\right]\big)\Big) - 1. \tag{51}$$

If $ce > 0$, the alternative regime yields a higher level of welfare, which means that the households would require $(100 \cdot ce)$ percent of consumption to equate the welfare in the benchmark regime to that of the alternative regime. The opposite holds for the household if *ce* is negative.

Table 4 presents the results regarding comparing welfare improvement across different policy regimes in terms of consumption equivalence. To better interpret the welfare improvement, I use consumption equivalence in percentage form: $CE = 100 \cdot ce$. Welfare comparison outcomes in the unregulated economy suggest that the standard Taylor rule performs better than an adjusted policy rule that reacts to the interest rate spread as the consumption equivalence for the alternative policy yields a negative value. However, the value of welfare loss is negligible, as it is approximately 0.006%. Hence, these results suggest that within an unregulated economy, the standard Taylor rule is sufficient in terms of social welfare as an adjusted monetary policy rule that leans against interest rate spread performs relatively weaker.

In the case of a regulated economy, all alternative policy regimes perform better than the benchmark regime. The welfare gain in the form of the consumption equivalence percentage ranges from 0.010% to 0.019%. Moreover, the results indicate that even if the tax policy in the banking system does not consider the interest rate spread, a monetary policy rule can be welfare-improving if it reacts to the interest rate spread. Welfare gain, in this case, is equivalent to 0.010% in consumption equivalence terms.

Table 4: Consumption equivalence (constrained $\phi_{r,\pi}$)

Without regulation	CE (%)	SD(Y)	SD(R)	SD(ς)	SD(Π)
Benchmark	-	0.0065	0.0053	0.0049	0.0021
Benchmark + ς	-0.0054	0.0064	0.0044	0.0040	0.0016
With regulation	**CE (%)**	**SD(Y)**	**SD(R)**	**SD(ς)**	**SD(Π)**
Benchmark	-	0.0065	0.0045	0.0042	0.0015
Benchmark + ς	0.0089	0.0064	0.0056	0.0048	0.0023
Benchmark + macroprudential	0.0148	0.0065	0.0062	0.0056	0.0027
(Benchmark + ς) + macroprudential	0.0183	0.0064	0.0065	0.0055	0.0029

Notes: This table reports welfare gain/loss in terms of consumption equivalence for different monetary settings. Second moments of output, borrowing interest rate, and inflation are reported. The response to inflation in the monetary policy rule is set bounded ($0 < \phi_{r,\pi} < 5$). For more details, see Table 2.

On the other hand, a monetary policy rule that does not react to the interest rate spread is even a better welfare-improving tool if there is a tax policy or, in other words, a macroprudential instrument that considers the interest rate spread. This specification results in an almost 50% higher consumption equivalence equal to 0.015%.

Furthermore, the monetary policy rule reacting to the interest rate spread has the best performance when it is accompanied by a tax policy that also considers the interest rate spread. This specification yields consumption equivalence equal to 0.019%. Overall, these results imply that considering the interest rate spread either by monetary policy rule or macroprudential instruments helps the economy in terms of social welfare.

Additionally, Table 4 shows the economic stabilization performance of policy regimes. In the unregulated economy, even though the standard Taylor rule performs better than the alternative augmented policy rule, the latter seems superior in stabilizing the economy. The augmented policy rule is related to lower output, inflation, and interest rate volatilities. For all variables, the augmented Taylor rule has a significantly better performance. Thus, I conclude that within an unregulated economy, the best choice would be the augmented Taylor rule that reacts to the interest rate spread, since it performs remarkably better in stabilizing the economy and performs only marginally worse than the standard Taylor rule in terms of consumption equivalence.

For the regulated economy, the results of stabilization performance demonstrate that there is no difference in output volatility across different policies. However, the results show that the better a policy performs in welfare improvement, the higher

Table 5: Consumption equivalence (unconstrained $\phi_{r,\pi}$)

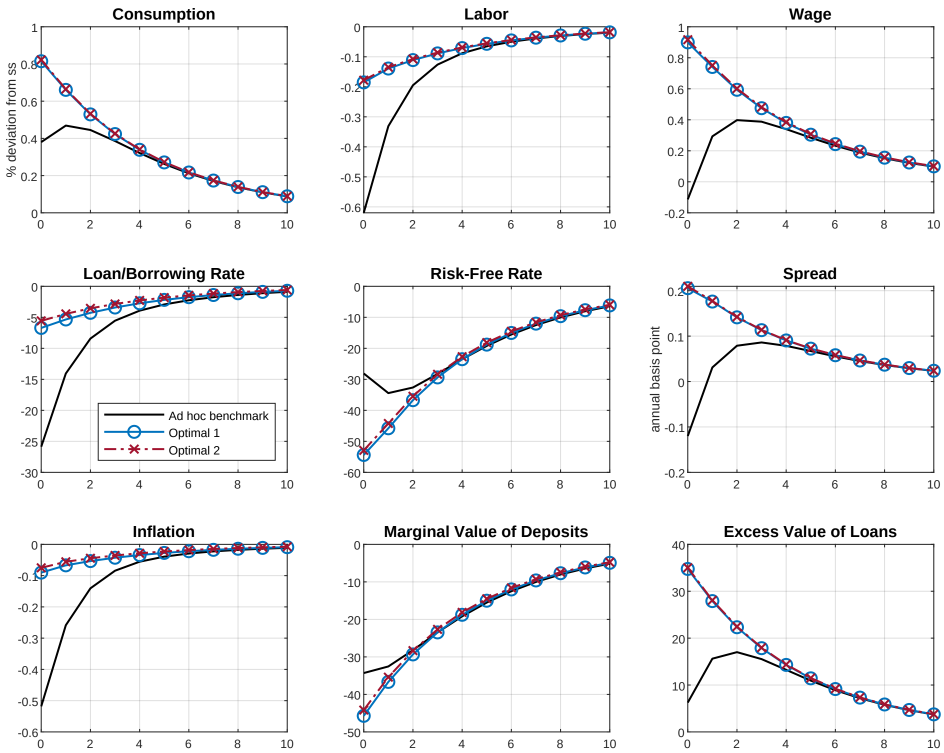
Without regulation	CE (%)	SD(Y)	SD(R)	SD(ς)	SD(Π)
Benchmark	-	0.0065	0.0053	0.0049	0.0021
Benchmark + ς	-0.0114	0.0065	0.0028	0.0028	0.0001
With regulation	**CE (%)**	**SD(Y)**	**SD(R)**	**SD(ς)**	**SD(Π)**
Benchmark	-	0.0065	0.0045	0.0042	0.0015
Benchmark + ς	0.0010	0.0065	0.0028	0.0028	0.0001
Benchmark + macroprudential	0.0148	0.0065	0.0062	0.0056	0.0027
(Benchmark + ς) + macroprudential	0.0183	0.0064	0.0065	0.0055	0.0029

Notes: This table reports welfare gain/loss in terms of consumption equivalence for different monetary settings. Second moments of output, borrowing interest rate, and inflation are also reported. The response to inflation in the monetary policy rule is set unbounded ($-\infty < \phi_{r,\pi} < +\infty$). For more details, see Table 2.

its volatility. All alternative policy regimes are related to higher standard deviations of inflation. They are also associated with a more volatile interest rate, which by having a higher level of consumption in the economy would imply a higher chance of hitting the zero lower bound. Therefore, considering the overall performance of alternative policies in terms of welfare maximization and economic stabilization, one cannot conclude confidently which policy, including the benchmark regime, is the best option to compromise between these two factors.

I conduct the same exercise for optimal policies when ($-\infty < \phi_{r,\pi} < +\infty$). Table 5 shows the relevant results. The welfare outcomes are almost identical to the previous results. The only difference is the performance of the augmented Taylor rule in the unregulated economy. The results indicate that this policy regime is associated with a welfare loss equal to 0.011%, which is twice as large as what is presented in Table 4. Moreover, in contrast with the previous results, the optimal policies with the infeasible large values of $\phi_{r,\pi}$ have the best performance from the point of view of economic stabilization. The alternative policy regime is associated with significantly lower inflation, spread, and interest rate volatilities in the unregulated economy. Furthermore, in the regulated economy, in the absence of a tax policy that considers the spread, the augmented monetary policy rule that reacts to the spread results in a welfare gain. This specification also has the best performance in stabilizing inflation and the interest rate. This policy regime yields inflation with a virtually zero standard deviation and the lowest interest rate volatility, which is 40% lower than the next smallest volatility on the list. Hence, I conclude that this policy would be the best among all the policy

Figure 3: Impulse Response to a Technology Shock (unregulated economy)



Notes: Ad hoc rule is without a response to the spread. The blue circle line indicates the impulse responses when the optimal monetary policy does not include the response to the spread. The red-crossed line is associated with the optimal policy considering the spread. The unit of the horizontal axis is a quarter.

regimes as it is the only one that is welfare-improving and, at the same time, associated with the lowest volatilities.

3.3 Impulse Responses

I investigate impulse responses to understand the mechanism of different policy rules within unregulated and regulated economies. I define an ad hoc specification using the values presented in Table 1 together with common values used for the Taylor rule parameters in the literature. As explained in the calibration section, I assume that the parameters of this ad hoc Taylor rule are $\rho_r = 0.8$, $\phi_{r,\pi} = 1.5$, $\phi_{r,y} = 0.25$, and $\phi_{r,\varsigma} = 0.3$. The ad hoc specification is presented by a solid black line in figures related to impulse responses.

Figure 3 illustrates impulse responses to a one percent technology shock for the ad hoc specification and the optimal alternative policy. The ad hoc rule does not react to fluctuations in the spread. There are also two alternative optimal monetary policy rules. The two other rules are the optimal standard Taylor rule, which does not include the response to the interest rate spread and the absence of a tax policy reacting to the spread (blue-circle line), and the optimal augmented Taylor rule reacting to the interest rate spread in the presence of a tax policy that also reacts to the spread (red-cross line). The same colors denote the same regimes for all the figures in this section.

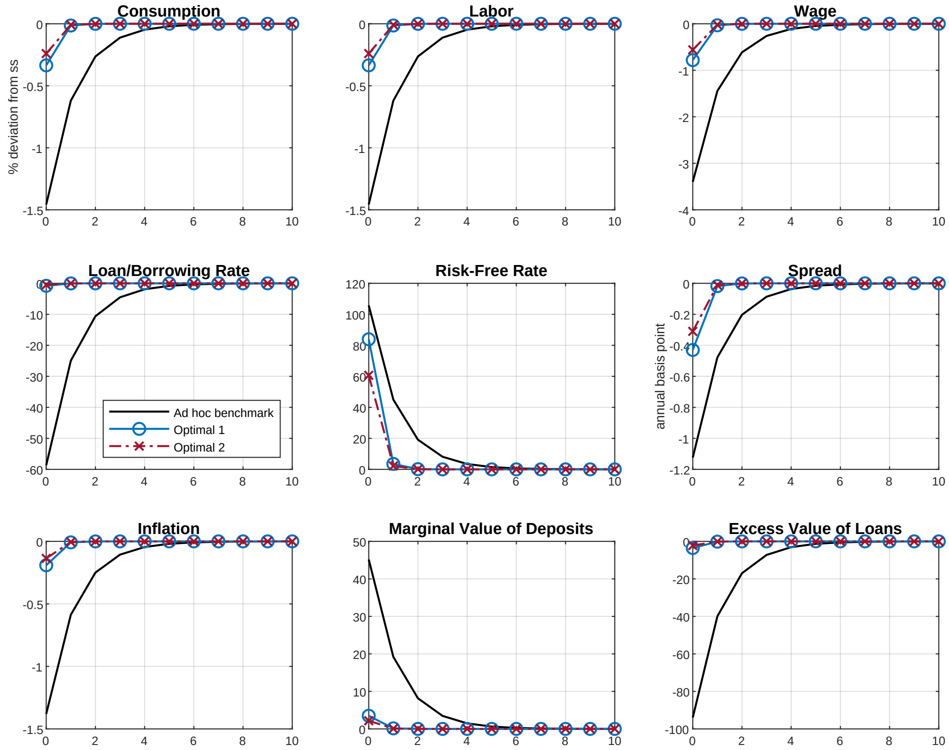
The magnitude and direction of responses differ across alternative regimes. For instance, consumption almost doubles in the alternative policy regimes compared to the ad hoc policy. Moreover, inflation has a minimal response to the technology shock if an optimal alternative policy is in place, while there is a relatively sharp decline in inflation in the case of an ad hoc policy regime. The responses of loan and borrowing rates are also identical in the case of two alternative policies, which are noticeably different from the responses in the case of the ad hoc policy regime. In addition, impulse responses indicate an increase in the interest rate spread in the case of optimal policy regimes and the opposite for the ad hoc regime. The impulse responses for other variables are in the same direction but with different magnitudes for alternative regimes compared to the ad hoc policy regime.

The alternative optimal policies seem to cause a larger but smoother response than the ad hoc policy. If we consider only alternative policies, the impulse responses are almost identical. However, the impulse responses of optimal augmented Taylor rule do not show a significantly better performance. This result verifies the conclusion in Table 4 that a Taylor rule augmented by a response to the spread seems to be a better option to practice in an unregulated economy.

Figure 4 plots impulse responses to a monetary policy shock for the abovementioned regimes. Contrary to the responses to a technology shock, alternative optimal policy regimes tend to produce smaller responses. For example, while there is a sharp decline in consumption and inflation for the ad hoc regime, the alternative policies' impulse responses are far less significant. The borrowing rate does not respond to the monetary policy shock if the optimal adjusted Taylor rule is considered, whereas it decreases 60% in the case of the ad hoc policy. Furthermore, the impulse responses are less significant, and deviations from the steady state last one quarter for almost all the variables of interest if we move from the ad hoc regime to the alternatives.

The results depicted in Figures 3 and 4 suggest that the alternative optimal policy

Figure 4: Impulse Response to a Monetary Policy Shock (unregulated economy)

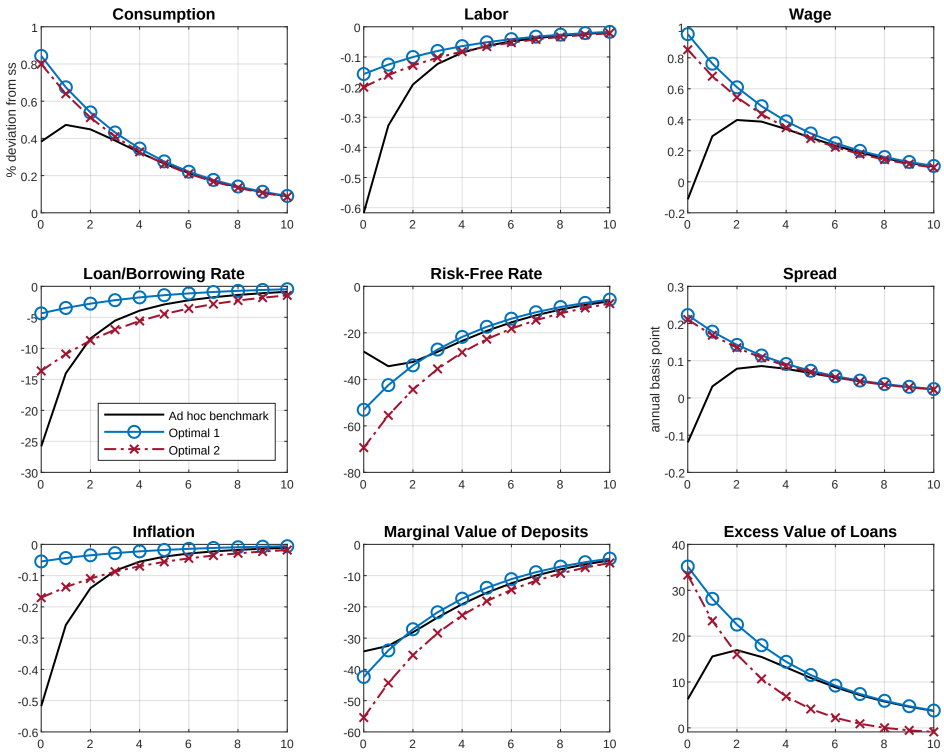


Notes: Ad hoc rule is without a response to the spread. The blue circle line indicates the impulse responses when the optimal monetary policy does not include the response to the spread. The red-crossed line is associated with the optimal policy considering the spread. The unit of the horizontal axis is a quarter.

that reacts to the interest rate spread performs better than the ad hoc regime constructed by the common parameter values used in the literature in response to both monetary and technology shocks. However, in an unregulated economy, the impulse responses relevant to the standard Taylor rule imply an almost equal performance compared to those related to the regime associated with an augmented Taylor rule that reacts to the interest rate spread.

Furthermore, I conduct the same exercise within the regulated economy. Figure 5 plots the impulse responses to a technology shock in the regulated economy across three different policy regimes. As in the unregulated economy, we observe a similar pattern in impulse responses across different policy regimes. Consumption increases by a larger magnitude for alternative policies. Its increase is marginally higher for the policy regime that reacts to the interest rate spread. The labor market response also differs by moving from the ad hoc regime to alternative policy regimes. While there is a decline in labor and wages across all regimes, an augmented Taylor rule considering the interest rate spread results in a larger reduction in both labor and wages. In the

Figure 5: Impulse Response to a Technology Shock (regulated economy)

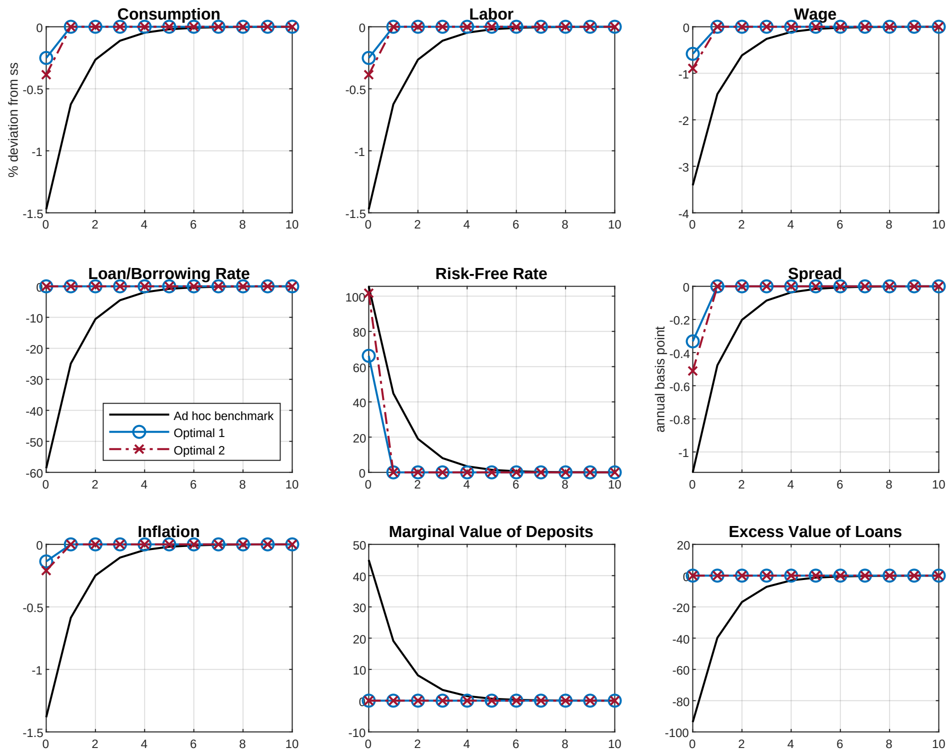


Notes: Ad hoc rule is without a response to the spread. The blue circle line indicates the impulse responses when the optimal monetary policy does not include the response to the spread. The red-crossed line is associated with the augmented optimal monetary policy and a tax policy that consider the interest rate spread. The unit of the horizontal axis is a quarter.

ad hoc regime, inflation decreases almost ten times lower than the level of reduction if the standard Taylor rule is in place, while the inflation response within a regime with an augmented Taylor rule lies between those of two other regimes. In all cases, despite the difference in the initial response, inflation moves back to its steady state level after ten quarters.

Both the optimal standard Taylor rule and its optimal augmented counterpart yield almost identical impulse responses of the interest rate spread in terms of magnitude and direction. In both cases, the spread increases by 0.2 annual basis points. This is the opposite of the spread response in the ad hoc regime, which yields a reduction equal to 0.01 basis point. In the banking sector, the marginal value of deposits declines more significantly for the regime associated with the augmented standard Taylor rule. At the same time, the marginal value of loans increases are larger than those of the ad hoc rule and equal to that of the optimal standard Taylor rule regime. Based on these results, One cannot conclude if the optimal augmented Taylor rule has the best performance across all policies in response to a positive technology shock in a regulated economy.

Figure 6: Impulse Response to a Monetary Policy Shock (regulated economy)



Notes: Ad hoc rule is without a response to the spread. The blue circle line indicates the impulse responses when the optimal monetary policy does not include the response to the spread. The red-crossed line is associated with the augmented optimal monetary policy and a tax policy that consider the interest rate spread. The unit of the horizontal axis is a quarter.

Finally, regarding impulse responses to a monetary policy shock, Figure 6 illustrates the mechanism across alternative policy regimes. Similar to the unregulated economy, optimal alternative Taylor rules are associated with a more effective response to a monetary policy shock in the economy. Marginal values of deposits and loans do not react to the shock if the optimal monetary policy rules are considered. The rest of the results are similar to those I obtained in the unregulated economy. In all cases where there is a response from the variable of interest to the shock under optimal alternative monetary regimes, the deviation from the steady state value lasts for only one quarter. Overall, these results suggest that, in the regulated economy, an augmented Taylor rule is an effective tool in response to a monetary policy shock. However, its associated responses are marginally less significant than those of an optimal standard Taylor rule. Hence, the impulse responses verify that even though an augmented Taylor rule that considers the interest rate spread is the most effective among the alternative policies in terms of welfare improvement, it seems not to be the most effective substitute for the standard Taylor rule in response to monetary and technology shocks.

4 Conclusion

This paper incorporates the banking system into a two-agent New Keynesian model à la Gertler and Karadi (2011). I mainly focus on the interest rate spread movement and its effect on household consumption and social welfare in the economy. The motivation is based on the countercyclical movements of spread during business cycles that indicate the procyclicality of banks' net worth. This pattern of movements is crucial for consumption fluctuations as recessions affect households that face a borrowing constraint more adversely than wealthier agents (employed households in the model), resulting in a decline in poorer (unemployed) households' consumption. I consider two alternative economies: an unregulated economy with no macroprudential instrument and a regulated economy in which macroprudential interventions are present in the form of tax policy within the banking system. The tax policy thus takes into account only the interest rate spread. I also introduce an augmented Taylor rule that reacts to the interest rate spread. In particular, I investigate the optimal monetary policy rules and their relative performance regarding welfare improvement within regulated and unregulated economies.

The welfare experiment results show that in the unregulated economy without any macroprudential instrument, the standard Taylor rule seems to be a more effective policy in terms of social welfare compared to an augmented Taylor rule that reacts to the interest rate spread, as there is virtually no welfare improvement when we move from the former to the latter. On the other hand, an augmented Taylor rule seems to perform relatively better in stabilizing the economy compared to its counterpart.

The results suggest a significant welfare improvement in the regulated economy if a monetary policy rule reacts to the interest rate spread. The maximum welfare gain is achieved when both augmented monetary and tax policies consider the deviation of the expected interest rate spread from its steady state value. The results also demonstrate that a regulated economy with an augmented Taylor rule is associated with a faster recovery after a monetary policy shock hits the economy. However, an adjusted Taylor rule considering the interest rate spread, which is also associated with a tax policy that reacts to the spread, does not have the best performance in responding to monetary and technology shocks. Hence, the results cannot be conclusive about the best policy regime for economic stabilization.

The results of this paper provide several insights into the literature in the following ways. First, this study adds to the current literature by introducing a new model consisting of two types of agents and a simplified version of the banking sector that is flexible enough to allow for studying the impact of various financial frictions and relevant macroprudential interventions on the welfare of households. Second, the analysis adds to the literature on the interest rate spread and its impact on households' welfare. The findings show that in the case of macroprudential interventions in the form of a tax policy on banks' capital, a monetary rule reacting to the spread is associated positively with the level of consumption for households. In line with a large body of literature, e.g., Cúrdia and Woodford (2016), these findings confirm the better performance of a policy rule incorporating the interest rate spread compared to the standard Taylor rule regarding stabilizing the economy and the welfare improvement of households. However, it is worth mentioning that since the primary purpose of this paper is to examine the welfare effect of monetary policy rules, I abstract from optimal macroprudential policy analysis, which can be a question of future research.

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Appendix

A Summary of the model

The nonlinear equilibrium consists of 23 variables $\{C_t, C_t^e, C_t^u, D_t^e, D_t, L_t^u, L_t, N_t, R_t, R_t^\ell, \varsigma_t, H_t^e, H_t, Y_t, W_t, MC_t, \Lambda_{t,t+1}, \Phi_t, x_{d,t}, z_{\ell,t}, \Pi_t, T_t^u, \tau_t\}$ and 23 equations.

$$0 = \frac{1}{C_t^e} - \beta_e \mathbb{E}_t \left[\frac{1+R_t}{1+\Pi_{t+1}} \frac{1}{C_{t+1}^e} \right] \tag{A1}$$

$$0 = \frac{1}{C_t^u} - \beta_u \mathbb{E}_t \left[\frac{1+R_{t+1}^\ell}{1+\Pi_{t+1}} \frac{1}{C_{t+1}^u} \right] \tag{A2}$$

$$0 = C_t^u + \frac{1+R_t^\ell}{1+\Pi_t} L_{t-1}^u - \nu - L_t^u - T_t^u \tag{A3}$$

$$0 = W_t - \chi C_t^e (H_t^e)^{\frac{1}{\eta}} \tag{A4}$$

$$0 = W_t - A_t MC_t \tag{A5}$$

$$0 = H_t - \gamma H_t^e \tag{A6}$$

$$0 = Y_t - A_t H_t \tag{A7}$$

$$0 = C_t - \gamma C_t^e - (1-\gamma) C_t^u \tag{A8}$$

$$0 = \left(1 - \frac{\xi}{2}\Pi_t^2\right) Y_t + (1-\gamma)\nu - C_t \tag{A9}$$

$$0 = T_t^u - T_t^e - \tau_t L_{t-1}^u \tag{A10}$$

$$0 = R_{t+1}^\ell - R_{t+1} - \varsigma_{t+1} \tag{A11}$$

$$0 = D_t - \gamma D_t^e \tag{A12}$$

$$0 = L_t - (1-\gamma) L_t^u \tag{A13}$$

$$0 = L_t - N_t - D_t \tag{A14}$$

$$0 = N_t - \Big((1-\mu)(R_t^\ell - \tau_{t-1}) + \sigma R_t^\ell\Big) L_{t-1} + (1-\mu) R_t D_{t-1} \tag{A15}$$

$$0 = L_t - \frac{x_{d,t}}{\theta - z_{\ell,t}} N_t \tag{A16}$$

$$0 = \Phi_t - \mu - (1-\mu)\left(\frac{\theta x_{d,t}}{\theta - z_{\ell,t}}\right) \tag{A17}$$

$$0 = \Lambda_{t,t+1}^e - \beta_e \frac{C_t^e}{C_{t+1}^e} \tag{A18}$$

$$0 = x_{d,t} - \mathbb{E}_t \frac{\Lambda_{t,t+1}^e}{1+\Pi_{t+1}} \Phi_{t+1} R_{t+1} \tag{A19}$$

$$0 = z_{\ell,t} - \mathbb{E}_t \frac{\Lambda_{t,t+1}^e}{1+\Pi_{t+1}} \Phi_{t+1} \big(R_{t+1}^\ell - R_{t+1} - \tau_t\big) \tag{A20}$$

$$0 = \ln R_t - \rho_r \ln R_{t-1} - (1-\rho_r) \Big[\ln R + \phi_{r,\pi}(\ln \Pi_t - \ln \Pi) + \phi_{r,y}(\ln Y_t - \ln \bar{Y}_t) + \phi_{r,\varsigma} \mathbb{E}_t (\ln \varsigma_{t+1} - \ln \varsigma) \Big] - \epsilon_t^R \tag{A21}$$

$$0 = \ln \tau_t - \rho_\tau \ln \tau_{t-1} - (1-\rho_\tau) \Big[\psi_{\tau,\varsigma} \mathbb{E}_t (\ln \varsigma_{t+1} - \ln \varsigma) \Big] - \epsilon_t^\tau \tag{A22}$$

$$0 = (1-\varepsilon) + \varepsilon MC_t - \xi \Pi_t (1+\Pi_t) + \xi \mathbb{E}_t \left[\Lambda_{t,t+1}^e \frac{Y_{t+1}}{Y_t} \Pi_{t+1} (1+\Pi_{t+1}) \right] \tag{A23}$$

B Unconditional welfare

Figure B1: Unconditional welfare varying $\phi_{r,y}$

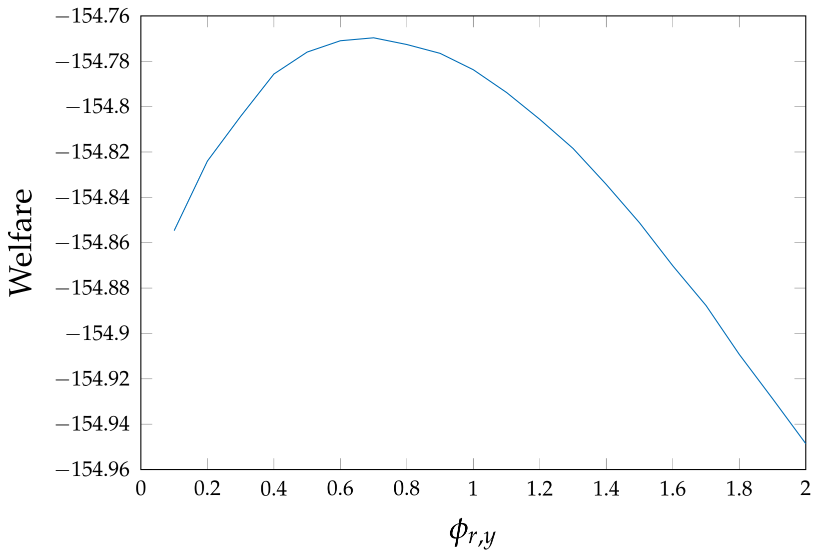

Figure B2: Unconditional welfare varying $\phi_{r,\varsigma}$