Monetary Policy and Financial Stability*

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Abstract

How should monetary policy respond to evolving financial conditions? To answer this question we develop and Bayesian estimate a dynamic macro model with a detailed financial sector and long-term defaultable nominal debt contracts to quantify how monetary policy response to movements in credit conditions can mitigate losses in aggregate consumption and output associated with macro fluctuations. We show that a (credible) monetary policy rule that includes credit spreads is often welfare-improving and generally obviates the need for explicit inflation targeting.

Keywords: Credit spreads, monetary policy rules, financial stability

JEL Codes: E12, E43, E44, E52, G32

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1 Introduction

Monetary policy remained extremely loose during the economic recoveries that followed the 2008 and 2020 recessions. Despite accumulating evidence of rising economic growth and even inflation expectations, most Central banks around the world increased interest rates only reluctantly and very slowly. Concerns about financial stress and the possible consequences of sharp increases in policy rates on defaults, and financial stability more broadly, were often mentioned as a possible justification.[1]. Notably, as Figure 1 shows, deviations from the Taylor rule in the US have become consistently negative since 2008. Significantly, this has coincided with a period where credit spreads have often been unusually high, suggesting that the Fed has indeed become less willing to target inflation over time and has perhaps focused more on financial variables (Bhamra, Fisher, and Kuehn (2011); Haddad, Moreira, and Muir (2021)).

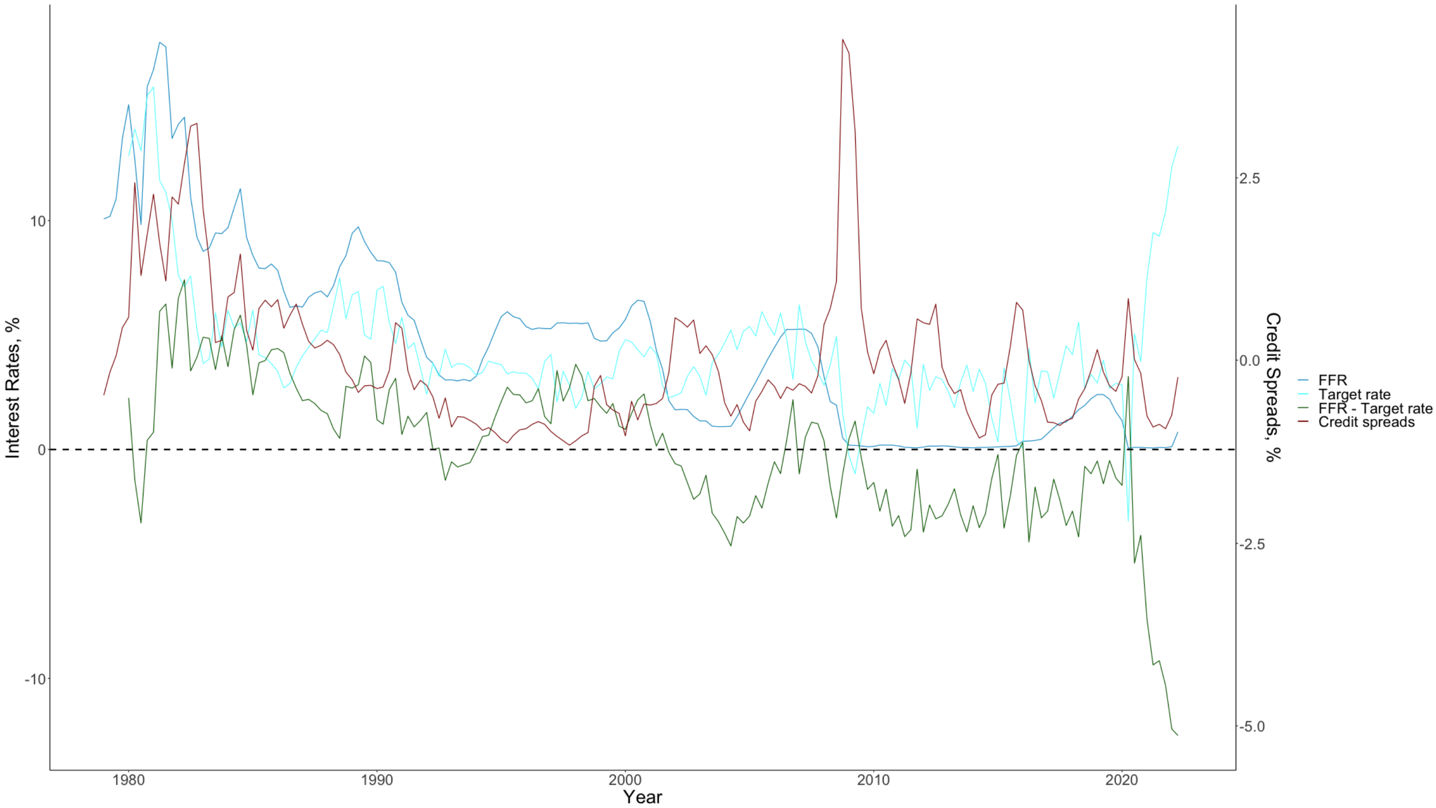
In this paper, we investigate how concerns about financial resilience should impact how monetary policy responds to various macroeconomic shocks. To do this, we develop a rich computable dynamic general equilibrium model that integrates banks, or financial intermediaries, with nominal rigidities in wages, prices *and* nominal debt contracts. As Gomes, Jermann, and Schmid (2016) show, introducing long-term defaultable nominal debt in general equilibrium monetary models greatly enhances the impact of a deterioration in financial market conditions on real variables through an endogenous debt overhang effect, which, in turn, leads to persistently high credit spreads (other examples are Bhamra, Kuehn, and Strebulaev (2010); Kuehn and Schmid (2014)).

In our model, credit spreads are driven both by separate shocks to the expected profitability of the corporate sector and that of the the banking sector's (Haddad and Sraer (2020); Elenev, Landvoigt, and Van Nieuwerburgh (2021); Haddad and Muir (2021); Baron and Muir (2022)).[2] Additionally, banks accept short-term deposits to make long-term loans to firms. When a bank is unable to pay for deposits, the government is forced

[1] E.g, Waller (2022)

[2] An example of the latter is the near the collapse of several banks in March 2023.

Figure 1: Deviations from Taylor Rule and Credit Spreads



This figure plots deviations from an estimated Taylor rule in the US against demeaned corporate credit spreads. The dark blue line corresponds to the actual Federal Funds rate (FFR), the light blue line to the target FFR predicted by the Taylor rule, the green line to deviations of actual FFR from its target, and the red line to the Baa-Aaa corporate credit spreads. The Taylor rule is estimated using iterative GMM following Clarida, Gali, and Gertler (2000). All data are downloaded from the St. Louis Fed FRED database.

to bail out depositors and recapitalize the bank but with sizable associated deadweight losses and persistent contractions in their future lending. Increases in the cost of borrowing lead firms to reduce investment and hiring, impacting current and future output and consumption.

To perform a detailed quantitative analysis of our model, we first estimate most of its key parameters using state-of-the-art Bayesian methods.[3] The estimated parameters include the average debt maturity, the cost of default, a measure of the sensitivity of credit prices to leverage, as well as the persistence and volatility of shocks to productivity and corporate default rates. This ensures that our model can portray a fairly plausible

[3] Other papers that estimate models of leverage and spreads are Graham (2000); Korteweg (2010); Whited and Zhao (2021)

quantitative picture of the aggregate US economy.

We next examine how this quantitative model economy responds to a set of specific shocks under both a classic Taylor rule, that seeks to stabilize output and inflation, and a *a modified Taylor rule* that also seeks to stabilize corporate spreads. We show that the latter further mitigates the losses in many key macro variables, such as consumption, investment, labor, and output, as well as reducing average default rates. This is true regardless of whether a recession is triggered by a negative productivity shock, a corporate default shock, or one to the banking system directly.

Our results also show that targeting credit spreads can often be welfare-improving. Perhaps more remarkably, a policy rule that seeks to aggressively stabilize credit spreads can even reduce the need for explicit inflation targeting. Using a detailed second-order welfare analysis across a wide range of values for the monetary policy weights on the inflation rate, the output gap, and corporate spreads we show that when the central bank commits to react to corporate spreads strongly enough, aggressive inflation targeting is no longer necessary or even desirable.[4]

Taken together, our results suggest that monetary policy benefits from taking into account indicators of financial market conditions, such as corporate credit spreads, more so when the economy is hit by direct shocks to the corporate sector.

Importantly, we show that our results are driven by sticky nominal debt, which is long-term and defaultable. As a result, when the Fed hikes interest rates to combat inflation, it effectively creates deflationary pressure, which in turn increases the real value of debt. Credit spreads then rise and reduce consumption and output. By contrast, without sticky leverage, responding to financial conditions is ineffective when facing productivity and banking shocks, and much less effective in response to corporate default shocks.

We view our paper as primarily a contribution to an important emerging literature on the financial aspects of monetary policy and thus to the even older literature on optimal monetary policy rules (Clarida and Gertler (1999); Woodford

[4]Formally, the weight on inflation in the policy rule must remain marginally above 1 to ensure dynamic stability (Taylor principle).

(2001); Giannoni and Woodford (2003); Orphanides (2001, 2003); Aoki (2003); Mertens and Williams (2021)). To the best of our knowledge, only a few papers suggest incorporating financial variables in monetary rules (Taylor and Williams (2008); Curdia and Woodford (2010)). However, they do not analyze the general equilibrium and welfare effects of such policy changes. Instead, the general consensus among many monetary economists remains that policy should ignore asset markets since they are only important if they impact aggregate output and inflation.

Our paper also relies very heavily on extant work macro models with financial constraints. Most of these models, however, use real debt contracts (eg. Kiyotaki and Moore (1997); Carlstrom and Fuerst (1997); Bernanke, Gertler, and Gilchrist (1999); Cooley, Marimon, and Quadrini (2004); Jermann and Quadrini (2012); Gourio (2013); Elenev, Landvoigt, and Van Nieuwerburgh (2021); Nikolov, Schmid, and Steri (2021)) or one period nominal contracts (eg. Doepke and Schneider (2006); Fernández-Villaverde (2010); Bhamra, Fisher, and Kuehn (2011); Fiore, Teles, and Tristani (2011); Gârleanu, Panageas, and Yu (2015); Gomes and Schmid (2021)). As a result, they fail to produce a nominal overhang effect—an important source of financial distress (Gomes, Jermann, and Schmid (2016)).

The rest of the paper is organized as follows. Section 2 sets up a dynamic general equilibrium model. Section 3 provides details on our computation strategy and the Bayesian estimation of the model. Section 4 shows the results of our quantitative analysis and 5 describes its welfare implications. Section 6 concludes.

2 Model

In this section, we develop a medium-scale dynamic general equilibrium framework that integrates price rigidities, long-term nominal debt contracts, and financial intermediaries. The model has several types of agents, including households, producers, financial intermediaries, and policy authorities. We discuss each of them in turn.

2.1 Households

There is a continuum of households, indexed by $i \in [0,1]$, that choose consumption, $C_{i,t}$, hours worked, $N_{i,t}$, and bank deposits, $D_{i,t}$ to maximize their lifetime utility function:

$$U = \mathbb{E}_t \left[\sum_{s=0}^{\infty} \beta^s \left(\frac{(C_{i,t+s})^{1-\kappa} - 1}{1-\kappa} - \zeta_n \frac{(N_{i,t+s})^{1+\theta}}{1+\theta} \right) \right] \tag{1}$$

where β is the intertemporal discount factor, $1/\kappa$ is the intertemporal elasticity of substitution for consumption, $1/\theta$ is the intertemporal elasticity of substitution for labor, and ζ_n is a labor disutility parameter.

The per-period budget constraint for each agent i is given by

$$P_t C_{i,t} + D_{i,t+1} = W_t N_{i,t} + (1 + R_t) D_{i,t} + T_{i,t} \tag{2}$$

where P_t is the aggregate price level, R_t is the nominal interest rate, and $T_{i,t}$ summarizes the total net transfers from firms, banks, and the government.

The optimal Euler equation for bank deposits is given by

$$1 = \mathrm{E}_t M_{t,t+1} \frac{1 + R_{t+1}}{1 + \pi_{t+1}} \tag{3}$$

where $M_{t,t+1} = \beta \left[\frac{C_{t+1}}{C_1} \right]^{-\kappa}$ is the real stochastic discount factor and $\pi_{t+1} = P_{t+1}/P_t - 1$ is the rate of inflation in the economy.

2.2 Production

A continuum of perfectly competitive firms indexed $j \in [0,1]$ combines capital and labor using the following production function

$$Y_{j,t} = A_t K_{j,t}^{\alpha} N_{j,t}^{1-\alpha} \tag{4}$$

where $K_{j,t}$ is the number of capital goods used, $N_{j,t}$ is the labor input, and A_t is the aggregate level of total factor productivity that evolves according to the following stationary AR(1) process

$$\ln A_t = \rho^a \ln A_{t-1} + \sigma^a \epsilon_{A,t} \tag{5}$$

where $\epsilon_{A,t}$ is standard normal.

Intermediate producers accumulate capital through the usual equation:

$$K_{j,t+1} = (1-\delta)K_{j,t} + I_{j,t} \tag{6}$$

so that the gross growth rate of capital is $g_{j,t} = \frac{I_{j,t}}{K_{j,t}} + (1-\delta)$.

Pre-tax, operating profits for intermediaries can be constructed from solving for optimal labor demand:

$$R_t^k K_{j,t} = \max_{N_{j,t}} A_t K_{j,t}^{\alpha} N_{j,t}^{1-\alpha} - W_t N_{j,t} \tag{7}$$

where $R_t^k = \alpha \frac{Y_t}{K_t}$ is equalized across all firms j.

To generate cross-sectional variation in corporate defaults, we assume that operating profits are subject to additive idiosyncratic shocks, $z_{j,t}K_{j,t}$, where $z_{j,t}$ is distributed with c.d.f. $F_t^z(z)$ with mean μ_t^z and standard deviation σ^z. The mean of these shocks is time-varying and follows the AR(1) process

$$\ln \mu_{t+1}^z = \rho^z \ln \mu_t^z + \epsilon_{t+1}^z \tag{8}$$

where ϵ_{t+1}^z is i.i.d Normal. In what follows we use $\Phi^{\mu}(\mu_t)$ to denote the c.d.f. of μ_t.

Financing takes place through the issuance of new equity and long-term, defaultable debt with nominal face value $B_{j,t}$. As a result, inflation reduces the real value of long-term *sticky* nominal debt (Gomes, Jermann, and Schmid (2016)).

Every period, with probability η, the economy is hit by an aggregate liquidity shock that requires that every firm must repay the outstanding debt plus its periodic coupon, c immediately.

A firm that does not currently have the resources to repay its debt obligations enters into default. Formally, this is defined implicitly by an equation for a threshold level of firm-level productivity, $z^{\star}_{j,t}$:

$$(1-\tau)\left(R^k_t - z^{\star}_t\right)K_{j,t} - (1+(1-\tau)c)\frac{B_{j,t}}{1+\pi_t} + (1-\delta(1-\tau))K_{j,t} + J(K_{j,t+1}, B_{j,t+1}, \mu^z_t) = 0 \tag{9}$$

where τ is the (effective) corporate income tax rate and $J(K_{j,t+1}, B_{j,t+1}, \mu^z_t)$ captures the continuation value of the firm, which we define more precisely below. The probability of default is then given by $F^z_t(z^{\star}_t)$ and increases in the shock, μ^z_t.

Default triggers a change in ownership, whereby lenders take over the firm and resell it to a new operator, which resumes operations with unchanged capital stock and leverage. We assume that re-structuring entails a one-time charge equal to a fraction, $1-\xi$, of the firm's value, paid by the creditors.

Exploiting homogeneity, each producer problem becomes a function of the leverage ratio $b_{j,t} = \frac{B_{j,t}}{K_{j,t}}$ and the value function $j(b_{t+1}, \mu^z_t) = \frac{J(K_{j,t+1}, B_{j,t+1}, \mu^z_t)}{K_{j,t+1}}$.

Dropping the index j, the firm's problem can thus be described by the triplet of value functions:

$$v_t = \max_{g_t}\Big\{\eta v^1_t(b_t, z_t, A_t, g_t) + (1-\eta)v^0_t(b_t, z_t, A_t, g_t)\Big\} \tag{10}$$

$$v^1_t(b_t, z_t, A_t, g_t) = \max_{b_{t+1}}\Big\{q_t b_{t+1} g_t + (1-\tau)(R^k_t - z_t) + (1-\delta) \tag{11}$$

$$+\tau\delta - g_t - (1+(1-\tau)c)\frac{b_t}{1+\pi_t} + \mathbb{E}_t M_{t,t+1}\int_{-1}^{z^*_{t+1}} v_{t+1} dz_{t+1}\Big\}$$

$$v^0_t(b_t, z_t, A_t, g_t) = \Big\{(1-\tau)(R^k_t - z_t) + (1-\delta) + \tau\delta \tag{12}$$

$$- g_t - (1-\tau)c\frac{b_t}{1+\pi_t} + \mathbb{E}_t M_{t,t+1}\int_{-1}^{z^*_{t+1}} v_{t+1} dz_{t+1}\Big\}$$

where $v^1(b_t, \mu^z_t)$ is the value of the firm if it has to repay the debt and $v^0(b_t, \mu^z_t)$ is the value of the firm if the repayment shock is not realized and $q^b_t = q^b(b_{t+1}, \mu^z_t)$ is the (real) price of debt.

2.3 Financial Intermediaries

Following Elenev, Landvoigt, and Van Nieuwerburgh (2021), we assume that there is a continuum of identical banks, or financial intermediaries, with unit measure. Each representative bank offers one period deposits, d_{t+1} to households at (real) price q_t^d and uses the proceeds to buy a perfectly diversified portfolio of corporate debt issues, b_{t+1}, valued at (real) price q_t^b. Deposits are perfectly insured by the fiscal authority so that $q_t^d = (1+\pi_{t+1})/(1+R_{t+1})$.

At the beginning of every period, we define a bank's (real) net worth as the difference between the market value of its loan portfolio minus the value of its deposit liabilities:

$$nw_t = F_t^z(z_t^\star)[(1-\eta)(c+q_t^b)+\eta(1+c)]\frac{b_t}{(1+\pi_t)} + \eta\int_{z_t^\star}^{\bar{z}} \xi v_t^1 dF_t^z(z_t) - d_t \tag{13}$$

where the second term captures the impact of corporate defaults on the value of the banks' assets (loans).

The bank's balance sheet constraint then requires that the market value of net new loans and deposits equals the retained net worth:

$$b_{t+1}q_t - d_{t+1}q_t^d = (1-\phi)nw_t \tag{14}$$

where, for simplicity, we assumed that banks always pay out a constant fraction, ϕ, of their net worth as dividends to their shareholders.

In addition, banks also face a leverage constraint which regulates the amount of risk-weighted deposits that banks can supply:

$$q_t^d d_{t+1} \leq \xi^d q_t b_{t+1} \tag{15}$$

Including market values ensures that we capture risk-weights with a Basel-type leverage constraint.

Banks maximize shareholders' value, w, which obeys the Bellman equation

$$w(d_t, b_t, \epsilon_t) = \max_{d_{t+1}, b_{t+1}} \left[\phi \cdot nw_t - z_t^b + \mathbb{E}_t \int M_{t,t+1} \max\{w(d_{t+1}, b_{t+1}, \epsilon_{t+1}), 0\} \right] \tag{16}$$

where z_t^b is an exogenous shock to bank profits that with c.d.f $F_t^b(z^b)$ that has with time-varying mean μ_t^b which follows a stationary AR(1) process:

$$\mu_t^b = \rho_b \mu_{t-1}^b + \sigma_b \epsilon_t^b \tag{17}$$

where ϵ_t^b is standard normal.

Equation (16) captures the fact that bank defaults may occur independently of the corporate sector.[5] Higher expected future default probabilities reduce bank willingness to lend and increase spreads between their lending and deposit rates.

In the event a bank defaults, we assume the government seizes the bank franchise, fully insures its depositors, and resells it to a new operator that resumes operations in the following period. Recapitalization incurs a deadweight loss equal to $\xi^b(nw_t + \delta)K_t$.

2.4 Monetary and Fiscal Policy Rules

Monetary and fiscal policies are governed by separate authorities that follow credible policy rules.

In our baseline case, monetary policy is described by a standard feedback rule, i.e., "Taylor" rule, for the short term nominal interest rate, R_t

$$R_t = R_t^{*1-\rho_R} R_{t-1}^{\rho_R} e^{\sigma_M \epsilon_{R,t}} \tag{18}$$

where $R_t^\star$ is the target policy rate and $\epsilon_{R,t}$ is (a standard normal) monetary policy shock.

[5]The classic example is a bank run. Recent examples include US regional banks and Credit Suisse during March 2023.

The policy rate follows the reactive rule

$$R_t^\star = r(1+\pi^\star)\left(\frac{1+\pi_t}{1+\pi^\star}\right)^{\psi_1}\left(\frac{Y_t}{Y_t^\star}\right)^{\psi_2} \tag{19}$$

where r is the steady state real interest rate, $\pi^\star$ is the inflation target, and $Y_t^\star$ is the natural level of aggregate output.

The fiscal authority consumes a fraction ζ_t of aggregate output, that is $G_t = \zeta_t Y_t$. We assume that $g_t = 1/(1-\zeta_t)$ follows a stationary AR(1) process

$$\ln g_t = (1-\rho_g)\ln g + \rho_g \ln g_{t-1} + \sigma_g \epsilon_{g,t} \tag{20}$$

where $\epsilon_{g,t}$ is standard normal.

2.5 Price and Wage Frictions

Finally, to complete the model, we add the typical wage and price rigidities embedded in modern macro environments. To do this, we follow the literature and assume that labor supply is regulated by labor unions to which households belong while final goods are sold by retailers that repackage the output of producers. For brevity, we omit the (well-known) details about optimal price-setting behavior, which are available in our Online Appendix.

2.5.1 Labor Unions

Labor unions aggregate the labor choice of households through a Dixit-Stiglitz technology:

$$N_t = \left(\int_0^1 N_t(i)^{1-v_{w,t}} di\right)^{\frac{1}{1-v_{w,t}}} \tag{21}$$

where $v_{w,t}$ is an elasticity parameter. Each individual labor supply then obeys:

$$N_{i,t} = \left(\frac{W_{i,t}}{W_t}\right)^{-1/v_{w,t}} N_t \tag{22}$$

where $W_{i,t}$ is the wage that satisfies household i and W_t is the average wage in the economy. They are linked through the usual Dixit-Stiglitz aggregator:

$$W_t = \left(\int_0^1 W_{i,t}^{\frac{v_{w,t}-1}{v_{w,t}}} di \right)^{\frac{v_{w,t}}{v_{w,t}-1}} \tag{23}$$

Nominal wage stickiness is added by assuming unions can change their wage optimally in period t with probability $1 - \gamma_w$. We assume that mark-ups, $\lambda_{w,t} = 1/(1 - v_{w,t})$, are time-varying and follow the AR(1) process:

$$\ln \lambda_{w,t} = (1 - \rho_w)\lambda_w + \rho_w \lambda_{w,t-1} + \sigma_w \epsilon_{w,t} \tag{24}$$

where $\epsilon_{w,t}$ is standard normal.

2.5.2 Retailers

Output is repackaged as a continuum of differentiated goods, Y_r, each sold by a single monopolistic retailer or final producer, indexed in $r \in [0, 1]$. They are aggregated using the Dixit-Stiglitz technology

$$Y_t = \left(\int_0^1 Y_{r,t}^{1-v} dr \right)^{\frac{1}{1-v}} \tag{25}$$

where $1/v$ is an elasticity parameter.

Thus, each individual retailer $r \in [0, 1]$ faces the downward slopping demand function

$$Y_{r,t} = \left(\frac{P_{r,t}}{P_t} \right)^{-1/v} Y_t \tag{26}$$

where $P_{r,t}$ is the price for good r, and P_t is the average price level in the economy, defined through the usual Dixit-Stiglitz aggregator.

$$P_t = \left(\int_0^1 P_{r,t}^{\frac{v-1}{v}} dr \right)^{\frac{v}{v-1}} \tag{27}$$

We assume each retailer can only change their price optimally in period t with probability $1-\gamma$.

2.6 Market Clearing

The market clearing conditions are given by the following equations

$$Y_t = C_t + G_t + I_t + (1-\xi)(1-F(z_t^*))(\tau\delta K_t - I_t) + (1-\xi_b) * (1 - F(z_t^{\star,b}) * (nw_t + \delta) * K_t \tag{28}$$

$$N_t = n_t \tag{29}$$

where $1 - F(z_t^{\star,b})$ is the bank default rate.

3 Model Computation and Estimation

3.1 Numerical Solution

Most of the model can be solved using standard local perturbation methods. However, this method is significantly complicated by the recursive nature of long-term debt problem. Specifically, we need to solve for j_t^*, v_t^1, v_t^0, and $\frac{\partial q_t}{\partial b_{t+1}}$. Note that q_{t+1} depends only on b_{t+1} and not b_{t+2} because debtholders are done with firms once the debt is repaid. Hence, losses take place in the current period and are absorbed by debtholders. Therefore, we only need the expression for the derivative of the debt price to fully characterize the firm's problem.

We partly follow Gomes, Jermann, and Schmid (2016) and obtain the value of this derivative by solving the firms' problem (11)-(12) globally. This yields the optimal value, leverage, and investment policies, as well as an expression for the default threshold and price of the debt.

We then approximate the exact derivative, $\frac{\partial q_t}{\partial b_{t+1}}$ with a quadratic function of leverage, b_{t+1} as well as a linear function of the exogenous state variables. The R-squared from this approximation exceeds 99% and it does not increase further when we add higher order terms. Hence, we have all the components of the firm problem to proceed with the local perturbations. Since the shocks in the full model occur only around the steady state, the impact on the approximation parameters is minimal.

The tools deployed to solve the problems of the remaining agents in the model are now well understood. Specifically, we aggregate prices and wages following the procedure described by Calvo (1983) and Christiano, Eichenbaum, and Evans (2005).

3.2 Calibration and Estimation

Some parameters in our model have been reliably estimated in the past, while others have a relatively minor impact on our results. We calibrate the value for all of them and then estimate most of the remaining parameters by matching targeted moments well. Most of the parameters for bank's problem come from the detailed work in Elenev, Landvoigt, and Van Nieuwerburgh (2021), while the process for bank default shocks is calibrated to match the average ratio of bank deposits to GDP and average interest rate on bank deposits. We use Clarida, Gali, and Gertler (2000)'s estimate of a Taylor rule but update the size of the monetary shock using the estimates in Gomes, Jermann, and Schmid (2016). The aggregate productivity is constructed by estimating the Solow residuals using FRED data on US GDP, hours, capital stock, and GDP deflator.

The remaining parameters are estimated using Bayesian methods. Specifically, the set of parameters to be estimated includes the capital share, risk aversion, labor disutility, labor elasticity, default distribution, costs of recovery and the remaining exogenous process parameters. We propose prior distributions and initial values for all parameters. We use the Blocked Metropolis-Hastings MCMC algorithm to first compute modes and tune scaling parameters and then to draw from the posterior distribution (Smets and Wouters (2003); An and Schorfheide (2007); Smets and Wouters (2007)). As discussed above the estimation analysis is somewhat complicated by the fact that we require value function

Table 1: Calibration of the Model

Parameter	Symbol	Value	Source
Preferences and taxes			
Discount rate	β	0.99	Smets and Wouters (2007)
Corporate tax rate	τ	0.25	Authors
Capital costs			
Depreciation rate	δ	0.025	Christiano et al. (2005)
Banks			
Dividend share	ϕ_0	0.07	Elenev et al. (2021)
Leverage constraint	ξ_d	0.93	Elenev et al. (2021)
Default Recovery Rate	ξ_b	0.6	Elenev et al. (2021)
Prices			
Calvo price parameter	γ	0.6	Christiano et al. (2005)
Output aggregation parameter	ν	0.2	Gertler and Karadi (2011)
Wages			
Calvo wage parameter	γ_w	0.8	Christiano et al. (2005)
Labor aggregation parameter	ν_w	0.2	Authors
Taylor rule			
Inflation target	π^*	0.005	Clarida et al. (2000)
Inflation parameter	ψ_1	1.5	Clarida et al. (2000)
Output gap parameter	ψ_2	0.2	Clarida et al. (2000)
Smoothing parameter	ρ_R	0.5	Clarida et al. (2000)
Exogenous processes			
TFP process persistence	ρ_a	0.95	Solow residuals
TFP process volatility	σ_a	0.007	Solow residuals
Mark-up shock persistence	ρ_w	0.95	Smets and Wouters (2007)
Mark-up shock volatility	σ_w	0.004	Smets and Wouters (2007)
Monetary shock persistence	ρ_m	0.85	Gomes et al. (2016)
Monetary shock volatility	σ_m	0.004	Gomes et al. (2016)
Bank shock persistence	ρ_a	0.9	Authors
Bank shock volatility	σ_B	0.07	Authors

This table provides values of the calibrated parameters. All of them, except for the labor aggregation parameter, tax rate, and productivity shock, are taken from the literature. The labor aggregation parameter is chosen by the authors. As shown by Christiano, Eichenbaum, and Evans (2005), the value of that parameter does not impact the qualitative results of the model. We calibrate the TFP process parameters using Solow residuals that we construct using data on GDP, hours, capital stock, and GDP deflator. The calibration is based on quarterly data. The rest of the parameters are estimated.

iterations to approximate the derivative of the debt price function, $q(b)$.

We use four shocks – TFP, default, wage mark-up, and government spending. To identify the model, we can use up to four series from the data and choose output, labor share, corporate BAA spreads, and the inflation rate between 1984 and 2008. We gather all macro series from the St. Louis Fed FRED database and detrend them following Smets and Wouters (2007).

We use priors that have been proposed by the literature on Bayesian estimation (Smets and Wouters (2003, 2007); An and Schorfheide (2007)). Specifically, we assume that the probability of being hit by a repayment shock, recovery cost, and persistence of the processes follow the Beta distribution and all standard deviations of the processes follow the inverse Gamma distribution. All other parameters follow normal distributions.

Our estimation results are shown in Table 2. Modes and posterior means of the parameters are fairly close to the prior means, but posterior standard errors are small which means that parameters are well identified.

Notably, the debt repayment probability is 81%, implying an average duration of between 1 and 2 years while the debt recovery rate is $\xi = 0.54$.

Although the shock to corporate profits shock is estimated to be less persistent and less volatile than the TFP shock, this is a shock that hits the value of firm's the capital stock. The government spending process is slightly less persistent and about as volatile as the TFP process since government spending is usually used to recover from the recession.

4 Quantitative Analysis

Using the estimates from the stochastic processes above we show how the estimated model fits various empirical moments. Next, we show how the model responds to individual shocks.

Table 2: Bayesian Estimation Results

		Prior distribution			Posterior distribution			
Parameter	Symbol	Distr.	Mean	St. Dev.	Mode	Mean	10%	90%
Preferences and production								
Risk aversion	κ	Normal	1.4	0.38	2.26	2.25	2.20	2.31
Labor elasticity	θ	Normal	0.1	0.02	0.109	0.113	0.108	0.117
Labor disutility	ζ_n	Normal	15	1.24	10.8	10.9	10.5	11.3
Capital share	α	Normal	0.33	0.01	0.403	0.404	0.395	0.411
Firm parameters								
Repayment rate	η	Beta	0.8	0.1	0.806	0.806	0.804	0.808
Recovery cost	ξ	Beta	0.4	0.02	0.538	0.532	0.525	0.541
Average default rate	$F(z^{\star})$	Normal	0.023	0.001	0.024	0.024	0.024	0.024
Default distribution	η_1	Normal	0.47	0.05	0.434	0.434	0.431	0.437
Derivative constant	d_1	Normal	0.15	0.03	0.131	0.133	0.127	0.139
Derivative slope	d_2	Normal	-1.07	0.2	-1.036	-1.045	-1.064	-1.028
Exogenous processes								
Default persistence	ρ_{Def}	Beta	0.9	0.01	0.898	0.899	0.898	0.899
Default volatility	σ_{Def}	Gamma	0.007	0.008	0.004	0.004	0.004	0.005
Government persistence	ρ_g	Beta	0.95	0.005	0.887	0.887	0.887	0.888
Government volatility	σ_g	Gamma	0.007	0.019	0.009	0.009	0.006	0.006

This table provides results of the Bayesian estimation of the model structural parameters obtained using the Blocked Metropolis-Hastings MCMC algorithm. Columns 3-5 provide prior distribution, means, and standard deviations. Columns 6-9 show posterior mode, mean, and 90% confidence interval. Standard deviations and persistences of exogenous processes are estimated relative to the respective parameters of the TFP process.

4.1 Aggregate Moments

Table 3 compares aggregate HP-filtered moments from the model simulations to their data counterparts. We obtain macro data from the St. Louis Fed FRED database, data on defaults from Moody's, and balance sheet data on leverage from Compustat. Panel A shows that the model does a very good job in matching the first moments except for slightly lower corporate default rates (0.9% as opposed to 0.5% in the data).

Panel B shows that our model consistently predicts slightly lower volatilities for most of the key data series, while Panels C and D show it does quite well in matching their cross-correlations with GDP and serial correlations. The relatively high correlation of inflation is likely due to the absence of a lower bound in our implementation of the baseline Taylor rule. Finally, Panel D presents first-order auto-correlations.

4.2 Impact of Alternative Monetary Policy Rules

We now rely on our baseline economy to assess the impact of actively targeting credit spreads on macroeconomic fluctuations. Specifically, we study the response of the economy to several alternative shocks when monetary policy follows the augmented Taylor rule:

$$R_t^* = r(1+\pi^*)\left(\frac{1+\pi_t}{1+\pi^*}\right)^{1.5}\left(\frac{Y_t}{Y_t^*}\right)^{0.2}\left(\frac{sp_t}{sp^*}\right)^{-\psi_3} \tag{30}$$

where sp^* is a steady-state corporate spread, defined as $sp_t = 1/q_t^f - 1/q_t$ where q_t^f is the price of a risk-free bond with identical maturity. The negative parameter implies that the central bank should tighten monetary policy when spreads are low. For now, we set a very small value for the elasticity $\psi_3 = 0.1$ and delay a more complete analysis in Section 5. This means that if corporate spreads are 1 p.p. above their steady state, the target policy rate should decrease by just 10 b.p.

Figure 2 shows impulse response functions (IRFs) to a one-standard-deviation negative shock to aggregate productivity, A_t. The solid lines depict the baseline case when monetary policy follows the standard Taylor rule given by (19), while the dashed lines

Table 3: Aggregate Moments

	Description	Model	Data	Source
Panel A: First moments				
C/Y	Consumption to GDP	0.66	0.67	FRED
I/Y	Investment to GDP	0.14	0.17	FRED
Sp	Credit spreads, %	0.33	0.30	FRED
π	Inflation, %	0.5	0.5	FRED
lev	Corporate market leverage	0.23	0.23	Compustat
Φ	Default rates, %	0.9	0.5	S&P Global
Panel B: Second moments				
$\sigma(C)/\sigma(Y)$	Consumption to GDP	0.27	0.52	FRED
$\sigma(I)/\sigma(Y)$	Investment to GDP	4.29	4.23	FRED
$\sigma(N)/\sigma(Y)$	Labor to GDP	0.85	1.07	FRED
$\sigma(Sp)/\sigma(Y)$	Spread to GDP	0.09	0.12	FRED
$\sigma(\pi)/\sigma(Y)$	Inflation to GDP	0.12	0.3	FRED
Panel C: Correlations				
$\rho(C,Y)$	Consumption with GDP	0.46	0.78	FRED
$\rho(I,Y)$	Investment with GDP	0.88	0.84	FRED
$\rho(N,Y)$	Labor with GDP	0.95	0.86	FRED
$\rho(\pi,Y)$	Inflation with GDP	0.86	0.53	FRED
Panel D: Auto-correlations				
Y	GDP	0.76	0.84	FRED
C	Consumption	0.80	0.83	FRED
I	Investment	0.84	0.81	FRED
N	Labor	0.78	0.89	FRED
π	Inflation	0.81	0.81	FRED

This table provides aggregate moments in the model and data. The third column provides the moments simulated and HP-filtered from the model. The fourth column shows the moments from the pre-2019 data.

show the behavior of the economy when policy also reacts to credit spreads.

Consistent with standard New Keynesian models a negative productivity shock leads to a drop in GDP, consumption, investments, and inflation. Corporate leverage increases because lower inflation and productivity make firms owe more – phenomenon that Gomes, Jermann, and Schmid (2016) call *sticky leverage*. Default rates increase and corporate spreads default rates soar. The effects are less persistent than in Gomes, Jermann, and Schmid (2016) potentially because corporate leverage reverses quickly since the debt duration implied by our estimated η is lower.

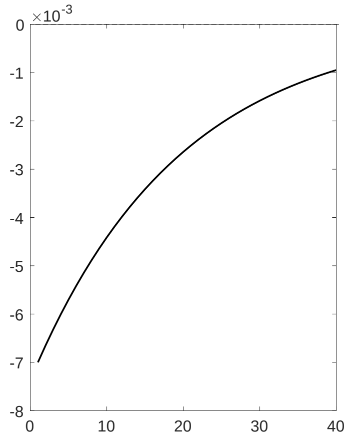
Movements in credit spreads are more muted when policy follows the augmented Taylor rule (30). As a result, the cost of borrowing is reduced for firms, producing smaller reductions in corporate investment, output, and hiring. This, in turn, helps to stabilize household consumption in equilibrium.

Figure 3 shows the various impulse response functions to a one-standard-deviation unexpected (and persistent) increase to the average corporate default rate, μ_t^z. As expected output, consumption, investments, and labor all drop significantly in response. This is caused partly by the fact that there are fewer firms left to produce in the current period and partly by the additional deadweight capital losses from firms' recoveries. Expected future default rates increase so corporate spreads naturally rise as well. Overall the effects on impact are similar although somewhat larger than with a productivity shock, although most variables also seem to recover more quickly.

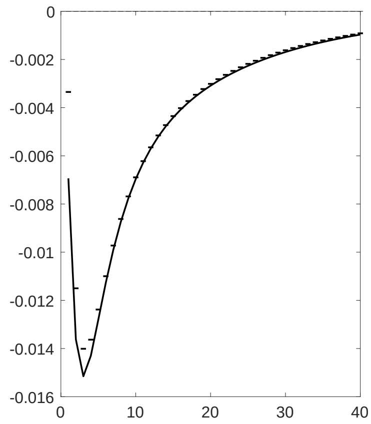
When monetary policy follows an augmented Taylor rule that includes corporate spreads we again see a smaller drop in investment, output and consumption. Lower credit spreads reduce the cost of capital and encourage leverage and investment in the early periods of the recovery. Overall, the impact of following this policy rule on the macro variables is generally larger than what we saw with a productivity shock.

Finally, Figure 4 compares the impact of the two alternative monetary policy rules when the economy is faced with a persistent shock to the expected profits of financial intermediaries, μ_t^b, that increases the probability of banks default.

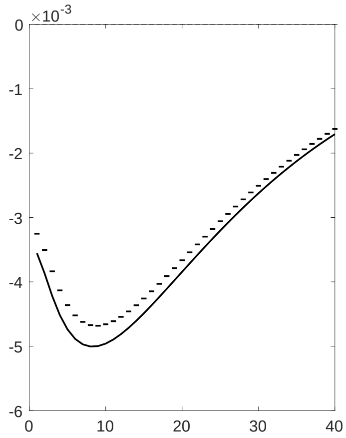
Figure 2: Impulse Response Functions to a TFP Shock with Spreads



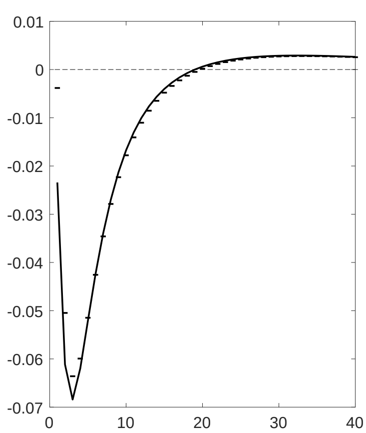
(a) TFP



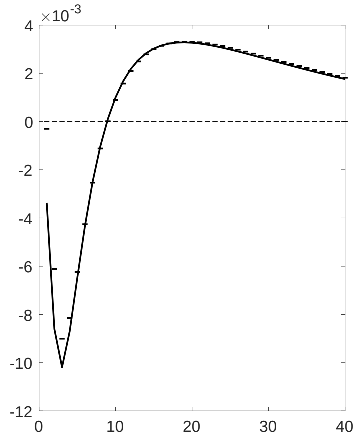
(b) Output



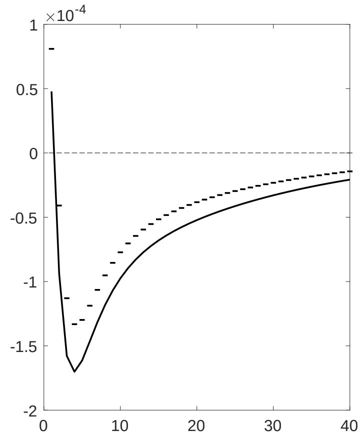
(c) Consumption



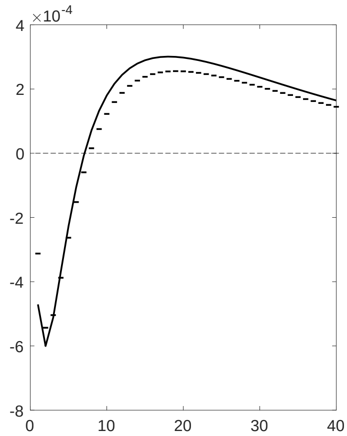
(d) Investment



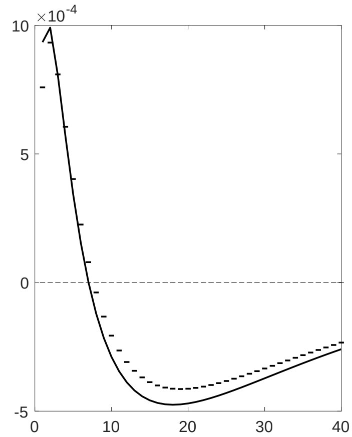
(e) Labor



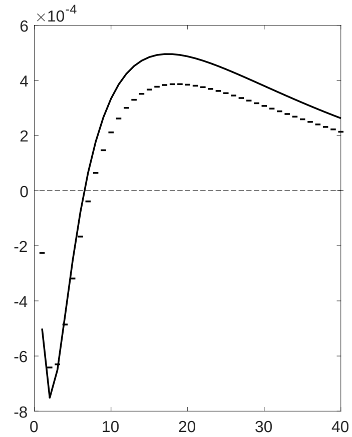
(f) Leverage



(g) Survival Rate



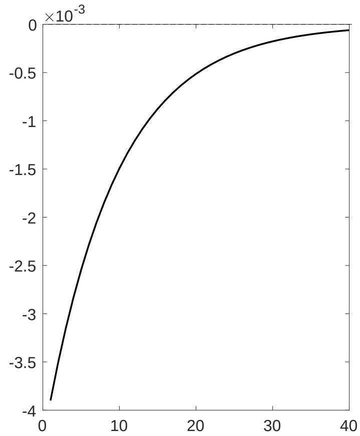
(h) Corporate Spreads



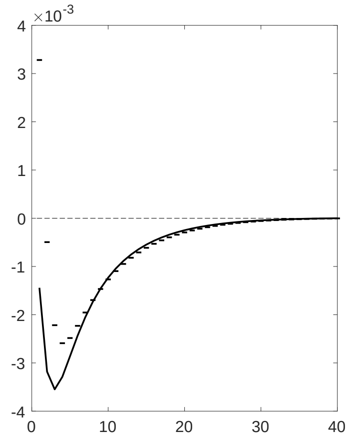
(i) Inflation

This figure provides impulse response functions (IRFs) of the model key variables to a one-standard-deviation negative shock to aggregate productivity, A_t. The solid lines show the IRFs when monetary policy follows a standard Taylor rule, while the dashed lines depict the case when the target policy rate reacts to credit spreads with an elasticity of $\psi_3 = 0.1$.

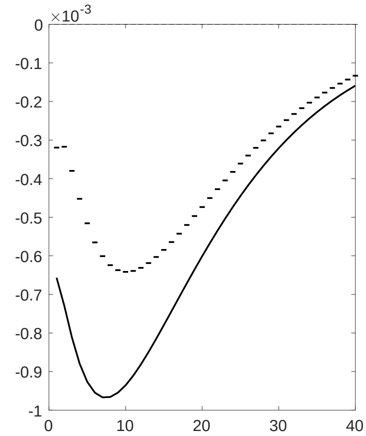
Figure 3: Impulse Response Functions to a Corporate Default Shock with Spreads



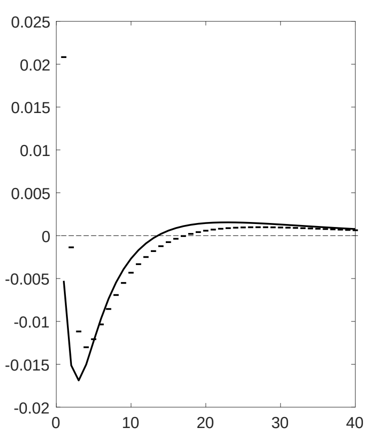
(a) Survival Shock



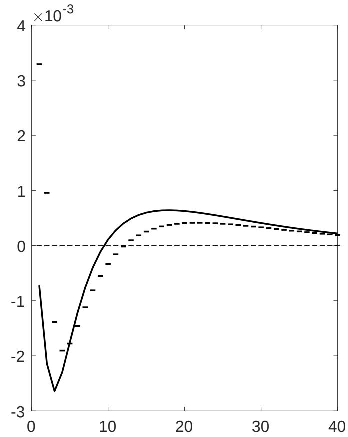
(b) Output



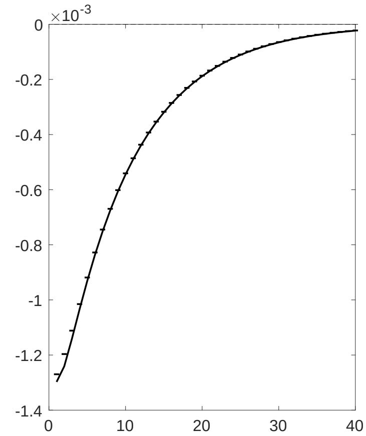
(c) Consumption



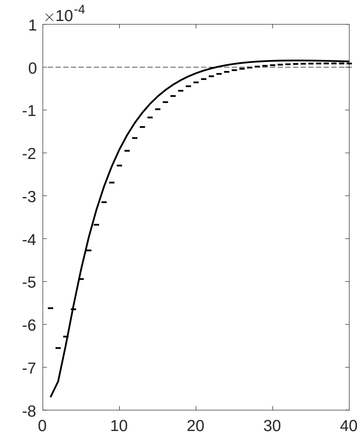
(d) Investment



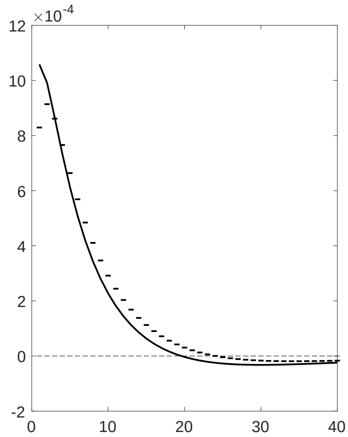
(e) Labor



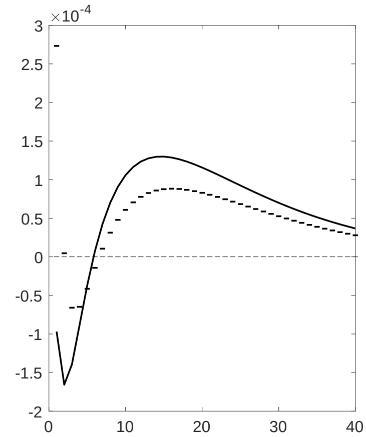
(f) Leverage



(g) Survival Rate



(h) Corporate Spreads



(i) Inflation

This figure provides impulse response functions (IRFs) of the model key variables to a one-standard-deviation negative shock to corporate default rates. The solid lines show the IRFs when monetary policy follows a standard Taylor rule, while the dashed lines depict the case when the target policy rate reacts to credit spreads with an elasticity of $\psi_3 = 0.1$.

Recall that a bank default requires a costly government recapitalization to bail out depositors. Higher expected default probabilities also reduce banks' willingness to lend and raise the implied spreads between their lending and deposit rates. Effectively, then, this shock works as a mixture of a pure productivity (or supply) shock that shrinks aggregate resources and a cost of capital shock that raises the cost of borrowing and investing to firms. Nevertheless, the former strongly dominates in our baseline calibration because the default bank recapitalization costs are quite large.

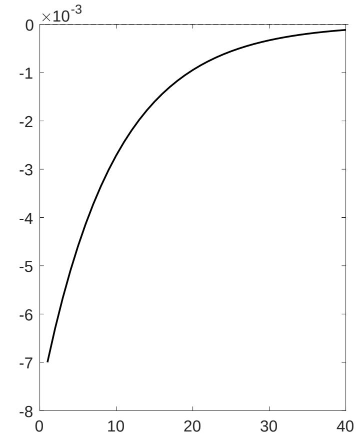
As a result, a persistent increase in μ_t^b impacts output, consumption, and investment much like a drop in aggregate productivity, A_t. Similarly, corporate spreads rise. Once again, we see that the augmented Taylor rule mitigates the effect of this shock on all the key variables.

Taken together each of these three examples shows how including spreads in the monetary policy rule - even with a very small elasticity - stabilizes the response of many aggregate macro variables regardless of the source of the adverse economic shocks. It is possible however that this is not welfare-improving since our analysis does not consider volatilities. Moreover, there may also be better ways to mitigate the consequences of these shocks by either targeting inflation more strictly or by increasing the elasticity of the target rate to the output gap.

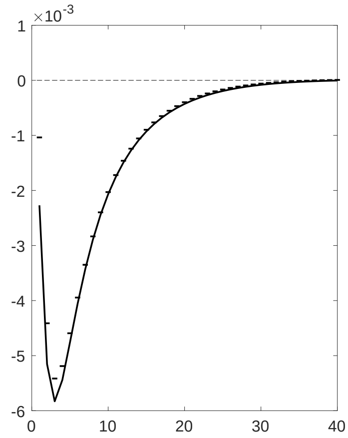
5 Welfare Analysis

In this section we conduct a detailed analysis to understand the impact of targeting credit spreads on social welfare. An important component of any welfare calculation is the impact of the policies on volatilities. More aggressive output or inflation targeting can also help households smooth their consumption and leisure offset adverse effects on their mean values.

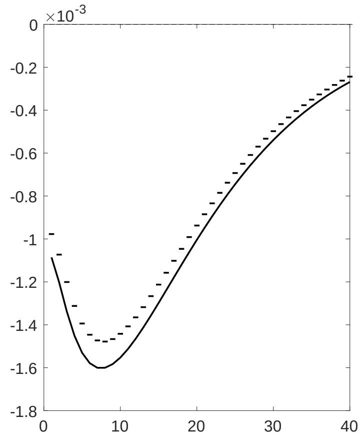
Figure 4: Impulse Response Functions to a Bank Default Shock with Spreads



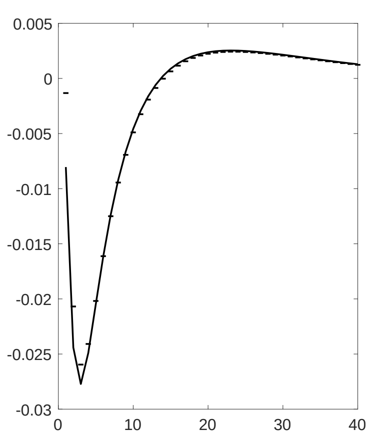
(a) Bank Survival Shock



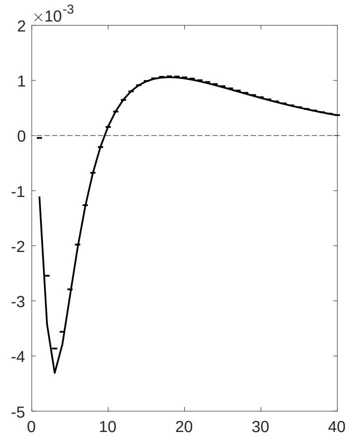
(b) Output



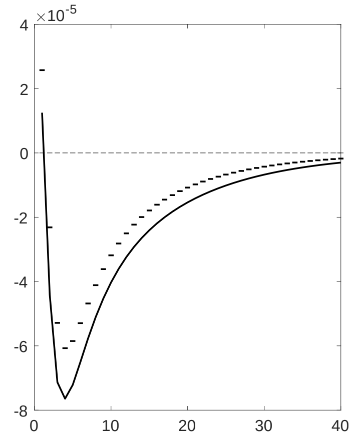
(c) Consumption



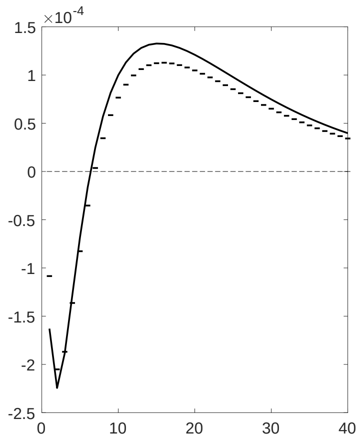
(d) Investment



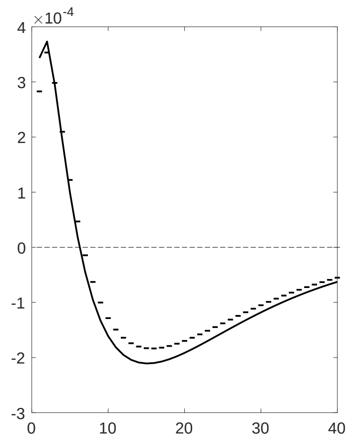
(e) Labor



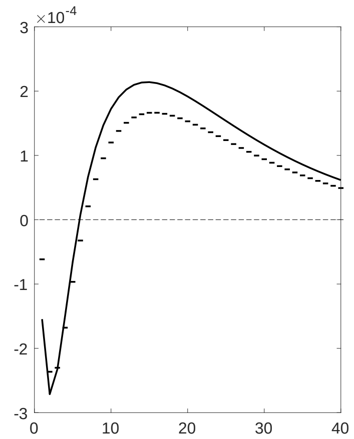
(f) Leverage



(g) Survival Rate



(h) Corporate Spreads



(i) Inflation

This figure provides impulse response functions (IRFs) of the model key variables to a one-standard-deviation negative shock to bank profitability, z_t^b. The solid lines show the IRFs when monetary policy follows a standard Taylor rule, while the dashed lines depict the case when the target policy rate reacts to credit spreads with an elasticity of $\psi_3 = 0.1$.

5.1 *Computation*

To properly compute social welfare we thus construct a second-order approximation to express it as a function of average consumption, labor, and their respective volatilities for a large range of different values of Taylor rule parameters, ψ_1, ψ_2 and ψ_3.[6]

We then use the simulated response functions to compute the welfare gains and losses and compare them across different monetary policy rules. As in the previous section, we compute separate analyses for each of the possible independent sources of economic fluctuations: aggregate productivity, corporate defaults, and shocks to the health of the financial sector.

5.2 *Analysis*

Figure 5 provides a visual illustration of the behavior of (normalized) social welfare when the economy is buffeted by productivity shocks alone for different values of the monetary policy rule. Panel (a) shows the impact of using different inflation, ψ_1 and credit spread, ψ_3, parameters, holding the output elasticity at its baseline level, $\psi_2 = 0.2$. We see that for relatively low values of ψ_3, it is welfare-improving to target inflation aggressively. However, for higher values of the ψ_3, aggressive inflation targeting is no longer welfare-improving.

Panel (b) shows welfare across different output and credit spread parameters, holding the response to inflation, at its baseline level $\psi_2 = 1.5$. We see that for low values of the output elasticity, it is welfare-improving to respond more aggressively to credit spreads, but this effect eventually tapers off. The panel shows that it is better for the monetary authority to simply respond more aggressively to the output gap.

Overall then, our results suggest that, when the economy is primarily faced with productivity shocks, central banks should prioritize stabilizing the output gap rather than paying attention to the financial markets or even inflation. Arguably, this view seems to have been internalized by central banks in the aftermath of the primarily

[6] Recall that satisfying the Taylor principle for stability requires $\psi_1 > 1$ (Taylor (1993)).

productivity/supply driven, 2020 recession.

Figure 6 repeats the welfare analysis but for the case when the economy is primarily hit by shocks that impact the average level of corporate defaults in the economy, μ_t^z. In this case, as Panel (a) shows, it is always very effective for monetary policy to aggressively target corporate spreads. Significantly, even for very low values of the corporate spread response parameter, ψ_3, it is optimal for monetary policy to become progressively less responsive to inflation.

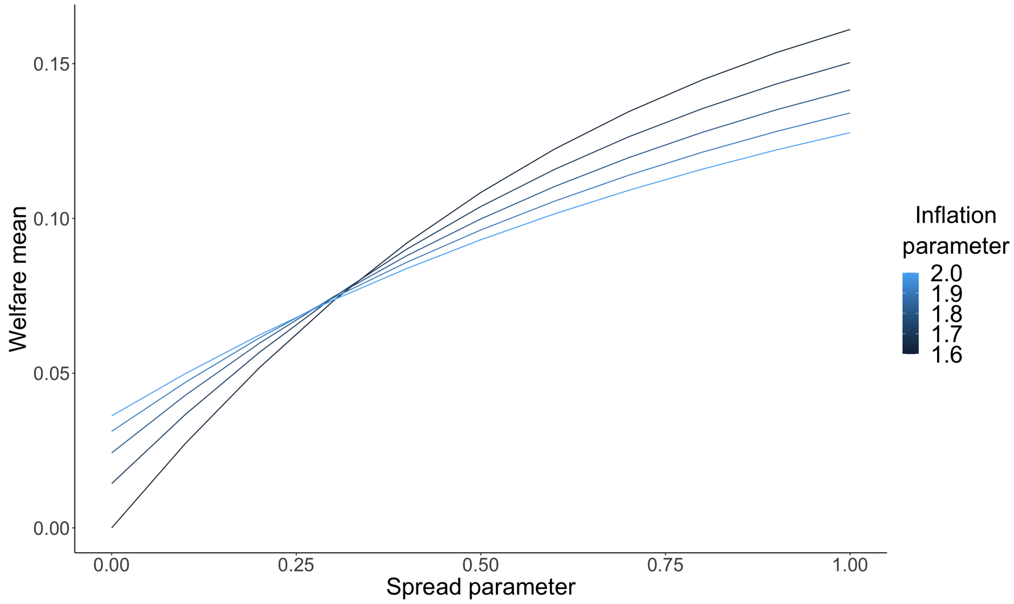
The results in Panel (b) confirm this finding. Strong policy responses to output gap are now no longer necessary when the policy rate targets credit spreads sufficiently aggressively. Now, for values of ψ_3 (approximately) above 0.35, a strong response of policy interest rates to the output gap actually reduces social welfare.

Finally, Figure 7 shows the results of our welfare analysis for the case where the economy is instead only impacted by direct shocks to the profitability (and stability) of its banking system. As discussed above this shock is a mixture of the first two but our calibration of the recapitalization costs ensures that it more closely resembles a productivity shock.

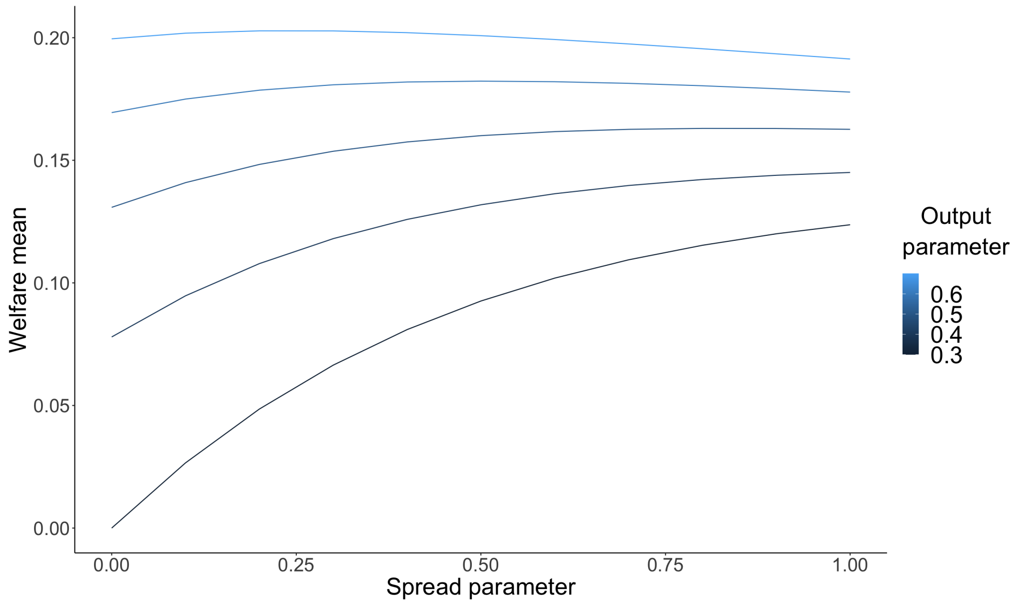
As before, Panel (a) shows that it is generally welfare-improving for monetary policy to target corporate spreads, and eventually, it is best down-weight inflation targeting. However, Panel (b) shows that targeting the output gap is generally the best choice for policymakers to minimize the impact of increases in bank defaults on social welfare

Overall, our results show that targeting credit spreads is generally preferable to targeting inflation. The choice between output and spreads depends on the source of the shocks hitting the economy. Shocks reducing the overall supply of resources are best addressed by aggressively minimizing the output gap directly, while the impact of shocks that affect defaults and borrowing more generally is better mitigated by responding to credit spreads instead.

Figure 5: Welfare Changes due to Shocks to Aggregate Productivity Across Different Taylor Rule Parameters



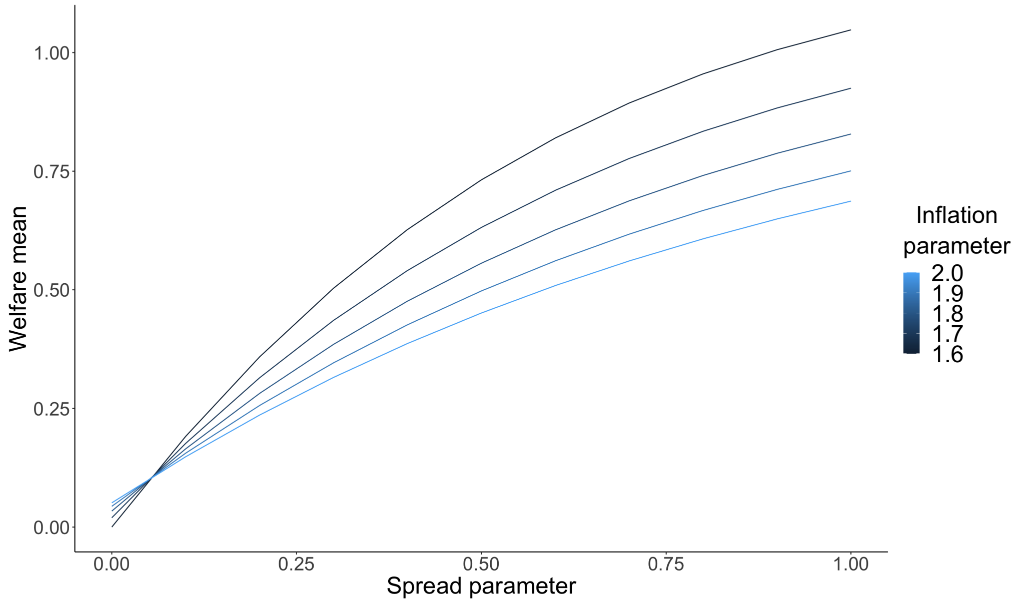
(a) Inflation Rate vs Credit Spreads



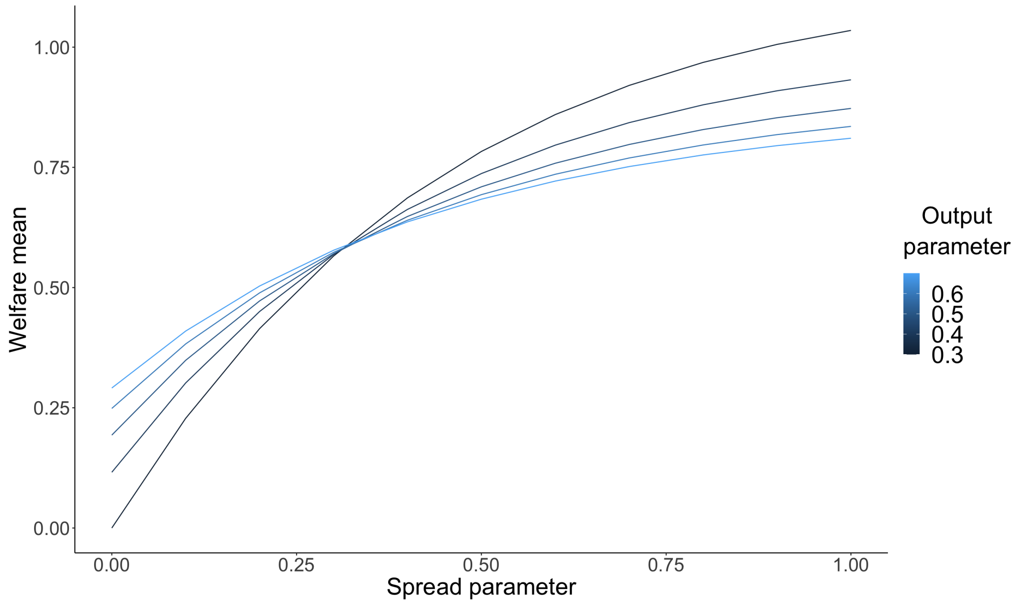
(b) Output Gap vs Credit Spreads

This figure compares social welfare in economies driven by productivity shocks for different parameter values for the Taylor rule (30). Panel (a) compares welfare across different inflation and credit spread parameters, holding the output gap parameter fixed at its baseline level of 0.2, whereas Panel (b) compares welfare across different output gap and credit spread parameters, holding the inflation parameter fixed at its baseline level of 1.5.

Figure 6: Welfare Changes due to Shocks to Corporate Defaults Across Different Taylor Rule Parameters



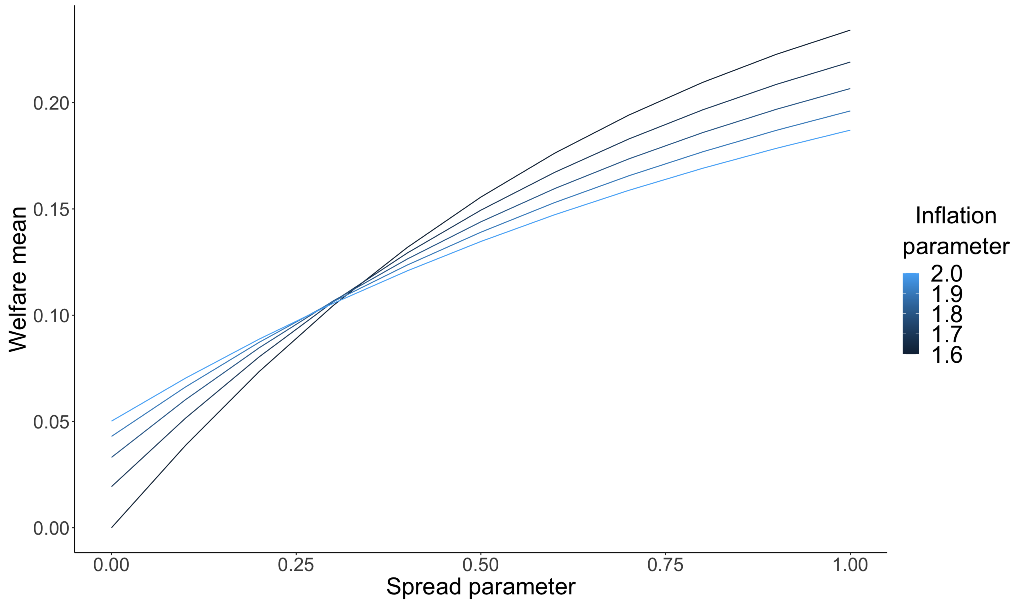
(a) Inflation Rate vs Credit Spreads



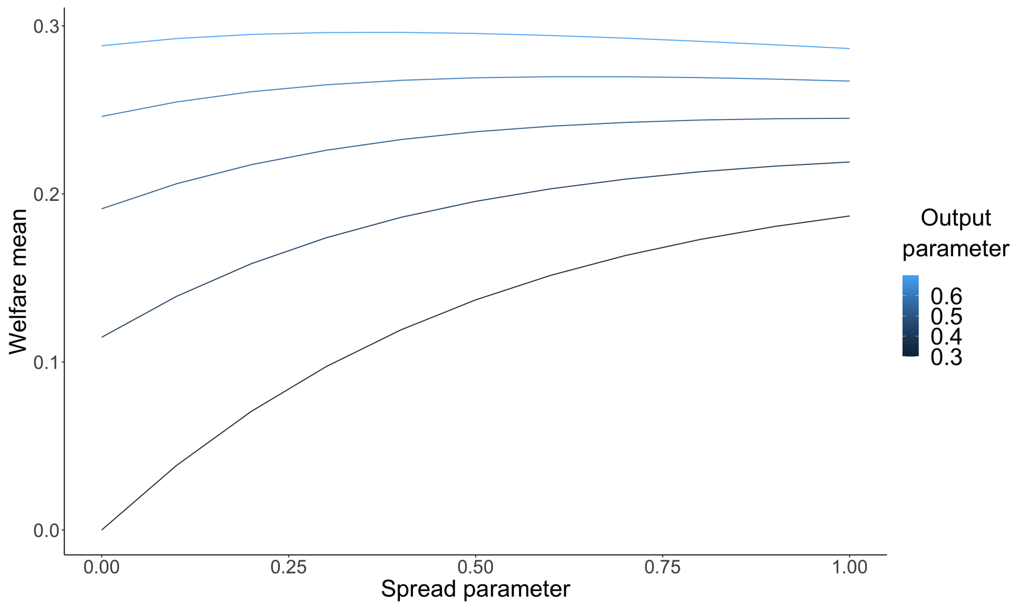
(b) Output Gap vs Credit Spreads

This figure compares social welfare in economies driven by shocks to corporate defaults for different parameter values for the Taylor rule (30). Panel (a) compares welfare across different inflation and credit spread parameters, holding the output gap parameter fixed at its baseline level of 0.2, whereas Panel (b) compares welfare across different output gap and credit spread parameters, holding the inflation parameter fixed at its baseline level of 1.5.

Figure 7: Welfare Changes due to Shocks to the Financial Sector Across Different Taylor Rule Parameters



(a) Inflation Rate vs Credit Spreads



(b) Output Gap vs Credit Spreads

This figure compares social welfare in economies driven by shocks to the profitability of the financial sector for different parameter values for the Taylor rule (30). Panel (a) compares welfare across different inflation and credit spread parameters, holding the output gap parameter fixed at its baseline level of 0.2, whereas Panel (b) compares welfare across different output gap and credit spread parameters, holding the inflation parameter fixed at its baseline level of 1.5.

5.3 The Role of Sticky Leverage

To better understand some of the intuition behind our main results consider the following example. Suppose the Central bank hikes policy rates to combat inflation. The Central Bank is effectively creating deflationary pressure, which increases the real value of long-term nominal debt. This means that the firms will effectively owe more and default rates will likely increase. Credit spreads rise leading to a drop in investment, consumption, and output. These unique effects of monetary policy are entirely absent when debt is real, one-period or risk-free.

In our model then, credit spreads are a function of discount factors (adjusted for bank survival probabilities), shocks to expected corporate default rates and - with long-term debt - also *expected future inflation*. This is because an increase in expected inflation reduces the real burden of debt and thus expected default. As a result, with sticky leverage, targeting credit spreads also helps target inflation.

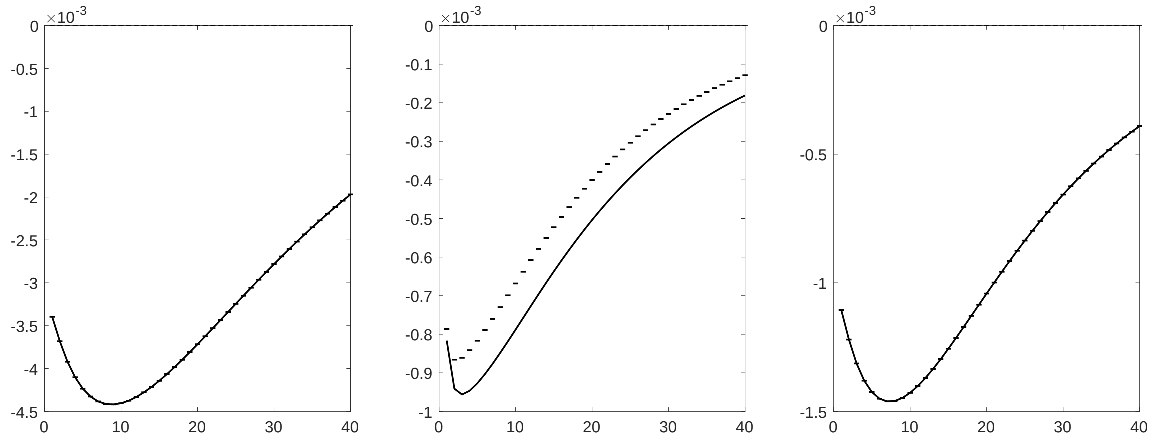
Figure 8 illustrates this point. It compares the impulse response functions (IRFs) of aggregate consumption to our three different shocks for an economy without sticky defaultable nominal debt. As we can see from Panels (a) and (c), these responses are now essentially identical when the economy is hit by shocks to productivity or the banking sector, regardless of the specific monetary policy rule followed by the Central Bank.

However, Panel (b) shows that responding to credit spreads is still effective at mitigating the drop in equilibrium consumption when the underlying shock directly impacts expected corporate defaults since this, although the difference between the two economies is smaller than in the case with sticky leverage.

6 Conclusion

How should monetary policy respond to evolving financial conditions? The inflation-targeting consensus of the 1990s and the widespread adoption of Taylor rules by policy authorities generally treated financial markets as a sideshow - at least until the crisis of

Figure 8: Impulse Response Functions of Consumption without Sticky Leverage



(a) TFP shock (b) Default shock (c) Bank shock

This figure provides impulse response functions (IRFs) of consumption without sticky leverage, i.e. when $\eta = 1$. Panel (a) plots IRFs to a one standard deviation negative productivity shock, Panel (b) plots the IRFs to a one standard deviation positive shock to corporate defaults, and Panel (c) plots the IRFs to a one standard deviation decrease in bank profitability. Solid lines show IRFs with a standard Taylor rule, while dashed lines correspond to IRFs with an augmented Taylor rule that includes corporate spreads with parameter $\psi_3 = 0.1$.

2008. Since then, however, it is slowly becoming apparent that policy makers are increasingly relying on financial data for their policy assessments and decisions, although never explicitly. Especially in the early stages of the post-Covid recovery, most Central Banks remained worried about financial conditions and were especially cautious in targeting rising inflation. Conversely, threats to the banking system after March of 2023 did not stop the US Federal Reserve from continuing to raise policy rates to fight inflation.

In this paper, we provide a rich theoretical framework for this discussion by developing and estimating a medium-scale dynamic macro model with a detailed financial sector and long-term defaultable nominal debt contracts that can be used to quantify monetary policy responses to movements in credit conditions.

We show that using the policy rate to directly target credit spreads can help mitigate the losses in aggregate consumption and output associated with macro fluctuations. A (credible) monetary policy rule that includes credit spreads is often welfare-improving and generally obviates the need for explicit inflation targeting. Targeting credit spreads is most effective when shocks are financial in nature but it is generally suboptimal when the economy is faced with productivity or supply shocks. In this case, it is better for the policy rate to aggressively respond to the output gap instead.

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