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Monetary Policy Interactions: The Policy Rate, Asset Purchases and Optimal Policy with an Interest Rate Peg*

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Abstract

We study monetary policy in a New Keynesian model with a variable credit spread and scope for central bank asset purchases to matter. A novel financial and labor market interaction generates an endogenous cost-push channel in the Phillips curve and a credit wedge in the IS curve. These channels arise due to a liquidity premium to long-term debt present in our model. The "divine coincidence" holds with the nominal short rate and central bank balance sheet available as policy tools—dual-instrument policy. Targeting the liquidity premium using balance sheet policy provides a determinate equilibrium with a fixed policy rate, as does inflation-targeting balance sheet policy. While the liquidity premium in our model depends on unobservable components, the slope of the yield curve serves as a proxy for the liquidity premium when thinking about implementable monetary policy strategies that respond to observable variables alone. We quantify the welfare costs to various monetary policy strategies relative to the analytically derived optimal dual-instrument policy.

Keywords: unconventional monetary policy, optimal monetary policy, New Keynesian model, policy rate lower bound, interest rate peg

JEL Codes: E43, E52, E58

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1 Introduction

Balance sheet policy, or quantitative easing (QE), has become a staple tool for central bankers.[1] QE programs have varied in the scope and types of assets purchased but have largely been conducted with policy rates at the effective lower bound (ELB). In 2019, however, the Federal Reserve began expanding its balance sheet with the federal funds rate above the ELB, including an increase of about $120 billion in non-bill Treasury securities holdings. Balance sheet expansion away from the ELB is at odds with the idea that balance sheet policy is a substitute for interest rate policy at the ELB. For this reason, this paper revisits optimal monetary policy—both interest rate and balance sheet policy—asking whether active balance sheet policy away from the ELB can be optimal.

We point out that limits to central bank interest rate policy arise and balance sheet policy matters in a world where indebted households alter their labor supply in response to changing financial conditions.[2] We then ask two questions. First, can dual-instrument policy, meaning simultaneous interest rate and balance sheet policy, overcome these limitations? Second, is balance sheet policy effective if interest rate policy is unavailable to the central bank? Given our answers to these questions, we investigate the welfare costs of various single-instrument monetary policy strategies, e.g., inflation-targeting interest rate or balance sheet policy, relative to the optimal dual-instrument policy.

We analyze monetary policy strategies in a model where households finance a part of their consumption bundles with debt and financial markets are incomplete. The model adds two features to a standard New Keynesian (NK) model framework.

First, a representative household simultaneously saves and borrows, issuing debt to finance a second expenditure type in addition to conventional consumption, dubbed debt-financed expenditure (e.g., housing, education, or automobiles).[3] The household finances debt-financed expenditure and debt repayment with a chosen fraction of labor income and new debt issuance, while financing conventional consumption and saving

1. Following the financial crisis, the Federal Reserve (Fed) implemented several rounds of quantitative easing (QE 1, 2, 3), followed closely by the Bank of England, the European Central Bank (ECB), and other central banks. QE aimed to (i) influence inflation (e.g., Fed: November 2010, Sep 2012, Dec 2012; ECB: Feb 2015, Sep 2015, Nov 2015, Dec 2015), (ii) restore market functioning and spreads (e.g., Fed: Nov 2008, Dec 2008, March 2009, Sep 2012, Dec 2012, Sep 2019, March 2020; ECB: Feb 2015, Sep 2015, Nov 2015, Dec 2015, March 2020) near the ELB (e.g., Fed: March 2009, Nov 2010, Sep 2012, Dec 2012, March 2020; ECB: Feb 2015, Sep 2015, Nov 2015, Dec 2015, March 2020) and outside the ELB (e.g., Fed: Nov 2008, Sep 2019). For a broader overview, see Appendix A.

2. For example, Zator (2024) delivers evidence on labor supply reactions to mortgage payment changes, and Graves et al. (2023) on labor supply reactions to monetary policy.

3. Our household setup is a consolidated version of Guerrieri and Iacoviello (2017), a generalization of Sims et al. (2023), and a simplification of Cúrdia and Woodford (2011, 2016).

in a separate account with the remainder of its labor income and non-labor income.

Second, incomplete financial markets arise from constrained private lending due to an agency problem between banks and depositors, as in Gertler and Karadi (2011, 2013). Banks in the Gertler and Karadi setup stochastically exit and face a limited enforcement constraint. We introduce bank reserve holdings that are fully recoverable by depositors in the event of bank default.[4] Central bank reserve issuance in exchange for debt securities relaxes the limited enforcement constraint, bringing the economy closer to the complete markets case. Focusing on the deterministic bank exit limit maintains the endogenous nature of the constraint while generating analytical tractability.[5]

The combination of the household borrowing setup and constrained financial sector cause financial conditions to vary with non-financial economic conditions, providing a new propagation mechanism for shocks originating outside the financial sector. Conventional consumption and debt-financed expenditure have the same price. For this reason, the household desires to equate the marginal utilities from both expenditure types. However, incomplete financial markets limit the household's ability to do so, generating a wedge between these marginal utilities, which we call the *liquidity premium*.

The liquidity premium is time-varying due to fluctuations in household borrowing costs relative to the deposit rate, micro-founded by the constrained banking problem. In response to liquidity premium fluctuations, the household alters its labor income allocation between the expenditure accounts and its labor supply. The interaction of changes in financial conditions, labor supply, and the household's labor income allocation delivers a source and propagation force of shocks emerging in the financial and non-financial sectors. Furthermore, we show that this new propagation mechanism limits the ability of interest rate policy to stabilize inflation and the output gap simultaneously.

An approximation of the model simplifies to seven structural equations. The first two equations are the Phillips and IS curves. The liquidity premium acts as an *endogenous* cost-push channel in the Phillips curve and credit wedge in the IS curve because a fraction of aggregate expenditures varies with the lending rate.[6] A third equation shows that the liquidity premium equals the ex-ante forward-looking path of the loan to deposit rate, or credit, spread. This causes the output gap to vary with a weighted average of the real deposit and lending rate paths. The remaining equations define the financial

4. For a bank that holds non-reserve assets and reserves, backed by deposits and equity, we define bank leverage as the ratio of non-reserve asset holdings to equity.

5. This is a more complex banking setup than Sims et al. (2023) but a simplification, in the form of a limiting case, of Gertler and Karadi (2011, 2013).

6. For certain parameter restrictions, our model nests the standard Phillips and IS curves in the 3-equation NK model as presented in Galí (2015), for example.

block in the economy. These equations can be combined into a single equation defining the liquidity premium in terms of the output gap, inflation, policy instruments, and exogenous economic shocks. The policy instruments include the interest rate on reserves, which the nominal deposit rate equals, and the quantity of reserve issuance.

To first order, the general equilibrium output level in this economy varies with derived labor demand and supply shifts. The labor supply shift depends on both the real deposit and lending rate paths. Optimal monetary policy must simultaneously balance the impact of both rates on labor supply. The so-called "divine coincidence", coined by Blanchard and Galí (2007), reflects the ability of a monetary authority to simultaneously target inflation and the output gap in the textbook NK model. In that case, inflation-targeting interest rate policy eliminates inefficient labor demand variability due to the time-varying markup and provides the optimal labor supply response with the policy rate equal to the natural rate. This result fails to hold in our model due to the labor supply dependency on the lending rate. Output variability stemming from variation in the credit spread generates welfare losses with inflation-targeting interest rate policy.

Balance sheet policy that targets the liquidity premium restores the divine coincidence. Balance sheet expansion in response to tightening financial conditions, or vice versa, stabilizes the liquidity premium. Under this policy, the labor supply shift only varies with the real deposit rate. Inflation-targeting interest rate policy eliminates inefficient labor demand shifts and, in combination with this balance sheet policy, restores the optimal labor supply shift in response to the natural rate shock. Both the deposit and lending rates equal the natural rate. In summary, targeting the liquidity premium with balance sheet policy causes inflation-targeting interest rate policy to simultaneously stabilize the output gap, providing the welfare-maximizing outcome. This result points to the potential need for policymakers to use balance sheet policy much more. The key lesson being that, in a credit crunch, expand the balance sheet *independent* of the source of financial market variability or the policy rate level relative to the ELB.

A natural question arises in our modeling context as to how well balance sheet policy performs independent of interest rate policy—a somewhat extreme but theoretically interesting question. A policy rate peg typically leads to nominal indeterminacy in macroeconomic models (Sargent and Wallace, 1975), a point not lost on NK models. In our model, a policy rate peg does not necessarily lead to nominal indeterminacy when considering active balance sheet policy.

We prove that balance sheet policy that targets the credit spread path via the liquidity premium or inflation in the face of a policy rate peg leads to a determinate linear rational expectations equilibrium. Despite this theoretically interesting result, there are sizable welfare losses from constraining the monetary authority to balance sheet policy alone. Our results point to balance sheet policy being a useful supplement to interest rate policy given our optimal dual-instrument policy result, but not a substitute. Implementable policy strategies that rely solely on observable variables, such as an interest rate policy that flexibly targets inflation and output growth and a balance sheet policy strictly targeting the slope of the yield curve—an observable proxy for the liquidity premium—lead to similarly sized welfare losses.

This paper contributes to the literature on the "financial accelerator" (see Bernanke et al., 1996, 1999) by characterizing this mechanism through the labor supply decision. Consider a deflationary natural rate shock that raises conventional consumption. From an accounting perspective, the household must save less, work more, or retain more labor income for conventional consumption. Retaining more labor income for conventional consumption crowds out debt-financed expenditure, but the household desires to equate marginal utilities from both expenditures. Thus, the household issues more debt or works more than it otherwise would in the complete markets case to counteract the crowding-out effect. However, incomplete financial markets restrict the household's ability to issue more debt, potentially dampening the debt-financed expenditure and, thus, output responses relative to a model with complete financial markets. The household internalizes this effect and further increases its labor supply, generating an amplified output response due to the altered labor supply shift.

This paper also relates to the broader literature on general equilibrium macroeconomic modeling. We provide an alternative micro-foundation for an endogenous cost channel to input cost borrowing as in Christiano et al. (2005) or Ravenna and Walsh (2006), endogenizing the "cost-push" shock introduced in Clarida et al. (1999). In addition, we micro-found an endogenous credit wedge in the IS curve (similar to Cúrdia and Woodford, 2011, 2016) without assuming utility over safe and liquid security holdings as in Fisher (2015), endogenizing the "risk premium" shock from Smets and Wouters (2007). These mechanisms provide a unified framework for analyzing the demand- and supply-side effects of financial market variability on the economy.

Finally, this paper adds to the literature on optimal QE policy outside of the positive analysis of QE policy.[7] While Sims et al. (2023) prescribe balance sheet policy in response to shocks originating in the financial sector only, we prescribe the use of balance sheet policy in response to all shocks. Balance sheet policy alone neutralizes the effects of

7. For literature on optimal QE policy, see, e.g., Jones and Kulish (2013), Ellison and Tischbirek (2014), Darracq-Pariès and Kühl (2017), Mau (2023), or Sims et al. (2023), and for positive analysis of QE policy, see, e.g., Gertler and Karadi (2011, 2013), Carlstrom et al. (2017), Cui and Sterk (2021) or Boehl et al. (2024).

financial shocks as in Sims et al. (2023), but non-financial shocks require a combination of interest rate and balance sheet policy responses. This calls for an interplay of interest rate and balance sheet policy as shown in Ellison and Tischbirek (2014) or Darracq-Pariès and Kühl (2017). Furthermore, to the best of our knowledge, our paper is the first to show that balance sheet policy alone suffices to render model determinacy under a permanent interest rate peg.

The rest of this paper is structured as follows: Section 2 outlines a model of household finance in which a representative household simultaneously saves and borrows. Section 3 embeds this household setup into an NK model with financial frictions and a role for asset purchases to matter, and shows how shock transmission differs in our model compared to flexible- and sticky-price models with complete financial markets. Section 4 highlights the properties of single- and dual-instrument interest rate and balance sheet policy strategies. Section 5 quantifies the welfare losses to single-instrument monetary policy strategies relative to optimal dual-instrument policy, and implementable monetary policy strategies based on observable variables. Section 6 concludes. Online appendices provide additional model details, derivations of theoretical results, accompanying proofs, and additional quantitative results.

2 A Model of Household Debt Issuance

In this section, we outline a model of household finance in which a representative household simultaneously saves and borrows. We embed this household setup into a general equilibrium model in Section 3. The representative household setup we consider generalizes: (i) a model in which a patient household saves and an impatient household borrows; and (ii) the parent/child relationship described in Sims et al. (2023).

A representative household supplies labor, N_t, to firms and receives the real wage W_t per unit of labor. The household is the residual claimant in the economy with the aggregate real dividend denoted by D_t. The household operates two accounts for different types of purchases, choosing its labor income allocation between the accounts. Intuitively, these two accounts are like a checking account and a longer-term line of credit that the household makes payments into each period. The checking account is used for consumption, $C_{p,t}$, and saving, $S_t - S_{t-1}$, with a $1 - \Omega_t$ fraction of labor income allocated to this account. Past savings pay the gross nominal rate R_{t-1} in the current period.

Resource flows in this account are summarized by the following budget constraint

$$C_{p,t} + S_t = (1 - \Omega_t) W_t N_t + R_{t-1} \Pi_t^{-1} S_{t-1} + D_t, \tag{2.1}$$

where Π_t is the gross inflation rate.

The line of credit is used for debt-financed expenditure, $C_{b,t}$. The remaining Ω_t fraction of labor income is used to finance this second expenditure type in addition to debt, B_t. We model household debt as a perpetuity with geometrically decaying coupon flows as in Sims et al. (2023). The coupon decay rate is κ and Q_t denotes the current price of this debt instrument. The value of real new issuance each period is given by $Q_t \left(B_t - \kappa \Pi_t^{-1} B_{t-1} \right)$ and the real obligation due on past issuance each period is $\Pi_t^{-1} B_{t-1}$. Resource flows in this account are summarized by the following budget constraint

$$C_{b,t} + \Pi_t^{-1} B_{t-1} = \Omega_t W_t N_t + Q_t \left(B_t - \kappa \Pi_t^{-1} B_{t-1} \right). \tag{2.2}$$

Per period household utility is the sum of utility flows from each consumption type and the associated labor supporting it, but the household exhibits relative myopia over utility flows from debt-financed expenditure. Current expected lifetime household utility is given by

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left\{ u\left(C_{p,t+j}, (1 - \Omega_{t+j}) N_{t+j} \right) + \zeta^j \Gamma u \left(C_{b,t+j}, \Omega_{t+j} N_{t+j} \right) \right\},$$

where β is the household's subjective discount factor, ζ determines the degree of relative myopia over utility flows from debt-financed consumption, and Γ is a measure of the household's uniform relative preference for debt-financed expenditure.

With additively separable preferences, $u(x, y) = \ln x - \psi (y^{1+\eta}) / (1+\eta)$, household expected lifetime utility can be rewritten as

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left\{ \ln C_{p,t+j} - \Psi_j \left(\Omega_{t+j} \right) \frac{N_{t+j}^{1+\eta}}{1+\eta} + \zeta^j \Gamma \ln C_{b,t+j} \right\}, \tag{2.3}$$

where

$$\Psi_j \left(\Omega_{t+j} \right) = \psi \left[\left(1 - \Omega_{t+j} \right)^{1+\eta} + \zeta^j \Gamma \Omega_{t+j}^{1+\eta} \right].$$

In this case, the household's labor preference shifter is endogenous and varies with its labor income allocation. That is, changes in the household's labor income allocation will generate shifts in the household's labor supply curve all else equal.

Maximizing (2.3) subject to (2.1) and (2.2) implies

$$\Xi_t = \Gamma \frac{C_{p,t}}{C_{b,t}}, \tag{2.4}$$

$$\Psi_0 \left(\Omega_t\right) N_t^{\eta} C_{p,t} = W_t \left[1 - \Omega_t + \Omega_t \Xi_t\right], \tag{2.5}$$

$$\Psi_0' \left(\Omega_t\right) \frac{N_t^{\eta}}{1+\eta} C_{p,t} = W_t \left[\Xi_t - 1\right], \tag{2.6}$$

$$1 = \mathbb{E}_t \Lambda_{t,t+1}^{N} R_t, \tag{2.7}$$

$$1 = \zeta \mathbb{E}_t \Lambda_{t,t+1}^{N} \frac{\Xi_{t+1}}{\Xi_t} R_{t+1}^{L}, \tag{2.8}$$

where the nominal stochastic discount factor, $\Lambda_{t-1,t}^{N}$, and gross nominal long-term rate, R_t^L, are defined as

$$\Lambda_{t-1,t}^{N} = \beta \frac{C_{p,t-1}}{C_{p,t}} \Pi_t^{-1}, \tag{2.9}$$

$$R_t^L = \frac{1 + \kappa Q_t}{Q_t}. \tag{2.10}$$

Equation (2.4) defines the marginal rate of substitution between expenditure types, which we refer to as the liquidity premium, Ξ_t. Subtracting (2.7) from (2.8) shows that the liquidity premium is time-varying if the spread between the long- and short-term interest rates is time-varying, which is the case when financial markets are incomplete. Relative myopia, $\zeta < 1$, generates a positive steady-state spread between the two rates.

Equation (2.5) is the labor supply curve. Labor supply can shift in two new ways relative to a standard model. First, as the liquidity premium rises, the effective wage that the household faces, $W_t[1 - \Omega_t + \Omega_t \Xi_t]$, rises. A higher liquidity premium incentivizes the household to work more at a given wage. Second, as the household's labor income allocation changes, both the effective wage and the household's preference for labor shift. When the household is closer to a corner solution where it is allocating nearly all of its labor income to one account or the other, $\Omega_t \to 0$ or $\Omega_t \to 1$, the labor preference shifter is higher, putting downward pressure on household labor supply relative to the case where the household is splitting labor income between the two accounts.

Equation (2.6) defines the optimal labor income allocation. To develop intuition about this variable and its dynamics, combine (2.5) and (2.6) and simplify, implying

$$\Omega_t = \frac{\Xi_t^{1/\eta}}{\Gamma^{1/\eta} + \Xi_t^{1/\eta}}. \tag{2.11}$$

As the liquidity premium rises, debt-financed expenditure is effectively too low relative to consumption. In this case, the household is incentivized to allocate more labor income to support debt-financed expenditure, and Ω_t rises. If the household's debt-financed expenditure level is relatively high, the liquidity premium is lower and the household allocates more labor income to consumption.

In the next section, we embed this household problem in a general equilibrium model with constrained banking and nominal price rigidity. The necessary equations that we carry over to Section 3 for defining a competitive equilibrium are equations (2.2), (2.4)-(2.5), and (2.7)-(2.11). Before diving into the details of the general equilibrium model, the rest of this section highlights how our household setup compares to a patient/impatient agent setup commonly used to generate household borrowing in the DSGE literature, and the parent/child relationship from Sims et al. (2023).

2.A Relation to Other Household Setups

The household setup described by (2.1)-(2.3) is non-standard but is a generalization of a common household setup in models with household debt issuance. One way to generate debt issuance is to introduce two agents, one of which is relatively impatient. Our setup directly maps into a patient/impatient agent setup—Proposition 1. In addition, our setup is similar to the parent/child relationship in Sims et al. (2023), but with an endogenous transfer from the "parent" to the "child" rather than being taken as given by either agent and following a particular rule.

Proposition 1. *The household setup described by equations (2.1)-(2.3) nests a patient/impatient agent setup, and these are equivalent when* $\Gamma = 1$.

Proof. Consider a patient/impatient agent setup where each agent supplies labor to the production sector, the patient household saves in short-term markets, and the impatient household borrows in long-term markets. Markets are segmented. The patient household cannot hold long-term debt and the impatient household cannot hold short-term securities. The lifetime utility maximization problem for each agent, when both have additively separable preferences, are given by

$$\max \quad \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left\{ \ln C_{p,t+j} - \psi \frac{N_{p,t+j}^{1+\eta}}{1+\eta} \right\}$$

$$\text{s.t.} \quad C_{p,t} + S_t = W_t N_{p,t} + R_{t-1} \Pi_t^{-1} S_{t-1} + D_t$$

and

$$\max \quad \mathbb{E}_t \sum_{j=0}^{\infty} (\beta\zeta)^j \left\{ \ln C_{b,t+j} - \psi \frac{N_{b,t+j}^{1+\eta}}{1+\eta} \right\}$$

$$\text{s.t.} \quad C_{b,t} + \Pi_t^{-1} B_{t-1} = W_t N_{b,t} + Q_t \left(B_t - \kappa \Pi_t^{-1} B_{t-1} \right)$$

with optimality conditions

$$\psi N_{p,t}^{\eta} C_{p,t} = W_t, \tag{2.12}$$

$$\psi N_{b,t}^{\eta} C_{b,t} = W_t, \tag{2.13}$$

$$1 = \mathbb{E}_t \Lambda_{t,t+1}^{N} R_t, \tag{2.14}$$

$$1 = \zeta \mathbb{E}_t \Lambda_{t,t+1}^{N} \frac{C_{p,t+1}/C_{b,t+1}}{C_{p,t}/C_{b,t}} R_{t+1}^{L}. \tag{2.15}$$

Defining the auxiliary variable $\Xi_t = C_{p,t}/C_{b,t}$ proves that the (2.14) and (2.15) are identical to (2.7) and (2.8). Rewriting (2.12) and (2.13) in terms of labor shares, dividing the (2.13) from (2.12) and simplifying provides equation (2.11). Finally, imposing (2.11) on (2.5) provides (2.12),

$$\Psi_0 (\Omega_t) N_t^{\eta} C_{p,t} = W_t [1 - \Omega_t + \Omega_t \Xi_t] \iff \psi ((1 - \Omega_t) N_t)^{\eta} C_{p,t} = W_t.$$

□

3 A General Equilibrium Model with Household Debt Issuance and Constrained Banking

In this section, we incorporate the household finance model from Section 2 into an NK model with financial frictions and a role for asset purchases by a monetary authority to matter. The economy consists of the representative household, financial and production sectors, and a monetary authority. In this section, we discuss the financial sector, production sector, and monetary authority setups. We then define a linear approximation of the equilibrium. Finally, we outline monetary policy transmission in the model.[8]

8. Appendix B provides a linear approximation of the model and derives the simplified version of the approximated model presented here.

3.A Financial Sector

The financial sector follows Gertler and Karadi (2011, 2013) with the addition of reserve issuance by the monetary authority to financial intermediaries as in Sims and Wu (2021).[9] For analytical tractability, we consider the deterministic bank exit limit to the Gertler and Karadi financial sector setup.[10]

Banks indexed by j, $j \in [0,1]$, operate under perfect competition. Banks are financial intermediaries that originate bonds for financing household debt-financed expenditures and hold reserves with funding from deposits and bank equity. Banks are born each period endowed with a transfer $\widetilde{X}^s$ from the household that is uniform across banks, exit the subsequent period, and pay accumulated equity to the household.[11] Consider a bank balance sheet with nominal private debt, $Q_t\widetilde{B}^{FI}_{jt}$, paying the interest rate R^L_{t+1} in the subsequent period and nominal reserves, $\widetilde{RE}_{jt}$, paying the interest rate R^{re}_t, backed by deposits, $\widetilde{S}_{jt}$, requiring interest payments, R_t, and the seed funding, $\widetilde{X}^s$,

$$Q_t\widetilde{B}^{FI}_{jt} + \widetilde{RE}_{jt} = \widetilde{S}_{jt} + \widetilde{X}^s.$$

The bank cash flows imply that the present discounted value of future bank equity, or the value of the bank, is given by

$$\widetilde{V}_{jt} = \mathbb{E}_t\Lambda^N_{t,t+1}\left\{\left(R^L_{t+1} - R_t\right)Q_t\widetilde{B}^{FI}_{jt} + \left(R^{re}_t - R_t\right)\widetilde{RE}_{jt} + R_t\widetilde{X}^s\right\}.$$

Banks can default in the current period prior to paying out accumulated equity in the next. In the event of bank default, banks walk away with 100% of private debt holdings, $Q_t\widetilde{B}^{FI}_t$, with exogenous probability Θ_t whereas reserves are fully recoverable by depositors. We assume that this recovery probability follows an AR(1) process in logs,

$$\ln\Theta_t = (1-\rho_\theta)\ln\Theta + \rho_\theta\ln\Theta_{t-1} + \sigma_\theta\epsilon^\theta_t, \quad \epsilon^\theta_t \sim N(0,1). \tag{3.1}$$

To prevent strategic default, depositors impose the following limited enforcement constraint on banks to ensure bank continuation

$$\text{Expected value of default} = \Theta_t Q_t\widetilde{B}^{FI}_{jt} \leq \widetilde{V}_{jt}$$

9. Sims and Wu (2021) consider reserve requirements on the banking sector, which we abstract from.

10. Appendix C presents a version of the banking sector with probabilistic bank exit as in Gertler and Karadi (2011, 2013) to show that the deterministic exit case is truly a special case of the probabilistic exit case and that assuming deterministic exit does not fundamentally change the banking problem relative to these papers.

11. Variables, Z_t, with a tilde, $\widetilde{Z}_t$, reflect nominal quantities.

Bank-j maximizes the present discounted value of future bank equity subject to the limited enforcement constraint implying

$$\Theta_t \frac{\varkappa_{jt}}{1+\varkappa_{jt}} = \mathbb{E}_t \Lambda^N_{t,t+1} \left(R^L_{t+1} - R_t \right), \tag{3.2}$$

$$0 = \mathbb{E}_t \Lambda^N_{t,t+1} \left(R^{re}_t - R_t \right), \tag{3.3}$$

where $\varkappa_{jt}$ is the multiplier on the limited enforcement constraint and does not vary with bank-specific factors implying that $\varkappa_{jt} \equiv \varkappa_t$ for all j.

Substituting the definition of the value of the bank from the limited enforcement constraint and imposing the optimality conditions allows us to write the constraint as

$$Q_t B^{FI}_{jt} = Q_t B^{FI}_t \leq \left[\Theta_t - \mathbb{E}_t \Lambda^N_{t,t+1} \left(R^L_{t+1} - R_t \right) \right]^{-1} X^s.$$

The limited enforcement constraint defines the maximum level of the market value of financial intermediary private debt holdings. These holdings do not vary with any bank-specific factors and are therefore symmetric across banks.

For sufficiently limited enforcement, higher values of Θ_t, the limited enforcement constraint binds more frequently. We consider calibrations of the model and shocks to Θ_t such that the constraint always binds. Higher values of Θ_t reduce the quantity of bonds that the financial sector can hold for given levels of seed funding from households and the term spread, $\mathbb{E}_t \Lambda^N_{t,t+1} \left(R^L_{t+1} - R_t \right)$. This constraint differs from Sims et al. (2023) who assume an exogenous allowed modified leverage ratio, $Q_t B^{FI}_t / X^s$, as this ratio is endogenous in our model. As the term spread rises, the financial sector is allowed to hold more private bonds for a given level of seed funding and limited enforcement.

3.B Monetary Policy and Bond Market Clearing

Reserve issuance, RE_t, by a monetary authority is backed by long-term debt holdings, $Q_t B^{cb}_t$,

$$Q_t B^{cb}_t = RE_t,$$

where central bank reserves pay the interest rate R^{re}_t, which, from (3.3), determines the deposit rate. The monetary authority controls both the real size of its balance sheet and the interest rate on reserves. Debt market clearing with a binding limited enforcement constraint implies

$$Q_t B_t = \left[\Theta_t - \mathbb{E}_t \Lambda^N_{t,t+1} \left(R^L_{t+1} - R_t \right) \right]^{-1} X^s + RE_t. \tag{3.4}$$

The market value of long-term debt outstanding, Q_tB_t, equals debt holdings from the financial sector plus holdings by the monetary authority, equal to the size of its balance sheet in terms the stock of reserves, RE_t.

3.C Production Sector

The production sector is standard to NK models with Calvo pricing and a linear production technology. Labor demand defines marginal cost, MC_t in terms of the wage and labor productivity, A_t,

$$\text{MC}_t = \frac{W_t}{A_t}, \tag{3.5}$$

where

$$\ln A_t = (1-\rho_a)\ln A + \rho_a \ln A_{t-1} + \sigma_a \epsilon_t^a, \quad \epsilon_t^a \sim N(0,1). \tag{3.6}$$

For price-resetting firms, the optimal price-setting problem follows

$$\max_{P_t(j)} \quad \mathbb{E}_t \sum_{s=0}^{\infty} \left(\beta\phi_p\right)^s \frac{C_{p,t}}{C_{p,t+s}} \left[\frac{P_t(j)}{P_{t+s}} - \text{MC}_{t+s}\right] \left(\frac{P_t(j)}{P_{t+s}}\right)^{-\varepsilon} Y_{t+s},$$

where $1-\phi_p$ is the probability that a firm can reset its price in any given period and $\phi_p = 0$ defines the flexible price environment. For price-resetting firms, the optimal reset price, $P_t(j) = P_{\#,t}$, is given by

$$P_{\#,t} = \frac{\varepsilon}{\varepsilon-1} \frac{\mathbb{E}_t \sum_{s=0}^{\infty} \left(\beta\phi_p\right)^s C_{p,t+s}^{-1} \text{MC}_{t+s} P_{t+s}^{\varepsilon} Y_{t+s}}{\mathbb{E}_t \sum_{s=0}^{\infty} \left(\beta\phi_p\right)^s C_{p,t+s}^{-1} P_{t+s}^{\varepsilon-1} Y_{t+s}}.$$

Written relative to the prior period price level, $\Pi_{\#,t} = {}^{P_{\#,t}}/_{P_{t-1}}$, this simplifies to

$$\Pi_{\#,t} = \frac{\varepsilon}{\varepsilon-1} \Pi_t \frac{G_t}{H_t} \tag{3.7}$$

where

$$G_t = C_{p,t}^{-1} \text{MC}_t Y_t + \beta\phi_p \mathbb{E}_t \Pi_{t+1}^{\varepsilon} G_{t+1}, \tag{3.8}$$

$$H_t = C_{p,t}^{-1} Y_t + \beta\phi_p \mathbb{E}_t \Pi_{t+1}^{\varepsilon-1} H_{t+1}. \tag{3.9}$$

Aggregate output, price dispersion, the aggregate inflation rate, and aggregate expenditures are given by

$$Y_t = \frac{A_t N_t}{\Delta_t}, \tag{3.10}$$

$$\Delta_t = (1-\phi_p)\left(\frac{\Pi_t}{\Pi_{\#,t}}\right)^{\varepsilon} + \phi_p \Pi_t^{\varepsilon}\Delta_{t-1}, \tag{3.11}$$

$$\Pi_t^{1-\varepsilon} = (1-\phi_p)\Pi_{\#,t}^{1-\varepsilon} + \phi_p, \tag{3.12}$$

$$Y_t = C_{p,t} + C_{b,t}. \tag{3.13}$$

A competitive equilibrium is defined by sequences of quantities, $\{C_{p,t}, C_{b,t}, Y_t, N_t, \Omega_t, B_t, RE_t\}$, prices, $\{W_t, \mathrm{MC}_t, \Pi_t, \Lambda_t^N, R_t, Q_t, R_t^L, R_t^{re}, \Xi_t, \Pi_{\#,t}, G_t, H_t, \Delta_t, \varkappa_t\}$ and exogenous processes $\{\Theta_t, A_t\}$, such that equations (2.2), (2.4)-(2.5), (2.7)-(2.11), and (3.1)-(3.13) hold given policy decisions for the interest rate on reserves, R_t^{re}, and the size of the monetary authority's balance sheet, RE_t.

For policy and analytical purposes, define a benchmark level of output, Y_t^*, by considering the labor market equilibrium in the flexible price, $\phi_p = 0$, and complete markets, $\Xi_t \equiv 1$, economy assuming that a constant fraction of labor income equal to the steady state value in the incomplete markets model, Ω, is paid to the financial account,

$$Y_t^* = \left[\frac{1}{\psi}\frac{1+\Gamma}{(1-\Omega)^{\eta}}\frac{\varepsilon-1}{\varepsilon}\right]^{\frac{1}{1+\eta}} A_t.$$

We define the output gap as the relative output percentage deviations from steady state in the baseline and benchmark economies

$$Gap_t = \frac{Y_t}{Y_t^*}\frac{Y^*}{Y}.$$

3.D Key Equations

A log-linear approximation of the nonlinear model around the zero net inflation steady state simplifies to seven structural equations. In Section 4, we use these equations to describe analytical results related to monetary policy design. The first two equations are the Phillips and IS curves,

$$\pi_t = \gamma gap_t + \beta \mathbb{E}_t \pi_{t+1} + \frac{\gamma}{1+\eta}\left(\overline{C}_b - \Omega\right)\xi_t, \tag{3.14}$$

$$gap_t = \mathbb{E}_t gap_{t+1} - \left(\left(1-\overline{C}_b\right) r_t + \overline{C}_b \mathbb{E}_t r_{t+1}^L - \mathbb{E}_t \pi_{t+1} - r_t^n\right), \tag{3.15}$$

where lower-case variables denote percentage deviations of the variable from its steady state value, $x_t = {(X_t - X)}/{X} \approx \ln X_t - \ln X$, and r_t^n is the natural rate of interest.[12]

The natural rate is the real rate in the flexible price benchmark economy and varies with the current productivity level, $r_t^n = -(1-\rho_a)a_t$, implying that it is exogenous and follows an AR(1) process itself. γ is the product of the output gap elasticity of marginal cost and the marginal cost semi-elasticity of inflation. η is the inverse wage elasticity of labor supply. $\overline{C}_b$ is the steady-state debt-financed expenditure share of aggregate expenditures. Ω is the steady-state labor income allocation to the financial account. $\overline{C}_b - \Omega$ is the liquidity premium elasticity of marginal cost.

The Phillips curve is standard absent the liquidity premium term. The liquidity premium acts as an endogenous cost channel in the model. The IS curve reflects the fact that a fraction of aggregate expenditures, $1-\overline{C}_b$, vary with the ex-ante real deposit rate, whereas the remaining fraction, $\overline{C}_b$, are debt-financed and vary with the ex-ante real lending rate. For $\overline{C}_b = \Omega = 0$, these equations nest the standard Phillips and IS curves in the 3-equation NK model. That is, if there is no debt-financed expenditure, then no wage income is allocated to the financial account, and the output gap only varies with ex-ante real deposit rate deviations from the natural rate.

Asset pricing conditions from the household problem define the nominal lending rate and the liquidity premium in the economy,

$$r_t^L = \kappa\beta\zeta q_t - q_{t-1}, \tag{3.16}$$

$$\xi_t = \mathbb{E}_t \xi_{t+1} + \mathbb{E}_t r_{t+1}^L - r_t, \tag{3.17}$$

In Section 5, we provide further details that relate the liquidity premium to other asset pricing relations such as the slope of the yield curve or term premium, but (3.17) provides a clear intuition for our analytical results related to dual instrument policy presented in Section 4. From (3.17), the liquidity premium equals the forward-looking path of the credit spread. If a policymaker can use balance sheet policy to stabilize the credit spread implying $\mathbb{E}_t r_{t+1}^L = r_t$, then equations (3.14) and (3.15) are the standard IS and Phillips curves from the 3-equation NK model. In this case, the policymaker can stabilize inflation with interest rate policy, and the "divine coincidence" implies that there is no output gap variability.

12. For interest and inflation rates, this approximates to the level deviation in the variable from its steady state value, $x_t \approx \ln X_t - \ln X \approx (X_t - 1) - (X - 1) = X_t - X$.

Finally, the model includes a financial block,

$$c_{b,t} = gap_t - \left(1 - \overline{C}_b\right)\xi_t - \frac{1}{1-\rho_n} r_t^n, \tag{3.18}$$

$$\overline{C}_b c_{b,t} = \Omega \frac{\varepsilon - 1}{\varepsilon}\left(\left(\frac{1-\Omega}{\eta} + \overline{C}_b - \Omega\right)\xi_t + (2+\eta) gap_t - \frac{1}{1-\rho_n} r_t^n\right), \tag{3.19}$$
$$+ \frac{QB}{Y}\left(q_t + b_t - \frac{1}{\beta\zeta}\left(q_{t-1} + b_{t-1} + r_t^L - \pi_t\right)\right),$$

$$q_t + b_t = \left(1 - \overline{RE}\right)\left[\frac{\Phi}{\zeta}\left(\mathbb{E}_t r_{t+1}^L - r_t\right) - \left(1 + \Phi\frac{1-\zeta}{\zeta}\right)\theta_t\right] + \overline{RE} re_t. \tag{3.20}$$

The financial block can be combined into one equation defining the liquidity premium in terms of the output gap, inflation, policy instruments, and exogenous economic shocks.

Equation (3.18) is the aggregate resource constraint, written in terms of debt-financed expenditure, the output gap, the liquidity premium, and the natural rate. Equation (3.19) defines debt-financed expenditure in terms of the labor income allocation to the financial account, written in terms of the liquidity premium, output gap, and natural rate, and the current market value of debt net of obligations due on past debt. As ε increases, the steady-state markup falls and the steady-state wage rises, resulting in higher debt-financed expenditure sensitivity to the labor income allocation. The same is true with a higher steady state share of labor income allocated to this account, Ω. The larger the relative size of the financial sector to the economy, QB/Y, the more sensitive debt-financed expenditure is to the equilibrium quantity of debt in the economy, $q_t + b_t$, and current debt obligations, $q_{t-1} + b_{t-1} + r_t^L - \pi_t$. A higher steady-state real lending rate, $1/\beta\zeta$, amplifies the effects of the household debt obligation. Equation (3.20) defines the market value of debt. This includes both private financial sector debt holdings and holdings by the monetary authority, summarized by the size of its balance sheet. Private debt holdings vary with the credit spread where $\Phi = QB^{FI}/X^s$ is the steady-state modified leverage ratio and exogenous variation due to the financial shock, θ_t.

An approximation of the competitive equilibrium is defined by sequences of quantities, $\{gap_t, c_{b,t}, b_t, re_t\}$, and prices, $\{\pi_t, r_t, r_t^L, \xi_t, q_t\}$, such that equations (3.14)-(3.20) hold given: (i) policy decisions for the interest rate on reserves and balance sheet size, $\{r_t, re_t\}$; and (ii) sequences of the natural rate, financial and monetary shocks, $\{r_t^n, \theta_t, \epsilon_t^r\}$. In this section, we consider rules-based interest rate policy, $r_t = \phi_\pi \pi_t + \sigma_r \epsilon_t^r$, holding the relative size of the monetary authority's balance sheet to output fixed, $qe_t = re_t - y_t = 0$, where $y_t = gap_t - r_t^n/(1-\rho_n)$.[13,14] Output equals the output gap absent natural rate variability.

Table 1 provides the model parameterization. The discount rate (β) implies a 2% annualized steady-state real deposit rate. The Frisch wage elasticity of labor supply $(1/\eta)$ is one-third. The goods elasticity of substitution (ε) implies a 15% steady-state goods price markup. The relative impatience over debt-financed expenditures (ζ) implies a 1.5% annualized steady-state credit spread. The steady-state ratio of private bond holdings to the seed funding is 4. The concepts of debt-financed expenditure and the labor income allocation in our model are not well-measured. For this reason, we calibrate the size of the financial sector be between the recent ratios of bank assets to GDP, 8, and the overall level of financial assets to GDP, 20. This single calibration target implies values for both Ω and $\overline{C}_b$ when fixing steady-state output and labor to unity.[15] We calibrate the steady-state share of long-term debt held by the monetary authority $(\overline{RE})$ to the pre-2008 relative size of the reserve stock to quarterly GDP flows.

The persistence of the natural rate and financial shock processes is 0.8, similar to Sims et al. (2023), while the standard deviations of the natural rate and monetary processes are set to generate an impact output gap response of 0.25% in the baseline model. The financial shock is scaled to explain 20% of the variability in the output gap in the FF+NK model. The standard deviation of the output gap under this calibration is 1.6 percent, slightly below the standard deviation of the CBO-measured output gap for the United States from first quarter 1984 to fourth quarter 2019 of 1.7 percent.

To gain intuition about the model mechanism, Figure 1 shows the impulse responses to a natural rate shock under assumptions of a real business cycle (RBC) model with flexible prices and no financial frictions (FF), an NK model with sticky prices, an RBC model with FF, and an NK model with FF (our baseline model). The shock is scaled such that the impact output gap response in our model, labeled "FF+NK", is 0.25%. We present the responses in the corresponding RBC model ($\gamma \to \infty$ and $\xi_t \equiv 0$), NK model ($\gamma = 0.204$ and $\xi_t \equiv 0$), and a financial frictions (FF) model with our constrained financial sector ($\gamma \to \infty$ and ξ_t time-varying). The NK model responses highlight the

13. Allowing for interest rate smoothing yields qualitatively similar impulse responses of macroeconomic variables (see Appendix D.2).

14. We hold the relative size of the balance sheet to output fixed, initially, as a proxy for the pre-ELB balance sheet policy. From 1984q1 to 2007q4, the relative size of the stock of depository institution reserves (FRED code: $MADIRL$) to the quarterly GDP flow (FRED code: GDP, quarterly flow meaning $GDP/4$) averaged 1.6% with a persistent decline from a peak of 4.1% to 0.6% in 2007q4. From 2000q1 to 2007q4 this ranged from 0.5% to 1.0%, whereas by 2008q4 the relative size of reserves to GDP was 21.7%, with a pre-Covid peak in 2014q1 at 56.6%.

15. See Appendix B for a definition of the nonlinear steady-state system and outline of our steady-state calibration strategy.

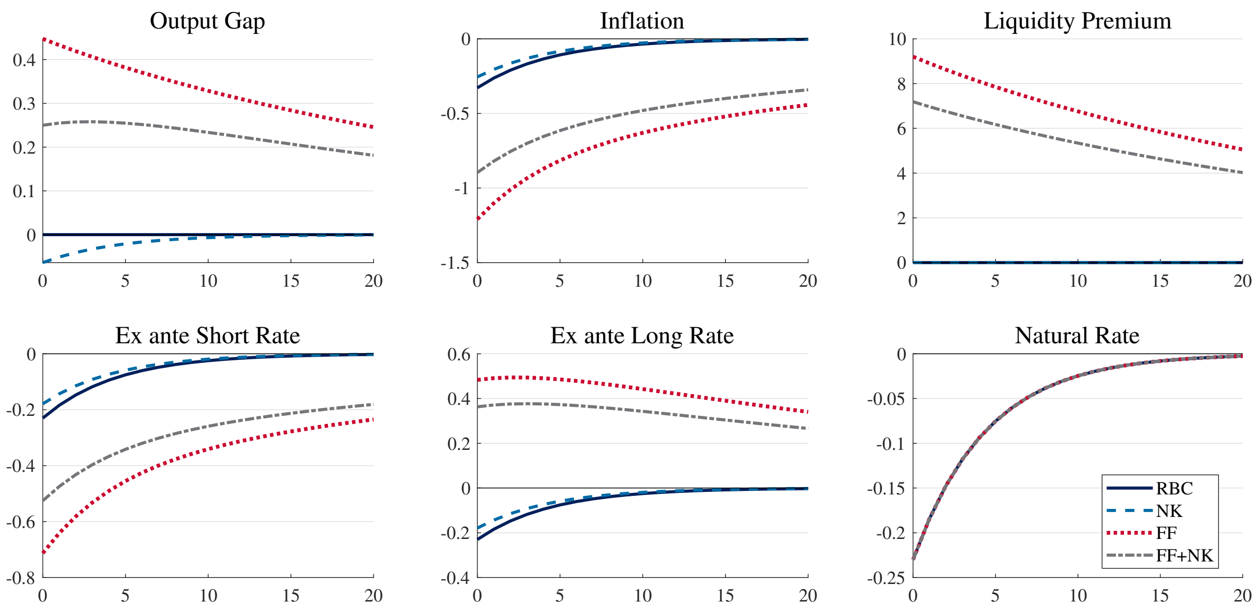
Table 1: Calibration

Parameter	Description	Target/Value
β	Discount factor	0.995
η	Inverse wage elasticity of labor supply	3
ε	Goods elasticity of substitution	7.667
ζ	Relative impatience over debt-financed expenditure	0.996
QB^{FI}/X^s	Steady-state modified leverage ratio	4
Ω	Steady-state labor income allocation to the financial account	0.550
$\overline{C}_b$	Steady-state share of credit good expenditure	0.3551
$\overline{RE}$	Steady-state share of debt held by monetary authority	0.005
QB/Y	Relative size of financial sector to output	14
κ	Coupon decay rate	1-1/40
ρ_n	Natural rate shock autoregressive parameter	0.8
ρ_θ	Financial shock autoregressive parameter	0.8
σ_n	Natural rate shock standard deviation	0.0029
σ_θ	Financial shock standard deviation	0.0062
σ_r	Monetary shock standard deviation	0.0052
ϕ_π	Policy rule inflation	1.5

dampening effect of nominal price rigidity relative to the RBC model, whereas the FF responses highlight a financial accelerator-type mechanism present due to the constrained financial sector, i.e., a more pronounced inflation response and expansionary response of the output gap. By financial accelerator-type mechanism, we specifically allude to the words of Ben Bernanke, "an economic upswing tends to improve the financial conditions of...banks, which in turn encourages greater lending..." see Bernanke (2022, p. 375). Taken together, our model exhibits a relatively "dampened" financial accelerator due to the combination of nominal price rigidity and financial frictions.

The functioning of the financial accelerator mechanism in our model is quite different—tightening financial conditions (a rising liquidity premium) generate an amplified output response. For example, rising productivity (a negative natural rate shock) is deflationary and the policy rate falls. With falling prices, desired consumption and debt-financed expenditure levels rise. The latter can only increase if the household allocates a higher fraction of labor income to the financial account, works more, or issues more debt. However, the financial sector can only hold so much debt due to the limited enforcement constraint. The equilibrium lending rate rises. Given these dynamics, the partial equilibrium response of debt-financed expenditure to higher productivity is dampened. In general equilibrium, the household allocates more income to the financial account and works more than it otherwise would in the complete markets case, amplifying the pro-

Figure 1: Impulse Responses to a Natural Rate Shock



Notes: Solid lines: RBC model, $\gamma \to \infty$ and equations (3.18)-(3.20) replaced by $\xi_t \equiv 0$; dashed lines: NK model, $\gamma = 0.204$ and equations (3.18)-(3.20) replaced by $\xi_t \equiv 0$; dotted lines: a financial frictions (FF) model described by equations (3.14)-(3.20) with flexible prices, $\gamma \to \infty$; dashed-dotted lines: the complete model described by equations (3.14)-(3.20) with nominal price rigidity (FF+NK), $\gamma = 0.204$. The natural rate shock is scaled such that the output gap response in the FF+NK model is 0.25%. All variables are in terms of percentage deviations from steady state outside of the inflation and interest rates which are deviations from steady state in annualized percentage units.

ductivity shock effects.

Note, we can define output in our model in terms of labor demand and supply shifts, capturing the dynamics described above. Relative to the textbook NK model, the labor supply shift is a weighted average of the ex-ante real short- and long-term rate paths. Combining the Phillips, (3.14), and IS curves, (3.15), defined in terms of output instead of the output gap, $gap_t = y_t + r_t^n/(1-\rho_n)$, iterating the IS curve forward, and substituting out the liquidity premium solved forward, defines the equilibrium level of output,

$$(3.21) \quad y_t = \underbrace{-\frac{r_t^n}{1-\rho_n}}_{\text{productivity}} + \underbrace{\frac{1}{\eta}\left[\underbrace{-\frac{r_t^n}{1-\rho_n} + \frac{1}{\widetilde{\gamma}}(\pi_t - \beta\mathbb{E}_t\pi_{t+1})}_{\text{labor demand shift}} + \underbrace{\mathbb{E}_t\sum_{j=0}^{\infty}\left\{(1-\Omega)r_{t+j} + \Omega r_{t+j+1}^L - \pi_{t+j+1}\right\}}_{\text{labor supply shift}}\right]}_{\text{equilibrium labor level}},$$

where $\widetilde{\gamma}$ is the marginal cost semi-elasticity of inflation, $\widetilde{\gamma} = \gamma/(1+\eta)$.

This equation is the production function. The first term is the productivity level. Output varies one-for-one with the productivity level. The second term is the equilibrium labor response, decomposed into the respective labor demand and supply shifts. With inelastically supplied labor, $\eta \to \infty$, labor is fixed. Labor demand varies with the productivity level and an inefficient labor wedge due to nominal price rigidity. With flexible prices, $\widetilde{\gamma} \to \infty$, the labor wedge drops out. Labor supply varies with a weighted average of the forward-looking paths of the ex-ante real deposit and lending rates.

As the real deposit rate path falls in response to the natural rate shock, labor supply shifts in. However, worsening financial conditions cause the credit spread to rise. As the real lending rate path rises, labor supply shifts out. This is the financial accelerator mechanism in our model. Endogenously tightening financial conditions amplify the labor supply response to the natural rate shock relative to a model without debt-financed expenditure ($\Omega = 0$) or complete financial markets ($\mathbb{E}_t r_{t+1}^L \equiv r_t$ for all t). Figure A.5 visualizes the labor supply channel within the four models presented in Figure 1.

The output response is decomposed into the productivity, labor supply, and labor demand channels, as suggested by (3.21). In a canonical RBC model, the labor demand and labor supply effects cancel each other out, and the output response equals the productivity gain (and hence the output gap equals zero). In the presence of financial frictions, the sign of the labor supply channel flips and amplifies the labor demand effect from the RBC model, so that the output response is greater than the productivity gain and the sign of the output gap is positive. In a standard NK model, the opposite is the case, the labor demand channel from the RBC model is dampened while labor supply still falls, the output gap declines. Our model, FF+NK, exhibits a combination of the FF and NK labor market dynamics. Labor supply rises (but by less due to the effects of price rigidity) while the labor demand effect is dampened, leading to a positive, but dampened, output gap similar to the flexible price with incomplete markets case.

Figure 2 shows the impulse responses to a financial shock. The size of the financial shock is set to explain 20% of the variability in the output gap in the FF+NK model. We do not show the RBC and NK responses. With complete financial markets ($\xi_t \equiv 0$), the financial shock has no effect on the non-financial block of the economy. A positive financial shock corresponds to tightening financial conditions. That is, the liquidity premium rises, raising the ex-ante real credit spread. The financial shock acts as a supply shock in the sense that output rises as inflation falls in the RBC model with FF. This is due to a shift in aggregate labor supply in response to tightening financial conditions in the economy, similar to the response to the natural rate shock described above.

In the FF+NK model, output increases in response to a financial shock, less than in the FF model, due to the presence of nominal rigidities causing a drop in aggregate demand. Allowing for interest rate inertia, as in Sims et al. (2023) or Gertler and Karadi (2011), implies a contraction in output and a decline in inflation (see Figure A.3) The sign of the output gap response in response to the financial shock in our model, which is of the same structure as the financial shock in Sims and Wu (2021), is a quantitative question in nature, left to future research.

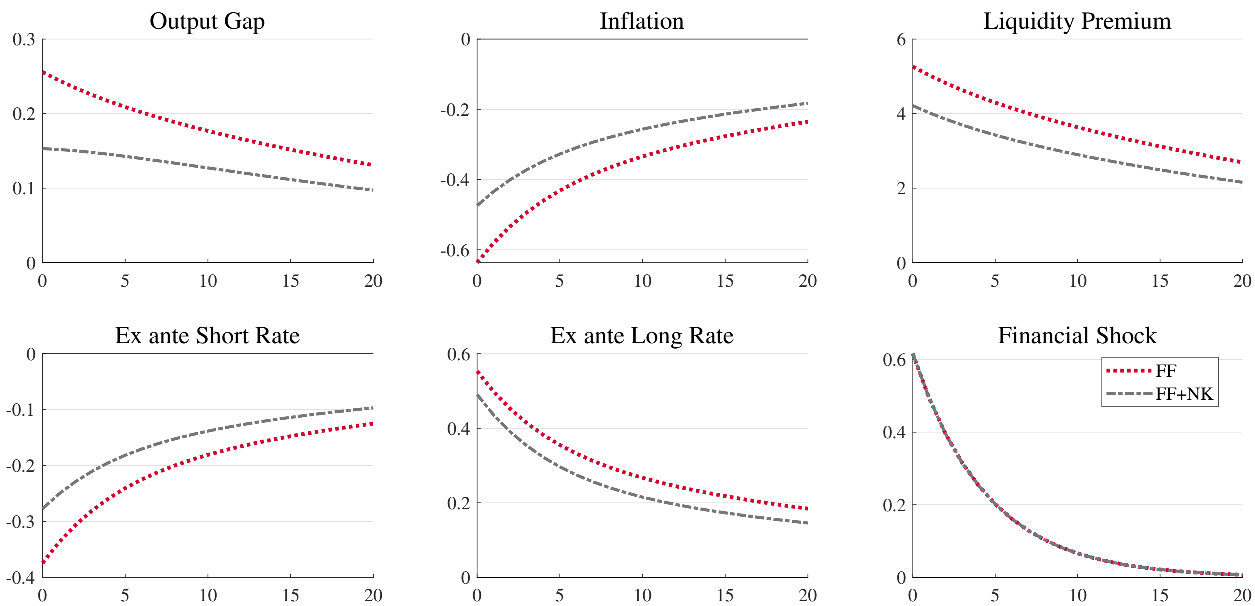
Figure A.1 shows the impulse responses to a monetary shock. The shock is scaled so that the output gap response in our model, labeled "FF+NK," is 0.25%. In a model without interest rate smoothing, the effect of the monetary shock is very short-lived, lasting one period.[16] The responses are standard: a contractionary response of the output gap and inflation. The liquidity premium rises in the FF+NK model, further reducing inflation dynamics. Two forces are at play in the FF+NK model, endogenous labor supply increases output and financial frictions further dampen the output response—offsetting each other.

4 Properties of Endogenous Balance Sheet Policy

This section highlights the properties of single- and dual-instrument monetary policy strategies in the linear model from Section 3. We study the cases where: (i) the monetary authority has both the balance sheet and policy rate as policy instruments available, or

16. Section D.2 presents similar results allowing for interest rate smoothing.

Figure 2: Impulse Responses to a Financial Shock



Notes: Dotted lines: a financial frictions (FF) model described by equations (3.14)-(3.20) with flexible prices, $\gamma \to \infty$; dashed-dotted lines: the complete model described by equations (3.14)-(3.20) with nominal price rigidity (FF+NK), $\gamma = 0.204$. The financial shock is scaled to explain 20% of the variability in the output gap in the FF+NK model. All variables are in terms of percentage deviations from steady state outside of the inflation and interest rates which are deviations from steady state in annualized percentage units.

(ii) the monetary authority only uses its balance sheet to support a permanent interest rate peg. Appendix E provides all proofs to the propositions and corollaries below.

Dual-instrument Policy Ensures that the Divine Coincidence Holds. The divine coincidence is a canonical result in the textbook NK model, absent the effects of an ELB. Targeting inflation simultaneously stabilizes the output gap with the policy rate equal to the natural rate. In our model, this result does not hold with interest rate policy alone.

Proposition 2. *Absent endogenous balance sheet policy, the divine coincidence fails due to liquidity premium variability.*

The liquidity premium acts as an endogenous cost channel in the Phillips curve due to the financial frictions in the economy. This means that targeting inflation leads to the output gap varying proportionally to the liquidity premium,

$$x_t = \frac{\Omega - \overline{C}_b}{1+\eta}\xi_t.$$

Inflation-targeting interest rate policy *does not* simultaneously stabilize the liquidity premium. This also implies that the output gap is time-varying and that the policy rate does not equal the natural rate. However, handing the monetary authority an additional policy tool—its balance sheet—restores a version of the divine coincidence.

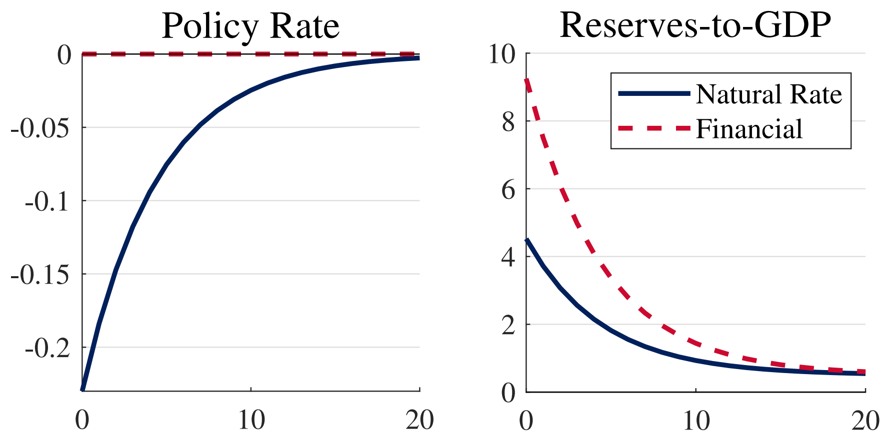
Proposition 3. *There exists endogenous balance sheet policy, re_t^*, that stabilizes the output gap, inflation, and the liquidity premium, the equivalent of the "divine coincidence" in this economy,*

$$\text{(DC)} \qquad re_t^* = \frac{1}{\beta\zeta}re_{t-1}^* + \frac{1-\overline{RE}}{\overline{RE}}\left(1+\Phi\frac{1-\zeta}{\zeta}\right)\left(\theta_t - \frac{1}{\beta\zeta}\theta_{t-1}\right) - \frac{1}{\overline{RE}}\left(\frac{\kappa(1-\rho_n)}{1-\kappa\beta\zeta\rho_n} - \frac{Y}{QB}\left(\Omega\frac{\varepsilon-1}{\varepsilon} - \overline{C}_b\right)\right)\frac{r_t^n}{1-\rho_n} + \frac{1}{\overline{RE}}\frac{1}{\beta\zeta}\frac{r_{t-1}^n}{1-\kappa\beta\zeta\rho_n}.$$

Corollary 3.1. *The policy rate, r_t, equals the natural rate when balance sheet policy supports liquidity premium stabilization.*

The endogenous balance sheet policy that instills the divine coincidence responds to financial and natural rate shocks. Under this policy, the credit spread is fixed. A fixed credit spread implies that the size of the financial sector, $q_t + b_t$, only varies with the financial shock and the size of the monetary authority's balance sheet. Furthermore, balance sheet policy alone is sufficient to stabilize the economy in response to financial shocks. That is, the policy rate *only* responds to the natural rate as shown in Figure 3. In

Figure 3: Optimal Policy Responses to a Financial and Natural Rate Shock



Notes: Balance sheet policy, re_t, follows (DC). The policy rate equals the natural rate and is reported in deviations from steady state in annualized percentage points. The reserves-to-GDP ratio is in level percentages. The natural rate shock is scaled to generate a 0.25% output gap response in our model and the financial shock to explain 20% of output gap variability, as shown in Figure 1 and Figure 2.

contrast, the monetary authority's balance sheet expands in response to *both* a negative natural rate shock and tightening financial conditions, $\theta \uparrow$.

Our balance sheet policy prescription differs from previous studies of balance sheet policy using small-scale NK models. For example, Sims et al. (2023) find that the balance sheet policy only responds to financial shocks, whereas we show that this is insufficient in an environment with an endogenous labor supply and an endogenous limited enforcement constraint. Our result provides a clear policy prescription in a tractable model that is consistent with optimal balance sheet policy in a medium-scale model with a similar financial sector setup (see Mau, 2023). An important message for policymakers is to employ balance sheet policy much more often, and even away from the ELB. Section 5 discusses how to conduct balance sheet policy in practice. We show that targeting the slope of the yield curve serves as a reasonable proxy for liquidity premium-targeting balance sheet policy—an implication of our policy prescription.

Balance Sheet Policy Supports Model Determinacy with a Policy Rate Peg. A natural question related to active balance sheet policy is: is balance sheet policy sufficient to conduct monetary policy, independent of interest rate policy? More concretely, do balance sheet policy strategies exist such that the model is determined with a fixed policy rate? The answer is yes! We view this exercise as an extreme proxy for the ELB. At the ELB, the policy rate is fixed for an (ex-ante) indefinite period of time. Here, we push that to the limit by fixing the policy rate forever.

Proposition 4. *Endogenous balance sheet policy can provide a determinate rational expectations equilibrium with a permanent policy rate peg.*

Corollary 4.1. *Inflation-targeting balance sheet policy, re_t^{π}, leads to a determinate linear rational expectations equilibrium, even with a permanent policy rate peg.*

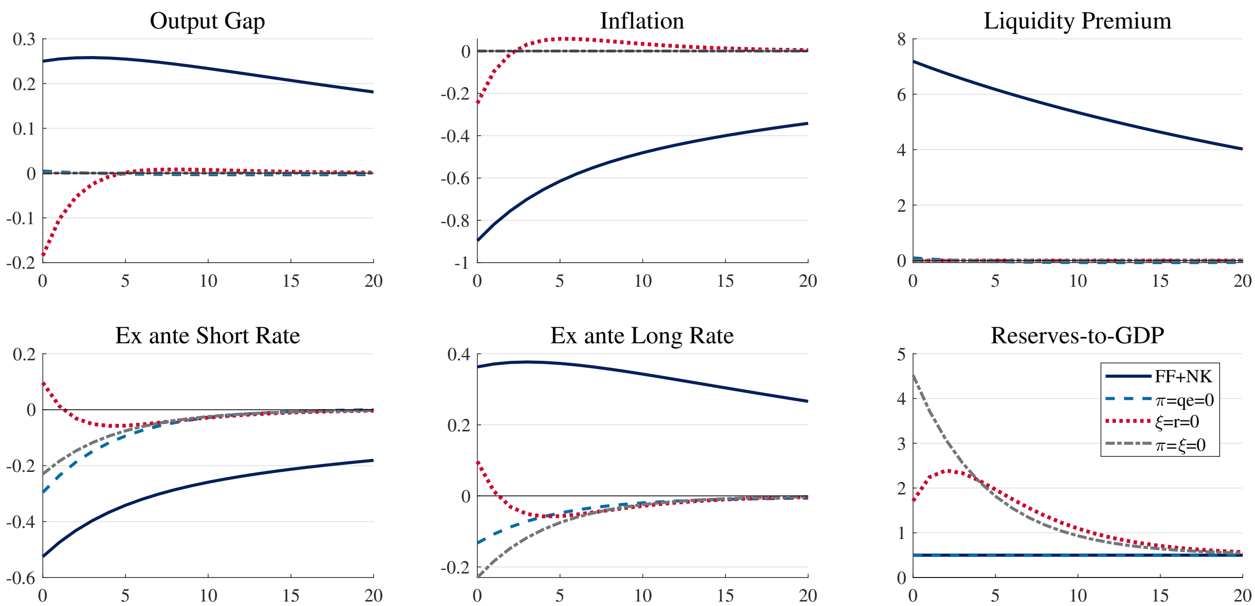
Corollary 4.2. *Balance sheet policy that targets the output gap, re_t^{gap}, with a permanent policy rate peg results in model indeterminacy.*

Under a permanent policy rate peg, liquidity premium targeting balance sheet policy leads to a determinate linear rational expectations equilibrium. In addition, inflation-targeting balance sheet policy leads to a determinate solution. Conversely, output gap-targeting balance sheet policy under an interest rate peg results in model indeterminacy. With output gap-targeting balance sheet policy, the financial block simplifies to one equation with two unknowns - the liquidity premium and endogenous balance sheet policy - and thus results in model indeterminacy.

The result that active balance sheet policy suffices for supporting model determinacy is novel to the literature. So far, the literature has argued that only interest rate policy satisfying a generalized Taylor principle renders model determinacy, meaning that permanently fixing the policy rate is not possible. Here, we have shown that this is not the case with the balance sheet available as a policy tool. Figure 4 and Figure 5 compare the model responses to natural rate and financial shocks, respectively, across monetary policy strategies. These figures plot the "FF+NK" responses from Figure 1 and Figure 2, along with: (i) inflation-targeting interest rate policy with no balance sheet policy, $\pi_t = qe_t = 0$; (ii) liquidity premium-targeting balance sheet policy with an interest rate peg, $r_t = \xi_t = 0$; and (iii) the optimal dual-instrument policy, $\pi_t = \xi_t = 0$; using the same shock specifications from Section 3.

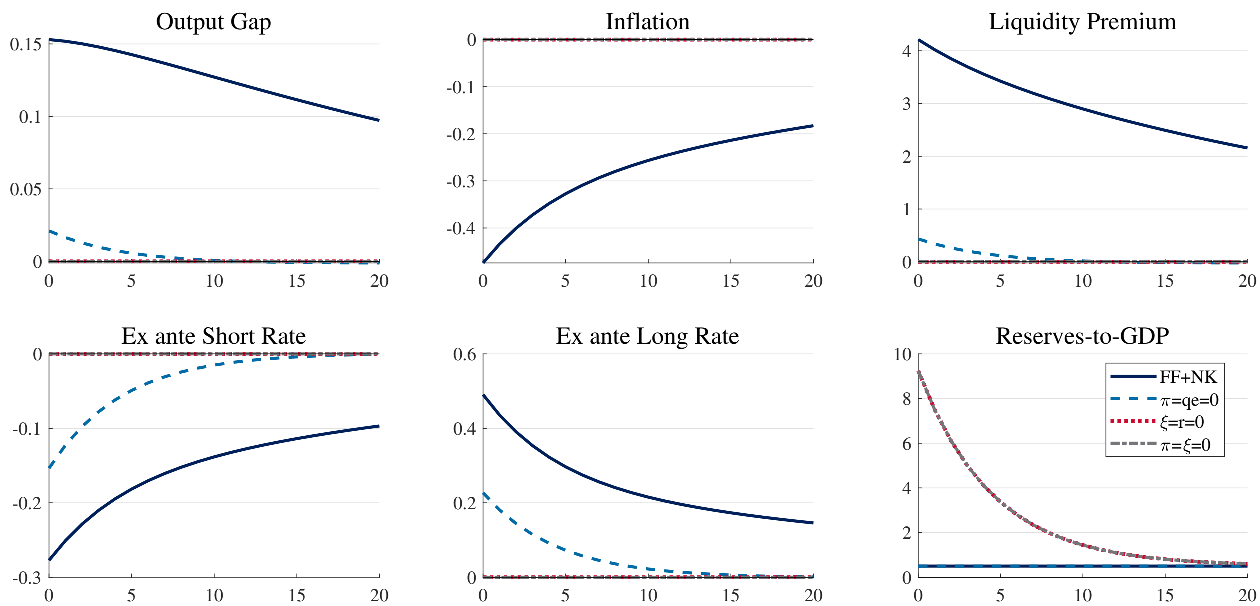
Inflation-targeting interest rate policy results in inefficient output gap and liquidity premium variability in response to financial shocks—the divine coincidence fails. Liquidity premium-targeting balance sheet policy results in inefficient output gap and inflation variability in response to natural rate shocks. Inflation and output gap volatility is quite high under this policy likely leads to sizable welfare costs. We quantify the welfare costs of these policy strategies, and others, in Section 5.

Figure 4: Impulse Responses to a Natural Rate Shock: Varying Policy Instruments/Strategies



Notes: Solid lines: the complete model described by equations (3.14)-(3.20) with nominal price rigidity (FF+NK), $\gamma = 0.204$, flexible inflation-targeting interest rate policy $r_t = 1.5\pi_t$, and passive balance sheet policy, $qe_t = 0$; dashed lines: strict inflation-targeting interest rate policy, $\pi_t = 0$, with passive balance sheet policy, $qe_t = 0$; dotted lines: liquidity premium-targeting balance sheet policy, $\xi_t = 0$, with a fixed policy rate, $r_t = 0$; dashed-dotted lines: optimal dual-instrument policy with strict inflation and liquidity premium targeting, $\pi_t = \xi_t = 0$. The natural rate shock is scaled such that the output gap response in the FF+NK model is 0.25%. All variables are in terms of percentage deviations from steady state outside of the inflation and interest rates which are deviations from steady state in annualized percentage units.

Figure 5: Impulse Responses to a Financial Shock: Varying Policy Instruments/Strategies



Notes: Solid lines: the complete model described by equations (3.14)-(3.20) with nominal price rigidity (FF+NK), $\gamma = 0.204$, flexible inflation-targeting interest rate policy $r_t = 1.5\pi_t$, and passive balance sheet policy, $qe_t = 0$; dashed lines: strict inflation-targeting interest rate policy, $\pi_t = 0$, with passive balance sheet policy, $qe_t = 0$; dotted lines: liquidity premium-targeting balance sheet policy, $\xi_t = 0$, with a fixed policy rate, $r_t = 0$; dashed-dotted lines: optimal dual-instrument policy with strict inflation and liquidity premium targeting, $\pi_t = \xi_t = 0$. The size of the financial shock is set such that the shock explains 20% of the variability in the output gap in the FF+NK model. All variables are in terms of percentage deviations from steady state outside of the inflation and interest rates which are deviations from steady state in annualized percentage units.

5 Policy Evaluation

In this section, we first quantify the welfare losses to various single-instrument monetary policy strategies related to our theoretical results. We report the relative losses under these strategies to optimal dual-instrument policy which targets inflation and the liquidity premium using a combination of interest rate and balance sheet policy—the divine coincidence policy from Section 4. The single-instrument strategies we consider include inflation-targeting with either the policy rate or balance sheet, and liquidity-premium-targeting with the balance sheet. We then turn to implementable policy strategies to address the fact that the liquidity premium in our model is unobservable.

To compute welfare losses across various strategies, we consider a second-order approximation of the non-linear model defined in Section 3. A second-order approximation of the model allows us to compute the stochastic steady-state welfare level in the economy, W_m^s, or the steady-state welfare level accounting for the risk of future shocks, for a given monetary policy strategy, m. The deterministic steady-state welfare level, W, is constant across monetary policy strategies. The deterministic steady-state welfare level is a function of the steady-state levels of consumption, C_p, debt-financed expenditure, C_b, aggregate labor, N, and the labor income allocation to the financial account, Ω,

$$W = W^d \left(C_p, C_b, N, \Omega\right).$$ [17]

We define the expenditure- and labor-equivalent welfare losses for a given monetary policy strategy, λ_m^e and λ_m^n, respectively, similar to the consumption-equivalent welfare measures in Mau (2023),

$$W_m^s = W^d \left(\left(1-\lambda_m^e\right) C_p, \left(1-\lambda_m^e\right) C_b, N, \Omega\right) = W^d \left(C_p, C_b, \left(1+\lambda_m^n\right) N, \Omega\right). \tag{5.1}$$

These welfare loss measures quantify either how much each deterministic steady-state expenditure level must fall or aggregate labor must rise such that the deterministic

17. Section 2 defines the household welfare function which decomposes into

$$W_t = \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left\{\ln C_{p,t+j} - \psi \frac{\left((1-\Omega_{t+j})N_{t+j}\right)^{1+\eta}}{1+\eta}\right\} + \mathbb{E}_t \sum_{j=0}^{\infty} (\beta\zeta)^j \left\{\Gamma \ln C_{b,t+j} - \psi \frac{\left(\Omega_{t+j} N_{t+j}\right)^{1+\eta}}{1+\eta}\right\}$$

and allows us to define the deterministic steady-state welfare level,

$$W = \frac{1}{1-\beta}\left[\ln C_p - \psi \frac{\left((1-\Omega)N\right)^{1+\eta}}{1+\eta}\right] + \frac{1}{1-\beta\zeta}\left[\Gamma \ln C_b - \psi \frac{(\Omega N)^{1+\eta}}{1+\eta}\right] = W^d \left(C_p, C_b, N, \Omega\right).$$

steady-state welfare level equals the stochastic steady-state level. Comparing equivalent welfare loss measures across various monetary policy strategies, for example, $m \in \{1,2\}$, quantifies the relative performance of each specification,

$$\lambda_1^e - \lambda_2^e \quad \text{or} \quad \lambda_1^n - \lambda_2^n.$$

Given these definitions, $\lambda_1^e - \lambda_2^e > 0 \iff \lambda_1^n - \lambda_2^n > 0$, providing a consistent welfare performance ordering independent of the equivalent welfare loss measure considered.

Table 2 presents the quantitative welfare results under the calibration from Table 1. The welfare costs to any particular sub-optimal monetary policy strategy are small in this calibrated, simple model designed for the theoretical analysis of balance sheet policy.[18] That being said, these quantitative results are useful for characterizing how a policy-maker could rank the monetary policy strategies we have outlined in this paper. Under the parameterization from Section 3, the financial shock accounts for 20% of output gap variability in the baseline model, FF+NK. That is, the financial shock has a modest effect on output under the baseline calibration. Even so, welfare costs to inflation-targeting interest rate policy with no balance sheet policy arise due to the presence of the financial shock and the binding limited enforcement constraint. Failing to stabilize the liquidity premium generates inefficient shifts in the IS and Phillips curves in response to both natural rate and financial shocks. Note, there are no welfare costs to inflation- and liquidity premium-targeting dual-instrument policy as this results in dynamics consistent with the friction-less RBC model—the efficient outcome.

These results provide a few takeaways for policymakers when it comes to the trade-offs of various monetary policy strategies. First, if faced with constraints either due to legislation or a preference for single-instrument monetary policy, choose the policy rate over the balance sheet. This is consistent with the conventional view of monetary policy implementation over the post-Volcker period. Second, in the event that the policy rate is unavailable, such as due to the ELB, stabilizing inflation results in smaller welfare losses than targeting financial market conditions as summarized by the liquidity premium, counter to the policy prescription of optimal dual-instrument policy to stabilize the liquidity premium with the balance sheet. Again though, stabilizing financial market conditions—the liquidity premium—using balance sheet policy and inflation using the policy rate minimizes welfare losses as this restores the divine coincidence.

Most of the welfare losses associated with single-instrument, inflation-targeting in-

18. For analysis of the welfare costs to various monetary policy strategies in a quantitative model where costs are larger, see Mau (2023).

Table 2: Welfare Results

Policy, m	Equivalent Loss λ_m^e	λ_m^n
$\pi_t = \xi_t = 0$	0	0
$\pi_t = re_t = 0$	0.101	0.115
$\pi_t = r_t = 0$	0.208	0.237
$\xi_t = r_t = 0$	0.513	0.585

Notes: Expenditure- and labor-equivalent welfare costs as defined by equation (5.1) across various monetary policy strategies under the model calibration from Table 1 in basis points. $\pi_t = \xi_t = 0$ corresponds to inflation- ($\pi_t = 0$) and liquidity premium-targeting ($\xi_t = 0$) dual-instrument monetary policy (r_t and re_t time-varying). $\pi_t = re_t = 0$ corresponds to single-instrument ($re_t = 0$) inflation-targeting ($\pi_t = 0$) interest rate policy (r_t time-varying). $\pi_t = r_t = 0$ corresponds to single-instrument ($r_t = 0$) inflation-targeting ($\pi_t = 0$) balance sheet policy (re_t time-varying). $\xi_t = r_t = 0$ corresponds to single-instrument ($r_t = 0$) liquidity premium-targeting ($\xi_t = 0$) balance sheet policy (re_t time-varying).

terest rate policy are due to the presence of the financial shock in the economy, even if it is small. As the financial shock's importance in the economy rises, these costs rise. Table 3 quantifies this result, varying the importance of the financial shock in driving output gap variability. With active balance sheet policy, the financial shock requires no interest rate response. Thus, the welfare cost to balance sheet policies with a fixed interest rate does not vary with the relative importance of the financial shock in the economy, conditional on the size of the natural rate shock.

5.A Implementable Policy Strategies

In Section 4, we derived the optimal dual-instrument monetary policy. This policy strategy requires that balance sheet policy stabilizes the liquidity premium which, in turn, allows interest rate policy to target inflation as in the textbook NK model. However, the liquidity premium is unobservable, as are the financial and natural rate shocks that balance sheet policy must respond to achieve liquidity premium stabilization.

Next, we examine the welfare performance of implementable dual-instrument policy strategies that respond to observable variables alone. We use a simple implementable rule for interest rate policy where the policy rate responds to output growth and inflation, similar to Schmitt-Grohe and Uribe (2007). For balance sheet policy, we propose a possible solution for an observable proxy to targeting the liquidity premium—the slope of the yield curve, derived in Appendix F.

Table 3: Welfare Results—Varying Output Gap Variability due to Financial Shock

	10%		20%		30%	
	Equivalent loss					
Policy, m	λ_m^e	λ_m^n	λ_m^e	λ_m^n	λ_m^e	λ_m^n
$\pi_t = \xi_t = 0$	0	0	0	0	0	0
$\pi_t = re_t = 0$	0.058	0.066	0.101	0.115	0.157	0.179

Notes: Expenditure- and labor-equivalent welfare costs as defined by equation (5.1) across various monetary policy strategies under the model calibration from Table 1 in basis points. We vary the contribution of the financial shock to the variability of the output gap, explaining 10%, 20%, and 30% of the variability of the output gap. $\pi_t = \xi_t = 0$ corresponds to inflation- ($\pi_t = 0$) and liquidity premium-targeting ($\xi_t = 0$) dual-instrument monetary policy (r_t and re_t time-varying). $\pi_t = re_t = 0$ corresponds to single-instrument ($re_t = 0$) inflation-targeting ($\pi_t = 0$) interest rate policy (r_t time-varying).

We assume that interest rate policy follows a conventional Taylor rule,

$$r_t = \rho_r r_{t-1} + (1 - \rho_r)\left(\phi_\pi \pi_t + \phi_g (y_t - y_{t-1})\right), \tag{5.2}$$

where ρ_r governs the monetary authority's desire to smooth interest rates, ϕ_π is the weight on inflation, and ϕ_g is the weight on output growth.[19] We examine different conventional interest rate rules by varying the weights on the target variables.

Rather than specifying an arbitrary balance sheet rule analogous to the interest rate rule, we assume that the monetary authority optimally utilizes its balance sheet policy to explicitly target the slope of the yield curve, which serves as an observable indicator that relates directly to the liquidity premium.[20] Implementing this type of policy is similar to the use of open market operations to implement conventional interest rate policy. A monetary authority can buy and sell long-term treasuries to target the yield curve slope, similar to targeting any other policy rate.

The yield curve slope is the difference between the long- and short-term yields to maturity in the economy—the rate of return on either asset when held to maturity. Rearranging this slope allows it to be rewritten in terms of a term premium and the

19. We set ρ_r to 0.8 and allow for different weights on inflation and output growth as shown in Table 4. Output growth sensitivity equal to the inflation sensitivity provides a benchmark to responding to output growth at all, the resulting comparison being flexible inflation- versus NGDP-targeting interest rate policy.

20. The goal of this section is to characterize the effects of implementable policy strategies comparable to our theoretical results discussed in Section 4 rather than characterize rules-based balance sheet policy which is outside the scope of this paper.

expected path of future nominal short rate policy,[21]

$$\text{(5.3)}\qquad \frac{slope_t}{1-\kappa\beta} = \underbrace{\xi_t - \mathbb{E}_t \sum_{j=0}^{\infty} \left[1-(\kappa\beta)^j\right]\left(r^L_{t+1+j} - r_{t+j}\right)}_{\text{term premium}} + \underbrace{\mathbb{E}_t \sum_{j=0}^{\infty} (\kappa\beta)^j\, r_{t+j} - \frac{r_t}{1-\kappa\beta}}_{\text{future policy rate expectations}}.$$

Table 4 shows the quantitative welfare results for the considered implementable policy strategies, analogous to the single- and dual-instrument strategies in Table 2. Relative to the optimal dual-instrument policy, $\pi_t = \xi_t = 0$, targeting only observable variables, $\pi_t = sl_t = 0$, leads to welfare costs. These welfare costs correspond directly to the costs of targeting an observable versus an unobservable variable and are relatively small, but more than the welfare costs of single-instrument, inflation-targeting interest rate policy.

TABLE 4: WELFARE RESULTS—IMPLEMENTABLE POLICY STRATEGIES

Policy, m	Equivalent loss λ^e_m	λ^n_m
$\pi_t = \xi_t = 0$	0	0
$\pi_t = sl_t = 0$	0.128	0.145
$\phi_\pi = 2$	3.562	4.060
$\phi_\pi = \phi_g = 2$	3.353	3.822
$\phi_\pi = 2, sl_t = 0$	0.135	0.154
$\phi_\pi = \phi_g = 2, sl_t = 0$	0.744	0.849

Notes: Expenditure- and labor-equivalent welfare costs as defined by equation (5.1) across varying monetary policy specifications under the model calibration from Table 1 in basis points. $\pi_t = \xi_t = 0$ corresponds to inflation- and liquidity-premium-targeting dual-instrument policy. $\pi_t = sl_t = 0$ corresponds to inflation- and yield-curve-slope-targeting dual-instrument monetary policy. $\phi_\pi = 2$ corresponds to a single-instrument interest rate policy responding to inflation only (re_t fixed). $\phi_\pi = \phi_g = 2$ corresponds to a single-instrument interest rate policy responding to inflation and output growth (re_t fixed). $\phi_\pi = 2, sl_t = 0$ corresponds to interest rate policy responding to inflation and balance sheet policy to yield curve-targeting ($sl_t = 0$) (r_t and re_t time-varying). $\phi_\pi = \phi_g = 2, sl_t = 0$ corresponds to interest rate policy responding to inflation and output growth and yield-curve-slope-targeting balance sheet policy.

Welfare costs to targeting the yield curve slope rather than the liquidity premium with inflation-targeting interest rate policy arise because the output gap is proportional to the liquidity premium in this case, consider (3.14) with $\pi_t = 0$, and the liquidity premium is not entirely stabilized, consider (5.3) with $slope_t = 0$. Because this policy strategy generates small welfare costs relative to strict inflation-targeting interest rate policy

21. See Appendix F for definitions of the yields-to-maturity, yield curve slope, and related asset pricing equations along with a derivation of (5.3).

with a fixed balance sheet, it means that when thinking about operational/political costs to more complex policy that actively uses the balance sheet at all times, there is likely limited argument to do so if balance sheet policy must target the yield curve slope. Figure A.6 and Figure A.7 in the online appendix provide model responses to natural rate and financial shocks, respectively, across implementable monetary policy prescriptions.

Conventional single-instrument interest rate policy that responds to inflation with inertia results in much larger welfare losses relative to other policy strategies we have considered to this point.[22] Combining this policy with balance sheet policy that targets the yield curve slope reduces the welfare costs to a level comparable to strict inflation-targeting policy ($\pi_t = 0$) with no balance sheet policy, but the welfare cost is still higher than single-instrument, inflation-targeting interest rate policy. Responding to output growth reduces the welfare cost to following rules-based interest rate policy slightly as it counteracts some of the variability in the economy due to the financial shock, but with the balance sheet available to target the yield curve slope it is not beneficial to respond to output growth.

6 Conclusion

This paper studies interest rate and balance sheet policy in a tractable NK model with incomplete financial markets. A household that simultaneously saves and borrows attempts to equate its marginal utility from consumption and debt-financed expenditure. Because a binding limited enforcement constraint in the financial sector generates incomplete financial markets, a time-varying wedge referred to as the liquidity premium arises between these two marginal utilities. The liquidity premium acts as an endogenous cost channel in the Phillips curve and an endogenous credit wedge in the IS curve, and varies with non-financial variables, acting as a propagation mechanism for non-financial shocks in the economy. We show that the model setup considered alters the labor supply response to monetary policy.

Inflation-targeting interest rate policy fails to generate the efficient labor supply response counter to the textbook NK model. The divine coincidence fails due to a financial accelerator mechanism present in the model. Inflation-targeting interest rate policy does not simultaneously stabilize the financial accelerator. Introducing balance sheet policy

22. The size of the inflation coefficient in the interest-rate rule has a direct impact on welfare—the stronger the response to inflation, the lower the welfare costs (in contrast to Schmitt-Grohe and Uribe (2007) finding no differences). Additionally, policy rate inertia yields modest welfare gains in our model.

that stabilizes the liquidity premium neutralizes the financial accelerator effect. That is, dual-instrument policy restores the divine coincidence. Balance sheet policy can provide a determinate equilibrium with a fixed policy rate. Welfare calculations show that simply prioritizing inflation variability via interest rate policy absent balance sheet policy in the model considered leads to welfare costs. However, these costs are small when compared to constraining a monetary authority to balance sheet policy alone.

Our results hinge on the binding limited enforcement constraint in the financial sector, a point addressed by Karadi and Nakov (2021). If this constraint is occasionally binding, then economic states arise for which balance sheet policy is useless (both at and away from the ELB). This criticism applies to any paper that relies on financial sector constraints to generate incomplete financial markets and a role for balance sheet policy such as Gertler and Kiyotaki (2010), Gertler and Karadi (2011, 2013), Carlstrom et al. (2017), Sims and Wu (2021), Boehl et al. (2024), or Mau (2023). However, alternative financial sector setups generate incomplete financial markets and a role for balance sheet policy absent any type of financial sector constraint. For instance, Cúrdia and Woodford (2011, 2016) do so by introducing resource costs to lending and incomplete intermediary information on loan types. This financial sector setup would not affect the structural changes to the IS and Phillips curves due to incomplete financial markets as presented in the current paper. That is, our main result—balance sheet policy should respond to all types of shocks in the economy—is robust to the financial sector model considered.

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