Monetary and Financial Tax Interventions in Liquidity Traps*

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Abstract

We characterize the joint optimal conduct of unconventional monetary and financial tax policies in a New Keynesian model wherein endogenous supply-side financial frictions generate inflationary credit spreads. Cost-push borrowing costs and private asset taxes substantially alter the transmission of optimal monetary policy under both discretion and commitment. State-contingent asset tax regimes remove the zero lower bound restriction on the nominal policy rate, thus minimizing output and price fluctuations following both supply-driven and demand-driven liquidity traps. Discretionary and commitment policies with financial taxation deliver virtually equivalent welfare gains, and invalidate calls for time-inconsistent forward guidance strategies.

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1 Introduction

The zero lower bound (ZLB) on nominal interest rates has severely impeded the effectiveness of monetary policy during the liquidity trap episodes that have lingered since the Great Recession. With the most recent unprecedented economic response to the Covid-19 crisis, we are once again reminded of the limitations of merely using conventional monetary policy. Such challenges to traditional interest rate strategies have called for the implementation of supplementary (un)conventional fiscal and monetary policies aimed at minimizing the social costs of output gap and price fluctuations. Most of the literature has so far focused on optimal monetary commitment-forward guidance schedules (Eggertsson and Woodford (2003), Adam and Billi (2006), and Nakov (2008)), increased government spending (Eggertsson (2011), Christiano, Eichenbaum, and Rebelo (2011), and Schmidt (2013)), and flexible adjustments in consumption and/or labor taxes (Eggertsson and Woodford (2006), Correia, Farhi, Nicolini, and Teles (2013), and D’Acunto, Hoang, and Weber (2018)). Less attention has been given to the normative implications of corrective financial tax-based policies and their interactions with monetary policy in state-contingent liquidity traps. Our paper fills this gap by developing a simple theoretical New Keynesian model that examines the stabilization roles of state-dependent monetary and fiscal interventions - the latter taking the form of private asset (deposit) taxes - in response to both demand-driven and supply-driven liquidity traps.¹

We characterize the optimal monetary and asset tax stabilization policy mix under both discretion and commitment in a stylized textbook New Keynesian model à la Galí (2015). The core framework is modified for: i) an inflationary credit spread arising from an endogenous supply-side collateral constraint and firm default risk; ii) financial deposit taxes; and iii) occasionally-binding lower bound restrictions on the effective nominal interest rates faced by the economic agents. Our paper sheds new positive and normative insights to the ongoing debate around the role of unconventional policies, as well as to the benefits of fiscal and monetary policy coordination against two different sources of business cycle fluctuations: demand and financial-supply shocks. As recently highlighted by Ghassibe and Zanetti (2020) and Jo and Zubairy (2022), the source of economic fluctuations determines policy efficacy. We contribute to this growing literature by focusing on optimal policies against liquidity traps driven by different fundamentals.²

This paper argues that financial taxes should be activated in a state-dependent fashion based on the underlying structural shock driving the economy to a liquidity trap. Access to deposit taxation substantially alters the transmission of discretionary (time-consistent) and commitment (Ramsey)

¹Financial taxes, (private) asset taxes, savings taxes, and deposit taxes are used interchangeably throughout the text.
²Our model nevertheless abstracts from more conventional Keynesian fiscal policies that are spending-based and that may have an adverse impact on existing and longer-term debt levels.
monetary policies, and significantly alleviates the severity of liquidity trap episodes that are also influenced by the degree of the cost-push financial frictions. Through both demand- and supply-side channels affecting output and the credit spread, we find that introducing otherwise distortionary taxes produces non-trivial stabilization and welfare benefits relative to an optimal monetary policy plan alone.

Importantly, a deposit subsidy allows to overcome the inflation-output trade-off arising from stagflationary shocks by enabling the policymaker to set nominal interest rates deep in negative territory. Agarwal and Kimball (2019) and Lilley and Rogoff (2020) also claim that readily available stabilization tools could enable deep negative interest rates whenever needed. We show that altering deposit taxes could indeed rationalize such unconventional monetary policy in the short-run, thus ending a stagflationary recession quickly or even preventing it when the policy toolkit is optimally deployed. In the steady state, we present a modified Friedman (1969) rule through which a policy mix combining financial subsidies and negative nominal interest rates removes long-run inefficiencies induced by the supply-side credit friction. This unique policy plan is feasible and does not violate the ZLB on effective borrowing and tax-augmented savings rates.

In line with Ravenna and Walsh (2006), firms must borrow in advance to finance working-capital, thereby giving rise to an inflationary credit cost channel effect. Compared to their paper, firms here face collateral constraints and ex-ante idiosyncratic risk, resulting in a loan rate set as an endogenous finance premium over the nominal policy (deposit) rate. Moreover, the credit friction produces a structural financial shock that becomes akin to a cost-push shock in the standard New Keynesian model, but with a markedly different interpretation related to default and the credit spread. This modeling approach is largely motivated by Christiano, Eichenbaum, and Trabandt (2015), who show that the working-capital cost channel is important in explaining business cycle fluctuations, as well as the ‘missing deflation puzzle’ observed during the Great Recession. The missing deflation phenomenon and elevated credit spreads were also features of the Covid-19 economic meltdown in the U.S.\(^3\)

Although we share the view of Farhi and Werning (2016) and Korinek and Simsek (2016) regarding the importance of financial asset taxes in alleviating credit market inefficiencies and liquidity traps, the source of distortion in our framework is of a supply-side nature rather than merely an aggregate demand externality. Particularly, in the absence of shocks, higher aggregate demand raises demand for external working-capital finance used to support production. With

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\(^3\)Moody’s Seasoned BAA Corporate Bond minus Federal Funds Rate increased sharply by around 2 percentage points on the onset of the Covid-19 crisis in March 2020. Moreover, Gilchrist, Schoenle, Sim, and Zakrajšek (2017) have shown that firms with limited internal liquidity and high leverage significantly increased prices in response to the 2008 financial market crash that corresponded with a steep output contraction and extremely high credit spreads. See also Abbate, Eickmeier, and Prieto (2021) who find that financial shocks act as supply-type disturbances.
output pinning down the level of collateral, higher leverage - as measured by the total cost of debt to GDP - results in greater risk and inflated borrowing costs. This financial supply-side friction leads to a distorted long-run allocation, and to inefficient exacerbated economic dynamics, both of which justify corrective fiscal interventions in the form of asset taxation. Our main contribution relative to the aforementioned papers is to illuminate the asset tax policy transmission at play across different states of the economy.

To highlight the role of state-contingent taxes, we first analyze a model without taxes. During a persistent demand-driven deflationary trap, the credit spread limits the relative spell at the ZLB induced by optimal forward guidance policies compared to discretion. Here, optimal monetary commitment exhibits a Neo-Fisherian property in which raising borrowing costs lifts medium-run inflation, thereby allowing for a relatively earlier termination of the ZLB. This comes in contrast to the benchmark New Keynesian model where commitment requires a “lower-for-longer” interest rate regime. Welfare gains from monetary policy commitment over discretion in a deflationary spiral are therefore considerably larger with respect to the benefits calculated in a standard model without financial frictions.

Nevertheless, compared to the restricted regime involving only optimal monetary policy, unconstrained optimal time-consistent and Ramsey policies with flexible dynamic tax systems produce identical welfare gains in response to inflationary financial shocks and near-equivalent gains following deflationary demand shocks. Put differently, time-inconsistent commitment policies involving optimal forward guidance are of secondary importance so long as the policymaker can optimally change the tax on loanable funds - deposits.

Our state-contingent policy prescriptions and intuition can be further explained as follows. In the face of cost-push financial shocks that directly raise borrowing costs and inflation through the credit cost channel, unrestricted optimal policy necessitates an equal reduction in both the financial tax and the nominal risk-free policy rate. In this way, the effective tax-augmented nominal deposit rate faced by households is completely stabilized at its long-run positive level. The lower bound constraint on the effective nominal deposit rate is therefore entirely removed with the first-best allocation attained at all times. This bliss outcome holds regardless of whether the economy is in a liquidity trap or not, and does not require any policy commitments. Interestingly, despite the inflationary nature of the financial shock, restricted optimal monetary policy under commitment triggers the ZLB due to the large inefficient and persistent slump in output. Under unrestricted optimal policy with deposit subsidies, the policymaker can freely set a negative nominal interest rate.

\footnote{In a cost channel model but without the endogenous financial friction and credit shock attached, Chattopadhyay and Ghosh (2020) also advocate for Neo-Fisherian policies to escape a deflationary trap. See also Garin, Lester, and Sims (2018).}
rate without breaching the effective ZLB constraint stemming from the household's indifference between saving deposits and cash-financed consumption. The expansionary policy mix limits cost-push inflationary pressures as well demand-pull inflation that would transpire in the absence of tax policies. Negative nominal interest rates and implicit fiscal-financial subsidies echo some of the non-standard policy measures undertaken by policy makers in advanced economies during the Covid-19 crisis, and from a conceptual standpoint represent an optimal policy plan against a supply-driven liquidity trap.

When the economy enters a liquidity trap triggered by large adverse demand shocks, optimal policy warrants a hike in the financial tax rate and a relatively more modest increase in the nominal policy rate. Such counterfactual policy combination lowers the effective nominal and real deposit rates, which, in turn, limit the shrinkage in GDP through intertemporal substitution. At the same time, the monetary contraction lifts borrowing costs, and generates a sufficient cost-push inflationary force that fosters price stability. These qualitative results hold under both discretion and commitment, and represent a Neo-Fisherian approach to escape a deflationary trap. Finally, both time-consistent and Ramsey regimes with tax interventions yield a near-analogous welfare gain relative to the constrained optimal monetary policy plan, despite marginal differences in the implied optimal dynamics that emerge due to policy promises under commitment. The attempts by the European Central Bank (ECB) between 2014 and 2020 to lower deposit rates by paying negative rates on bank reserves are conceptually consistent with the implications of a higher and inflationary tax on deposits that our economy advocates for when the liquidity trap is demand-driven.

Despite abstracting from more complex unconventional financial and monetary policy instruments used in the world of policy making, the generic specification of the asset tax in our theoretical model preserves the transmission channels of credit market interventions and enhances analytical tractability (see also Farhi and Werning (2016) and Bianchi and Mendoza (2018)). Arguably, a deposit tax may not be the first tool to spring to mind of policymakers, but its relative simplicity, effectiveness, and resemblance to other more complicated policies, could and should bring about extra consideration to this unique stimulative policy measure. While our contribution to the New Keynesian optimal policy literature is mainly theoretical, we believe the above results are also important from a more practical viewpoint given the yet-to-be fully revealed inflationary and/or deflationary nature of the liquidity trap that resulted from the pandemic recession.

Our generalized framework with financial frictions, asset taxes, and the ZLB benefits from nest-

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5 The macroeconomic effects of more general and implicit macroprudential financial taxes are also examined in Gertler, Kiyotaki, and Queralto (2012) and De Paoli and Paustian (2017). In also related work yet in a model with housing, Rubio and Yao (2020) analyze interactions between monetary and macroprudential policies at the ZLB. These authors perform optimal simple rules-based analysis as opposed to the discretion versus commitment analysis performed here.
ing the prototypical New Keynesian model developed in Galí (2015), as well as the frictionless cost channel setup of Ravenna and Walsh (2006). This stylized small-scale framework enables the derivation of analytical optimal target rules using the linear-quadratic approach. Cúrdia and Woodford (2016) and Benigno, Eggertsson, and Romei (2020) also develop simple New Keynesian models with credit frictions to examine the optimal conduct of monetary policy, but posit a reduced-form intermediation technology to justify the existence of default and spreads. In our setup, borrowing costs are endogenous with monetary policy having direct supply-side effects. Similar to our approach, Demirel (2009) and De Fiore and Tristani (2013) derive a micro-founded risk premium, yet focus solely on optimal monetary policy away from the ZLB. Here, optimal monetary and asset tax policies are examined against the backdrop of state-contingent liquidity traps.

Optimal tax policies when interest rates are at the zero bound have been studied in the New Keynesian models of Eggertsson and Woodford (2006) and Correia, Farhi, Nicolini, and Teles (2013). The former illustrate how consumption taxation can be used to partially offset the adverse effects of the policy rate reaching the ZLB, while the latter show that adjusting labor and consumption taxes can circumvent the zero bound and always attain the efficient outcome. We also emphasize the need for tax flexibility to neutralize shocks, although our motivation is different. First, we focus on the cyclical properties of financial taxation as opposed to more standard labor and consumption taxes. Second, we highlight the role of supply-side financial frictions, which prove to be imperative to the state-dependant optimal policy plans. Our work also complements Correia, De Fiore, Teles, and Tristani (2021) who show within a classic monetary economy framework that credit subsidies to firms can prevent the economy from entering a liquidity trap. Unlike their paper, we develop a simple two-equation New Keynesian model with an explicit analysis of optimal discretionary versus commitment policies.

Finally, relative to Fernández-Villaverde (2010), Eggertsson (2011), and Ghassibe and Zanetti (2020) who examine the multiplier effects of various fiscal policies, we explore the normative properties of optimal financial taxation. To the best of our knowledge, the welfare and business cycle implications of novel financial tax policies, and their interactions with monetary policy in response to both demand and supply shocks, have not been fully addressed in the context of a tractable workhorse New Keynesian model augmented for credit frictions.

The remainder of the paper proceeds as follows. Section 2 describes the model. Section 3 characterizes the long- and short-run equilibrium properties. Section 4 explains the parameterization of the model and the solution strategy. Section 5 derives the state-contingent optimal policy target rules and studies their dynamics and welfare implications. Section 6 concludes.
2 The Model

Consider a discrete-time infinite-horizon economy populated by a representative household, a representative final good (FG) firm, a continuum of intermediate goods (IG) producers, a competitive commercial bank, and a benevolent public authority that is responsible for monetary, fiscal, and financial policies.\footnote{This model features no distinction between the central bank and the government who operate under full coordination with the same objective function. These entities therefore fall under the category of the “public authority” or “policymaker”.
}

2.1 Households

The objective of the representative household is to maximize the following expected lifetime utility:

\[
U_t = \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t Z_t \left[ \ln (C_t) - \frac{N_t^{1+\phi}}{1 + \phi} \right], \tag{1}
\]

where $C_t$ is aggregate consumption, and $N_t$ are the total units of labor supplied to the various IG firms. Moreover, $\beta \in (0, 1)$ is the discount factor and $\phi$ is the inverse of the Frisch elasticity of labor supply. The preference (demand) shock follows an AR(1) process:

\[
Z_t = (Z_{t-1})^{\rho_Z} \exp \left( s.d(\alpha_Z) \cdot \alpha_Z \right), \tag{2}
\]

where $\rho_Z \in (0, 1)$ is the degree of persistence, and $\alpha_Z$ is a random shock distributed as standard normal with a constant standard deviation $s.d(\alpha_Z)$.

The household enters period $t$ with real money balances ($M_t$). They receive wage income $W_t N_t$ paid as cash at the beginning of period $t$, where $W_t$ denotes the real wage. This cash is then used to supply real deposits $D_t$ to the banking sector. The remaining cash balances become available to purchase the aggregate consumption good subject to the following cash-in-advance constraint:

\[
C_t \leq M_t + W_t N_t - D_t. \tag{3}
\]

Constraint (3) represents the implicit cost of holding intraperiod deposits that yield interest but that cannot be used for transaction services. At the end of the period, the household earns the after-tax gross return on deposits, $(1 - \tau_t^D) R_t^D D_t$, where $R_t^D$ is the gross nominal deposit rate, and $\tau_t^D$ is the tax rate on deposits. Importantly, $\tau_t^D$ serves as a state-contingent financial policy instrument that can be used to stabilize the economy following various shocks resulting potentially...
in liquidity trap episodes. Note that we could either have $\tau^P_t > 0$, corresponding to a tax, or $\tau^P_t \leq 0$ representing a savings subsidy. Similar to Farhi and Werning (2016), $\tau^P_t$ is simply an unconventional fiscal-financial intervention. Finally, the household receives a lump-sum transfer from the public authority ($T_t$), as well as total profits from the production and banking sectors ($J_t^{P,B} \equiv J_t^P + J_t^B$). Thus, cash carried over to period $t+1$ is:

$$M_{t+1} \frac{P_{t+1}}{P_t} = M_t + W_t N_t - D_t - C_t + (1 - \tau^D_t) R^P_t D_t + J_t^{P,B} + T_t.$$  \hspace{1cm} (4)

Taking real wages ($W_t$), prices ($P_t$), and financial taxes ($\tau^P_t$) as given, the first-order conditions of the household’s problem with respect to $C_t$, $D_t$, $M_{t+1}$, and $N_t$ can be summarized as:\footnote{Money is the only asset through which the household can smooth consumption across periods. Without constraint (3), the tax-augmented interest rate would always satisfy $\frac{1 - \tau^D_t}{\pi_{t+1}} R^P_t \geq 1$. The cash-in-advance restriction motivates and gives rise to occasionally-binding ZLB periods as further elaborated below.}

$$C_t^{-1} = \frac{\beta \mathbb{E}_t}{Z_t} \frac{Z_{t+1}}{Z_t} C_t \frac{1 - \tau^D_t}{\pi_{t+1}} R^P_t,$$  \hspace{1cm} (5)

$$N_t C_t = W_t,$$  \hspace{1cm} (6)

where $\pi_{t+1} \equiv P_{t+1}/P_t$ is defined as the gross inflation rate. Equation (5) is the Euler equation augmented for the financial tax. The effective real interest rate is thus $\frac{(1 - \tau^P_t) R^P_t / \mathbb{E}_t \pi_{t+1}}{\pi_{t+1}}$, implying that fiscal interventions directly distort the household’s intertemporal consumption-savings pattern. Furthermore, with deposits used to facilitate working-capital loans supplied by the financial intermediary, a tax on deposit returns can also be treated as a tax / subsidy on bank liquidity. Equation (6) determines the optimal labor supply.

The optimality conditions and flow of funds constraints are written under the lower bound equilibrium restriction on the effective nominal deposit rate in which $\frac{1 - \tau^D_t}{\pi_{t+1}} R^P_t \geq 1$. Without unconventional fiscal policies nor a cash-in-advance constraint, the non-negativity bound is attached only to the nominal risk-free interest rate (as in Eggertsson and Woodford (2003, 2006) and Eggertsson (2011)). However, the actual observed savings rate that enters the household’s Euler equation accounts for any potential changes in the financial tax, and serves as the opportunity cost to money holdings. Cash, in turn, carries a zero nominal interest rate and is used to purchase consumption goods subject to (3). Therefore, the effective lower bound that satisfies the household’s no-arbitrage condition between cash-financed consumption and deposits must apply to $\frac{1 - \tau^D_t}{\pi_{t+1}} R^P_t \geq 1$. 

Without constraint (3), the tax-augmented interest rate would always satisfy $\frac{1 - \tau^P_t}{\pi_{t+1}} R^P_t = 1$. The cash-in-advance restriction motivates and gives rise to occasionally-binding ZLB periods as further elaborated below.
2.2 Production

A FG firm produces aggregate output $Y_t$ by assembling differentiated output of IG firms $Y_{j,t}$, indexed by $j \in (0, 1)$, using a Dixit-Stiglitz (1977) technology: $Y_t = \left( \int_0^1 Y_{j,t}^{(1-\epsilon)\epsilon} \, dj \right)^{1/(1-\epsilon)}$, with $\epsilon > 1$ denoting the constant elasticity of substitution between intermediate goods. The relative demand for intermediate good $j$ is then given by $Y_{j,t} = (P_{j,t}/P_t)^{-\epsilon} Y_t$, where $P_t = \left( \int_0^1 P_{j,t}^{1-\epsilon} \, dj \right)^{1/(1-\epsilon)}$ is the aggregate price index such that $P_t Y_t = \int_0^1 P_{j,t} Y_{j,t} \, dj$.

There is a continuum of measure one of monopolistically competitive IG firms who produce a differentiated good $Y_{j,t}$ using the following linear production function:

$$Y_{j,t} = \varepsilon_{j,t} N_{j,t},$$

where $N_{j,t}$ is the employment demand by firm $j$, and $\varepsilon_{j,t}$ represents an idiosyncratic shock that occurs as period $t$ comes to a close. This shock is distributed uniformly over the interval $(\bar{\varepsilon}, \bar{\varepsilon})$ with a constant variance and a mean of unity. Each firm has to borrow in advance in order to finance the household’s wage bill in the subsequent period. Specifically, working-capital loans decided at the very end of period $t-1$ are held in zero-interest bearing cash accounts, and are then used to pay the wage bill at the start of period $t$. Loans are paid back with interest towards the end of date $t$, with the gross lending rate determined by $R_t^L$. Let $L_{j,t}$ be the amount borrowed by firm $j$, then the borrowing constraint is:

$$W_t N_{j,t} \leq L_{j,t}. \tag{8}$$

The pricing decision takes place at the start of period $t$ and consists of two stages. In the first stage, each borrowing producer minimizes the cost of employing labor, taking its effective costs as given. Defining profits in the first stage as $Y_{j,t} - W_t N_{j,t} - (R_t^L - 1) L_{j,t}$, then the first order conditions, accounting for the expectations with respect to the idiosyncratic shock, yield the real marginal cost:

$$mc_t = \frac{R_t^L W_t}{\mathbb{E}_t \varepsilon_{j,t}}. \tag{9}$$

For $R_t^L \geq 1$, the borrowing constraint (8) is always binding. This non-negativity restriction on the equilibrium lending rate represents a no-arbitrage condition ensuring that firms cannot make large profits by keeping their working-capital loans in the form of zero-interest cash accounts. Thus,

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$^8$ We use the uniform distribution in order to generate a plausible data-consistent steady state credit spread, and to obtain simple closed-form solutions to the model without loss of generality.

$^9$ Note that $\mathbb{E}_t \varepsilon_{j,t}$ is identical across all firms during the pricing decision stage that takes place at the beginning of period $t$, just after the realization of aggregate shocks and before the idiosyncratic shocks that occur at the very end of the period. Hence, under symmetry, subscript $j$ can be dropped from the marginal cost and consequently from the optimal price level derived below.
$R_l^t \geq 1$ is the lower bound constraint on borrowing costs. In the specific case of $R_l^t = 1$, firms are indifferent between keeping their loans in cash accounts and paying back these loans at the prevailing lending rate. Under this marginal case, firms choose the latter.

In the second stage, each producer chooses the optimal price for its good subject to $Y_{j,t} = (P_{j,t}/P_t)^{-\epsilon} Y_t = N_{j,t}E_t \varepsilon_{j,t}$ and taking (9) as given. IG firms face Rotemberg (1982)-type quadratic adjustment costs in changing prices $\Theta \left( \frac{P_{t-1}}{P_{j,t-1}} - 1 \right)^2 Y_t$, where $\Theta > 0$ measures the magnitude of price stickiness. Standard profit maximization under symmetry yields the non-linear New Keynesian Phillips Curve (NKPC):

$$1 - \Theta (\pi_t - 1) \pi_t + \beta \mathbb{E}_t \Theta (\pi_{t+1} - 1) \pi_{t+1} \frac{Y_{t+1}}{Y_t} = \epsilon (1 - mc_t), \quad (10)$$

with $\beta$ representing the shared discount factor of the household and firms, and $mc_t$ given by (9).

In the special case where $\Theta = 0$, the price mark-up is $M \equiv \frac{\epsilon}{(\pi_t - 1)} = mc_t^{-1}$.

A fraction $\chi_t$ of the firm’s expected output ($Y_{j,t}$) must be pledged as collateral in order to secure loans. Moreover, the borrowing firm has the option to ‘run away’ and default on its debt. In the good states of nature, each firm pays back the bank principal plus interest on credit. Default occurs if the firm’s value after non-payment is non-strictly greater than its value following loan repayment,

$$(1 - \chi_t) Y_{j,t} \geq Y_{j,t} - R_l^t L_{j,t}, \quad (11)$$

with $(1 - \chi_t) Y_{j,t}$ denoting the expected value of the firm after defaulting, and $\chi_t Y_{j,t}$ representing the share of collateralized output the bank is able to retain in case of default. Further, $\chi_t$ follows the $AR(1)$ shock process:

$$\chi_t = (\chi)^{1-\rho_\chi} (\chi_{t-1})^{\rho_\chi} \exp (s.d. (\alpha^\chi) \cdot \alpha_t^\chi), \quad (12)$$

where $\chi \in (0, 1)$ is the long-run enforcement parameter, $\rho_\chi \in (0, 1)$ is the degree of persistence, and $\alpha_t^\chi$ is a white-noise process with constant standard deviation $s.d. (\alpha^\chi)$. The enforcement shock $\chi_t$ represents a structural financial supply-side shock, as it directly impacts borrowing costs and consequently the marginal cost and inflation, as shown below.

Using (7), (8), and re-arranging (11) results in the threshold value ($\varepsilon_{j,t}^M$) below which the firm defaults:

$$\varepsilon_{j,t}^M = \varepsilon_t^M = \frac{R_l^t W_t}{\chi_t}. \quad (13)$$

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10 Steady state values are denoted without the time subscript.
11 Jermann and Quadrini (2012) and Tayler and Zilberman (2016) also motivate a similar type of financial shock.
The cut-off point is related to aggregate credit shocks, borrowing costs, and real wages, and is identical across all firms.\textsuperscript{12} As $W_t$ is approximated by the loan-to-output ratio (with $Y_{j,t} = N_{j,t}$ for $E_t \varepsilon_{j,t} = 1$, and output serving as collateral), then higher leverage ($R^L_t L_{j,t} / Y_{j,t}$) driven by increased demand for working-capital loans raises the firms’ marginal costs and translates into elevated financial risk. Later we show that this supply-side friction leads to an inefficient long-run output level, and can destabilize the economy in the short-run. Thus, corrective fiscal policies are warranted to alleviate these inefficiencies. Given the uniform properties of $\varepsilon_t$, the default probability is:

$$\Phi_t = \int_{\Xi}^\Xi f(\varepsilon_t) d\varepsilon_t = \frac{\varepsilon^M_t - \Xi}{\Xi - \Xi}.$$  \hspace{1cm} (14)

### 2.3 Financial Intermediation

A perfectly-competitive bank raises deposits from the household in order to finance the working-capital costs of IG firms. The bank’s balance sheet satisfies:

$$L_t = D_t,$$  \hspace{1cm} (15)

where $L_t = \int_0^1 L_{j,t} dj = W_t N_t$ is the total lending to the production industry, and $N_t = \int_0^1 N_{j,t} dj$.

The loan rate is set at the very beginning of period $t$, just after the realization of aggregate shocks, but before firms engage in production and pricing decisions. The bank breaks-even from its intermediation activity, such that the expected income from lending to a continuum of firms is equal to the total costs of borrowing these funds. The bank’s expected intraperiod zero-profit condition from lending is:

$$\int_{\varepsilon^M_{j,t}}^\Xi R^L_t L_{j,t} f(\varepsilon_{j,t}) d\varepsilon_{j,t} + \int_{\Xi}^{\varepsilon^M_{j,t}} \chi_t Y_{j,t} f(\varepsilon_{j,t}) d\varepsilon_{j,t} = R^D_t D_t,$$  \hspace{1cm} (16)

where $f(\varepsilon_{j,t})$ is the probability density function of $\varepsilon_{j,t}$. The first element on the left hand side is the expected repayment to the bank in the non-default states, while the second element is the expected return in the default states, measured in terms of collateralized output ($\chi_t Y_{j,t}$). The term $R^D_t D_t$ is the gross interest payment on deposit liabilities. To derive $R^L_t$, we use the balance sheet equation (15), the binding constraint (11) for $\chi_t \varepsilon_{j,t}^M N_{j,t} = R^L_t L_{j,t}$, the production function (7), divide by $L_{j,t}$, and apply the characteristics of the uniform distribution. After some algebra, the loan rate

\textsuperscript{12} As we solve explicitly for default risk using a threshold condition, the collateral constraint (11) is always binding.
equation reads: \(^{13}\)

\[ R_t^L = \nu_t R_t^D, \]  

(17)

with \( \nu_t = \left[ 1 - \left( \frac{\varepsilon_t \delta}{2 \varepsilon_t \delta} \right) \Phi_t^2 \right]^{-1} > 1 \) defined as the risk premium, \( \varepsilon_t^M \) given by (13), and \( \Phi_t \) determined by (14). The loan rate is set as a finance premium over the risk-free policy rate due to the possibility of default.

### 2.4 Public Authority

The public authority targets the short-term risk-free policy rate \( R_t^D \) and the financial tax rate \( \tau_t^P \) that respect the ZLB constraint on the effective nominal deposit rate:

\[ (1 - \tau_t^P) R_t^D \geq 1. \]  

(18)

Furthermore, to maintain the firms’ no-arbitrage condition between cash holdings and loan repayments, policy must be set such that borrowing costs cannot fall below zero:

\[ R_t^L = \nu_t R_t^D \geq 1. \]  

(19)

Finally, the public authority’s budget constraint satisfies:

\[ M_{t+1} \frac{P_{t+1}}{P_t} - M_t + \tau_t^P R_t^P D_t = T_t. \]  

(20)

### 2.5 Market Clearing

Market clearing requires \( Y_t = N_t \int_0^1 \varepsilon_{j,t} dj \), where \( N_t = N_{j,t} \) and \( P_t = P_{j,t} \) in a symmetric equilibrium. Using (4), (7), (20), and the distribution properties of the idiosyncratic shocks, which satisfy \( \int_0^1 \varepsilon_{j,t} dj = 1 \) and have a mean of unity, we obtain the following aggregate resource constraint:

\[ Y_t = N_t = C_t + \frac{\Theta}{2} \left( \frac{P_t}{P_{t-1}} - 1 \right)^2 Y_t. \]  

(21)

Using (9) and (17), the marginal cost is:

\[ mc_t = R_t^L W_t = \nu_t R_t^D W_t. \]  

(22)

\(^{13}\)The cut-off value \( \varepsilon_{j,t}^M \) is identical across all producers (see (13)). Similarly, real wages and labor employed by each firm are identical such that the volume of demand-determined loans is also the same. Thus, the subscript \( j \) is dropped.
Moreover, for $R^L_t \geq 1$ the borrowing constraint (8) is binding and identical across all firms:

$$L_t = W_t N_t = D_t.$$  \hspace{1cm} (23)

3 Equilibrium

We log-linearize the behavioral equations and the resource constraint around the non-stochastic, zero inflation ($\pi = 1$) steady state. Using the log-linear versions of (6), (10), (21), and (22) yields:

$$\widetilde{\pi}_t = \beta E_t \widetilde{\pi}_{t+1} + \lambda \left[ (1 + \varphi) \dot{Y}_t + \dot{R}^L_t \right],$$  \hspace{1cm} (24)

with $\lambda \equiv (\epsilon - 1) / \Theta$.

The aggregate lending level is obtained from the log-linear versions of (6), (21), and (23):

$$\dot{L}_t = (2 + \varphi) \dot{Y}_t.$$  \hspace{1cm} (25)

To derive the loan rate, we first log-linearize equations (6), (13), (14), and (21) to obtain the log-linearized default risk:

$$\dot{\Phi}_t = \left( \frac{\epsilon^M}{\epsilon^M - \epsilon} \right) \left[ \dot{R}^L_t + (1 + \varphi) \dot{Y}_t - \dot{\chi}_t \right].$$  \hspace{1cm} (26)

By log-linearizing (17) and using (26), the credit spread is:

$$\dot{R}^L_t - \dot{R}^D_t = \left( \frac{\Psi}{1 - \Psi} \right) \left[ \dot{R}^D_t + (1 + \varphi) \dot{Y}_t - \dot{\chi}_t \right].$$  \hspace{1cm} (27)

with $\Psi \equiv \frac{(\epsilon^M + \epsilon)(\epsilon^M - \epsilon)}{[2 \epsilon (\epsilon - 2) - (\epsilon^M - \epsilon)^2]} \in (0, 1)$ measuring the degree of financial market imperfections. The term $\epsilon^M = mc / \chi$ is the steady state threshold value below which the IG firm defaults (see (9) and (13)), where $mc = (\epsilon - 1) / \epsilon \equiv M^{-1}$. Steady state default risk is thus $\Phi = \frac{M^{-1} \chi^{-1} - \epsilon}{\epsilon - \epsilon^M}$ while the long-run credit spread is $R^L / R^D = \nu$, with $\nu \equiv [1 - (\frac{\epsilon^M + \epsilon}{2 \epsilon}) \dot{\Phi}^2]^{-1} > 1$ and

$$R^D = \frac{1}{(1 - \tau^D) \beta}.$$  \hspace{1cm} (28)

Equations (26) and (27) show that the credit spread increases with aggregate demand, the policy rate, and in response to an adverse financial shock. Intuitively, a rise in the demand for goods, all else equal, raises the firms demand for external working-capital finance used to support production.
With production pinning down the level of collateral, higher leverage elevates the firms marginal costs, the probability of default, and thus the credit spread. Furthermore, a rise in $\hat{R}^D_t$ pushes up $\hat{R}^L_t$ through the standard monetary policy cost channel. In the absence of the financial friction, $\Psi = 0$, the loan rate tracks only the risk-free policy rate, $\hat{R}^L_t = \hat{R}^D_t$, as in the basic cost channel framework of Ravenna and Walsh (2006). Also, an exogenous decline in the collateral recovery rate, $\check{\chi}_t < 0$, translates directly to a hike in default risk, leading to a higher spread. Finally, observe from (25), (26), and (27), that the credit spread and risk are positively related to variations in the loan-to-GDP ratio as $(1 + \varphi) \hat{Y}_t = \check{L}_t - \check{Y}_t$. Contributing to Cúrdia and Woodford (2016) and Benigno, Eggertsson, and Romei (2020), this positive relationship is micro-founded, and does not hamper the analytical tractability of the model.

Long-run output is calculated from the steady state versions of equations (6), (10), (21), (22), and (28):

$$Y^{1+\varphi} = \frac{1}{\nu R^D \mathcal{M}^{-1}} = \frac{\beta (1 - \tau^D)}{\nu} \mathcal{M}^{-1},$$ (29)

where $Y^{1+\varphi}$ is the long-run marginal rate of substitution between consumption and hours worked. The unconstrained first-best allocation, absent of financial frictions and the price mark-up, corresponds to $Y^{1+\varphi} = 1$. This efficiency condition can be supported through the implementation of the following long-run corrective hypothetical financial subsidy:

$$\tau^D, I = 1 - \frac{\mathcal{M} \nu}{\beta} < 0,$$ (30)

where superscript $I$ denotes unconstrained first-best policy. Under standard parameterization with $\beta < 1 < \mathcal{M} \nu$ and $\mathcal{M}, \nu > 1$, a deposit subsidy can completely offset both the credit friction stemming from ex-ante default, and the price mark-up resulting from monopolistic competition in the deterministic steady state. The negative relationship between $Y$ and the loan rate ($\nu R^D = \nu / (1 - \tau^D) \beta$) arising from the risk-adjusted cost channel enables the policymaker to eliminate steady state distortions using a deposit subsidy.

However, this theoretical unconstrained first-best policy is not feasible as it must be accompanied by a negative loan rate. Specifically, substituting (30) in (28) and using the steady state equation for $R^L$ yields $R^L = \nu R^D = \mathcal{M}^{-1} < 1$ for $\nu > 1$. Such outcome violates the firms no-arbitrage condition between loan repayments and storing loans in zero-interest bearing cash accounts. As optimal policy in the deterministic steady state pushes the loan rate to non-viable negative territory, the constrained-efficient long-run policy that respects the non-negativity constraint on borrowing costs is obtained by setting $\nu R^D = 1$. Combining (28) with $\nu R^D = 1$ results
in:

\[ \tau^{D,II} = 1 - \frac{\nu}{\beta} < 0, \]  

(31)

with superscript \( II \) standing for the constrained-efficient long-run policy and \( |\tau^{D,I}| > |\tau^{D,II}| \). In contrast to the unconstrained first-best policy, the more modest and restricted financial subsidy is feasible, and serves as a natural policy instrument that can remove the long-run inefficiency induced by the supply-side credit friction, \( \nu = f(\Phi(\chi)) \). A higher value of \( \nu \) (or a lower \( \chi \)) calls for a larger subsidy which helps to alleviate the credit friction by lowering the cost of loanable funds. Importantly, the implementation of the constrained-efficient tax policy enables the public authority to set a negative policy rate, \( R^D = \nu^{-1} < 1 \), which together with \( \tau^{D,II} < 0 \), satisfy also the household’s no-arbitrage condition between deposits and cash-financed consumption, i.e., \( (1 - \tau^{D,II}) R^D = \beta^{-1} \). In this way, there exists a single combined policy plan of the financial tax and the nominal policy rate set to their effective lower bounds. This policy prescription represents a modified Friedman (1969) rule. Without seeking a rate of deflation, zero effective savings and loan rates can be accomplished through the enactment of financial subsidies. Corrective fiscal interventions thus provide a justification for adopting a prolonged negative nominal deposit rate; a policy measure that echoed some of the post-Great Recession practices undertaken by several central banks in advanced economies.\(^{14}\)

To capture the ZLB constraint on the effective savings rate in the short-run, we log-linearize (18) to obtain:

\[ \hat{R}_t^D - \hat{\tau}_t^D \geq \ln(\beta) , \]  

(32)

with \( \hat{\tau}_t^D = -\ln \left( \frac{1 - \tau_t^D}{1 - \tau_t^D} \right) \). Log-linearizing (19) and the expression for the risk premium (\( \nu_t \)) yields the lower bound constraint on the lending rate represented in terms of deviations from steady state:

\[ \hat{R}_t^L = \frac{1}{1 - \Psi} \left( \hat{R}_t^D + \Psi \left( (\sigma + \varphi) \hat{Y}_t - \hat{\chi}_t \right) \right) \geq \ln \left( (1 - \tau_t^D) \beta \nu_t^{-1} \right) . \]  

(33)

Notice that in steady state where each variable satisfies \( \hat{\chi}_t = 0 \), the tax level that brings the loan rate to its ZLB is set to \((1 - \tau_t^D) \beta \nu_t^{-1} - 1 = 0 \) or \( \tau^{D,II} = 1 - \nu \beta^{-1} \), as suggested by the constrained-efficient policy (31). Consequently, a steady state deposit subsidy brings the economy closer to its constrained-efficient long-run equilibrium.

To simplify the subsequent short-run optimal policy analysis, we examine the normative policy implications following large shocks that cause \( \hat{R}_t^D \) and potentially \( \hat{R}_t^D - \hat{\tau}_t^D \) to hit their lower bounds,\(^{14}\)

\(^{14}\) Abo-Zaid and Garín (2016) also find a role for implementing optimal negative nominal interest rates in a model with financial frictions and money demand. Here, the optimal long-run negative interest rate policy is rationalized by the presence of the asset tax and the supply-side credit distortion.
but not significant enough to drive $\hat{R}_L$ to its floor. The analysis below is therefore conducted with one occasionally-binding constraint. Indeed, in the aftermath of the Great Recession, both deposit and lending rates have hovered at historically low levels. Despite the downward pressures placed on borrowing costs, especially in response to adverse demand-driven disturbances, the data does not suggest loan rates being set to their effective lower bounds. Lending rates have remained consistently elevated relative to the policy rate and the various risk-free market savings rates, even during the Covid-19 economic crisis.\footnote{The theoretical prospect of $\hat{R}_L$ hitting its lower bound acts as mere amplification mechanism following only negative demand shocks that produce a procyclical relationship between credit spreads and GDP (see also De Fiore and Tristani (2013), Eggertsson, Juelsrud, Summers, and Wold (2022), and our analysis below). Conversely, an adverse financial shock inherent in a lending rate spike can be completely contained with an appropriate combination of state-contingent monetary and fiscal-financial policies. Put differently, optimal policy results in $\hat{R}_L$ being stabilized at its long-run positive level. Therefore, little economic insight is gained from the introduction of a short-run non-negativity constraint on the loan rate.}

Substituting (27) in (24), and log-linearizing (5) together with the market clearing conditions, the model can now be expressed in terms of the following equations:

\begin{equation}
\hat{\pi}_t = \beta \mathbb{E}_t \hat{\pi}_{t+1} + \frac{\lambda}{(1 - \Psi)} \left[ \hat{R}_L^D + (1 + \varphi) \hat{Y}_t - \Psi \hat{\chi}_t \right], \quad (34)
\end{equation}

\begin{equation}
\hat{Y}_t = \mathbb{E}_t \hat{Y}_{t+1} - \sigma^{-1} \left( \hat{R}_L^D - \hat{\pi}_t - \mathbb{E}_t \hat{\pi}_{t+1} - \hat{\pi}_t^{R_o} \right), \quad (35)
\end{equation}

with $\hat{\pi}_t^{R_o} \equiv \hat{Z}_t - \mathbb{E}_t \hat{Z}_{t+1}$ defined as the natural rate of interest that is a function only of the preference shock. Equation (34) is the extended NKPC establishing the short-run aggregate supply (AS) relation between inflation and output, augmented for the degree of credit frictions, $\Psi = f (\varepsilon^M (\chi))$, and the financial shock, $\hat{\chi}_t$. The financial shock, which has a structural interpretation in our model as explained above, manifests itself in a direct cost-push disturbance without altering the efficient level of output.\footnote{Without TFP shocks, the efficient level of output is set to unity, implying that cyclical output is equal to the output gap.} The cost-push component of the financial friction and the credit shock quantify and reflect the nature of the risk-adjusted credit cost channel, in which higher risk and credit spreads push up marginal costs and inflation.\footnote{Without the financial friction ($\Psi = 0$), the cost-push financial shock disappears from the model. Indeed, the financial market imperfection and consequently the risk-adjusted cost channel give rise to the inflationary shock in this framework. In a different yet related model, De Fiore and Tristani (2013) introduce a financial shock to the banks’ monitoring efficiency and show that such a shock also produces immediate supply-side effects without directly impacting aggregate demand. The structural financial shock in our model (and theirs) is therefore akin to a cost-push shock in the standard New Keynesian model.} These inflationary pressures arise independently from the direct monetary policy cost channel linking $\hat{R}_L^D$ to $\hat{\pi}_t$. While the direct effect of an increase in $\hat{R}_L^D$ is to raise $\hat{\pi}_t$, the overall impact, that takes into account the standard demand channel of monetary policy, is calculated by $\frac{\partial \hat{\pi}_t}{\partial \hat{R}_L^D} = \frac{\lambda}{(1 - \Psi)} - \frac{\lambda}{(1 - \Psi)} \frac{\varphi}{\sigma} \text{ or } \frac{\partial \hat{\pi}_t}{\partial \hat{R}_L^D} = -\frac{\lambda}{(1 - \Psi)} \frac{\varphi}{\sigma} < 0$. Conditional
on inflation expectations, a rise in $\hat{R}^D_t$ lowers inflation, with a higher $\Psi$ amplifying the decline in $\hat{\pi}_t$ following the monetary contraction.

Equation (35) is the Euler equation that determines the aggregate demand ($AD$) schedule, augmented for the preference shock and the financial tax. A lower deposit tax increases desired savings such that in equilibrium output falls more than in the absence of tax changes. Nevertheless, in response to inflationary shocks, a savings subsidy can act to stabilize inflation and consequently be welfare improving. The optimal state-contingent policy plans against financial and demand shocks are investigated below and are the key contributions of this paper.

A novel aspect of our model is that output and debt (proxies for the marginal costs) largely determine the finance premium and the ensuing credit spread (see equations (26) and (27)). The risk premium effect operates via the wider credit cost channel, and provides additional means through which monetary and tax policies can alter the economic activity. Finally, our model nests the frictionless cost channel framework of Ravenna and Walsh (2006) by setting $\Psi = 0$ and $\hat{\pi}^D_t = 0$, $\forall t$, as well as the Galí (2015) textbook New Keynesian setup by ignoring the term $\lambda (1 - \Psi)^{-1} \hat{R}^D_t$ in equation (34) and setting again $\Psi = 0$ and $\hat{\pi}^D_t = 0$, $\forall t$.

The competitive approximate equilibrium is defined as a collection of real allocations $\{\hat{Y}_t\}_{t=0}^{\infty}$, prices $\{\hat{\pi}_t\}_{t=0}^{\infty}$, interest rates $\{\hat{R}^D_t\}_{t=0}^{\infty}$, and financial tax policies $\{\hat{\tau}^D_t\}_{t=0}^{\infty}$ such that for a given sequence of exogenous AR(1) shock processes $\{\hat{Z}_t, \hat{\chi}_t\}_{t=0}^{\infty}$, conditions (32), (33), (34), and (35) are satisfied.

## 4 Parameterization and Solution Strategy

Although many of our results are shown analytically, in order to illuminate the implications of the state-contingent optimal policies for economic dynamics and welfare, the model is also solved numerically. We employ parameters largely used in the New Keynesian literature and which match some moments in the U.S. data.

The discount factor is set to $\beta = 0.9975$, while the steady state financial tax is $\tau^D = 0$ given its use as a short-run stimulative policy. The implied long-run risk-free interest rate for this parameterization is 1%. Furthermore, we set the range of the idiosyncratic shock to $(0.8, 1.2)$, and the fraction of output received in case of default to $\chi = 0.97$. These values, together with a price mark-up of 20% ($\epsilon = 6$), $\varsigma = 0.5$, and $\Theta = 180$, yield an annual credit spread of $\nu = 2.04\%$ and a NKPC slope of $\frac{\lambda}{(1 - \Psi)} (1 + \varphi) = 0.0486$. Such estimates roughly correspond with the long-run U.S. data that has exhibited a weakened relationship between inflation and output in the NKPC over
recent decades and particularly following the Great Recession.\footnote{Our qualitative results are robust to alternative parameterizations.}

We use standard Bayesian techniques to estimate the persistence and standard deviations of the structural shock processes. Our optimal policy analysis is examined with respect to the financial and preference demand shocks, but to obtain more reliable shock moments, we introduce an additional shock through a monetary policy rule that takes the form:

\[
\hat{R}_t^D = \max \left[ \rho_R \hat{R}_{t-1}^D + (1 - \rho_R) \left( \phi_{\pi} \hat{\pi}_t + \phi_y \hat{Y}_t \right) + \hat{\eta}_t, \ ln (\beta) \right],
\]

where \(\rho_R\) is a smoothing parameter, \(\phi_{\pi} > 1\), and \(\phi_y \geq 0\). The interest rate shock \(\hat{\eta}_t\) follows an \(AR(1)\) process with persistence \(\rho_{\eta}\) and a standard deviation \(s.d(\eta)\). We fix \(\rho_R = 0.75\), \(\phi_{\pi} = 2.1\), and \(\phi_y = 0.5\), and use the same priors as in Jermann and Quadrini (2012) to calculate the shock moments. Particularly, we compute the posterior means of the six parameters \(\rho_{\chi}, s.d(\chi); \rho_{Z}, s.d(\alpha^Z); \) and \(\rho_{\eta}, s.d(\eta)\), to approximately match the standard deviations in inflation, output growth, and the credit spread over the period 1985 : Q1 – 2021 : Q2. This estimation yields \(\rho_{\chi} = 0.9279, s.d(\alpha^x) = 0.0233; \rho_{Z} = 0.9235, s.d(\alpha^Z) = 0.0117; \) and \(\rho_{\eta} = 0.9492, s.d(\eta) = 0.0016\). Despite the stylized and deliberately small-scale nature of our model, these shock moments are within range of the estimated values obtained in Jermann and Quadrini (2012), Christiano, Motto, and Rostagno (2014), and Becard and Gauthier (2022).\footnote{Naturally, there may be other shocks that are key to understanding the behavior of inflation, output, and credit spreads in the data. We also acknowledge that the financial shock may be picking up variation from different kinds of disturbances with cost-push effects. Thus, the exercise should not be viewed as a full-fledged quantitative analysis but rather a suggestive quantitative illustration of the model’s predictions. The Bayesian estimation employed in this simple model with three shocks is still useful and enables a more meaningful welfare analysis compared to a model that takes shock moments as given.}

To quantitatively solve and estimate the model with an occasionally-binding ZLB constraint, we have implemented the piecewise-linear OccBin methodology developed in Guerrieri and Iacoviello (2015). The simulated results presented below are confirmed with Holden’s (2016) DynareOBC algorithm.

5 Optimal Monetary and Tax Interventions at the ZLB

The presence of nominal rigidities, the supply-side credit distortions, and the various shocks generate inefficient economic dynamics. Moreover, as shown above, in the deterministic steady state fiscal-financial interventions cannot fully correct for the long-run price mark-up friction despite being able to offset the credit market imperfection. As our main focus is on financial taxation and its interaction with monetary policy in the short-run, we introduce a labor subsidy that eliminates all average distortions as in Ravenna and Walsh (2006). Therefore, we take a second-order approx-
imation of the household’s ex-ante utility function around the efficient deterministic steady state. The appropriate welfare measure is given by:\(^20\)

\[
W_t = \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left( \frac{U_t - U}{UC} \right) \approx -\frac{1}{2} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left( \Theta \hat{\pi}_t^2 + (1 + \varphi) \hat{Y}_t^2 \right). 
\]

(36)

Period losses scaled by the price adjustment cost parameter read:

\[
\Theta^{-1} \mathcal{L}_t = \frac{1}{2} \left( \hat{\pi}_t^2 + \vartheta \hat{Y}_t^2 \right), 
\]

(37)

where \(\vartheta \equiv (1 + \varphi) \Theta^{-1}\) is the relative weight on output variations. Relative welfare gains (losses) are expressed in terms of the equivalent permanent increase (reduction) in private consumption in percent of its deterministic steady state level.

We now turn to characterize optimal monetary and financial tax policies subject to the unique lower bound constraints of our model. Optimal policy is solved using the linear-quadratic approach.

5.1 Targeting Rules under Discretion and Commitment without Taxes

Before discussing the implications of fiscal-monetary policy interactions in liquidity traps, we first present the optimal monetary policy solution under discretion and commitment. In this subsection, \(\hat{R}_t^D\) acts as the sole stabilization tool available to the policymaker with \(\hat{\pi}_t^D = 0\).

Under discretion, the policymaker chooses \(\hat{\pi}_t, \hat{Y}_t,\) and \(\hat{R}_t^D\) to maximize its objective function (36) subject to the constraints (32)-(35), taking \(\hat{\pi}_t^n, \hat{\pi}_t,\) and \(\left\{ \hat{\pi}_{t+i}, \hat{Y}_{t+i}, \hat{R}_{t+i}^D \right\}_{i=1}^{\infty}\) as given. The Lagrangian for this problem takes the form:

\[
\mathcal{L}_t = -\frac{1}{2} \left( \hat{\pi}_t^2 + \vartheta \hat{Y}_t^2 \right) - \hat{\zeta}_{1,t} \left[ \hat{\pi}_t - \beta \mathbb{E}_t \hat{\pi}_{t+1} - \frac{\lambda}{(1 - \Psi)} \left[ \hat{R}_t^D + (1 + \varphi) \hat{Y}_t - \Psi \hat{\pi}_t \right] \right] \\
- \hat{\zeta}_{2,t} \left[ \hat{Y}_t - \mathbb{E}_t \hat{Y}_{t+1} + \hat{R}_t^D - \mathbb{E}_t \hat{\pi}_{t+1} - \hat{\pi}_t^n \right] - \hat{\zeta}_{3,t} \left[ -\hat{R}_t^D + \ln (\beta) \right],
\]

where \(\hat{\zeta}_{1,t}, \hat{\zeta}_{2,t},\) and \(\hat{\zeta}_{3,t}\) are the Lagrange multipliers on constraints (34), (35), and (32), respectively. The corresponding optimality conditions with respect to \(\hat{\pi}_t, \hat{Y}_t,\) and \(\hat{R}_t^D\) are:

\[
-\hat{\pi}_t = \hat{\zeta}_{1,t},
\]

(38)

\(^20\)The derivation of the welfare function with Rotemberg (1982) pricing strictly follows Nisticò (2007). For ease of notation, we suppress third-order terms and higher, as well as terms independent of policy. The full derivation is available upon request.
\[-\phi \hat{Y}_t + \left( \frac{\kappa}{(1 - \Psi)} \right) \hat{\zeta}_{1,t} = \hat{\zeta}_{2,t}, \quad (39)\]
\[\frac{\lambda}{(1 - \Psi)} \hat{\zeta}_{1,t} - \hat{\zeta}_{2,t} + \hat{\zeta}_{3,t} = 0, \quad (40)\]
and the slackness condition:
\[\hat{\zeta}_{3,t} \left( -\hat{R}_t^D + \ln (\beta) \right) = 0, \quad (41)\]
where \(\kappa \equiv (1 + \varphi) \lambda\).

Consider the case where the deposit rate is at its lower bound \((\hat{\zeta}_{3,t} > 0)\). The optimal discretionary targeting rule in this scenario is:
\[\partial \hat{Y}_t = -\left( \frac{(\kappa - \lambda)}{(1 - \Psi)} \right) \hat{\pi}_t - \hat{\zeta}_{3,t}, \quad (42)\]
or:
\[\left( \frac{(\kappa - \lambda)}{(1 - \Psi)} \hat{\pi}_t + \partial \hat{Y}_t \right) \left( \hat{R}_t^D - \ln (\beta) \right) = 0; \quad \hat{R}_t^D \geq \ln (\beta). \quad (43)\]
Thus, for a given variation in inflation, a tighter constraint on \(\hat{R}_t^D = \ln (\beta)\), as measured by \(\hat{\zeta}_{3,t} > 0\), leads to a more substantial fall in output following a deflationary demand shock. Once at the ZLB the policy rate is pegged and follows \(\hat{R}_t^D = 0\). Equilibrium paths for inflation and output during the ZLB episode are obtained by substituting \(\hat{R}_t^D = 0\) in (34) and (35):
\[\hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \frac{\lambda}{(1 - \Psi)} \left[ (1 + \varphi) \hat{Y}_t - \Psi \hat{X}_t \right], \quad (44)\]
\[\hat{Y}_t = E_t \hat{Y}_{t+1} + E_t \hat{\pi}_{t+1} + \hat{r}_n^o. \quad (45)\]
The discretionary rational expectations equilibrium at the ZLB is then determined by equations (42), (43), (44), and (45), taking expectations and the AR(1) shocks as given.

Substituting (44) and (45) in (42) reveals that \(\hat{\zeta}_{3,t}\) is a negative function of \(\hat{r}_n^o\), and a positive function of \(\hat{\chi}_t\). A sizeable negative demand shock that pushes \(\hat{Y}_t\) and \(\hat{\pi}_t\) in the same direction lowers the natural rate of interest and increases the risk of entering a liquidity trap, hence tightening the ZLB constraint. In contrast, a positive financial shock that lowers inflation acts to lift the real interest rate and further depress aggregate demand. Our model gives rise to a variant of the paradox of toil (as popularized by Eggertsson (2010)), wherein otherwise expansionary supply shocks can paradoxically lead to lower welfare by amplifying deflationary pressures and keeping the nominal policy rate at its effective lower bound. In our setup, this paradox stems from the existence of the risk-adjusted credit cost channel.

Under commitment, the benevolent public authority chooses state-contingent paths for infla-
tion, output, the nominal policy rate, and the financial tax to maximize its objective function (36) subject to constraints (32), (34), and (35). The associated Lagrangian is:

$$L_t = \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left\{ -\frac{1}{2} \left( \pi_t^2 + \vartheta \hat{Y}_t^2 \right) - \hat{\zeta}_{1,t} \left[ \hat{\pi}_t - \beta \mathbb{E}_t \hat{\pi}_{t+1} - \frac{\lambda}{(1 - \Psi)} \left[ \hat{R}_t^D + (1 + \varphi) \hat{Y}_t - \Psi \hat{\chi}_t \right] \right] - \hat{\zeta}_{2,t} \left[ \hat{Y}_t - \mathbb{E}_t \hat{Y}_{t+1} + \hat{R}_t^D - \mathbb{E}_t \hat{\pi}_{t+1} - \hat{\pi}_t^2 \right] - \hat{\zeta}_{3,t} \left[ -\hat{R}_t^D + \ln \left( \beta \right) \right] \right\}. $$

The resulting first-order conditions read:

$$-\hat{\zeta}_{1,t} - \hat{\zeta}_{1,t-1} + \frac{1}{\beta} \hat{\zeta}_{2,t-1} = 0, \quad (46)$$

$$-\vartheta \hat{Y}_t + \frac{\kappa}{(1 - \Psi)} \hat{\zeta}_{1,t} - \hat{\zeta}_{2,t} + \frac{1}{\beta} \hat{\zeta}_{2,t-1} = 0, \quad (47)$$

$$\frac{\lambda}{(1 - \Psi)} \hat{\zeta}_{1,t} - \hat{\zeta}_{2,t} + \hat{\zeta}_{3,t} = 0. \quad (48)$$

The complementary slackness constraint is:

$$\hat{\zeta}_{3,t} \left( -\hat{R}_t^D + \ln \left( \beta \right) \right) = 0; \quad \hat{\zeta}_{3,t} \geq 0, \quad (49)$$

where the initial conditions satisfy $\hat{\zeta}_{1,-1} = \hat{\zeta}_{2,-1} = \hat{\zeta}_{3,-1} = 0$. The optimal state-contingent evolution of the endogenous variables \{\hat{\pi}_t, \hat{Y}_t, \hat{R}_t^D\} is characterized by the above first-order conditions together with constraints (34) and (35), as well as (49). Optimal commitment policy becomes history-dependent as reflected by the lagged Lagrange multipliers in (46) and (47). These additional state variables reflect “promises” that must be kept from past commitments. After manipulating the first-order conditions, the optimal monetary commitment targeting rule can be written as:

$$\left[ \frac{(\kappa - \lambda)}{(1 - \Psi)} \hat{\pi}_t + \vartheta \hat{Y}_t - \frac{(\kappa - \lambda)}{(1 - \Psi)} \hat{\pi}_{t-1} - \left( \frac{(\kappa - \lambda)}{(1 - \Psi)} + 1 \right) \frac{1}{\beta} \hat{\zeta}_{2,t-1} \right] \left( \hat{R}_t^D - \ln \left( \beta \right) \right) = 0; \quad \hat{R}_t^D \geq \ln \left( \beta \right). \quad (50)$$

Notice that (50) boils down to the discretionary targeting rule (43) when the policymaker is not bound by past commitments (or when the lagged Lagrange multipliers are set to zero, $\hat{\zeta}_{1,t-1} = \hat{\zeta}_{2,t-1} = 0$). In both discretion and commitment cases, optimal monetary policy at the ZLB is affected by the cost channel and the degree of financial frictions, $\Psi(\chi)$. We now turn to compare discretion and commitment policies with an occasionally-binding ZLB constraint following recessionary cost-push and natural real rate shocks, and analyze how the regimes are altered by the credit frictions.

**Financial Shocks.** Figure 1 displays the optimal responses of the key variables of the model
to a significant adverse financial shock of size $6 \cdot s.d(\alpha^\chi)$.

**Figure 1 - Adverse Financial Shock: Discretion vs. Commitment with the ZLB**

![Graphs showing the impact of adverse financial shocks on inflation, output, nominal policy rate, real deposit rate, and loan rate under discretion and commitment with the ZLB.]

Note: Interest rates and inflation are measured in annualized percentage point deviations. Output and the shock are measured in annualized percentage deviations.

When examining discretionary monetary policy against the backdrop of an inflationary shock in this framework, it is important to first emphasize that in the Ravenna and Walsh (2006) frictionless cost channel setup where $\Psi = 0$, the coefficient on $\hat{\pi}_t$ in the targeting rule (42) is $\frac{(\kappa-\lambda)}{\sigma} < (1 - \Psi)^{-1} \frac{(\kappa-\lambda)}{\sigma}$. This implies a more muted output adjustment for a given inflation deviation relative to our setup. In their model, variability in inflation is larger because a rise in $\hat{R}^D_t$ not only acts to reduce $\hat{Y}_t$ and $\hat{\pi}_t$ through a standard demand effect, but also serves to increase $\hat{\pi}_t$ and amplify the fall in $\hat{Y}_t$ via the monetary policy cost channel. These effects make inflation stabilization more costly in terms of output stability, triggering a monetary policy trade-off. In our model, this trade-off is intensified due to the existence of the financial friction ($\Psi > 0$) that warrants a contractionary and more aggressive interest rate reaction against an inflationary shock. Intuitively, a higher degree of financial market imperfections (as also measured by a lower $\chi$) escalates the hike in $\hat{R}^L_t$ following an adverse financial disturbance. The upshot is a more pronounced inflation surge,
which forces the optimizing discretionary policymaker to raise $\hat{R}_t^D$ by around 1.7 percentage points. The stricter interest rate response accelerates the contraction in aggregate demand, which, in turn, dampens the rise in the credit spread and inflation via both intertemporal substitution as well as the risk-adjusted cost channel. Hence, under discretionary monetary policy, the ZLB constraint is less consequential following a fall in $\hat{\chi}_t$.

Under commitment monetary policy, a negative financial shock requires an initial cut in the nominal interest rate despite the immediate inflationary consequences precipitated by the rise in the credit spread. Similar to De Fiore and Tristani (2013), a supply-side credit shock that directly raises borrowing costs leads to an inefficient and entirely undesirable slump in output. The downward pressure on real wages generated by the escalation in inflation discourages both labor supply and consumption demand, resulting in a persistent contraction in $\hat{Y}_t$. For the calibration and moments used in this exercise, a large inefficient cost-push disturbance sends the nominal policy rate to its lower bound for 2 periods, with the accommodative monetary policy helping to smooth the adjustment of output at the expense of short-lived inflationary pressures. At the same time, such demand-pull inflation is mitigated by the direct monetary policy cost channel in which the fall in $\hat{R}_t^D$ contains part of the initial spike in $b_t$.

As the shock starts to dissipate, the forward-looking public authority promises to generate mild future deflation, which helps to further alleviate the immediate cost-push repercussions in the first few periods. Throughout the recovery stage under commitment, output is driven below the level implied by the discretionary outcome in order to partly moderate the initial inflationary ZLB episode. Values of the Lagrange multipliers in (50) reveal that once the economy enters a supply-driven liquidity trap, the policymaker commits to future deflation as a substitute for nominal rate cuts. The coefficients multiplying $\hat{\zeta}_{1,t-1}$ and $\hat{\zeta}_{2,t-1}$ in the targeting rule are increasing with $\Psi$, suggesting that the degree of financial market frictions amplifies expected deflationary pressures. As a result, the interest rate must gradually increase to lower future prices, which ultimately keeps output below target for a longer period of time. However, given the mitigated initial drop in output upon the impact of the shock and the muted asymptotic volatility in prices and GDP, commitment considerably outperforms discretion and yields an unconditional expected welfare gain of 0.026 percent.

Our model can explain why nominal policy rates may hover around their lower bounds also in response to inflationary cost-push shocks, as well as the ‘missing deflation puzzle’ observed during the Great Recession and the Covid-19 recession. The peculiar nature of the supply-side financial shock in our framework generates both a countercyclical credit spread and a negative comovement between inflation and output.

**Demand Shocks.** Figure 2 presents the optimal responses of the key variables of the model
to a negative natural real interest rate shock of size $4 \cdot s.d(\alpha^Z)$.

Under discretionary policy and in a demand-driven liquidity trap, output, the marginal cost, and prices decline. Beyond this direct demand-pull deflationary consequence, the slump in the marginal cost and aggregate demand exerts downward pressure on borrowing costs via the risk premium effect. The fall in the credit spread then magnifies the deflationary impact of the shock and deepens the economic recession by keeping the real policy rate at elevated levels. This amplification effect is captured by $\Psi$, as can be inferred from (44), and serves as a cost-push deflationary by-product. More formally, re-arranging (42) yields $\hat{\zeta}_{3,t} = - (\kappa - \lambda) (1 - \Psi)^{-1} \hat{\pi}_t - \partial \hat{Y}_t$, implying that $\hat{\zeta}_{3,t}$ rises with $\Psi$ for a given large decline in $\hat{\pi}_t$ and $\hat{Y}_t$. Thus, beyond the direct adverse implications of the exogenous shock, the release date from the ZLB under discretion is further postponed when the endogenous financial friction is more prevalent, making the liquidity trap more severe. As a result of the larger welfare losses caused by the risk-adjusted credit cost channel and given our calibration, the public authority creates an output overshooting even under discretion, and extends the zero interest rate policy to 9 periods. One can show that this duration is longer than the time spent at the ZLB in the benchmark New Keynesian model, wherein the liquidity trap lasts for only 5 periods if the same parameterization and shock moments as used in this exercise are applied.

**Figure 2 - Adverse Demand Shock: Discretion vs. Commitment with the ZLB**

![Figure 2](image_url)

Note: See note below Figure 1.
Under commitment policy, a negative demand shock provokes the policymaker to slash the nominal interest rate and keep it at its lower bound for 8 periods in order to induce a persistent, yet gradual, economic expansion from the second period. At the same time, the initial interest rate reduction places downward pressure on inflation due to the presence of the risk-adjusted credit cost channel ($\Psi > 0$). Compared to Adam and Billi (2006) and Nakov (2008), the amplified welfare losses generated in this model by the cost-push financial friction prompts the public authority to drive output above its steady state level for a longer period of time stretching even further beyond the lifespan of the trap. The objective here is to dampen the fall in prices at the time of the disturbance, as well as to raise expected inflation in order to drive down the real interest rate. The added stimulus to the system generated by the promise to keep expected inflation and output positive even after the economy escapes the liquidity trap substitutes for further nominal rate cuts. Such result is reinforced by the expected hike in the nominal interest rate from the eighth period that accelerates medium-run inflationary pressures via the credit cost channel.

A non-trivial result arising from the analysis above and the baseline calibration with a sufficiently persistent demand shock is that the liquidity trap spell is slightly shorter under commitment than under discretion. This comes in stark contrast to the basic New Keynesian model where optimal monetary policy under commitment warrants a later exit date from the ZLB and a slower adjustment of the policy rate towards its steady state. By minimizing the present discounted value of welfare, the anticipated future economic stimulus emerging from the commitment policy (as explained above), together with the positive impact of the credit cost channel on inflation as the economy exits the liquidity trap, enables the policymaker to raise the interest rate at an earlier date relative to discretion. The Neo-Fisherian property observed under commitment in a cost channel model like ours implies that “low-for-longer” optimal forward guidance policies in the standard model may be exaggerated in terms of the time spent at the ZLB. We find that the optimal commitment regime attains an unconditional expected welfare gain of 0.011% compared to the discretionary outcome. In the textbook New Keynesian model that applies the same calibration as in this exercise, the welfare improvement from optimal forward guidance amounts to only 0.007%. As a result, welfare gains from commitment at the ZLB in the basic New Keynesian model without financial frictions might be significantly underestimated.
5.2 Introducing Financial Taxation

Now suppose the public authority has access to the financial tax \( \hat{\tau}_D^D \). Under discretion, the Lagrangian for the policymaker’s problem takes the form:

\[
\mathcal{L}_t = -\frac{1}{2} \left( \hat{\pi}_t^2 + \partial \hat{Y}_t^2 \right) - \hat{\zeta}_{1,t} \left[ \hat{\pi}_t - \beta \mathbb{E}_t \hat{\pi}_{t+1} - \frac{\lambda}{(1 - \Psi)} \left( \hat{R}_t^D + (1 + \varphi) \hat{Y}_t - \Psi X_t \right) \right] \\
- \hat{\zeta}_{2,t} \left[ \hat{Y}_t - \mathbb{E}_t \hat{Y}_{t+1} + \hat{R}_t^D - \hat{\tau}_t^D - \mathbb{E}_t \hat{\pi}_{t+1} - \hat{\pi}_t^n \right] - \hat{\zeta}_{3,t} \left[ -\hat{R}_t^D + \hat{\tau}_t^D + \ln (\beta) \right].
\]

The corresponding first-order conditions with respect to \( \hat{\pi}_t, \hat{Y}_t, \) and \( \hat{R}_t^D \) are the same as in (38)-(40), with the additional optimality condition with respect to \( \hat{\tau}_t^D \) given by:

\[
\hat{\zeta}_{2,t} = \hat{\zeta}_{3,t}. \tag{51}
\]

Moreover, the modified slackness condition with taxes is:

\[
\hat{\zeta}_{3,t} \left( -\hat{R}_t^D + \hat{\tau}_t^D + \ln (\beta) \right) = 0. \tag{52}
\]

Using conditions (38)-(40) and (51), the optimal target rule under discretion with \( \hat{\zeta}_{3,t} > 0 \) becomes:

\[
\partial \hat{Y}_t = -\hat{\zeta}_{3,t}, \tag{53}
\]

or, using the slackness condition (52):

\[
\partial \hat{Y}_t \left( \hat{R}_t^D - \hat{\tau}_t^D - \ln (\beta) \right) = 0; \quad \hat{R}_t^D - \hat{\tau}_t^D \geq \ln (\beta). \tag{54}
\]

The financial tax adds the first-order condition \( \hat{\zeta}_{2,t} = \hat{\zeta}_{3,t} \), which together with (40), removes the policy restriction imposed by the AS curve (\( \hat{\zeta}_{1,t} = 0 \)). Complete price stability (\( \hat{\pi}_t = 0 \)) is therefore attained with the introduction of \( \hat{\tau}_t^D \).

To obtain the closed-form expressions for \( \hat{Y}_t \) and \( \hat{\zeta}_{3,t} \) under optimal discretion with financial taxation at the ZLB, combine the optimality conditions above, and then impose that rational private sector expectations are rational. The solution yields:

\[
\hat{Y}_t = \frac{1}{(1 - p)} (\hat{\tau}_t^D + \ln (\beta)), \tag{55}
\]

\[
\hat{\zeta}_{3,t} = -\frac{\partial}{(1 - p)} (\hat{\tau}_t^D + \ln (\beta)), \tag{56}
\]

26
where \( p \) satisfies \( \mathbb{E}_t \hat{Y}_{t+1} = p \hat{Y}_t \) (as in Clarida, Galí, and Gertler (1999)). Unconstrained discretionary policy with financial interventions eliminates the risk of entering a liquidity trap following a financial shock as \( \hat{\chi}_t \) does not enter neither (55) nor (56). Intuitively, without \( \hat{\tau}^D_t \), optimal time-consistent policy in the face of an adverse financial shock warrants a rise in \( \hat{R}^D_t \) to tackle the inflationary component of the credit spread. The ZLB constraint is therefore uneventful. With the financial policy, both \( \hat{R}^D_t \) and \( \hat{\tau}^D_t \) must fall in order to bring about complete output and inflation stabilization. For \( \hat{\pi}_t = 0, \forall t, \) and \( \hat{\zeta}_{3,t} > 0, \) the optimal effective savings rate satisfies \( \hat{R}^D_t - \hat{\tau}^D_t = \ln (\beta) \), insulating the real economy from the inflationary effect that would otherwise follow from the expansionary monetary policy. Given that the effective deposit rate is optimally set to its positive steady state value, the ZLB restriction is removed following supply-side shocks. In contrast, large adverse demand shocks increase the likelihood of entering a liquidity trap by raising \( \hat{\zeta}_{3,t} \) and as a result lowering \( \hat{Y}_t \).

With **commitment** and deposit taxation, the optimal targeting rule is shown to satisfy:

\[
\left( \vartheta \hat{Y}_t - \beta^{-1} \hat{\zeta}_{2,t-1} \right) \left( \hat{R}^D_t - \hat{\tau}^D_t - \ln (\beta) \right) = 0; \quad \hat{R}^D_t - \hat{\tau}^D_t \geq \ln (\beta), \tag{57}
\]

with inflation determined by:

\[
\hat{\pi}_t = \hat{\zeta}_{1,t-1} + \beta^{-1} \hat{\zeta}_{2,t-1}. \tag{58}
\]

Unlike the discretionary case where \( \hat{\pi}_t = 0, \) inflation now is dictated by the inherited Lagrange multipliers from the previous period.\(^\text{21}\) To illuminate the differences between discretion and commitment with financial taxation, we turn to simulate the model following supply and demand shocks in line with the analysis conducted in the previous subsection.

**Financial Shocks.** Figure 3 shows the optimal responses of the key variables of the model to a large negative financial shock of size \( 6 \cdot s_d(\alpha^Y) \). We compare the optimal commitment policy with monetary policy only, same as in Figure 1 (labeled “Commitment”), with the commitment regime involving tax interventions (labeled “Comm with Tax”), and with the discretionary case that also includes the financial tax policy (labeled “Disc with Tax”).

\(^{21}\)Note that (57) and (58) boil down to (54) and \( \hat{\pi}_t = 0, \) respectively, by setting \( \hat{\zeta}_{2,t-1} = \hat{\zeta}_{2,t-1} = 0.\)
Under unconstrained commitment policies, direct financial interventions allow for an \textit{unrestricted} reduction in the nominal policy rate that, in combination, insulate the economy from the adverse repercussions of the supply shock. In both the discretionary and commitment policies, $\hat{R}_t^D$ should be lowered one-to-one with respect to the cut in $\hat{D}_t^D$ such that the effective savings rate remains constant at its positive steady state level.

Intuitively, the nominal interest rate curtails the cost-push inflationary impact of the shock, and alleviates the drop in output via a standard intertemporal substitution effect. To prevent inflation escalating due to the monetary expansion, the tax instrument should track the short-run contemporaneous movements in the nominal policy rate. A financial tax cut raises the effective interest rate and incentivizes savings, both of which offset the output expansion caused by the monetary easing. The \textit{ceteris paribus} decline in $\hat{Y}_t$ attributed to the deposit subsidy exerts downward pressure on borrowing costs and consequently on prices due to the credit cost channel. Overall, demand-pull inflation is neutralized with output kept at its long-run level.
A more formal proof exemplifies this point even further. Suppose the policymaker sets \( \hat{\pi}_t = \hat{Y}_t = 0, \forall t \). Then, from the AS curve (34) we have \( \hat{R}^D_t = \Psi \hat{X}_t \). To satisfy the AD curve (35), the tax instrument should be set to \( \hat{\tau}^D_t = \Psi \hat{X}_t \) in order undo any effect of \( \hat{R}^D_t \) on \( \hat{Y}_t \). This outcome, however, is not unique, as it can be shown that both eigenvalues of the system lies outside the unit circle. This shortcoming leads us to consider the following monetary and tax policy rules:

\[
\hat{R}^D_t = \Psi \hat{X}_t, \tag{59}
\]

\[
\hat{\tau}^D_t = \Psi \hat{X}_t - \phi_\tau^\pi \hat{\pi}_{t+1}, \tag{60}
\]

where \( \phi_\tau^\pi \) is a coefficient that measures the strength of the financial tax response to variations in expected inflation. In this case, an optimal financial policy rule with a forward-looking inflation target satisfying \( \phi_\tau^\pi > 1 \) guarantees equilibrium uniqueness. For \( \phi_\tau^\pi > 1 \), the constrained-efficient allocation is attained as the distinct equilibrium outcome. Unlike the basic New Keynesian model, the Taylor principle is applied to the tax instrument, and is independent of the parameter values. Moreover, for \( \pi_t = \hat{Y}_t = 0, \forall t \), and from an ex-post perspective, the policy rate and the financial tax satisfy \( \hat{R}^D_t = \Psi \hat{X}_t \) and \( \hat{\tau}^D_t = \Psi \hat{X}_t \). The presence of a “threat” to adjust the deposit tax in reaction to deviations in expected future inflation leads to a determinate equilibrium outcome, and is sufficient to rule out any variations in equilibrium. According to the optimal financial policy rule, a rise in expected inflation warrants a more than one-to-one financial tax cut. The latter, in turn, acts to raise the real interest rate and thus limit fluctuations in output, which would otherwise result in inefficient variations in inflation. In this way, full access to monetary and financial policies, which include a credible signal to modify taxes in response to any deviations in expected inflation, yields the first-best time-consistent allocation. This optimal policy prescription holds regardless of whether the economy enters a liquidity trap or not.

Notice that while the loan rate is completely stabilized at its long-run positive value \( \hat{R}^L_t = 0 \), the credit spread remains elevated due to the sharp fall in \( \hat{R}^D_t \). The monetary expansion directly cushions the cost-push effects generated by the otherwise higher borrowing costs, while the financial tax cut prevents any demand-pull inflationary pressures. Furthermore, the identical optimal dynamics implied from the unconstrained Ramsey and time-consistent policies with tax interventions yield an equivalent welfare gain of 0.02% relative to the constrained optimal monetary policy commitment case. Unconventional financial policies remove the ZLB constraint for monetary policy, and enable the policymaker to set negative nominal interest rates without violating the household’s no-arbitrage condition between deposits and holding cash for consumption purposes. Such policies are not inconsistent with the practices of some central banks in advanced economies who set unprecedented negative nominal interest rates with the aim to stimulate aggregate demand.
in the aftermath of the Great Recession and during the start of the Covid-19 crisis. Our model shows that these policies are indeed feasible so long as financial measures are implemented correctly and in a state-contingent fashion. Deploying financial taxes nullifies the value of time-inconsistent commitment strategies.

**Demand Shocks.** Figure 4 presents the optimal responses of the key variables to a negative demand shock. The joint optimal monetary and tax policy plan under commitment (labeled “Comm with Tax”) is compared with the corresponding discretionary regime (“Disc with Tax”), and with the constrained commitment regime that involves only monetary policy as a stabilization tool (“Commitment”).

**Figure 4 - Adverse Demand Shock: Commitment & Discretionary Policies with Financial Taxes**

![Graph showing the optimal responses of key variables to a negative demand shock.]  

Note: See note below Figure 3.

With a credible commitment to adjust both the nominal policy rate and the tax instrument, the dynamics of output and inflation are considerably subdued compared to the case where $\hat{r}^D$ is not available. In the scenario where the financial tax is deployed, the negative demand shock does not require a zero nominal interest rate. Instead, and similar to the discretion case, optimal policy involves an increase in the tax rate and a more subtle initial hike in the nominal policy rate such that only the tax-augmented savings rate reaches its floor. This policy combination attenuates the
drop in output via a standard demand channel, and limits deflationary pressures through the credit cost channel. The latter mechanism, in turn, is driven by both the relative rise in $\tilde{R}_t^D$ and $\tilde{Y}_t$ which raise borrowing costs and consequently inflation. Both the discretion and commitment outcomes involving an increase in the nominal policy rate represent a Neo-Fisherian approach to escape a deflationary liquidity trap.

Moreover, conditions (57) and (58) reveal that once $\tilde{D}_t$ is accessible, the policymaker commits to future inflation as a substitute for the inability to further lower the effective savings rate. Specifically, for $\tilde{\zeta}_{2,t} = \tilde{\zeta}_{3,t}$ and $\tilde{\zeta}_{1,t} = 0$, promised inflation is positive as shown in (58). Note that compared to the discretionary case with financial taxes, the effective tax-augmented deposit rate is kept at its floor for 3 additional periods under the unconstrained optimal commitment regime with $\tilde{D}_t$. Importantly, the longer and looser anticipated policy mix, involving a modest nominal interest rate cut from the fourth period, dampens the initial decline in output and inflation but requires a small rise in these two variables for a short period of time in the future. Comparing discretion versus commitment from a welfare perspective, the first few periods more cushioned drop in output under the commitment case offsets the optimal amount of costly above-target promised inflation and output. Quantitatively, unconstrained commitment and discretionary policies with tax interventions yield a near-identical welfare gain of 0.0081% relative to the constrained commitment policy comprising only of monetary policy.22 Despite the modest welfare gains, the use of the tax policy is part of the optimal policy mix and achieves better stabilization outcomes in particular when it comes to minimizing price fluctuations.

A deposit tax in a liquidity trap, as we advocate for in this model, is in line with the unconventional policy attempts taken by the ECB to lower effective deposit rates and to increase credit spreads in light of the persistent low inflation experienced in the Eurozone between 2014 and 2020. We show that a tax on deposits stands out as a natural policy tool to address the inefficiencies associated with liquidity traps instigated by deflationary shocks. In fact, the results following both supply and demand shocks suggest that central banks can significantly limit the time-inconsistency involved with commitment interest rate and financial policies once the asset tax instrument is effectively utilized.

22 These welfare gains are the same up to the 6th decimal point. Thus, we comfortably argue that time-consistent and Ramsey plans with financial taxation are coequal from a quantitative welfare perspective. This near-identical welfare outcome for discretion and commitment with tax policies holds for various calibration values.
6 Conclusions

This paper has studied the properties of optimal time-consistent and Ramsey policies in the context of a stylized New Keynesian model modified for a credit cost channel, endogenous borrowing costs, and effective lower bound constraints on nominal interest rates. The model sheds new insights on the stabilization roles and transmission mechanisms of monetary and fiscal-financial interventions in liquidity traps driven by different fundamentals. We have shown that varying the deposit tax according to the state of the business and financial cycles has meaningful effects on the behavior of key macroeconomic variables, and substantially alters the transmission of optimal monetary policy under both discretion and commitment.

The distinctive supply-side credit market imperfections highlighted in this paper present an additional motivation for deploying state-contingent financial policies. In a liquidity trap, deposit tax policies unleash the restrictions imposed on the nominal policy rate, and substantially diminish the adverse consequences of both negative demand and financial shocks. Finally, the positive and normative implications of optimal unconstrained time-consistent policies with asset tax interventions are remarkably similar to their Ramsey counterparts. These results suggest that forward guidance (or more generally commitment) policies are of secondary importance so long as the policymaker can optimally alter the financial tax on loanable funds.

Like Correia, Farhi, Nicolini, and Teles (2013), Eichenbaum (2019), and Correia, De Fiore, Teles, and Tristani (2021), our state-dependent policy recommendations require taxes to be highly adaptable in times of economic uncertainty. It is well known that fiscal and financial policy tools may not be as versatile as monetary policy instruments, and require a long legislative process until they can actually be executed. Writing automatic stabilizer financial programs into law during tranquil times could circumvent these political and economic challenges faced by policymakers in the midst of a crisis. Nonetheless, the Great Recession and the recent outbreak of the Covid-19 pandemic have led to much more flexibility in terms of implementing rapid fiscal and financial policies. Either way, we make a normative point that financial tax policies should be at least as proactive and aggressive as monetary policy, so long as the policymaker can correctly identify the source and the size of the shock distorting the economy. Given that our quantitative and qualitative policy prescriptions depend crucially upon the source of economic fluctuations and the type of liquidity traps that follow, determining the extent to which business cycles are supply and/or demand driven is of paramount importance.
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