Optimal Stabilization Policies in the Wake of Large Shocks*

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March 19, 2025

Abstract

We study the joint optimal fiscal and monetary policy response to the large shocks that have affected the US economy between 2020 and 2024. Our approach allows for occasionally binding constraints on the monetary policy rate and on a household borrowing constraint. A benevolent policymaker seeks to minimize social losses due to the volatility of inflation, the output gap, and the difference in the marginal utility of consumption of borrowers and savers. Optimal monetary policy manages a standard inflation-output tradeoff while optimal fiscal policy sets transfers countercyclically to limit the inequality between different types of households. Through the lens of the model, the actual monetary policy tightening was too slow and not strong enough to contain inflationary pressures upon liftoff from the zero bound. Similarly, the first round of fiscal transfers was not generous and persistent enough, while the second was unwarranted.

JEL codes: E52, E58, G01, G28

Keywords: Monetary and fiscal policy; Covid crisis; inflation.

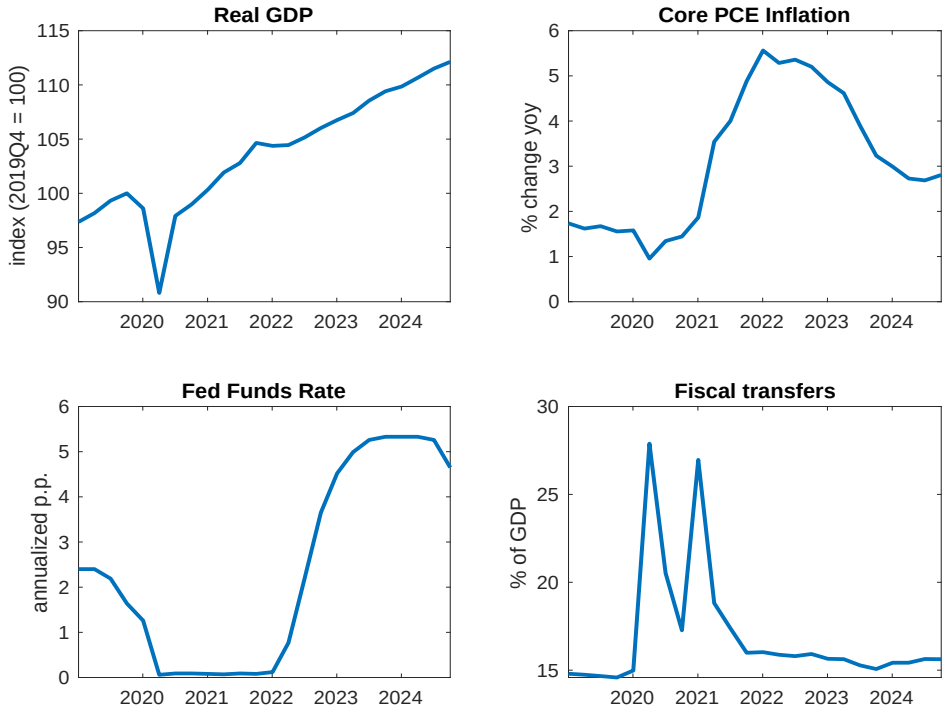
*The views expressed herein are those of the authors and do not necessarily represent those of the Bank of England or any of its policy committees. We are extremely grateful to Raf Wouters and Luigi Iovino for their discussions. We have also benefited from useful comments by participants in the ESM conference on "Economic Modelling in Policy Institutions," the 2024 ESADE Macro Meetings and the CAMRisk-RCEA Europe Workshop on "New Frontiers in Macroeconomics."

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Figure 1: US macroeconomic outlook 2019-2023.



NOTE: The figure shows real GDP (top-left), core PCE inflation (top-right), the Federal Funds rate (bottom-left) and fiscal transfers (bottom-right) in the US between 2019:Q1 and 2024:Q3.

1 Introduction

During the last five years, most economies around the world experienced two large shocks. First, the Covid-19 pandemic triggered unprecedented disruption across the global economy. Then, large supply shocks sent inflation to levels not seen since the oil crisis of the 1970s. Against this backdrop, policy authorities responded in size and at pace, deploying a range of monetary and fiscal tools to stabilize macroeconomic outcomes. As an example, Figure 1 documents the dynamics of real GDP (top-left panel), core PCE inflation (top-right panel), the Federal Funds rate (bottom-left panel) and the primary fiscal balance (bottom-right panel) for the United States between 2019 and 2023.

Motivated by these macroeconomic gyrations and the powerful and multi-dimensional policy response, this paper examines the monetary and fiscal policy

response to large shocks. Our approach compares a plausible illustration of the underlying forces that drove the main macroeconomic aggregates since 2020 with a normative analysis of how fiscal and monetary policy should have been conducted through the lens of a benchmark New Keynesian model.

The framework that we propose contains heterogeneity at the household level as in Cúrdia and Woodford (2016). A simple financial friction that limits private risk sharing (an exogenous borrowing constraint) can make fiscal transfers relevant for the determination of the equilibrium. At the same time, we also explicitly take into account the lower bound on the monetary policy rate as a constraint on the central bank's ability to stabilize aggregate variables.

A benevolent policymaker that can set both fiscal and monetary policy seeks to minimize the variation of a linear combination of inflation, the output gap, and a distributional gap between the marginal utility of those households who are constrained by borrowing limits and those who are not. In the special case in which the borrowing constraint always bind but the lower bound on the policy rate is always slack, we derive analytically optimal targeting rules for fiscal and monetary policy. The monetary policy rule trades off inflation and the output gap as in the baseline New Keynesian model (Woodford, 2003a). The fiscal rule aims to achieve co-movement in the marginal utility gap between borrowers and savers and the output gap, thus implying that optimal fiscal policy is countercyclical as long as the borrowing constraint remains binding.

A simulation exercise generalizes these results to the case in which the lower bound on the policy rate and the borrowing constraint can be occasionally binding. First, we back out the shocks that match the profile of the key aggregate variables from the model under simple policy rules. Then, we ask how the profile of those variables would have looked if policy had been conducted optimally. Under optimal policy, the Covid recession would have been half as deep and also significantly shorter, with negligible disinflationary pressures. The policymaker can achieve this outcome with a combination of a commitment to keep the nominal interest rate at zero for three more quarters than in practice (until the end of 2022) and a twice as generous initial fiscal stimulus.

Optimal policy also approximately halves the post-pandemic inflation spike. In this case, however, the gains in terms of inflation stabilization come at the

cost of a long recession, with the output gap remaining negative throughout the simulation horizon. When the nominal interest rate increases, the liftoff is sharp and very large. This commitment to an aggressive monetary policy tightening is what keeps inflation close to target. On the fiscal front, the initial increase in transfers is not only larger but also more persistent than in practice. However, the policymaker eventually raises taxes. Therefore, the overall profile of fiscal policy is very different from the one observed in the data.

Overall, our paper provides an analytical and quantitative characterization of the policy tradeoffs in response to large macroeconomic disturbances. As such, our work is related to a growing literature that examines optimal monetary and fiscal policy in the presence of the zero bound constraint on interest rates (Eggertsson and Woodford, 2003; Eggertsson and Woodford, 2006; Eggertsson, 2010), and a set of more recent papers examining the consequences of incomplete risk sharing for macroeconomic stabilization and welfare (Andres et al., 2013; Bilbiie et al., 2020; Benigno et al., 2020; Ferrero et al., 2023; Corbellini, 2025).[1]

An important feature of our model is the desire of borrowing-constrained agents to delever in the face of adverse shocks. The interaction of this force with the lower bound on the nominal interest rate has been a constant theme of the literature since the seminal papers by Eggertsson and Krugman (2012), Guerrieri and Lorenzoni (2017), Korinek and Simsek (2016) and Farhi and Werning (2016) in relation to the 2008 financial crisis.

Given the magnitude of the shocks involved, the recent literature has devoted considerable attention to both the Covid recession (see, for example, Faria-e-Castro, 2021; Eichenbaum et al., 2021; Guerrieri et al., 2022; Crump et al., 2024; Gertler and Cirelli, 2025) and the subsequent inflation surge (see, for example, Guerrieri et al., 2021; Lorenzoni and Werning, 2023; Ferrante et al., 2023; di Giovanni et al., 2022; di Giovanni et al., 2023; Benigno and Eggertsson, 2023; Eggertsson and Kohn, 2023; Gagliardone and Gertler, 2024; Comin et al., 2024; Giannone and Primiceri, 2024; Bernanke and Blanchard, 2025). In this respect, our contribution is to provide a joint account of the key macroeconomic variables

[1] In turn, both these strands of the literature are related to classic contributions on optimal fiscal and monetary policy, such as, for example, Lucas and Stokey (1983), Chari et al. (1991), Benigno and Woodford (2004), Siu (2004) and Correia et al. (2008).

around these two episodes.

Finally, our work is also related to the recent literature on fiscal inflation (Bianchi et al., 2023; Cochrane, 2023; Hazell and Hobler, 2024; Smets and Wouters, 2024; Barro and Bianchi, 2025), which extends and refines ideas from the fiscal theory of the price level (Leeper, 1991; Sims, 1994; Woodford, 1995).

The rest of the paper is organized as follows. Section 2 introduces the model. Section 3 presents the linear-quadratic framework for optimal policy analysis and derives the targeting rules for fiscal and monetary policy abstracting from occasionally binding constraints. Section 4 illustrates the optimal joint conduct of fiscal and monetary following the Covid-19 recession and subsequent bout of inflation taking full account of the occasionally binding constraints via numerical simulations. Finally, Section 5 concludes.

2 Model

This section describes the key building blocks of the model. As in Cúrdia and Woodford (2016), households are ex-ante identical, but at any point in time their preferences are heterogeneous due to the stochastic realization of the coefficient of relative risk aversion. A random switch in this utility parameter delivers a separation between savers and borrowers. At the beginning of time households sign state-contingent contracts, but only have access to payoffs from those contracts in the event of a new utility parameter draw. Intermittent access to the contract payments makes risk-sharing imperfect while avoiding ever-diverging marginal utilities of income due to different individual histories. In addition, borrowers are subject to an occasionally binding exogenous borrowing constraint.

The rest of the model is standard. Imperfectly competitive wholesale firms set prices on a staggered basis. Retailers are perfectly competitive and combine intermediate inputs to produce the final consumption good. The government conducts fiscal and monetary policy to address the inefficiencies arising from nominal rigidities and imperfect risk sharing.

Below, we present the problem of each economic actor. Further details on the microfoundations of the household problem with intermittent access to state-contingent transfers and the full derivations of the equilibrium conditions are in

the appendix.

2.1 Households

A continuum of measure one of ex-ante identical households populate the economy. At time t, a household can be of type b ("borrower") or s ("saver"). Households maximize the present discounted value of utility

$$\mathbb{V}_0^{\tau_t} \equiv \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \exp(\tilde{\varepsilon}_t^r) \left[\frac{(C_t^{\tau_t})^{1-\sigma^{\tau_t}}}{1-\sigma^{\tau_t}} - \chi_n \frac{(N_t^{\tau_t})^{1+\varphi}}{1+\varphi} \right] \right\},$$

where $\tau_t \in \{b, s\}$ indicates the type at time t, $C_t^{\tau_t}$ consumption of goods, and $N_t^{\tau_t}$ hours worked. The parameter $\beta \in (0,1)$ is the individual discount factor, σ^{τ_t} the coefficient of risk aversion (with $0 < \sigma^b < \sigma^s$), $\varphi > 0$ the inverse elasticity of labor supply, and χ_n is a positive parameter that determines steady state hours worked. The shock $\exp(\tilde{\varepsilon}_t^r)$ is an exogenous disturbance to the rate of time preference.[2]

The type τ evolves according to an independent two-state Markov chain. With probability $\delta \in [0,1]$, the type remains unchanged. With probability $1-\delta$, a household draws a new type, independently of the previous one. The probability of drawing type τ is $\xi^\tau \in [0,1]$. Since we assume the economy consists of a continuum of households of measure one, the probability of drawing a certain type corresponds to the share of that type in the population. To simplify the notation, we let $\xi^b = \xi$, which in turn implies $\xi^s = 1 - \xi$.

Households sign state-contingent contracts with each other at time $t_0 \leq 0$ to insure against idiosyncratic and aggregate risk. A competitive insurance agency provides the payments associated with such contracts. These payments, however, take place if and only if a household draws a new type in period t and before knowing the new type.

The beginning-of-period financial wealth inclusive of transfers for a household of type τ is

$$A_t^\tau \equiv R_{t-1} \max\{D_{t-1} + B_{t-1} - L_{t-1}, 0\} + \Gamma_t^\tau,$$

[2] We abstract from labor supply shocks, which in our model would be collinear to productivity shocks.

where D_t denotes private credit, B_t government bonds, L_t private debt, and Γ_t^τ insurance transfers.[3] Government bonds and private loans are perfect substitutes, and thus carry the same gross nominal return R_t.

The budget constraint for a household who is a saver at time t is

$$P_t C_t^s + (1 - \tilde{\nu}\tau^n)(D_t + B_t) = A_t^s + (1 - \tau^n) W_t N_t^s + \Omega_t^s - P_t T_t^s,$$

where P_t is the consumer price index, W_t is the nominal wage, Ω_t^s denotes profits rebated to savers from intermediate goods producers, and T_t^s are taxes. Savers are subject to the income tax rate $0 \leq \tau^n < 1$. However, a fraction $0 \leq \tilde{\nu} < 1$ of the household's gross saving $D_t + B_t$ is tax deductable. This formulation mimics the tax advantages to saving, including via pension contributions, in place in many advanced economies.[4] Because of the tax shield, saver households need exchange only $(1 - \tau^n)\tilde{\nu} + (1 - \tilde{\nu}) = 1 - \nu$ units of nominal consumption to obtain one unit of saving, where $\nu \equiv \tilde{\nu}\tau^n$. As we show in the appendix, a positive value of ν implies that the borrowing constraint binds in steady state. We assume that the government bears the fiscal cost associated with the tax deductability of savings.

The budget constraint for a household who is a borrower at time t is

$$P_t C_t^b - L_t = A_t^b + (1 - \tau^n) W_t N_t^b + \Omega_t^b - P_t T_t^b.$$

In addition, borrowers are subject to an exogenous—although potentially time-varying—debt limit, similar to the one in Eggertsson and Krugman (2012) and Benigno et al. (2020)

$$\frac{L_t}{P_t} \leq \Theta_t,$$

where $\Theta_t > 0$.[5]

[3] The appendix shows that the redistribution of financial wealth between borrowers and savers who change type at time t implies $A_t = R_{t-1} B_{t-1}$.

[4] For example, in the United States, employees may make elective deferrals into 401(k) retirement plans which, up to some limit, reduce taxable income. Similarly, in the United Kingdom, salary sacrifice schemes reduce taxable pay in exchange for employee benefits, which can include payments into a pension scheme.

[5] In principle, all households are subject to the borrowing constraint. We abstract from its presence for savers since, in equilibrium, such a constraint would never bind for households of this type.

The key difference between this model and one with either complete markets, or one with incomplete markets and fixed types, is that the expected future marginal utility of consumption is a weighted average of the marginal utility conditional on no type change and the average marginal utility of the two types.[6]

2.2 Firms

A representative retailer combines intermediate goods according to a technology with constant elasticity of substitution $\epsilon > 1$

$$Y_t = \left[\int_0^1 Y_t(f)^{\frac{\epsilon-1}{\epsilon}} df\right]^{\frac{\epsilon}{\epsilon-1}},$$

where $Y_t(f)$ represents the intermediate good produced by firm $f \in [0,1]$. Expenditure minimization implies that the demand for a generic intermediate good is

$$Y_t(f) = \left[\frac{P_t(f)}{P_t}\right]^{-\epsilon} Y_t, \tag{1}$$

where $P_t(f)$ is the price of the variety produced by firm f and the aggregate price index is

$$P_t = \left[\int_0^1 P_t(f)^{1-\epsilon} df\right]^{\frac{1}{1-\epsilon}}.$$

Intermediate goods producers operate in monopolistic competition, are owned by savers and borrowers according to their shares in the population, and employ labor to produce variety f according to

$$Y_t(f) = \exp(\varepsilon_t^z) N_t(f),$$

where ε_t^z is an exogenous productivity shock.

Intermediate goods producers receive a constant labor subsidy τ^w, such that the nominal wage bill is $(1-\tau^w)W_t N_t(f)$. We assume that the government sets this subsidy so that the labor market equilibrium is efficient in steady state.

[6] As in Cúrdia and Woodford (2016), the marginal utility of consumption is independent of the household type history. The same result also holds for the multiplier on the borrowing constraint, which is specific to this model.

As in Calvo (1983), intermediate goods producing firms keep their price unchanged with probability $\alpha \in (0,1)$. Those that can adjust choose the price of their product $\widetilde{P}_t(f)$ to maximize expected future profits conditional on no further changes, taking as given the demand for their variety and their marginal cost, which is equal to the real wage ($w_t \equiv W_t/P_t$) net of the labor subsidy divided by productivity

$$MC_t = \frac{(1-\tau^w)w_t}{\exp(\varepsilon_t^z)},$$

and is independent of firm-specific characteristics.

The optimal price setting decision for firms that adjust at time t is the solution of

$$\max_{\tilde{P}_t(f)} \mathbb{E}_t \left\{ \sum_{j=0}^{\infty} (\alpha\beta)^j \frac{\exp(\tilde{\varepsilon}_{t+j}^r)}{\exp(\tilde{\varepsilon}_t^z)} \frac{\lambda_{t+j}}{\lambda_t} \left[(1+\tau^f) \frac{\tilde{P}_t(f)}{P_{t+j}} - \exp(\varepsilon_{t+j}^\pi) MC_{t+j} \right] Y_{t+j}(f) \right\},$$

subject to (1), where $\tau^f > 0$ is a subsidy that makes steady state production efficient and ε_t^π is an exogenous cost-push shock. Since we assume that shares are non-tradable and the two types of households own firms in proportion to their size in the population, the discount factor for future profits corresponds to the average marginal utility of consumption

$$\lambda_t = \xi \lambda_t^b + (1-\xi)\lambda_t^s,$$

where $\lambda_t^\tau = (C_t^\tau)^{-\sigma^\tau}$ is the marginal utility of type τ.

2.3 Fiscal Policy, Market Clearing, and Private Debt Dynamics

The budget constraint for the fiscal authority implies that public debt in nominal terms evolves according to

$$B_t = R_{t-1}B_{t-1} + P_t G_t - P_t \widetilde{T}_t,$$

where G_t are exogenous real government purchases and $\widetilde{T}_t$ are tax revenues net of transfers in real terms

$$\widetilde{T}_t = \xi T_t^b + (1-\xi)T_t^s - \tau^f Y_t - (1-\xi)\nu(D_t + B_t).$$

The final term captures the fiscal cost of the tax deductability of saving. We focus on a steady state in which lump-sum taxes are the same across types ($T^b = T^s$), although we will consider policy configurations with type-specific taxes over the business cycle. In addition, we assume the income tax finances the employment subsidy ($\tau^n = \tau^w$), so that the effects of these policies are fiscally neutral.

The goods market equilibrium requires that total production equals the sum of consumption of the two types and government spending

$$Y_t = \xi C_t^b + (1-\xi)C_t^s + G_t.$$

In the credit market, total lending must equal total borrowing

$$\xi L_t = (1-\xi)D_t.$$

Finally, per-capita real private debt, derived by aggregating the budget constraint of new and existing borrowers over their respective measures, evolves according to

$$\frac{L_t}{P_t} = \delta \frac{R_{t-1}}{\Pi_t}\frac{L_{t-1}}{P_{t-1}} + C_t^b - (1+\tau^f)Y_t + T_t^b \\ - (1-\delta)\frac{R_{t-1}}{\Pi_t}\frac{B_{t-1}}{P_{t-1}} - (1-\xi)(1-\tau^n)\frac{W_t}{P_t}(N_t^b - N_t^s).$$

The last expression shows that probability of not changing type drives the persistence of private debt.

For a given specification of fiscal and monetary policy, an imperfectly competitive equilibrium for this economy is a sequence of quantities and prices such that households and firms maximize their objectives subject to the relevant constraints and all markets clear. The analytical appendix reports the full list of variables and the equilibrium conditions for the private sector.

3 Optimal Policy Problem

This section derives a linear-quadratic (LQ) characterization of the jointly optimal fiscal and monetary policy problem. The LQ approach allows us to derive some analytical results and is tractable enough to study numerically cases in which the lower bound on the nominal interest rate and the borrowing constraint are occasionally binding.

A second-order approximation to the welfare-based loss function around the efficient steady state contains components reflecting the effects of distortions generated by both nominal rigidities and imperfect risk sharing. In two special cases, we are able to derive targeting rules that fully characterize the optimal policy plan. The targeting rules demonstrate how optimal fiscal policy accounts for the potential tradeoff between stabilizing the effects of the two key distortions in the model.

We proceed by presenting the welfare-based loss function, the log-linearized equilibrium conditions that constrain the optimal policy problem, and a pair of targeting rules for fiscal and monetary abstracting from occasionally binding constraints, which we bring back in section 4.

3.1 Loss Function

We derive the loss function for the economy by taking the average of the utility functions of borrowers and savers, weighting each type according to their share in the population. A second-order approximation of the resulting objective around an efficient zero-inflation steady state in which the marginal utility of the two types is the same gives

$$\mathbb{L}_0 \propto \frac{1}{2}\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \left(x_t^2 + \lambda_\pi \pi_t^2 + \lambda_\omega \omega_t^2 \right) \right], \tag{2}$$

where $x_t \equiv y_t - y_t^*$ is the deviation of output from its efficient level, defined as

$$y_t^* = \frac{1}{\bar{\sigma} + \varphi}[(1+\varphi)\varepsilon_t^z + \bar{\sigma} s_g g_t], \tag{3}$$

with $\bar{\sigma}^{-1} \equiv \xi s_c^b/\sigma^b + (1-\xi)s_c^s/\sigma^s$, π_t is the inflation rate, and $\omega_t \equiv \sigma^s c_t^s - \sigma^b c_t^b$ is the marginal utility gap.[7]

The relative welfare weights in equation (2) are both positive. In particular, the relative weight on inflation is

$$\lambda_\pi \equiv \frac{\epsilon}{\gamma(\bar{\sigma}+\varphi)},$$

where $\gamma \equiv (1-\alpha)(1-\alpha\beta)/\alpha$ and $s_c^\tau \equiv C^\tau/Y$ is the steady-state consumption-to-output ratio for type τ. The relative weight on the marginal utility gap is

$$\lambda_\omega \equiv \frac{\xi(1-\xi)\sigma_\varphi}{\bar{\sigma}+\varphi},$$

where $\sigma_\varphi \equiv \varphi^{-1} + s_c^b s_c^s \bar{\sigma}/(\sigma^b \sigma^s)$.

As in a large class of New Keynesian models, the loss function features squares of the output gap and inflation. Their presence in the loss function reflects the two distortions associated with price rigidities. First, such rigidities open up a 'labor wedge,' causing the level of output to deviate from its efficient level. Second, staggered price setting implies an inefficient dispersion in prices, which is proportional to the rate of inflation.

The square of the marginal utility gap enters the loss function to capture the welfare costs of financial markets incompleteness. In particular, even though in steady state the marginal utility of consumption of the two types is the same, limited access to a full set of state-contingent securities generates excessive volatility of marginal utilities over time. In turn, this distortion affects the ability of households to smooth their consumption away from the steady state, leading to the presence of ω_t in the loss function. When a shock tightens the borrowing constraint, the amount of credit that borrowers can obtain is less than the desired level, thus increasing their marginal propensity to consume relative to savers.[8]

[7] From now on, all variables should be understood as log-deviations from the efficient steady state unless otherwise stated.

[8] As long as some fraction of savings is tax-deductable ($\tilde{\nu} > 0$), the borrowing constraint binds also in steady state because the additional incentives to save make the real interest rate lower than the inverse of the individual discount factor. Away from the steady state, shocks can make the borrowing constraint more or less tight, or even not binding.

Imperfect risk sharing therefore is a source of welfare losses that a benevolent policymaker takes into account when setting optimal fiscal and monetary policy.

3.2 Log-Linearized Equilibrium Conditions

In this section, we report the set of log-linearized equilibrium conditions, expressed in terms of welfare-relevant variables, that constrain the LQ approximation to the optimal policy problem.

Taking the average of the Euler equations of borrowers and savers yields the aggregate demand equation

$$x_t = -\bar{\sigma}^{-1}(i_t - \mathbb{E}_t\pi_{t+1} - r_t^\dagger) + \mathbb{E}_t x_{t+1}, \tag{4}$$

where i_t is the net nominal interest rate, and $r_t^\dagger$ is the equilibrium real interest rate, that is, the real interest rate consistent with a zero output gap in every period. Differently from the baseline New Keynesian model, the equilibrium real interest rate is partly endogenous given its relationship with the expected quasi-difference of the marginal utility gap

$$r_t^\dagger \equiv r_t^* + (\sigma_\omega + \delta\xi)\mathbb{E}_t\omega_{t+1} - (\sigma_\omega + \xi)\omega_t, \tag{5}$$

where $\sigma_\omega \equiv \xi(1-\xi)\bar{\sigma}(s_c^b/\sigma^b - s_c^s/\sigma^s) > 0$.[9] A shock that forces borrowers to cut consumption in order to delever increases the marginal utility gap and generates downward pressure on the equilibrium real interest rate (and vice versa). The exogenous component of $r_t^\dagger$ corresponds to the efficient real interest rate in the baseline New Keynesian model

$$r_t^* \equiv \varepsilon_t^r - \bar{\sigma}(y_t^* - \mathbb{E}_t y_{t+1}^*) + \bar{\sigma}s_g(g_t - \mathbb{E}_t g_{t+1}),$$

where $\varepsilon_t^r \equiv \tilde{\varepsilon}_{t+1}^r - \tilde{\varepsilon}_t^r$ is an aggregate demand shock.

[9]The reason why σ_ω is positive is that borrowers have a lower coefficient of relative risk aversion than savers ($\sigma^b < \sigma^s$), which, coupled with an equal steady state marginal utility of consumption, implies that their steady state consumption share is relatively higher ($s_c^b > s_c^s$).

The Phillips curve is

$$\pi_t = \gamma[(\bar{\sigma} + \varphi)x_t + \sigma_\omega \omega_t + \varepsilon_t^\pi] + \beta \mathbb{E}_t \pi_{t+1}. \tag{6}$$

Because of the different labor supply behavior of borrowers and savers, imperfect risk sharing affects inflation dynamics through the marginal utility gap as in Cúrdia and Woodford (2016), thus playing the role of an endogenous cost-push shock.

In addition to the aggregate demand and aggregate supply equations, which are typical of the baseline New Keynesian model, we need to keep track of the heterogeneity between borrowers and savers due the lack of full risk sharing. The difference between the Euler equations of the two types gives an equation for the marginal utility gap

$$\omega_t = \frac{\nu}{1-\nu}\hat{\mu}_t + \delta \mathbb{E}_t \omega_{t+1}, \tag{7}$$

where $\hat{\mu}_t \geq -1$ is the Lagrange multiplier on the collateral constraint. Equation (7) makes clear that the tightness of the borrowing constraint drives the dynamics of the marginal utility gap. This observation will be central to understand the role of fiscal policy in our experiments.

The approximation of the borrowing constraint gives

$$\ell_t \leq \theta_t, \tag{8}$$

where ℓ_t is the log-deviation of real private debt from its steady state value and θ_t is the log-deviation of the exogenous component of the borrowing limit from its steady-state level Θ.

As a consequence of the heterogeneity between borrowers and savers, private debt dynamics matter for the macroeconomic equilibrium. Real private debt evolves according to

$$\ell_t = \frac{\delta}{\beta}(\ell_{t-1} + i_{t-1} - \pi_t) + \frac{1}{\eta_\ell}\left[\left(\frac{s_c^b \bar{\sigma}}{\sigma^b} - 1 - \tau^f\right)x_t - (1-\xi)\sigma_\varphi \omega_t + (\tilde{\tau}_t^b - \bar{\tau}_t^b)\right], \tag{9}$$

where $\eta_\ell \equiv \ell / Y$ is the steady state ratio of private debt to GDP. Private debt crucially depends on fiscal policy. The variable $\tilde{\tau}_t^b$ is a modified tax for borrowers, which corresponds to the actual lump-sum tax net of the transfers received through

the insurance agency, defined as

$$\tilde{\tau}_t^b \equiv \eta_\tau \tau_t^b - \frac{(1-\delta)\eta_b}{\beta}(i_{t-1} + b_{t-1} - \pi_t), \tag{10}$$

where $\eta_\tau \equiv T/Y$ and $\eta_b \equiv b/Y$ are the steady state GDP shares of tax revenues and government debt, respectively, and the term $\bar{\tau}_t^b$ is a combination of exogenous shocks

$$\bar{\tau}_t^b \equiv \frac{s_c^b s_g \bar{\sigma}}{\sigma^b} g_t - \left(\frac{s_c^b \bar{\sigma}}{\sigma^b} - 1 - \tau^f \right) y_t^*.$$

Finally, we also need to account for the evolution of government debt. In log-deviations from steady state, the government budget constraint is

$$b_t = \frac{1}{\beta}(i_{t-1} + b_{t-1} - \pi_t) - \frac{1}{\eta_b}[\xi \tilde{\tau}_t^b + (1-\xi)\tilde{\tau}_t^s - \tau^f x_t - f_t], \tag{11}$$

where b_t is the log-deviation of real government debt from steady state. Like for borrowers, we have defined a modified tax for savers as

$$\tilde{\tau}_t^s \equiv \eta_\tau \tau_t^s + \frac{(1-\delta)\eta_b}{\beta}(i_{t-1} + b_{t-1} - \pi_t), \tag{12}$$

while the term f_t is a combination of exogenous shocks defined as

$$f_t \equiv s_g g_t + \tau^f y_t^*.$$

All the exogenous shocks (ε_t^r, ε_t^z, ε_t^π, g_t, θ_t) follow stationary autoregressive processes with persistence $\rho_j \in (0,1)$ and innovations $u_t^j \sim i.i.d.\ \mathcal{N}(0, \sigma_j^2)$ for $j = \{r, z, \pi, g, \theta\}$.

Given the three policy instruments $\{i_t,\ \tilde{\tau}_t^b,\ \tilde{\tau}_t^s\}_{t=0}^\infty$, the exogenous shocks and initial conditions on the state variables $\{\ell_{-1},\ b_{-1},\ i_{-1}\}$, an approximated imperfectly competitive equilibrium for this economy is a sequence $\{x_t\ ,\ r_t^\dagger,\ \pi_t,\ \omega_t,\ \ell_t,\ b_t,\ \hat{\mu}_t\}_{t=0}^\infty$ that satisfies (4), (5), (6), (7), (8), (9), and (11) $\forall t \geq 0$, as well as the non-negativity constraints $\mu_t \geq 0$ and $i_t \geq 0$.

3.3 Optimal Targeting Rules

This section builds some intuition for the quantitative experiments, which include occasionally binding constraints and we will solve numerically, by studying two simplified examples. First, we consider the case in which the borrowing constraint never binds. Second, we examine optimal policy when the borrowing constraint is always binding. In both cases, we assume the nominal interest rate never violates the ZLB ($i_t > 0 \ \forall t$). We focus on the commitment solution for comparability with the numerical experiments in the next section.[10]

The main result is that, in both examples, the optimal monetary policy targeting rule is identical to the one obtained in the baseline New Keynesian model. In addition, when the borrowing constraint binds, optimal fiscal policy balances a tradeoff between the stabilization of the distortions caused by imperfect risk sharing and those caused by nominal rigidities.

We begin with the case in which the collateral constraint never binds outside the steady state ($\hat{\mu}_t = -1 \ \forall t$). This example is particularly simple because, from equation (7), we can see that the marginal utility gap is constant and independent of policy. As a consequence, the cost-push shock component associated with the marginal utility gap in the Phillips curve disappears. Therefore, the loss function only depends on output and inflation, as in the standard New Keynesian model. Moreover, because private debt enters neither the aggregate demand equation (4) nor the Phillips curve (6), the solution of the optimal policy problem corresponds to a standard flexible targeting rule that trades off inflation and the change in the output gap

$$\epsilon \pi_t + x_t - x_{t-1} = 0. \tag{13}$$

In this special case, Ricardian equivalence holds and fiscal policy has no bearing on the equilibrium allocation. Despite its simplicity, this case clarifies that in our model fiscal policy is effective only if the borrowing constraint binds or is expected to bind at some point in the future, whether because of the realization of exogenous shocks or the implementation of certain policies.

[10] We abstract from time-inconsistency considerations. An alternative interpretation is that the results that we present in this section are optimal from the timeless perspective (Woodford, 1999).

In the second case that we study analytically, we assume that the collateral constraint always binds ($\hat{\mu}_t > -1 \; \forall t$). Inspecting the linearized equilibrium conditions, we can observe that taxes on savers ($\tilde{\tau}_t^s$) only enter the government budget constraint (11), while taxes on borrowers ($\tilde{\tau}_t^b$) only enter the government budget constraint and the dynamics of private debt (9). Therefore, we can characterize the optimal policy plan without imposing those two equations as constraints and back out ex-post the fiscal instruments that support the implied allocation. Moreover, since the nominal interest rate only enters aggregate demand (4), aside from the government budget constraint and the dynamics of private debt, we can also drop that constraint and calculate the monetary instrument residually. With a similar logic, since the Lagrange multiplier on the borrowing constraint only enters the evolution of the marginal utility gap (7), we can exclude that expression from the set of constraints and back out the implied multiplier ex-post. Finally, private debt does not enter any remaining equilibrium condition other than the borrowing constraint (8), which thus can be used to back out its value residually.[11]

Given these simplifications, the optimal policy problem under commitment is fully forward-looking and boils down to minimize the per-period loss function subject to the Phillips curve

$$\min_{\{x_t,\pi_t,\omega_t\}_{t=0}^{\infty}} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t (x_t^2 + \lambda_\omega \omega_t^2 + \lambda_\pi \pi_t^2) \right],$$

subject to

$$\pi_t = \gamma[(\bar{\sigma} + \varphi) x_t + \sigma_\omega \omega_t + \varepsilon_t^\pi] + \beta \mathbb{E}_t \pi_{t+1}, \; \forall t \geq 0,$$

plus the initial time-0 constraints that make optimal policy time-invariant.

After substituting the constraint into the objective to eliminate inflation, the first order condition for output gives again the targeting rule for monetary policy (13) that we have derived in the case in which the borrowing constraint never binds. The central bank continues to trade off output and inflation exactly as in the baseline New Keynesian model. Even though the borrowing constraint binds,

[11] Effectively, a version of Ricardian equivalence holds also in this case. The borrowing constraint at equality determines the amount of private debt. Its law of motion then pins down the tax on borrowers consistent with the equilibrium. As long as the intertemporal government budget constraint holds, the exact timing of taxes on savers and debt is irrelevant.

distributional concerns (summarized by the marginal utility gap) do not enter directly the optimal targeting rule for monetary policy.

The first order condition for the marginal utility gap gives an equation that we can interpret as a targeting rule for fiscal policy

$$\omega_t + \chi_\pi \pi_t = 0,$$

where $\chi_\pi \equiv \gamma \lambda_\pi \sigma_\omega / \lambda_\omega$. Given that the optimal targeting rule for monetary policy implies a negative relation between inflation and the output gap, we can also rewrite the optimal targeting rule for fiscal policy as

$$\omega_t - \frac{\chi_\pi}{\epsilon} x_t = 0.$$

The fiscal authority should aim to move the marginal utility gap and the output gap in the same direction since $\chi_\pi > 0$. Intuitively, a shock that creates a negative marginal utility gap corresponds to a situation in which borrowers' consumption is suboptimally high relative to savers' consumption. In these circumstances, the fiscal authority should push output below its efficient level and create a recession. The fiscal rule feeds back into the monetary policy rule, because in this scenario the central bank, faced with a negative output gap, would tend to inflate the economy. This logic also works in reverse, but only as long as the borrowing constraint binds. Therefore, the fiscal authority faces a limit on how much its transfers can support borrowers' consumption.

Albeit not fully symmetrical, optimal fiscal policy is countercyclical and focuses on addressing the lack of full risk sharing due to financial market incompleteness. In this sense, we obtain a full separation of tasks. Monetary policy manages the aggregate tradeoff between inflation and output gap, while fiscal policy manages the distributional inefficiencies. The two dimensions, however, interact, as the optimal targeting rule for fiscal policy demonstrates.

The next section extends the optimal policy analysis to the case of occasionally binding constraints on the borrowing limit and the monetary policy instrument.

4 Quantitative Experiments

This section presents our main results, demonstrating the dimensions along which fiscal policy can complement monetary policy in stabilizing large shocks when the lower bound on the nominal interest rate and the borrowing constraint can be occasionally binding.

A combination of exogenous shocks generates a large recession, similar to the downturn observed in the United States after the onset of the Covid-19 pandemic, followed by the sharp inflation surge that characterized the post-pandemic period. In the baseline scenario, fiscal and monetary policy follow simple feedback rules subject to shocks. The recession is associated with a tightening of the borrowing constraint and an extended period at the ZLB, which continues well into the recovery.

Optimal policy operates under commitment subject to non-negativity constraints on the interest rate and the multiplier on the borrowing constraint. The monetary authority sets the nominal interest rate while the fiscal authority seeks to relax the borrowing constraint via transfers, which however cease to be effective when the borrowing constraint becomes slack.

Before illustrating our results, we discuss the specification of the policy rules, the process for the exogenous shocks, the simulation methodology, and the calibration of the model.

4.1 Constructing the Baseline Scenario

The baseline scenario aims to capture the key features of US macroeconomic data between 2019 and 2023. The scenario combines a baseline specification of fiscal and monetary policy with a minimal set of shocks that replicate the evolution of output, employment, inflation, and the policy rate. We also match some dimensions of fiscal policy and credit conditions that have a direct mapping in the model. In subsequent sections, we use these shocks to simulate counterfactual histories under alternative assumptions about fiscal and monetary policy.

In the baseline scenario, we assume that the central bank follows a standard interest rate feedback rule (Taylor, 1993) that responds to inflation and the output

gap with some inertia (Clarida et al., 1999)

$$i_t = \rho_i i_{t-1} + (1 - \rho_i)\left(\psi_\pi \pi_t + \psi_x x_t\right) + u_t^i,$$

where $\rho_i \in (0, 1)$ is the inertia parameter, $\psi_\pi > 1$ and $\psi_x > 0$ are the coefficients on inflation and the output gap, respectively, and $u_t^i \sim \mathcal{N}(0, \sigma_i^2)$ is an i.i.d. exogenous monetary policy shock.

For the fiscal authority, in the baseline scenario we constrain taxes on borrower and savers to be the same ($\tau_t^b = \tau_t^s = \tau_t$), and assume a simple feedback rule

$$\eta_b^{-1} \tau_t = \psi_b b_{t-1} + u_t^\tau,$$

where $\psi_b > 0$ and $u_t^\tau \sim \mathcal{N}(0, \sigma_\tau^2)$ is an i.i.d. exogenous tax shock.[12] We calibrate ψ_b to a small value, albeit sufficient to ensure that the intertemporal government budget constraint is satisfied for any path of the nominal interest rate. Therefore, given the assumption $\psi_\pi > 1$, monetary policy is 'active,' while fiscal policy is 'passive' in the terminology of Leeper (1991).

The baseline scenario assumes that the model is at steady state for periods $t \leq 0$. The first quarter in which shocks start occurring is 2019Q1. We use the growth rate of real GDP and employment, quarterly percentage changes in the Core PCE price index and the level of the Federal Funds rate to extract innovations to demand (u_t^r), productivity (u_t^z), cost-push (u_t^π) and monetary policy (u_t^i) shocks. We extract government spending shocks (u_t^g) directly from the detrended series for real government consumption expenditures. In addition, we assume that the transfer component of the CARES Act and of the American Rescue Plan Act (corresponding to 6.5 and 9 percentage points of GDP, respectively) map directly into fiscal innovations (u_t^τ) in 2020Q2 and 2021Q1 (Bureau of Economic Analysis, 2021). Finally, using data on credit card loans, we introduce a shock that tightens the borrowing constraint (u_t^θ) by 15%.[13]

[12] The modified tax rates on borrowers and savers (10) and (12) remain type-specific because of the insurance transfers.

[13] The data that we use is the series "Consumer Loans: Credit Cards and Other Revolving Plans, All Commercial Banks" from the Board of Governors of the Federal Reserve, available on FRED, Federal Reserve Bank of St. Louis. Data on credit card issuance and bank lending standards also support the idea of a significant tightening of credit conditions in early 2020

We solve the model using a piecewise-linear solution method to account for the possibility that (i) the zero lower bound on the short-term nominal interest rate becomes binding and/or (ii) the borrowing constraint (8) becomes slack.[14] This approach accounts for the possibility that the occasionally binding constraints may apply in future periods but not for the risk that future shocks may cause the constraints to bind. Thus, our approach, which is based on the methods developed by Guerrieri and Iacoviello (2015) and Harrison and Waldron (2021), abstracts from the skewness in the expected distribution of future endogenous variables arising from the possibility of being constrained in future.[15]

4.2 Parameter Values

Table 1 reports the parameter values used in the simulations. The individual discount factor β takes the standard value of 0.99. We then pick the tax deductability parameter so that the annualized steady state real interest rate is 2.5% ($\tilde{\nu} = 0.012$). The share of borrowers ($\xi = 0.33$) is line with the evidence on borrowing constrained households in Kaplan et al. (2014). We set the probability that the type does not change (δ) equal to 0.917 to generate some persistence in private debt as in the data.[16] Following Cúrdia and Woodford (2016), we choose the ratio between the coefficient of risk aversion of the two types (σ^b/σ^s) equal to 0.2, and back out their levels by imposing that the inverse elasticity of output to the real interest rate $\bar{\sigma}$ in the aggregate demand equation (4) is equal to one, a common value in the literature (e.g. Galí, 2015).

We assume that the inverse elasticity of labor supply (φ) is equal to 1, within the range of the macro estimates (Peterman, 2016), though closer to the estimates from micro data (Chetty et al., 2011). Also standard is the value for the elasticity

(Horvath et al., 2023).

[14] In our model, a binding zero lower bound on the short-term nominal interest rate also implies a zero nominal rate of return to savings. Theoretically, a zero lower bound on savings rates arises from the existence of an unmodeled zero-interest-bearing alternative saving instrument (e.g. cash). In practice, the evidence on negative interest rates (e.g. Eisenschmidt and Smets, 2019) suggests that deposit rates feature a hard floor at zero, although anecdotally some banks may have introduced new fees on deposit accounts when official interest rates became negative.

[15] The online appendix of Ferrero et al. (2023) contains a full description of the approach.

[16] The calibrated value for δ implies an expected duration of three years before a household draws a new type and receives the transfers from the insurance agency.

Table 1: Parameter values.

Parameter	Description	Value
β	Individual discount factor	0.990
$\tilde{\nu}$	Share of tax-deductable savings	0.012
ξ	Fraction of borrowers	0.333
δ	Probability of not changing type	0.917
σ^b	Coefficient of risk aversion (borrowers)	0.731
σ^s	Coefficient of risk aversion (savers)	3.654
φ	Frisch labour supply elasticity	1.000
ϵ	Elasticity of substitution among varieties	6.000
α	Probability of keeping price unchanged	0.870
$\tau^n = \tau^w$	Labor subsidy / income tax rate	0.300
η_ℓ	Private debt to (quarterly) GDP ratio	1.280
ψ_π	Taylor rule coefficient on inflation	1.500
ψ_x	Taylor rule coefficient on output gap	0.125
ρ_i	Interest rate smoothing	0.750
ψ_b	Fiscal feedback parameter	0.010
s_g	Government spending to GDP ratio	0.139
η_b	Government debt to (quarterly) GDP ratio	4.200
η_τ	Tax revenues to GDP ratio	0.350
ρ_j	AR coefficient of exogenous shocks	0.600
σ_j	Standard deviation of exogenous shocks	0.003

of substitution among varieties ($\epsilon = 6$), which we choose to deliver a steady state markup of 20%. The labor subsidy to firms, which also corresponds to the income tax rate, is 30% ($\tau^w = \tau^n = 0.3$). While we assume the existence of a subsidy to eliminate the steady state monopolistic distortion, this parameter remains important in governing the optimal monetary policy tradeoff between inflation and the output gap (see equation 13). The value of the probability that firms do not adjust their price in a quarter ($\alpha = 0.87$) is in line with the recent estimates in Del Negro et al. (2015), which implies a slope of the Phillips curve of $\gamma(\bar{\sigma} + \varphi) = 0.04$, not far from the estimates in Hazell et al. (2022). Finally, using data on total household debt minus mortgage debt from the New York Fed Quarterly Report on Household Debt and Credit, we calibrate the steady-state share of private debt

share of annual GDP ($\eta_\ell/4$) to 32%, in line with US data for 2019.[17]

The monetary policy rule parameters on inflation and the output gap ($\psi_\pi = 1.5$ and $\psi_y = 0.125$) are standard in the literature since (Taylor, 1993). The persistence (ρ_i) is squarely within the range of estimates in Clarida et al. (2000). The fiscal policy rule parameter is close to the smallest value that ensures intertemporal solvency of the government budget constraint ($\psi_b = 0.5$). The steady-state government debt share of annual GDP ($\eta_b/4$) corresponds to 105%, while the steady-state government spending share of GDP (s_g) corresponds to 13.9%. Both numbers are in line with US data at the end of 2019, just before the Covid-19 pandemic began. The steady state government budget constraint implies a ratio of tax revenues to GDP equal to 35% ($\eta_\tau = 0.35$).

4.3 The Baseline Scenario

Figure 2 shows the baseline scenario (solid black lines) for output (top-left panel), employment (top-right panel), year-over-year inflation (bottom-left panel), and the nominal interest rate (right panel) in the model. Output and employment are expressed in percent deviations from steady state. Inflation and the nominal interest rate are in annualized percentage points.[18]

The colored bars correspond to the contributions of the structural shocks in each quarter. We extract the shocks using the piecewise Kalman filter proposed by Giovannini et al. (2021), which allows for more shocks than observable variables, as is the case in our model.[19]

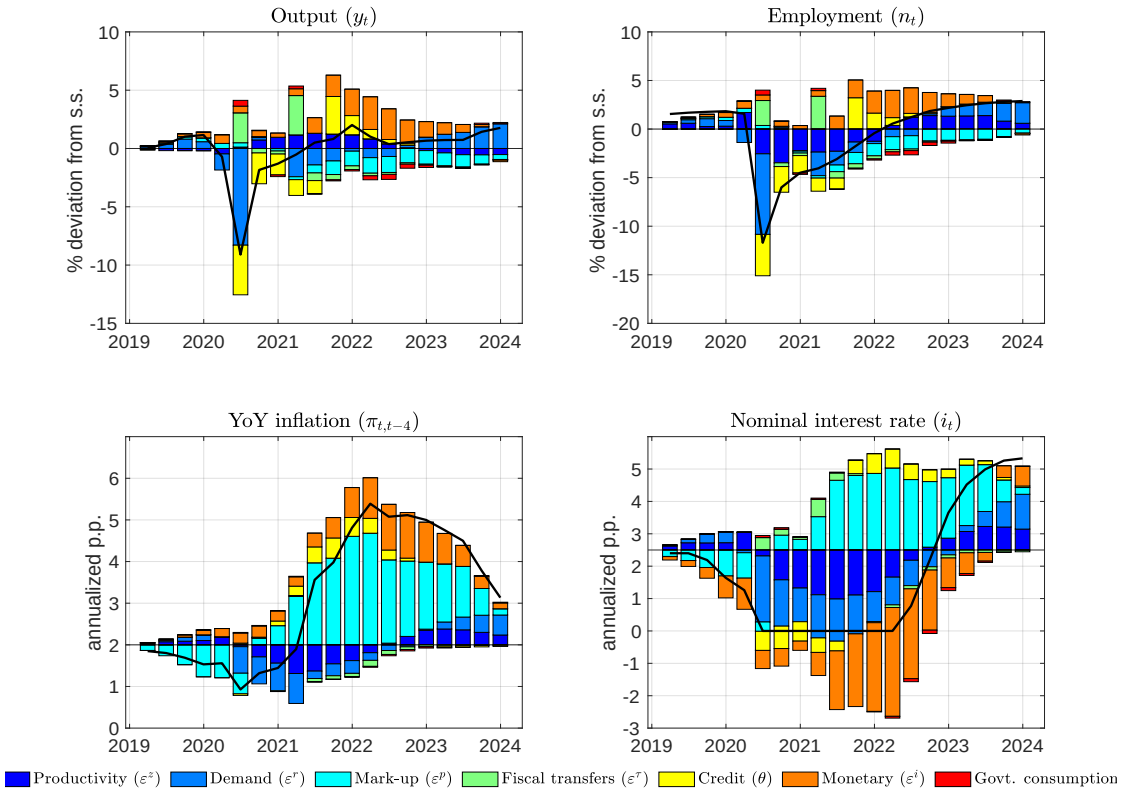
Shortly after the beginning of the pandemic, output falls by almost 9% but recovers relatively quickly (mid 2021). Employment declines at the same time as output but its fall exceeds 10% and remains below trend for longer, until the 2021. Inflation falls by about 1 percentage point by mid 2020, recovers to target

[17] In the model, we adjust per-capita debt ℓ by the share of borrowers ξ to ensure proper comparability with the data. The appendix describes how we use per-capita debt-to-GDP to back out χ_n, and a number of other steady-state variables.

[18] The observation equations for output and employment include trend growth of 2% and 1%, respectively. The figure for inflation adds an inflation target of 2% to the model, while our calibration implies that the level of the steady state nominal interest rate is 2.5%, which we also add back to the figure.

[19] While the inversion procedure also includes labor supply shocks, the smoother implies that their contribution to the observable variables is negligible.

Figure 2: Baseline scenario and shock decomposition.



NOTE: The solid black lines correspond to the baseline scenario for output (top-left panel), employment (top-right panel), year-over-year inflation (bottom-left panel) and the nominal interest rate (bottom-right panel). The colored bars (see the legend for details) correspond to the combination of exogenous shocks that, in each period, generate the simulated data.

by mid 2021 and then starts soaring. The nominal interest rate reaches the its lower bound in mid 2020 and remains there until the first quarter of 2022.

Demand and credit shocks (light blue and yellow bars, respectively) account for the bulk of the trough in output during the most acute phase of the pandemic. Monetary policy (orange bars) plays an important stimulatory role starting in the second half of 2021, essentially offsetting the demand headwinds. By then, credit shocks become a positive contributor to output dynamics. Towards the end of the sample, demand shocks keep output above trend, while the main negative contribution comes from markup shocks (turquoise bars).

The picture for employment is similar, with the key difference that productiv-

ity (dark blue bars) plays a bigger role both during the contraction, making the employment recovery slower than that of output, and during the boom at the end of the sample, when its contribution turns positive.

The shock decomposition for inflation is very stark. Initially, negative markup shocks drag inflation below target, with monetary policy only partially able to cushion the fall. From the second half of 2020, the contribution of markup shocks becomes positive and large. During this period, monetary policy shocks are the other key driver of inflation, while demand shocks only matter towards the end of the sample.

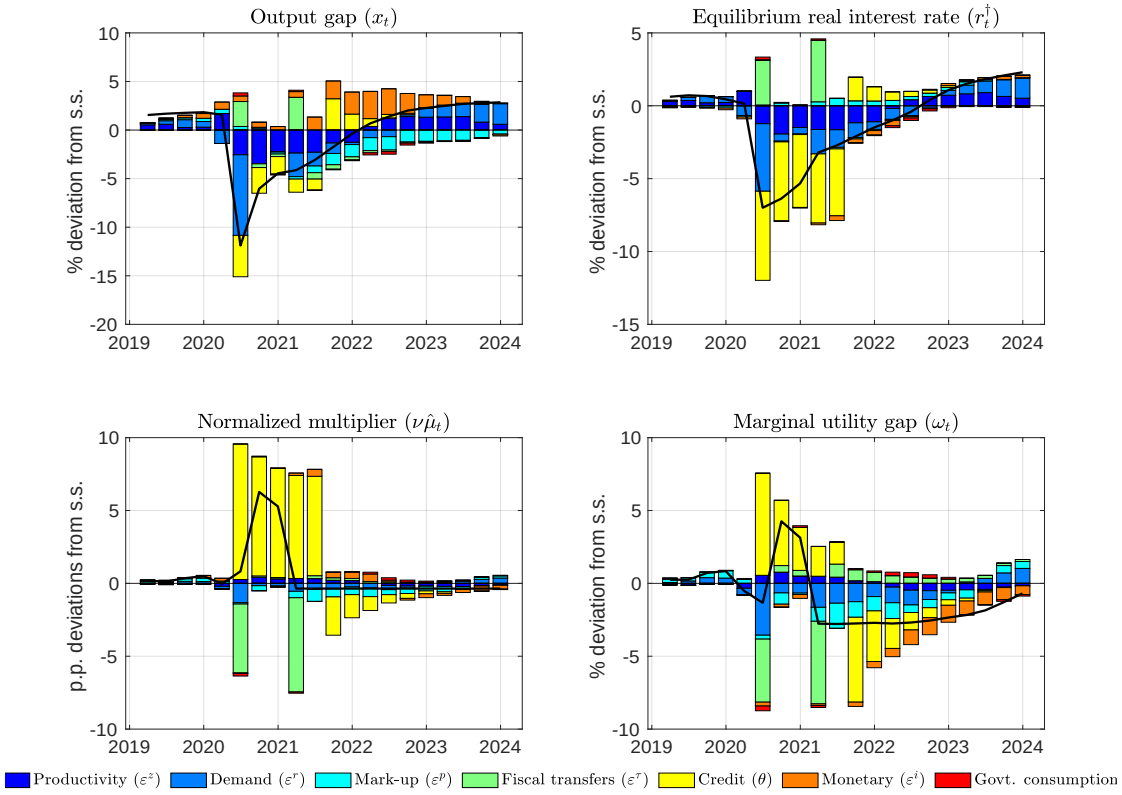
Markup shocks and monetary policy shocks account for the bulk of the decline in the interest rate. The fact that early in the sample monetary policy shocks represent a negative contribution to the path of the nominal interest rate suggests that the Fed was perhaps too slow in cutting the interest rate given output and inflation dynamics. Once the nominal rate reaches its lower bound, a combination of credit (early during the recession), productivity and especially demand shocks explain the data, with monetary policy shocks playing also an important role especially in the second half of 2021 and in 2022. Markup, and later demand, shocks drive the liftoff.

Figure 3 reports the implied dynamics and shock decomposition for four key unobservable variables: the output gap (top-left panel), the equilibrium real interest rate (top-right panel), the multiplier on the borrowing constraint (bottom-left panel) and the marginal utility gap (bottom-right panel).[20]

Because the smoother assigns a very small role to government spending shocks, equation (3) implies that productivity shocks are essentially the only driver of the efficient level of output. Given the linearity of the production function ($y_t = \varepsilon_t^z + n_t$) and our calibration for $\bar{\sigma}$ and φ (both equal to one), in our sample the model output gap approximately maps into observed employment ($x_t \approx n_t$). Therefore, the narrative for the historical decomposition of employment also applies to the output gap. Our model hence suggests an output gap in excess of -10% at the peak of the Covid recession. By 2022, output is back to its efficient level, while

[20] In the figure, for the sake of readability, we report the normalized multiplier $\nu\hat{\mu}_t = \mu_t - \mu$, which is equivalent to the deviation of μ_t from its steady state value. Accordingly, the units on the vertical axis are percentage point deviations from steady state.

Figure 3: Shock decomposition of four unobservable variables.



NOTE: The solid black lines correspond to the output gap (top-left panel), the equilibrium real interest rate (top-right panel), the (normalized) multiplier on the borrowing constraint (bottom-left panel) and the marginal utility gap (bottom-right panel) in the baseline scenario. The colored bars (see the legend for details) correspond to the combination of exogenous shocks that, in each period, generate the simulated data.

shocks to productivity and, especially, demand explain the boom in the latter part of the sample.

The equilibrium real interest rate shows an important contribution from credit shocks between mid-2020 and the second half of 2021, with demand and productivity shocks also playing a role. As expression (5) shows, the equilibrium real interest rate in our model is partly endogenous and depends on the evolution of the marginal utility of consumption, which is, in turn, driven by the multiplier on the borrowing constraint. When the constraint binds and the multiplier is positive, borrowers can access less credit than desired. While negative demand shocks induce some deleveraging, the exogenous credit contraction makes the borrowing

constraint bind for four quarters. As a consequence, the marginal utility gap increases (consumption of borrowers is suboptimally low relative to that of savers) and the equilibrium real interest rate collapses.

The last point that the shock decomposition makes clear is the role of fiscal policy. The fiscal transfers contribute to relax the tightness of the borrowing constraint by pushing in the opposite direction of negative credit shocks. The figure shows that the first installation of the fiscal transfers was not large enough to completely offset the impact of the credit crunch occurred in 2020. Conversely, the second deployment roughly undoes the contribution of the credit shock in early 2021.

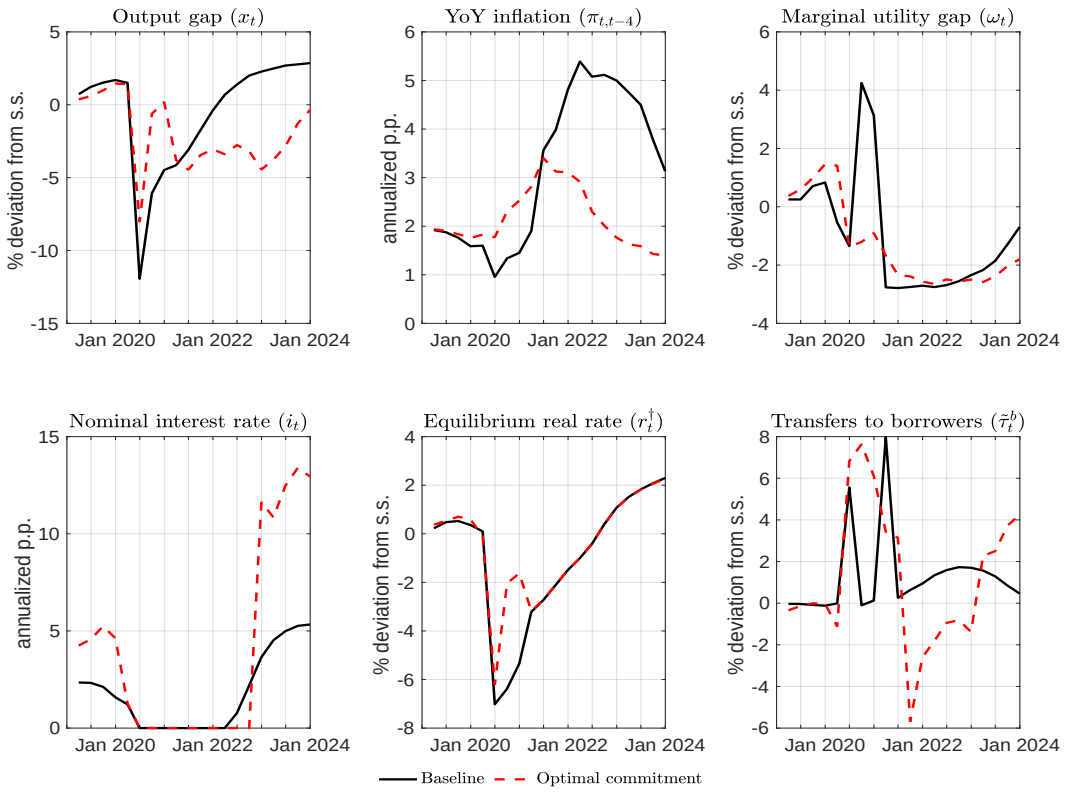
4.3.1 Optimal Commitment Policy in the Baseline Scenario

This section compares the baseline scenario with the macroeconomic outcomes under the optimal joint fiscal and monetary policy plan. The policymaker operates under commitment and sets the nominal interest rate i_t and the tax rates $\tilde{\tau}_t^b$ and $\tilde{\tau}_t^s$ to minimize the welfare-based loss function (2) derived in Section 3.1, subject to the zero lower bound ($i_t \geq 0$). In addition, the solution must be such that borrowers respect the constraint $\ell_t \leq \theta_t$.

Figure 4 shows the results of the optimal policy simulation. The solid black lines show the baseline scenario while the dashed red lines show the optimal commitment policy. Optimal policy manages to reduce the severity of the recession by about a quarter and its duration by one year. During this period, inflation remains roughly stable. Its lowest point is only about 25 basis points below target. The marginal utility gap turns from positive to negative at the time of the negative shock. Thus, optimal policy transfers consumption from savers to borrowers when the recession starts. The fall of the marginal utility gap limits the fall of the equilibrium real interest rate, which simplifies the job of monetary policy in stabilizing aggregate demand.

The policymaker achieves this outcome with a combination of a commitment to keep the nominal interest rates at zero for longer than in the baseline scenario and more generous and persistent fiscal transfers. In particular, the nominal interest rate remains at zero for three additional quarters relative to the baseline, while the

Figure 4: Optimal commitment policy against the baseline scenario.



NOTE: The solid black lines correspond to the output gap (top-left panel), year-over-year inflation (top-center panel), the marginal utility gap (top-right panel), the nominal interest rate (bottom-left panel), the equilibrium real interest rate (bottom-center panel) and transfers to borrowers (bottom-right panel) in the baseline scenario. The dashed red lines are the same variables under the optimal commitment (joint fiscal and monetary) policy.

transfers to borrowers are bigger on impact and stay in place for longer, although declining over time.

As discussed in the previous section, the model suggests that transfers in the CARES Act were not sufficient to fully offset the tightening of financial conditions so that the borrowing constraint becomes binding and the marginal utility gap spikes. Conversely, the transfers under optimal policy relax the borrowing constraint so that the marginal utility gap actually falls.

When markup shocks start exerting upward pressures on inflation, the optimal policy plan is already in the process of reducing transfers, in sharp contrast with the second wave in the American Rescue Plan Act. Therefore, the profile of fiscal

policy observed in practice appears highly suboptimal when observed through the lens of the model.

Perhaps the most striking feature of the optimal policy plan is the limited increase in inflation compared to the baseline at the expenses of a double-dip recession. Under optimal policy, year-over-year inflation peaks at 3.4% in 2021Q2 and is back to target by the end of 2022, while in the baseline scenario the increase continues for another year to reach 5.4% and inflation remains well above target into 2024. The commitment to increase interest rates sharply after the liftoff plays a key role in stabilizing inflation. While the extreme rise in interest rates largely reflects the stylized formulation of the model, the experiment powerfully illustrates the tension between the commitment to keep the interest at zero during a deep, albeit short-lived, recession and the need for an aggressive tightening when large and persistent tradeoff-inducing shocks materialize.

4.3.2 Optimal Commitment Policy with an Ad-Hoc Loss Function

Under the optimal commitment policy, the contractionary fiscal and monetary stance after the end of the most acute phase of the pandemic pushes the economy in a prolonged slump, which represents the unavoidable cost of lower inflation and a less unequal distribution of consumption than in the baseline scenario. Key to this result is the disproportionate weight that the welfare-based loss function attaches to the volatility of inflation relative to the other variables.[21]

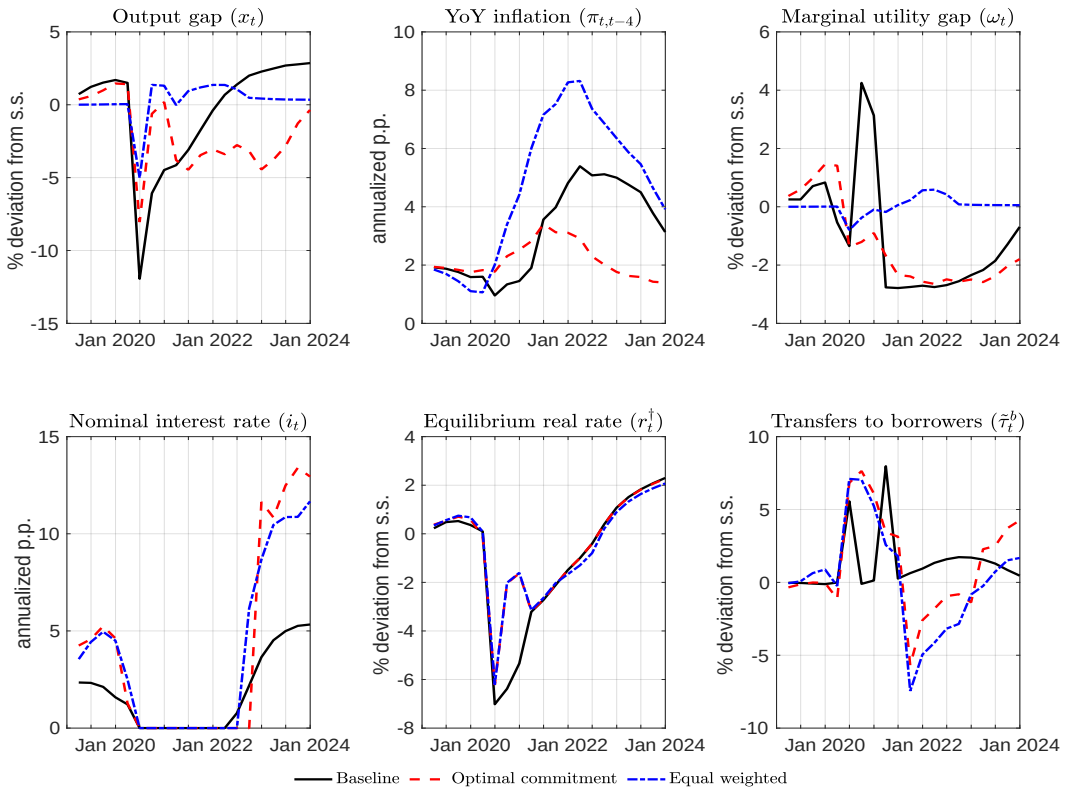
Figure 5 compares the baseline scenario with the fully optimal joint fiscal and monetary policy plan and with the macroeconomic outcomes when the policymaker seeks to minimize the present discounted value of the modified per-period loss function

$$\widetilde{\mathcal{L}}_t = -(x_t^2 + \pi_t^2 + \omega_t^2).$$

Differently from its model-consistent counterpart, this formulation arbitrarily assigns the same relative weight to the stabilization of the output gap, inflation and the marginal utility gap. The objective of this exercise is not to argue that, in

[21] Under our calibration, the weight on inflation in the loss function is more than two and three orders of magnitude bigger than that on the output gap and the marginal utility gap, respectively.

Figure 5: Optimal commitment policy with an ad-hoc loss function.



NOTE: The solid black lines correspond to the output gap (top-left panel), year-over-year inflation (top-right panel), the marginal utility gap (bottom-left panel) and the nominal interest rate (bottom-right panel) in the baseline scenario. The dashed red and dashed-dotted blue lines are the same variables under the optimal commitment (joint fiscal and monetary) policy with the model-based and ad-hoc loss function, respectively.

practice, policymakers weigthed real activity, inflation and distributional concerns equally. Rather, we aim to provide an illustrative example of how macroeconomic outcomes would change in a simple and transparent alternative.

With equally weighted targets, the pandemic would have caused a smaller recession (dashed-dotted blue line, top-left panel) than the one the US experienced in 2020 by more than a half, thus even less severe than under optimal policy with the model-consistent loss function (dashed red line). In addition, output would have been back to trend by 2020Q3 and experienced a long period of relative stability afterwards. The volatility of the marginal utility gap would have also been significantly smaller (top-right panel), not only than in the baseline scenario

(solid black line) but also than under optimal policy with the model-consistent loss function.

The key difference with optimal policy under the model-based welfare function concerns the dynamics of inflation (top-center panel). With equal weights on the welfare targets, inflation would have first fallen more at the early stages of the pandemic and then been significantly higher than in practice, exceeding 8 percentage points in early 2022. Thus, its peak would have been more than twice as much than in the case of optimal policy with the model-consistent loss function. The nominal interest rate (bottom-left panel) would have been at zero for only one additional quarter compared to the baseline. Its maximum level would have still been very high, as with the model-consistent loss function, but a policymaker that attaches equal weight to the output gap, inflation and the marginal utility gap would have hiked more progressively over the course of a year as opposed to abruptly in one quarter.

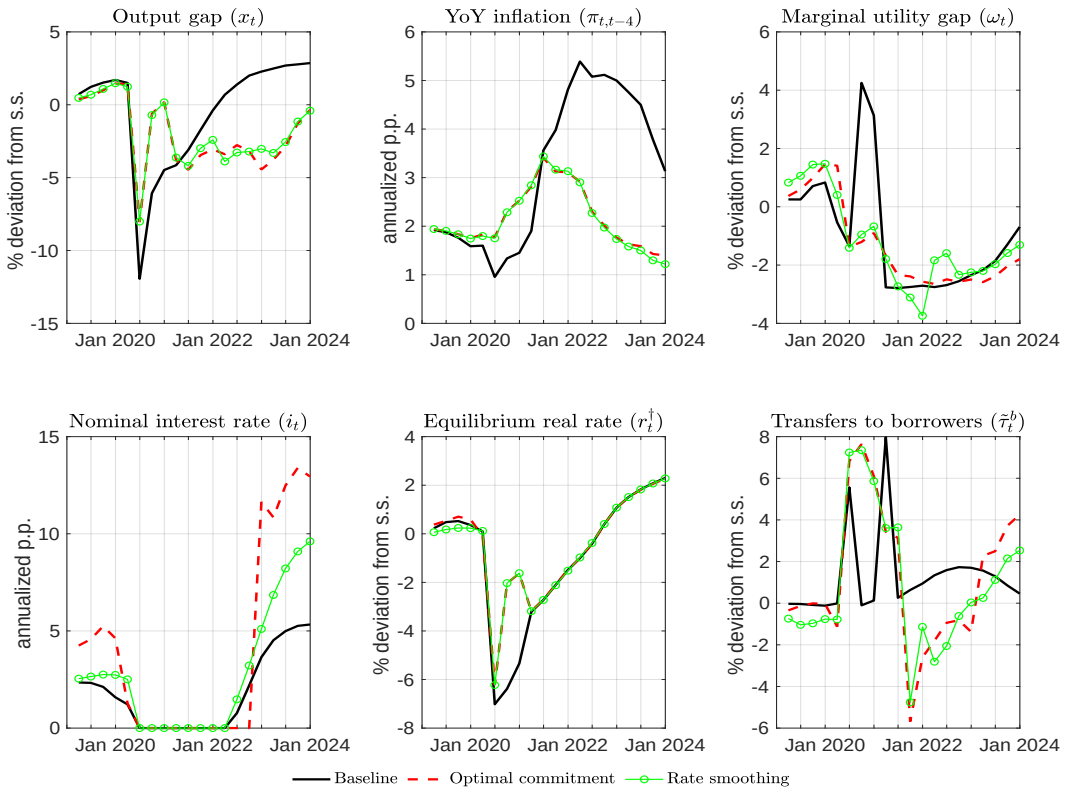
The profile of fiscal transfers (bottom-right panel) is not very different between the two optimal commitment cases, especially during the recession. If anything, transfers are less generous during the boom, highlighting that the monetary policy stance is indeed responsible for the different macroeconomic outcomes. Furthermore, the similarity of the fiscal stance across the two optimal policy configurations also reinforces the earlier point about the size and time profile of the transfers under optimal policy and in practice, with the first round not being large and persistent enough and the second not being necessary.

4.3.3 Interest Rate Smoothing

The other defining feature of the optimal commitment policy, besides the relative volatility of inflation and the output gap, is the sharp rise of the policy rate after the monetary stimulus ends. In practice, such an increase may be unrealistic given the potential consequences on financial market stability, which the model does not take into account.

In order to assess the robustness of the optimal policy message to this limitation of the model, we consider another modification of the loss function, in which the policymaker also penalizes changes in interest rates. Specifically, in this

Figure 6: Optimal commitment policy with interest rate smoothing.



NOTE: The solid black lines correspond to the output gap (top-left panel), year-over-year inflation (top-right panel), the marginal utility gap (bottom-left panel) and the nominal interest rate (bottom-right panel) in the baseline scenario. The dashed red and green lines with circles are the same variables under the optimal commitment (joint fiscal and monetary) policy with the model-based loss function and a loss function with interest rate smoothing, respectively.

configuration, the per-period loss function becomes

$$\overline{\mathcal{L}}_t = -[x_t^2 + \lambda_\pi \pi_t^2 + \lambda_\omega \omega_t^2 + \lambda_i (i_t - i_{t-1})], \tag{14}$$

where λ_π and λ_ω correspond to the model-based welfare weights.

Figure 6 compares the baseline scenario with the fully optimal joint fiscal and monetary policy plan and with the macroeconomic outcomes when the policymaker seeks to minimize the present discounted value of (14). In the simulation, we set $\lambda_i = 0.1 \times \lambda_\pi$, which is within the range of values considered in Woodford (2003b).

The overarching message of this exercise is that the presence of a motive for smoothing interest rates in the loss function does not significantly alter the evolution of the output gap and inflation during the recession and the subsequent energy crisis relative to their path under the fully optimal joint fiscal and monetary policy plan. The exact deployment of fiscal transfers after the pandemic is slightly different, yet their overall profile is also broadly similar in the two cases.

The key difference in the two optimal policy configurations concerns the nominal interest rate. Both at the onset of the recession and upon exiting the lower bound, the path for the nominal interest rate with a motive for smoothing is much closer to the baseline than under the fully optimal plan. When the policymaker seeks to minimize the present discounted value of (14), the duration of the ZLB becomes the same as in the data and the increases during the first year after the liftoff are also similar. Only starting in 2023 the two begin to diverge, with the interest rate under optimal policy reaching 10 percentage points even in the presence of smoothing. Therefore, the conclusion that interest rate should have increased more significantly remains valid even in the case of smoothing, although the overall profile of the interest rate is closer to the one observed in practice.

5 Conclusion

This paper has studied the joint optimal fiscal and monetary policy stabilization plan in response to large macroeconomic shocks. Our framework allows for the possibility of occasionally binding constraints on the nominal interest rate and on households' borrowing.

We show analytically that, aside from the lower bound on the nominal interest rate, the monetary policy tradeoff remains unchanged compared to the baseline model. The key policy objective for the fiscal authority is to engineer transfers that can relax the borrowing constraint and thus mitigate the inequality in consumption between borrowers and savers. Once the borrowing constraint goes slack, however, transfers cease to be effective and fiscal policy loses its bite.

Our simulations suggest that a more aggressive and persistent fiscal response during the Covid-19 recession, combined with a longer period of monetary accommodation, would have significantly reduced the severity and duration of the

downturn. In order to avoid the inflationary pressures of the post-pandemic period, the optimal policy plan requires an extremely aggressive tightening upon exiting the zero bound that causes a prolonged slump in economic activity. An experiment with an ad-hoc loss function illustrates how the relative weights placed on inflation and the output gap drive the tradeoff between those two variables.

On the fiscal front, the sequence of transfers observed in practice appear to be highly suboptimal. Through the lens of the model, the first deployment should have been significantly more generous and persistent to mitigate the financial headwinds, while the second deployment looks unnecessary.

Overall, our findings highlight the critical role of both monetary and fiscal policies in mitigating economic downturns and stabilizing inflation dynamics. Our framework delivers a stark separation result. Monetary policy should focus on managing the aggregate output-inflation tradeoff while fiscal policy should target distributional inefficiencies. Yet, the two policy realms are not in a complete vacuum, since the inequality between borrowers and savers affects the dynamics of the equilibrium real interest rate, which represents a key object for aggregate demand management. Introducing additional elements to allow for a richer interaction between fiscal and monetary policy represents an exciting avenues for research to enhance our understanding of the policy tradeoffs involved in managing large economic shocks.

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