Government Debt and Expectations-Driven Liquidity Traps*

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The presence of an effective lower bound on the nominal interest rate creates a risk that expectations of low inflation become entrenched. When this happens, distortionary taxation and expansionary fiscal policies may result in a large accumulation of debt that spurs inflation when the lower bound ceases to bind. The corresponding increase in expected real interest rates then further depresses consumption and output. In light of this outcome, the welfare-maximizing strategy in an expectations-driven liquidity trap is to downsize the government by concurrently cutting taxes and spending. This policy achieves the twin objective of stimulating the economy while containing the debt accumulation.

JEL Codes: E43, E52, E62, E63.

1. Introduction

The low rate environment observed since the Great Recession and until recently has reduced the cost of debt-financed fiscal stimuli. This opportunity has been exploited extensively by the U.S. government, with the ratio of privately held government debt over GDP ballooning to unprecedented levels. Conventional wisdom is that spending policies have large multiplicative effects in a liquidity trap because they alleviate the shortfall in inflation and reduce real rates. This insight concerns liquidity traps that are caused by large contractionary shocks on private demand. However, the long

duration of binding lower-bound episodes experienced in advanced economies suggests a potential shift in expectations. In this context, central banks have increasingly acknowledged the risk of low inflation expectations becoming entrenched because of the asymmetric response of interest rates to inflation.[1] While monetary policy can in principle curb inflation by tightening its stance, the presence of an effective lower bound on the policy rate renders the task of anchoring inflation expectations a more delicate one.

Hence, it is crucial to understand the implications of accumulating government debt in a liquidity trap caused by negative feedback loops on expectations. This paper seeks to answer this question based on a New Keynesian model in which occasional shifts in households' confidence lead to a stationary environment characterized by deflation and depressed output even in the absence of a deterioration in economic fundamentals. I label this environment the *unintended* regime as opposed to the *intended* regime where inflation is anchored at the central bank's target and the output gap is zero, and study the macroeconomic implications of a *regime shock* that causes switches from one regime to the other. I show that those dynamics have important consequences for deficit-financed fiscal stimuli when taxes are confined to labor income. More specifically, I consider a deficit-financed and *perfectly timed* exogenous spending increase and tax cut when government debt is stabilized through an endogenous response of labor taxes to the inherited level of debt. There are three main insights stemming from this analysis.

First, the unavailability of lump-sum taxes causes a negative shift in confidence to weigh more heavily on economic activity. The inflation shortfall in the unintended regime raises the real cost of debt while subdued consumption shrinks the tax base. Hence, the government accumulates debt in the unintended regime that spurs inflation once the lower bound stops binding through the cost-push effect of endogenous labor taxes. The ensuing monetary policy tightening increases real interest rates so that the intertemporal consumption smoothing of the households crowds out consumption in the unintended regime. I label the crowding-out effect of debt *the expectation*

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[1]In its 2020 strategic review, the Federal Reserve emphasized the importance of staying ahead of the inflation curve to avoid sliding inflation expectations.

channel and show that this channel offsets most of the upward pressure of endogenous taxes on the marginal costs of the firms in the unintended regime.

Second, standard fiscal stimuli are self-defeating in an expectations-driven liquidity trap; an expansionary fiscal policy leads to a net drop in output. Moreover, the effects are qualitatively different whether the policy consists in a spending stimulus or a tax cut. To understand this result, I study a simplified economy without debt and show that the inflation response to fiscal policy depends on the anticipated impact of price setting on firms' markup. An exogenous spending stimulus (tax cut) is deflationary (inflationary) because the long expected duration of the lower-bound episode implies that the price markup is decreasing in inflation. The deflationary effect of the spending stimulus causes the government to accumulate more debt in the liquidity trap to compensate for the increase in the real cost of its liabilities. Hence, endogenous labor taxes increase in the intended regime and monetary policy tightens in response to the cost-push effect, crowding out consumption through the expectation channel. By contrast, debt soars less with a tax cut because the rise in inflation reduces the real cost of debt and widens the tax base. Nevertheless, the crowding-out effect of the expectation channel dominates the crowding-in effect of lower real rates in the unintended regime and results in a negative net effect on output, albeit lower than the one of the spending stimulus. I show also that the recessionary effects of deficit-financed fiscal policies may be overturned if the duration of the policy intervention in the unintended regime is reduced, consistently with the findings of Wieland (2018).

Third, an analysis on optimized rules reveals that the welfare-maximizing policy consists in a reduction of the size of the state; the government should provide a significant tax cut combined with a spending cut. On the one hand, the tax cut allows to mitigate the inflation shortfall in the unintended regime. On the other hand, the spending cut reinforces this inflationary effect while slowing down the accumulation of debt. Exiting the liquidity trap with a lower debt burden is effective in stimulating consumption of forward-looking households because it reduces the cost-push effect of labor taxes and the expected real rates. Those benefits are also attested by the positive output effect of a faster debt consolidation in the tax rule.

The interactions between fiscal and monetary policy in a low rate environment have received considerable attention in the New Keynesian literature. Influential studies such as Christiano, Eichenbaum, and Rebelo (2011), Woodford (2011), and Erceg and Lindé (2014) have shown that the fiscal multiplier of government spending policies can be large in a liquidity trap driven by fundamental shocks because they create inflation and reduce the real rates.[2] Moreover, in the presence of distortionary taxes on labor income, financing the stimulus with bonds issuance turns out mostly innocuous because the enlargement of the tax base (partially) offsets the additional debt burden. Unsurprisingly, Burgert and Schmidt (2014) also find that deficit-financed stimuli constitute the optimal policy for a discretionary planner when dealing with large contractionary demand shocks. While those results build a solid case for an expansionary fiscal policy in a fundamental-driven liquidity trap, it remains unclear how they would extend to a liquidity trap driven by shifts in consumers' confidence.

Several papers have studied the characteristics of expectations-driven liquidity traps in a New Keynesian framework. The closest to this paper is Mertens and Ravn (2014), who study the effect of fiscal policy in a stationary environment characterized by deflation and depressed output. However, differently from this paper, their model is non-linear and they assume that lump-sum taxes balance the budget constraint of the government every period. Hence, Ricardian equivalence holds in their model and financing fiscal stimuli with debt or taxes does not affect other macroeconomic variables. More generally, the literature about expectations-driven liquidity traps can be divided into two strands. One strand studies the macroeconomic outcomes in this type of environment. For example, Borağan Aruoba, Cuba-Borda, and Schorfheide (2018) estimate a model subject to both fundamental- and expectations-driven liquidity traps and find that the former corresponds more to the U.S. experience while the latter can describe the Japan economy since the late 1990s. Schmitt-Grohé and Uribe (2017) show that adding job market frictions can help this kind of model in explaining jobless recoveries. Jarociński and Maćkowiak (2018) combine those insights with the

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[2]In particular, see Appendix B of Christiano, Eichenbaum, and Rebelo (2011) for the case of distortionary taxation most closely related to this paper.

literature on self-fulfilling debt crises to demonstrate the efficacy of mutualized debt in avoiding bad economic outcomes. Nakata and Schmidt (2022) show that traditional ingredients of optimal fiscal and monetary policy are largely powerless in stabilizing the economy when the liquidity trap is non-fundamental. The second strand of this literature studies how to suppress the existence of this type of liquidity traps altogether. Building on the insights of Benhabib, Schmitt-Grohé, and Uribe (2002), those papers have mainly focused on the design of ad hoc rules in achieving this outcome as in Sugo and Ueda (2008), Schmidt (2016), and Tamanyu (2022).

The remainder of the paper is organized as follows. Section 2 describes the model and the existence of expectations-driven liquidity traps. Section 3 provides a simplified example of an economy without debt to clarify the plain-vanilla effects of fiscal policy. Section 4 contains the main analysis on the role of debt in the expectations-driven liquidity trap. After discussing the equilibrium responses to fiscal policy, this section inspects the importance of the expectation channel as a driver of macroeconomic dynamics in the unintended regime. Section 5 considers optimized rules to identify the best fiscal strategy and extends the results of the previous section to recurrent regime shocks. Finally, Section 6 concludes.

2.   The Model

The model is a cashless New Keynesian economy with monopolistic competition and nominal rigidities. The private sector is composed of an infinitely lived representative household, a representative aggregate good producer, and a continuum of intermediate good producers. The public sector is represented by two institutions, a central bank and a government respectively in charge of monetary and fiscal policy decisions.

2.1   Households and Firms

The representative household derives utility from consuming the private good c_t and the public good G_t while it dislikes hours worked

h_t. I assume a separable utility function leading to the following expected lifetime utility:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \xi_t \left[\frac{c_t^{1-\gamma_c}}{1-\gamma_c} + \nu_g \frac{G_t^{1-\gamma_g}}{1-\gamma_g} - \nu_h \frac{h_t^{1+\gamma_h}}{1+\gamma_h} \right], \qquad (1)$$

where $\mathbb{E}_t$ is the rational expectations operator conditional on information in period t; β is the time discount factor. Parameters γ_c and γ_g are respectively the intertemporal elasticity for private and government consumption, and γ_h is the inverse of the Frisch elasticity. I also attach utility weights ν_g and ν_h to characterize preference for government consumption and hours, relative to private consumption.

The variable ξ_t is an exogenous process characterizing the time preference. Under this specification, time preference between states of two consecutive periods evolves according to $\xi_t/(\beta\xi_{t+1})$. This process characterizes the fluctuations at the origin of *fundamental-driven* liquidity traps (FDLT). Hence, I introduce the variable $d_t \equiv \xi_{t+1}/\xi_t$, which I refer to as a demand shock.

The household sells hours to intermediate firms for a wage W_t net of labor taxes τ_t and may save via a one-period nominal and non-state-contingent real government bond, b_t^h. Firm profits yield a dividend $\Pi_{i,t}$, and constant lump-sum transfers T are collected from the government to finance the steady-state employment subsidy (see intermediate firms' optimization problem below). The household budget constraint (in real terms) reads

$$c_t + \frac{b_t^h}{R_t} = (1-\tau_t)w_t h_t + \frac{b_{t-1}^h}{\pi_t} + \int_0^1 \frac{\Pi_{i,t}}{P_t} di - \frac{T}{P_t}, \qquad (2)$$

where R_t is the gross nominal interest rate, P_t is the price of consumption goods, and $\pi_t = P_t/P_{t-1}$ is the gross inflation rate. The household chooses $\{c_t, h_t, b_t^h\}_{t=0}^{\infty}$ to maximize expected lifetime utility (1) subject to (2) and the no-Ponzi scheme conditions on the nominal asset

$$\lim_{j \to \infty} \mathbb{E}_t \left(\left(\prod_{k=0}^{t+j} \frac{1}{R_k} \right) B_{t+j}^h \right) \geqslant 0.$$

Intermediate firms operate under monopolistic competition and seek to maximize profits subject to quadratic price adjustment costs

à la Rotemberg (1982). From the profit-maximization problem of the final producer, the demand function of the generic firm producing i is given by

$$y_{i,t} = \left(\frac{P_{i,t}}{P_t}\right)^{-\theta} y_t, \tag{3}$$

where θ is the marginal rate of substitution between varieties. The program of the firm i is

$$\max_{P_{i,t}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \xi_t \lambda_t$$

$$\times \left[\left(\frac{P_{i,t}}{P_t}\right)^{-\theta} y_t \left(\frac{P_{i,t}}{P_t} - (1-s)w_t\right) - \frac{\psi}{2}\left(\frac{P_{i,t}}{P_{i,t-1}} - 1\right)^2 y_t \right], \tag{4}$$

where λ_t is the multiplier of budget constraint from the household problem and ψ is the price adjustment cost factor.

Parameter s is a time-invariant employment subsidy, financed with lump-sum transfers, that offsets steady-state distortions stemming from monopolistic competition and distortionary taxation.[3] This subsidy is used in Section 5 on optimized rules to guarantee the efficiency of the economy at the steady state and derive the social loss function.

2.2 Log-Linear Approximation

The non-linear equilibrium equations are log-linearized around the zero inflation steady state.[4] In the benchmark model, the subsidy is set to zero ($s = 0$) and the steady state is distorted. The system of linear equations characterizing the private-sector decisions reads

$$\beta \tilde{b}_t - \tilde{b}_{t-1} - b(\beta \hat{\imath}_t - \hat{\pi}_t) - \Psi_G^b \hat{G}_t + \Psi_c^b \hat{c}_t + \Psi_\tau^b \tilde{\tau}_t = 0 \quad \text{(BC)} \tag{5}$$

$$\hat{c}_t = -\gamma_c^{-1}(\hat{\imath}_t - \mathbb{E}_t \hat{\pi}_{t+1} - \hat{d}_t) + \mathbb{E}_t \hat{c}_{t+1} = 0 \quad \text{(EE)} \tag{6}$$

$$\hat{\pi}_t = \beta \mathbb{E}_t \hat{\pi}_{t+1} - (\theta - 1)\psi^{-1}\hat{\mu}_t \quad \text{(PC),} \tag{7}$$

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[3]This implies that distortions from labor taxation do occur outside the steady state. See Leith and Wren-Lewis (2013) for a similar use of a steady-state subsidy.

[4]A description of the non-linear economy and the efficient steady state can be found in Appendix A.1 and Appendix A.3, respectively.

where the price markup of the firms is given by

$$\hat{\mu}_t = -\Psi_c^\mu \hat{c}_t - \Psi_G^\mu \hat{G}_t - \Psi_\tau^\mu \tilde{\tau}_t. \tag{8}$$

All variables are in log-deviations from their steady-state value, except for government debt ($\tilde{b}_t \equiv b_t - b$) and the tax rate ($\tilde{\tau}_t \equiv \tau_t - \tau$), which are expressed in deviations from their steady-state value.[5] The coefficients are defined as

$$\begin{aligned}
\Psi_G^b &\equiv 1 - \tau wy(1+\gamma_h)y^{-1}G & \Psi_G^\mu &\equiv \gamma_h y^{-1}G \\
\Psi_c^b &\equiv \tau wy(\gamma_c + (1+\gamma_h)y^{-1}c) & \Psi_c^\mu &\equiv \gamma_c + \gamma_h y^{-1}c \\
\Psi_\tau^b &\equiv wy(1-\tau)^{-1} & \Psi_\tau^\mu &\equiv (1-\tau)^{-1}.
\end{aligned}$$

The first equation is the budget constraint (BC) of the government. It states that the net nominal debt position must be financed with an appropriate surplus (or deficit). The government surplus depends positively on inflation and taxes (which include both the tax base and the tax rate) and negatively on interest rates and spending. The law of motion for debt is a constraint in my model because government liabilities are ultimately financed with distortionary taxes on labor income. The second equation is the Euler equation (EE) that links the real rate of return on assets to the intertemporal trade-off of the households. The third equation is the Phillips curve (PC) at the heart of the New Keynesian model that establishes a negative relationship between inflation and the infinite discounted stream of expected price markups.[6] Notice that the price markup of the firms (8) is decreasing in the fiscal instruments. An exogenous increase in government spending and/or in the labor tax rate creates excess demand in the labor market that pushes up the real wage and thus reduces the price markup.

2.3 Public Policy

In this paper, I consider the standard case of a monetary policy following a Taylor rule that responds to inflation deviations from target:

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[5] Under baseline calibration, $y = 0.25$ and so $\tilde{b}_t$ can be interpreted as debt deviations in percentage of annual steady-state output.

[6] To see this, substitute forward (7) recursively to obtain $\hat{\pi}_t = -(\theta-1)\psi^{-1}\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \hat{\mu}_{t+j}$.

$$\hat{i}_t = max[-log(\beta^{-1}), \phi_\pi \hat{\pi}_t]. \tag{9}$$

The max operator implies that monetary policy is constrained by an effective lower bound (ELB) on the nominal interest rate.

With regard to fiscal policy, I assume realistically that only distorting income taxes are available to the government and, hence, its solvency condition becomes binding. More specifically, tax variations have two components: an endogenous component that reacts to inherited government debt and an exogenous component that is independent of debt. The labor tax rule reads

$$\tilde{\tau}_t = \phi_\tau \tilde{b}_{t-1} + \epsilon_{\tau,t}, \tag{10}$$

where $\epsilon_{\tau,t}$ governs the tax stimulus and is contingent to the state of the economy.

2.4   Calibration

Numerical experiments in this paper are performed under the following calibration. A time period represents one-quarter of a year. The preference parameters, ν_g and ν_h, are chosen to be consistent with households working one-quarter of their time endowment and with a share of government spending equating one-fifth of output. The annual interest rate in the intended steady state is set to 2.5 percent and pins down the time discount factor, β. The parameters of the Phillips curve are standard to the literature. The intertemporal elasticity of private and public consumption, and the inverse of the Frisch elasticity, are equal to 1. The elasticity of substitution between intermediate goods, θ, corresponds to a price markup over the marginal cost of 10 percent. Given the value of θ, the parameter of the price adjustment cost, ψ, matches its Calvo (1983) equivalent (up to a first-order approximation around the deterministic steady state) when the average duration for setting prices equals one year.

Regarding public policy, I assume that the Taylor parameter is $\phi_\pi = 1.5$, a standard value in the literature. As a baseline calibration of the tax rule (10), I choose $\phi_\tau = 0.1$, implying that a 10 percentage point increase in the debt-to-output ratio lifts the labor tax rate by 1 percentage point. This calibration ensures medium-run fiscal solvency and makes fiscal policy passive in the sense of Leeper

Table 1. Baseline Calibration

Symbol	Description	Value
β	Subjective Discount Factor	0.9938
θ	Elasticity of Substitution among Goods	11
ϵ	Price Adjustment Cost	117.805
γ_c	Intertemporal Elasticity of c	1
γ_h	Intertemporal Elasticity of h	1
υ_h	Utility Weight on Labor	20
ϕ_π	Inflation Parameter in Taylor Rule	1.5
ϕ_τ	Tax Parameter in Fiscal Rule	0.1
βb	Steady-State Market Value of Debt (%)	50

(1991). Since the pace of debt consolidation is potentially influential for the macroeconomic dynamics, I investigate the sensitivity of the results when varying this parameter in Appendix E.2. Moreover, for the numerical exercises precluding the use of lump-sum taxes, I need to choose a steady-state value of government debt. Baseline calibration assumes that the market value of debt amounts to 50 percent of annual GDP, a value that is roughly consistent with the average debt ratio observed in the United States since the Great Recession (and before the COVID-19 crisis) according to the data of the Federal Reserve Economic Database (FRED) of the Federal Reserve Bank of St. Louis. The parameter values are summarized in Table 1. Finally, the baseline fiscal interventions are calibrated as follows (unless otherwise specified). The spending expansion corresponds to a 1 percentage point increase in the spending-to-output ratio from 20 percent to 21 percent ($\hat{G}^u = 0.0488$). The tax cut corresponds to a 1 percentage point decrease in the labor tax rate ($\epsilon_\tau^u = -0.01$).

2.5   Expectations-Driven Liquidity Traps

As first demonstrated by Benhabib, Schmitt-Grohé, and Uribe (2001), non-linear monetary policy rules such as (9) imply the existence of a stationary environment characterized by depressed inflation and consumption and a nominal rate that is constrained by the ELB. In what follows, I label this environment the *unintended* regime as opposed to the *intended* regime in which inflation is on target and the ELB does not bind. The unintended regime is often seen

(Arifovic, Schmitt-Grohé, and Uribe 2018; Tamanyu 2022) as resulting from self-fulfilling pessimism. For a reason that is left unspecified, rational agents begin to anticipate a negative economic outlook and reduce their demand for consumption goods. The central bank wants to alleviate the drop in inflation by cutting the nominal rate, but the ELB prevents the response to be sufficiently accomodative. This constrained policy response causes the initial pessimistic expectations to realize and the economy ends up trapped in a low inflation equilibrium. Consistently with this intuition, the unintended regime is often called an *expectations-driven liquidity trap* (EDLT). I use those two terms interchangeably. Before studying the implications of debt in this environment, I provide a simplified example in which lump-sum taxes balance the budget constraint every period to gain intuition about the effect of fiscal policy on inflation.

3.   Fiscal Policy with Lump-Sum Taxes

As we will see, an important driver of government debt dynamics and of macroeconomic outcomes is the response of inflation to a particular fiscal policy. To illustrate this inflationary effect, I start with a simplified economy in which lump-sum taxes are available and so the government budget constraint does not bind. Let's assume that the intended regime is absorbing and denote by p_u the probability of remaining in the unintended regime. In this case, Appendix B shows that inflation in the unintended regime can be written as
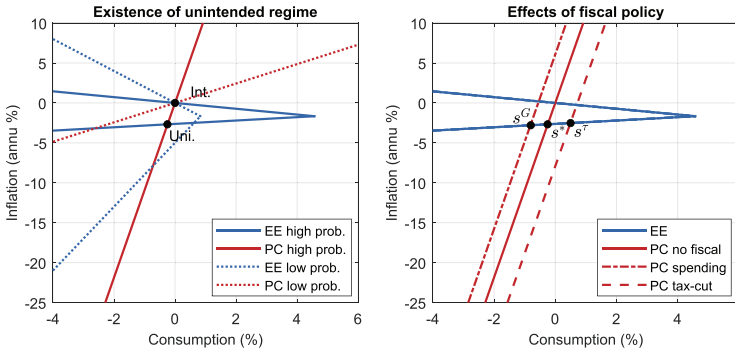
$$\hat{\pi}_t^u = \Lambda^{-1}\left[-\hat{\imath}^* - \frac{\kappa_G}{\overline{\kappa}_c}(1 - p_u)\hat{G}^u - \frac{\kappa_\tau}{\overline{\kappa}_c}(1 - p_u)\tilde{\tau}^u\right], \qquad (11)$$

where $\Lambda \equiv p_u - \frac{(1-p_u)}{\overline{\kappa}_c} + \frac{\beta p_u}{\overline{\kappa}_c}(1 - p_u)$ and $\kappa_G \equiv \frac{\gamma_h(\theta-1)}{\psi}Gy^{-1}$, $\kappa_\tau \equiv \frac{(\theta-1)}{(1-\tau)\psi}$, $\overline{\kappa}_c \equiv \frac{\gamma_c(\theta-1)}{\psi} + \frac{\gamma_h(\theta-1)}{\psi}cy^{-1}$.

Parameter Λ has two roots: $p_u^* = 0.68 < 1$ and $p_u^{*\prime} = 1.48 > 1$. Thus, for a bounded probability of remaining in the unintended regime $0 < p_u < 1$, the following sign restrictions apply:

$$\Lambda \begin{cases} < 0, & \text{if } 0 < p_u < p_u^* \\ > 0, & \text{if } p_u^* < p_u < 1. \end{cases}$$

Figure 1. Existence Condition and Fiscal Policy in the Unintended Regime without Government Debt

Note: Inflation is expressed as annualized percentages and consumption as percentage deviations from steady state. The Euler equation is in blue and the Phillips curve in red. Left panel: The solid lines correspond to a high probability ($p_u = 0.95$) of remaining in the unintended regime, while the dotted lines correspond to a low probability ($p_u = 0.5$). Right panel: The solid line corresponds to the absence of fiscal intervention, the dash-dotted line to a spending stimulus of 5 percent, and the dashed line to a tax cut of 1 percentage point.

When $p_u = p_u^*$, the equilibrium inflation rate is indeterminate. Assume first that there is no fiscal intervention, $\hat{G}^u = \tilde{\tau}^u = 0$. In this case, $\hat{\pi}_t^u = -\Lambda^{-1}\hat{\imath}^*$ and so a necessary condition for the existence of an unintended regime with binding ZLB is $p_u > p_u^*$ (otherwise $\hat{\pi}_t^u > 0$ and the Taylor rule gives a positive interest rate in the unintended regime). That is, the expected duration of the liquidity trap must be long enough. The left panel in Figure 1 shows this condition graphically. The solid lines correspond to the Euler equation (EE, blue) and Phillips curve (PC, red) when the probability of remaining in the unintended regime is $0.95 > p_u^*$. In this case, the PC crosses the EE two times. The lower intersection corresponds to the unintended regime with low inflation and consumption. The EE is upward sloping due to the positive effect of inflation on consumption when the nominal interest rate is pegged at zero. This unintended regime ceases to exist when the probability of remaining becomes too low. For example, the dotted lines correspond to $0.5 < p_u^*$ and cross only one time, at the intended regime.

Assume now that fiscal policy intervenes in the unintended regime. Consider first a perfectly timed increase in government spending ($\hat{G}^u > 0$). Labor demand increases in response to higher public consumption. All else equals, wages must rise to clear the labor market and so firms' markup deteriorates. From (11), the marginal effect of a change in government spending on inflation is given by $\partial \hat{\pi}_t^u / \partial \hat{G}^u = -\Lambda^{-1} \frac{\kappa_G}{\tilde{\kappa}_c}(1 - p_u)$ and is thus negative for $p_u > p_u^*$. In words, the lower markup stemming from the spending stimulus depresses inflation in the EDLT.

Next, consider a perfectly timed tax cut ($\tilde{\tau}^u < 0$). A tax cut increases the net disposable income of households and thus boosts labor supply. All else equal, wages must now drop to clear the labor market and thus firms' markup improves. From (11), the marginal effect of a change in labor taxes on inflation is given by $\partial \hat{\pi}_t^u / \partial \tilde{\tau}^u = -\Lambda^{-1} \frac{\kappa_\tau}{\tilde{\kappa}_c}(1 - p_u)$. In an EDLT ($p_u > p_u^*$), the higher markup stemming from the tax cut stimulates inflation.

Thus, in an EDLT, the inflation response depends on the impact of the fiscal intervention on the firms' markup. More specifically, inflation increases (decreases) if the exogenous fiscal policy improves (deteriorates) firms' markup. This result is analogous to the findings of Mertens and Ravn (2014) in a non-linear economy with Calvo (1983)-style sticky prices. The intuition is as follows. The Phillips curve (7) indicates that firms will adjust prices sluggishly whenever the observed markup deviates from their desired markup. In normal circumstances, this relationship implies an increase in prices when the markup deteriorates. However, when the economy is stuck in a liquidity trap of unusually long expected duration, such common price increase would have a long-lasting negative effect on the real interest rate and would thus crowd in consumption heavily. Since the markup would deteriorate further in this case (because of the upward pressure that additional demand puts on marginal costs), this outcome cannot restore equilibrium. Instead, prices must fall so that the corresponding expected rise in the real interest rate crowds out consumption to a level consistent with the firms' markup in the new equilibrium.

Those mechanisms are illustrated in the right panel of Figure 1. In the unintended regime, the Euler curve is flatter than the Phillips curve (the converse would hold in an FDLT). This slope implies that consumption is hypersensitive to changes in inflation because of the

strong effect on real interest rates explained above. Before the fiscal intervention, the economy rests at the equilibrium s^*. The spending expansion causes a fall in the price markup that shifts the Phillips curve upwards (dash-dotted red line). To reach the new equilibrium s^G, consumption has to move *left* along the Euler curve (from –0.24 percent in s^* to –0.81 percent in s^G), reflecting the crowding-out effect of higher real interest rates. By contrast, the increase in the price markup generated by the tax cut shifts the Phillips curve downwards (dashed red line) so that consumption now has to move *right* along the Euler curve to reach equilibrium s^τ (in which consumption is now positive with a gap of 0.5 percent). Thus, inflation and consumption must increase to recover the markup consistent with the new equilibrium.

4.   Fiscal Policy when Government Debt Matters

In this section, I explore how the financing source of fiscal stimuli affects their effectiveness in an EDLT. Consistently with the previous section, uncertainty is captured by a two-state Markov process. As explained, the existence of an EDLT requires that agents attach a high probability to staying in the unintended regime. As a benchmark calibration, I assume $p_u = 0.95$. Moreover, for the ease of the exposition, the intended regime is absorbing (I relax this assumption in the next section). The probability transition matrix is thus given by

$$\begin{bmatrix} p_i & (1-p_i) \\ (1-p_u) & p_u \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0.05 & 0.95 \end{bmatrix}.$$

Given that taxes are confined to labor income, government debt becomes a state variable that matters for the decisions of the households and firms. Hence, I write the policy function for any variable $x_t = \{\hat{c}_t, \hat{\pi}_t, \hat{i}_t, \hat{y}_t, \tilde{b}_t\}$ as follows:

$$x_t^i = \mathcal{X}_c^i + \mathcal{X}_b^i \tilde{b}_{t-1}$$

$$x_t^u = \mathcal{X}_c^u + \mathcal{X}_b^u \tilde{b}_{t-1},$$

where $\mathcal{X}_c^{u,i} = \{\mathcal{C}_c, \mathbf{\Pi}_c, \mathcal{I}_c, \mathcal{Y}_c, \mathcal{B}_c\}^{u,i}$ is a regime-dependent constant and $\mathcal{X}_b^{u,i} = \{\mathcal{C}_b, \mathbf{\Pi}_b, \mathcal{I}_b, \mathcal{Y}_b, \mathcal{B}_b\}^{u,i}$ is a regime-dependent policy response to inherited government debt. To recover the value of

Figure 2. Policy Functions with Respect to the Steady-State Debt Level
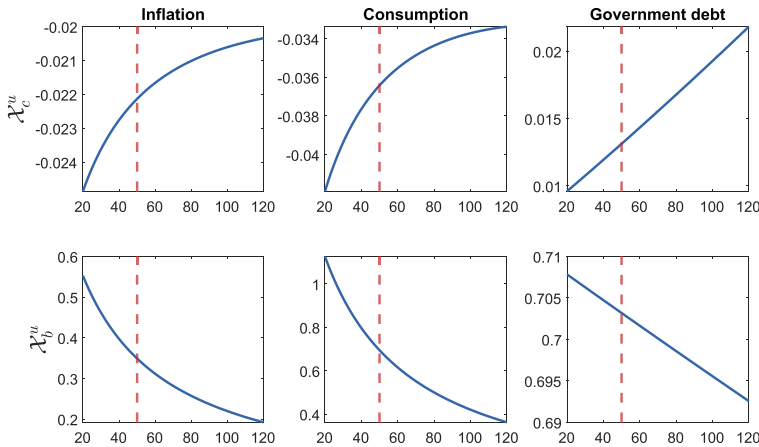
Note: The solid blue line corresponds to the constant coefficient (top panels) and to the debt coefficient (bottom panels) in the unintended regime policy function. The horizontal axis is the steady-state level of debt and the dashed red line indicates the baseline calibration (50 percent of annual GDP).

those coefficients, I rely on a method of undetermined coefficients. Appendix C provides more details about this method.

4.1 Intrinsic Role of Government Debt

Before considering the effectiveness of fiscal policy in stabilizing the economy subject to regime shocks, I provide intuition about the role of debt and the endogenous tax response without fiscal intervention. Figure 2 displays the policy functions for different levels of steady-state government debt. The vertical dashed red line corresponds to the baseline calibration (50 percent of annual output).

The figure reveals several important features of the policy functions when debt matters for private agents' decisions. First, government debt is above its steady-state level in the unintended regime even without exogenous fiscal intervention. The low inflation in the EDLT increases the real value of government debt and induces a monetary tightening upon the exit of the trap in response to the cost-push effect of taxes. Expectations of higher real interest rates

crowd out consumption in the unintended regime via the intertemporal consumption smoothing motive of the households. In what follows, I will refer to this crowding-out effect of government debt on consumption as *the expectation channel*.

Figure 2 shows that the level at which debt stabilizes in the unintended regime depends positively on steady-state debt. A same drop in inflation has a proportionally larger effect on the real value of debt when steady-state debt increases. As a result, inflation and consumption have a higher intercept and are less sensitive to variations in the inherited level of debt. Nevertheless, the larger debt accumulation aggravates the recession because of the anticipated contractionary monetary policy in the intended regime.

Notice also that the long-run level of inflation in the unintended regime is practically insensitive to the endogenous tax response to government debt. Although higher endogenous taxes tend to decrease the price markup of the firms in (8), the bulk of this effect is offset by the crowding out of consumption through the expectation channel.

To illustrate this argument, Figure 3 shows the long-run equilibrium values of selected variables (taxes, consumption, the product of the Phillips curve slope and the price markup, and inflation) in the unintended regime for values of the parameter ϕ_τ in (10) ranging from 0.05 to 0.4. The upper left panel reveals that endogenous taxes are higher in the long run when the pace of debt consolidation is lower because of larger debt accumulation. At the same time, this larger debt amplifies the crowding out of consumption via the expectation channel (upper right panel). As a result, the period t price markup effect in the Phillips curve given by $(\theta - 1)\psi^{-1}\hat{\mu}_t$ in (7) is left virtually unchanged (bottom left) and firms do not need to revise their prices (last panel).

4.2   Equilibrium Responses to Fiscal Policy

As we will see in this section, financing fiscal stimuli with government debt is not innocuous in my non-Ricardian economy. Figure 4 describes the equilibrium responses to various fiscal policies. Before the regime shock occurs, the economy is assumed to have been trapped in the unintended regime for a sufficiently long time so that

Figure 3. Unresponsiveness of Long-Run Inflation to Endogenous Taxes in the Unintended Regime
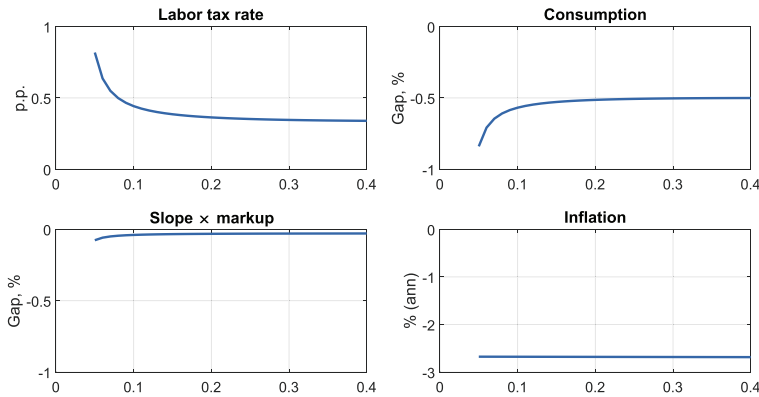
Note: Long-run equilibrium responses in the unintended regime (y-axis) to various calibrations of the feedback parameter ϕ_τ in the tax rule (x-axis). Variables slope × markup $((\theta - 1)\psi^{-1}\hat{\mu}_t$ in (7)) and consumption are expressed in percentage deviations from the steady state. Inflation is in annual percentages and the tax rate in absolute percentages. Despite varying levels of taxes, the inflation response remains flat across paces of consolidation.

government debt has converged to its stationary level.[7] To see what this level corresponds to, consider the debt policy function in period t after convergence has occurred:

$$\tilde{b}_t = \mathcal{B}_c^u + \mathcal{B}_b^u \tilde{b}_{t-1}.$$

Recursive backward substitution of this equation yields the following general expression:

$$\tilde{b}_t = \mathcal{B}_c^u \sum_{j=1}^{N} \mathcal{B}_b^{u\,j-1} + \mathcal{B}_b^{u\,N} \tilde{b}_{t-N} = \mathcal{B}_c^u \left(\frac{1 - \mathcal{B}_b^{u\,N}}{1 - \mathcal{B}_b^u} \right) + \mathcal{B}_b^{u\,N} \tilde{b}_{t-N}.$$

---

[7]Since the intended regime is absorbing, the economy has to start in the unintended regime before the transition occurs. The time needed to phase out an arbitrary level of initial debt in this regime depends on the gap with the stationary level but is typically short. For simplicity, it can be assumed that the economy starts with a stock of debt equal to the stationary level, in which case convergence is instantaneous.

Figure 4. Effects of a Fiscal Stimulus in an Expectations-Driven Liquidity Trap
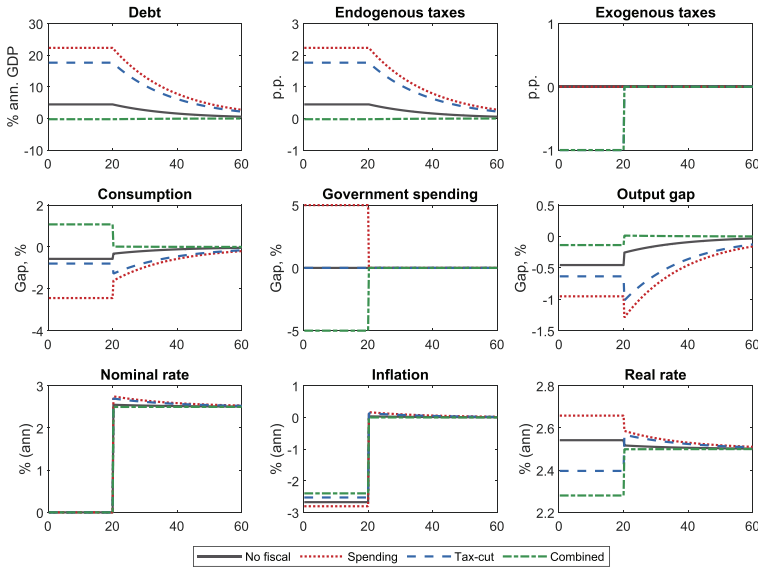
Note: The solid black line corresponds to the absence of fiscal intervention, the dotted red line to a spending increase of 1 percent of GDP, the dashed blue line to a tax cut of 1 percentage point, and the dash-dotted green line to a simultaneous spending cut and tax cut of 1 percent of GDP and 1 percentage point, respectively. Government spending, consumption, and the output gap are expressed in percentage deviations from the steady state. Inflation, the nominal interest rate, and the real interest rate are in annual percentages. Debt is in percentage of annual output and the tax rate in absolute percentages. The economy starts in the unintended regime after debt has converged to its long-run stationary level. The regime shock occurs after 20 years.

Hence, taking $N \to \infty$, the stationary level of debt for $\mathcal{B}_b^u < 1$ corresponds to $\tilde{b}_t = \mathcal{B}_c^u/(1 - \mathcal{B}_b^u)$. Notice also that when $\mathcal{B}_b^u \geq 1$, the path of government debt is explosive and so the system does not admit a stationary solution.

How do debt dynamics influence the transmission of fiscal policy? The dotted red line and the dashed blue line in Figure 4 correspond to the same fiscal stimuli as before but in an EDLT with endogenous debt accumulation. The effects turn out sensibly different from Section 3. First of all, both stimuli are now *self-defeating*;

by attempting to stimulate the economy, fiscal policy instead aggravates the recession. Second of all, the negative effect on consumption and output is more pronounced with a spending stimulus than with a tax cut. Appendix E.1 shows that those effects may be overturned by reducing the expected duration of the fiscal policy. As explained by Wieland (2018), this expected duration, rather than the type of liquidity trap, determines whether or not the policy expands output. In an FDLT, the expected duration of a perfectly timed stimulus is low enough for the policy to be expansionary because of the short expected duration of the lower-bound episode itself. In contrast, the high expected duration of the EDLT renders the same perfectly timed stimuli contractionary.

The first panel shows that expansionary fiscal policies increase debt accumulation in the unintended regime over the long run. At the onset of the intended regime, the larger stock of inherited debt translates into a higher tax rate that pushes up inflation and increases the nominal interest rate in the Taylor rule. This monetary tightening implies that real interest rates (bottom right panel) are consistently higher after the regime shock has occurred so that output plummets due to the crowding-out effect on consumption (middle right and middle left panels, respectively).

Hence, there is a trade-off between providing a stimulus in the unintended regime and reducing the debt burden inherited by the government upon the exit of the liquidity trap. Central to this trade-off are the rational expectations of the private sector. Forward-looking agents anticipate that real rates will be higher in the intended regime when the government accumulates more debt to finance its stimulus. As demonstrated in the next subsection, the expectation channel has adverse effects on consumption and inflation in the unintended regime.

In this respect, the spending stimulus (dotted red line) has the largest impact on debt accumulation in the unintended regime because of two combined effects on deficits: a direct effect from the increase in spending and an indirect effect from drop in inflation which increases the real cost of debt. Hence, with a spending stimulus, real rates stand in excess from their steady-state level in the unintended regime *and* for a prolonged period after the regime shock, strongly crowding out consumption in the unintended regime (–2.4 percent). This private consumption effect prevails over the

demand effect of the stimulus and produces a negative net effect on output.

By comparison, the tax cut (dashed blue line) has a lower impact on debt accumulation (17.6 percent of GDP against 22.3 percent of GDP with the spending policy). The inflationary effect associated with lower exogenous taxes partly offsets the drop in revenues by decreasing the real cost of debt and by widening the tax base. This higher inflation also implies that real interest rates inside and outside the liquidity trap have opposite effects on consumption. Nevertheless, the middle left panel shows that the crowding-out effect of the higher expected real rates and subdued economic activity upon the exit of the trap dominates in the unintended regime and implies that the tax cut is recessionary when financed with debt issuance.

Thus, purely deficit-financed fiscal stimuli are inadequate in an EDLT because of their recessionary effects in the intended regime and the intertemporal transmission through the expectation channel. This conclusion is disappointing when compared to outcomes of similar policies in a FDLT. Appendix D shows that the same increase in government spending is successful at stimulating output when the liquidity trap is caused by a large contractionary demand shock. This favorable outcome stems from the inflationary effect of additional public consumption that lowers the real interest rate when the zero lower bound (ZLB) is binding and crowds in consumption (see, e.g., Christiano, Eichenbaum, and Rebelo 2011; Erceg and Lindé 2014). In my non-Ricardian model, the larger deficits also trigger an endogenous rise in the labor tax rate that strengthens this channel by pushing up inflation further.[8] By contrast, the tax cut remains a self-defeating policy in this environment due to the deflationary effect of the large debt accumulation that boosts real interest rate expectations upon the exit of the liquidity trap (see Eggertsson 2011 for a similar self-defeating effect without debt accumulation).

The results discussed so far suggest that a desirable policy mix in the EDLT should aim at crowding in consumption in the unintended regime while simultaneously curtailing the accumulation of government debt. The dash-dotted green line in Figure 4 shows that this

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[8]The effectiveness of labor taxes in crowding in consumption at the ZLB depends on the presence of non-Ricardian households and the degree of wage stickiness as shown by de Beauffort (2023).

outcome can be achieved by cutting taxes and government spending at the same time. This combined strategy maintains government debt close to its steady-state level. In the EDLT, the lower level of taxes and government spending both improve the markup of the firms and thus call for a price increase (to persistently lower real rates and to stimulate consumption). Consequently, real interest rates in the unintended regime plummet and successfully crowd in consumption. The last section of the article demonstrates that a similar policy mix corresponds to the welfare-maximizing strategy of the government when EDLTs are recurring events.

4.3   Inspecting the Expectation Channel

In an EDLT, government debt thus provides an additional channel that feeds into expectations of private agents and weakens the effectiveness of expansionary fiscal policies. The way this expectation channel plays out is, however, not obvious. For example, Nakata and Schmidt (2022) show that an increase in the inflation target that lowers the real interest rate in the intended regime can reduce inflation and consumption in the unintended regime. Their findings suggest that the expectation channel in an EDLT may work in reverse with respect to an FDLT. This section shows, through two examples, that imposing non-Ricardian fiscal policy restores the conventional view on the expectation channel. The reason is the following.

An expected rise in the real interest rate upon the exit of the trap provides an incentive for households to consume less out of their current income. When Ricardian equivalence holds, the particular path of government debt and lump-sum taxes is irrelevant for the equilibrium values of consumption and other real variables. Hence, market clearing requires either households' income or the relative price of consumption to adjust. Nakata and Schmidt (2022) show that income cannot be the variable of adjustment in an EDLT because of the hypersensitivity of consumption (more than one-for-one) to income changes. Consequently, the real interest rate has to drop and, with nominal rates pegged at zero, this means inflation must increase. Imposing distortionary taxes changes this conclusion because it enables households to smooth consumption by investing in risk-free assets. In particular, households will respond to an expected drop in their consumption (because of higher expected real

rates) by increasing their current savings in nominal assets. As for FDLTs, this implies that an expected monetary tightening depresses consumption and inflation in the unintended regime.

Finally, notice that the effect of the expectation channel appears rather strong in Figure 4. Despite the lower real interest rates that the tax cut induces in the unintended regime, consumption deteriorates with respect to the no-intervention case. This can be explained by the relative duration of each regime in the figure. With $p_u = 0.95$, the unintended regime is expected to last for an average of five years. In contrast, the intended regime is absorbing, and thus the full increase in the real rate (until debt has returned to steady state) is expected to occur after the regime switch. Section 5 considers alternate regimes with limited duration. When the average duration is the same for each regime, a tax cut emerges as the optimized rule, provided that debt accumulation is contained through a concurrent cut in spending.

4.3.1   Policy Rules

To demonstrate the conventional effect of the expectation channel with non-Ricardian fiscal policy, this section revisits the impulse responses to a tax cut assuming two different policy rules: (i) a feedback rule that adjusts spending to stabilize government debt and (ii) a higher feedback coefficient on labor tax adjustments.

Consider first a spending rule that stabilizes debt according to $\hat{g}_t = \phi_g \tilde{b}_{t-1}$. For the numerical exercise, I set $\phi_g = -0.5$, which implies that a 10 percent increase in the inherited debt-to-output ratio reduces spending by 5 percent (about 1 percent of GDP). The middle column of Figure 5 shows the effect of a tax cut of 1 percentage point under this rule. The tax cut increases debt accumulation in the unintended regime and implies lower government spending and output in the intended regime due to the consolidation effort. Compared to the baseline tax rule (left column), inflation in the intended regime is now below the no-intervention case so that monetary policy turns expansionary. Despite a similar real rate gap (14 basis points) in the unintended regime, the two policy rules yield opposite consumption responses. The negative relationship between current consumption and expected real rates confirms the conventional view on the expectation channel when non-Ricardian fiscal policy prevails.

Figure 5. Alternative Policy Rules to Inspect the Expectation Channel
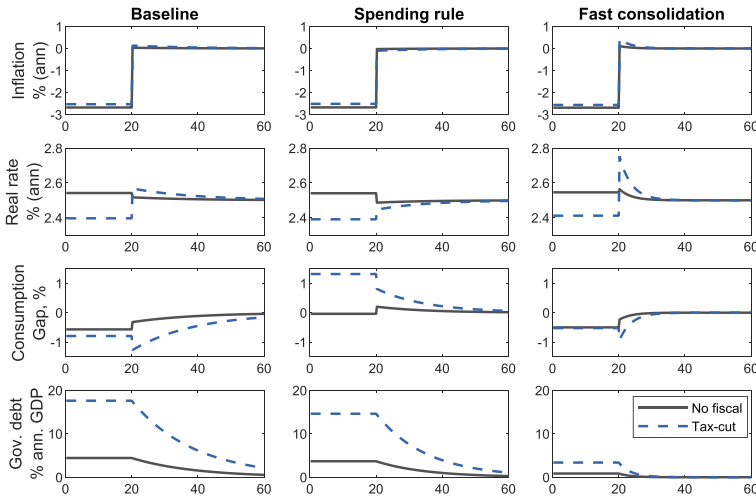
Note: The first column corresponds to the baseline model with endogenous tax response to lagged debt, the middle column to an endogenous response of government spending as an alternative fiscal rule, and the right column to the baseline but with accelerated consolidation pace ($\phi_\tau = 0.4$ instead of $\phi_\tau = 0.1$). The solid black line shows responses without fiscal intervention and the dashed blue line with a tax cut of 1 percentage point. Consumption is expressed in percentage deviations from the steady state. Inflation and the real interest rate are in annual percentages. Debt is in percentage of annual output. The economy starts in the unintended regime after debt has converged to its long-run stationary level. The regime shock occurs after 20 years.

The second example seeks to demonstrate that the path of expected real rates in the intended regime is a significant driving force of the consumption response in the unintended regime. To this end, I assume now that the feedback parameter in the labor tax rule (ϕ_τ) increases from 0.1 to 0.4.[9] The effect of this modification on the equilibrium responses to the tax cut is displayed in the last column of Figure 5. The higher consolidation pace implies that the government leaves the trap with a lower debt level (last panel). As a result, the total increase in labor taxes necessary to return debt to

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[9]Other intermediate values are considered in Appendix E.2, which studies the sensitivity of the main results to the calibration of the tax rule.

its steady-state level is both lower and concentrated in the first periods following the regime switch. Compared to the baseline calibration of the tax rule (first column), lower inflation persistence in the intended regime mitigates the total expected monetary tightening so that the consumption loss is now much closer to the no-intervention case. Thus, the expectation channel is sensitive to the amount of government debt accumulated upon the exit of the trap.

4.3.2 Convenience Yield

In this section, I investigate how the expectation channel depends on (i) the discounting of the households for future consumption and (ii) the link between the level of debt and its servicing costs at positive interest rates. To this end, consider a modified version of the model in which government bonds enter in the utility function of the representative household (referred to below as preference over safe assets (POSA)). Under this specification, bond yields are a function of two components: the underlying consumption claims (as previously) and the total supply of government bonds (the *convenience yield*). More details are provided in Appendix F. The modified Euler equation reads

$$\hat{c}_t = -\gamma_c^{-1}\delta(\hat{\imath}_t - \mathbb{E}_t\hat{\pi}_{t+1}) + \delta\mathbb{E}_t\hat{c}_{t+1} + (1-\delta)\gamma_b(b^{-1}\tilde{b}_t - \hat{\imath}_t). \quad (12)$$

Parameter $\delta = \beta R$ is the discounting wedge and parameter γ_b is the wealth curvature.[10] The discounting wedge represents the net weight that the household attaches to $t+1$ marginal consumption, while the wealth curvature controls the elasticity of the bond yield with respect to the bond supply.

Let us first focus on the effect of the discounting wedge on the expectation channel. To isolate this effect, I assume linear POSA ($\gamma_b = 0$) so that the supply of government bonds does not have a direct impact on interest rates. Then, by substituting (12) forward recursively and imposing a transversality condition on consumption, I obtain the following expression for the impact of expected real interest rates on current consumption:

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[10]For the calibration of the POSA parameters, see Appendix F.

$$\hat{c}_t = -\gamma_c^{-1} \mathbb{E}_t \sum_{j=0}^{\infty} \delta^{j+1} \hat{r}_{t+j}, \tag{13}$$

where $\hat{r}_{t+j} = \hat{\imath}_{t+j} - \hat{\pi}_{t+j+1}$. Notice that without POSA, the discounting wedge is $\delta = 1$.[11] Then, (13) implies that, for any positive integer T, a variation in the real interest rate that takes place in quarter $t + T$ will have the same effect on current consumption. By contrast, the presence of POSA introduces additional discounting in the Euler equation and lowers the strength of the expectation channel. When $\delta < 1$, the effect of the decline in future real interest rates on $\hat{c}_t$ becomes $\delta^{T+1} \mathbb{E}_t \hat{r}_{t+T}$ and thus converges to zero as $T \to \infty$. The left panel in Figure 6 investigates the implications of the discounting wedge for the tax-cut policy. Each marker in the figure corresponds to the inflation (blue circle) and consumption (red diamond) responses to the tax cut in the unintended regime in percentage deviations from the no-intervention scenario.

Without POSA ($\delta = 1$), the consumption gap caused by the tax cut is -0.23 percent when compared to the no-intervention scenario. As the discounting wedge decreases, the gap widens and reaches -1.47 percent when $\delta = 0.93$. What explains this stronger negative effect of the tax cut on consumption when δ decreases?

Figure 6 reveals that when $\delta < 0.95$ the inflation response to the tax cut in the unintended regime (blue circles) turns negative when compared to the no-intervention scenario. With strong enough discounting, the lower sensitivity of consumption to future real interest rates illustrated above implies that a common fall in prices is now effective in restoring equilibrium when firms' markup improves. The inflation response to the tax cut is thus analogous to the one observed in an FDLT (see Appendix D) and, likewise, implies that the policy is particularly damaging for consumption (red diamonds) because of higher real interest rates that prevail both inside and outside the liquidity trap. Increasing δ renders consumption more sensitive to future real rates and thus alleviates the drop in inflation and associated crowding-out effect. For $\delta > 0.95$, the positive inflation response to the tax cut in the EDLT is restored.

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[11] To see this, notice that the steady-state Euler equation gives $\chi c^{\gamma_c} \left(\frac{b}{R}\right)^{-\gamma_b} = 1 - \delta$. Hence, without POSA ($\chi = 0$), we have $\delta = 1$.

Figure 6. Effects of POSA in an Expectations-Driven Liquidity Trap
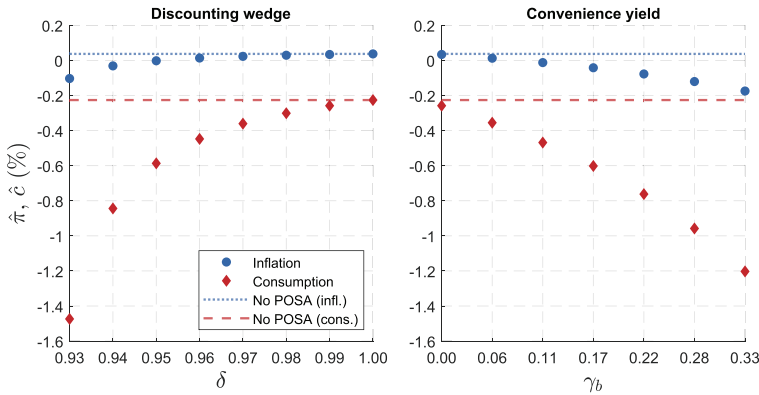
Note: Long-run equilibrium responses of inflation (blue circles) and consumption (red diamonds) to a 1 percentage point tax-cut policy in the unintended regime expressed as percentage deviations from the benchmark of no fiscal intervention. The horizontal lines (dotted blue for inflation and dashed red for consumption) correspond to the absence of POSA (i.e., $\delta = 1$ and $\gamma_b = 0$). The left panel and the right panel analyze respectively the role of the discounting wedge and the convenience yield (through the expectation channel) for the effectiveness of fiscal policy.

Next, I fix the discounting wedge to its baseline value ($\delta = 0.99$) to focus on the effect of the wealth curvature. The right panel of Figure 6 shows that the inflationary effect (blue circles) of a deficit-financed tax cut depends quantitatively and qualitatively on γ_b. With γ_b low enough, the tax cut remains inflationary with respect to the no-intervention policy. However, the inflation gap is decreasing in γ_b and even turns negative for $\gamma_b > 0.06$. In this case, the debt accumulation caused by the tax cut compresses the convenience yield and crowds out consumption at the onset of the intended regime. Expectations of lower real activity and inflation push prices down in the unintended regime. With the nominal rate pegged at zero, consumption plummets in response to the rise in real interest rate. The red diamonds in the right panel show that that the recessionary effect of the tax cut is strongly increasing in the wealth curvature because of the more negative response of convenience yields to debt accumulation. This result contrasts with Rannenberg (2021), who

finds that the wealth curvature does not matter much for the effectiveness of a perfectly timed spending stimulus in an FDLT because the high fiscal multiplier implies that debt accumulation is negligible. Evidently, this does not hold in an EDLT since, as I have demonstrated, a spending stimulus increases the debt burden significantly. Finally, notice that the results with POSA obtained in this section would also extend to a model with government default in which the perceived probability of default is correlated to the level of debt as in Bonam and Lukkezen (2019).

5.   Optimized Rules

The previous section explores the implications of accumulating debt for the effect of fiscal stimuli when fiscal and monetary policy are conducted according to standard ad hoc rules. While purely deficit-financed fiscal stimuli were clearly unsuccessful at stimulating output, combined strategies that contain debt accumulation seemed more promising. In this section, I thus investigate whether such strategies would prevail when fiscal policy rules are optimized in an environment of recurring regime shifts. For this purpose, I assume that the employment subsidy takes a value consistent with an efficient steady state. This assumption allows me to derive a meaningful welfare criterion to rank policy outcomes. As demonstrated in Appendix H, a second-order approximation of the household's utility around the efficient steady state gives an unconditional expected lifetime welfare loss equal to $\frac{1}{2}U_c\mathcal{L}$ with

$$\mathcal{L} = \sum_{t=0}^{\infty} \beta^t \left[\gamma_c c \hat{c}_t^2 + \gamma_g G \hat{G}_t^2 + \gamma_h y \hat{y}_t^2 + \iota y \pi_t^2 \right]. \qquad (14)$$

Moreover, a permanent reduction in private consumption by the share $\mathcal{S}$ lowers the utility of the household by an amount equivalent to $\frac{U_c C \mathcal{S}}{1-\beta}$. Hence, I express the welfare loss in consumption equivalent as $\frac{U_c C \mathcal{S}}{1-\beta} = \frac{1}{2}U_c\mathcal{L}$, or

$$\mathcal{S} = \frac{1}{2}(1-\beta)C^{-1}\mathcal{L}.$$

Figure 7. Welfare Loss for Different Fiscal Policies
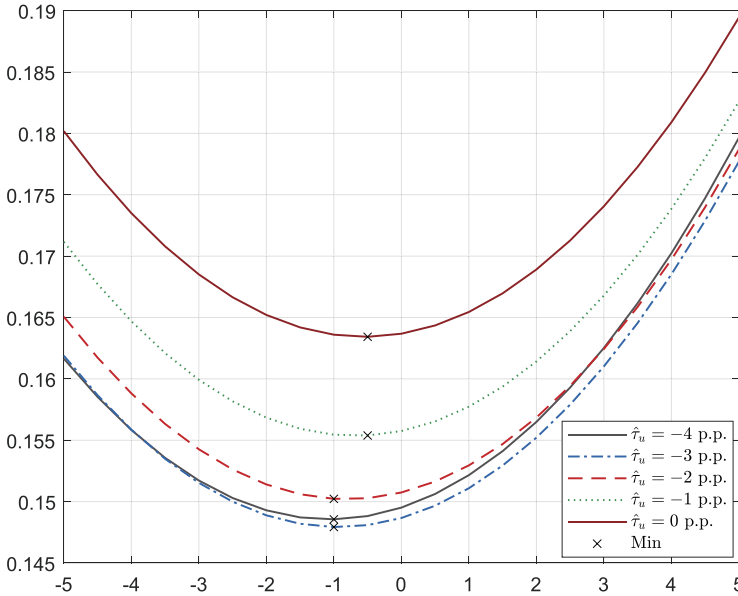
Note: Each curve corresponds to a different tax cut ranging from -0.4 pp to 0 pp. The vertical axis captures the associated welfare loss in consumption equivalent depending on a specific spending policy (gap, percents) in the horizontal axis.

To assess the effectiveness of fiscal policy in stabilizing target variables, I simulate the economy for 600 quarters and 500 samples.[12] The regime shock continues to follow a Markov chain; however, now I assume that none of the regimes is absorbing. Instead, I choose $p_u = p_i = 0.98$, a value that implies an average duration of 12.5 years for each regime. Figure 7 plots the welfare loss depending on the fiscal policy implemented in the unintended regime.

Each curve corresponds to a tax policy, while the horizontal axis represents the associated spending policy. From the position of the curves, cutting taxes in the unintended regime appears welfare improving provided that the stimulus is not too large. The optimal

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[12]The first 100 quarters of each sample are discarded as a burn-in period.

tax cut turns out to be −3 percentage points (pp) since any tax cut above this value moves the curve to the north. Notice that the no-intervention policy entails the largest consumption loss. Moreover, for any tax cut larger than or equal to zero, decreasing government spending by an adequate amount can further improve welfare. This amount depends positively on the size of the tax cut. To shed light on the mechanisms underlying those results, Table 2 shows the average outcome for key variables in the unintended (U) regime versus the intended (I) regime for selected fiscal policies.

First, notice that the optimized policy alleviates the inflation shortfall in the unintended regime (−2.33 percent) when compared to the case of no intervention (−2.55 percent). This result is intuitive, for both the tax cut and the spending cut are inflationary in an EDLT. Hence, this policy supports output and consumption by lowering real rates. However, the tax cut may not be too large because the increase in debt implies higher real rates when the ELB stops binding. The decrease in government spending provides some fiscal space in this regard. Nevertheless, government debt is on average 25 percent (13.5 percent) above its steady-state value in the unintended (intended) regime. Consequently, consumption and output are subdued in the intended regime because monetary policy tightens in reaction to the cost-push effect of labor taxes.

Hence, the optimized policy strikes a balance between the benefits occurring in the unintended regime and the costs occurring in the intended regime. This trade-off largely depends on the conditional expectations of the private agents in each regime. In this regard, the second line of the table shows that inflation in the intended regime is negative when fiscal policy is muted. The pronounced deflation in the unintended regime weighs negatively on inflation expectations even outside the liquidity trap since forward-looking households attach a positive probability (though low) for the EDLT to occur again in the future.

This analysis clarifies the role of fiscal policy in an EDLT when government debt matters. In this type of liquidity trap, monetary policy is helpless in stabilizing the economy. For example, Nakata and Schmidt (2022) show in a Ricardian economy with lump-sum taxes that increasing the inflation target of a time-consistent planner or increasing the weight it attaches to inflation stabilization in its objective has opposite effects on inflation inside and outside an

Table 2. Welfare Loss and Macroeconomic Outcomes of Fiscal Policy

Fiscal Policy	$\widehat{G}_u$	$\widetilde{\tau}_u$	$\mathcal{L}$	$\widehat{\pi}$		$\widehat{c}$		$\widehat{y}$		$\widehat{b}$	
				U	I	U	I	U	I	U	I
Optimized	−1	−3	0.15	−2.33	0.37	0.35	−0.84	0.08	−0.67	25.08	13.53
No Stimulus	0	0	10.57	−2.55	−0.13	−0.11	0.08	−0.09	0.06	0.07	−0.02
Excessive Tax Cut	0	−4	1.19	−2.26	0.53	0.22	−1.22	0.17	−0.97	35.43	19.08
Spending Cut Only	−5	0	21.74	−2.53	−0.09	0.95	0.35	−0.24	0.28	−7.49	−3.90

Note: Government spending, consumption, and output are expressed in percentage deviations from the steady state. Inflation is in annual percentages. Debt is in percentage of annual output and the tax rate in absolute percentages. Welfare loss is in percentage of permanent consumption equivalent for the optimized policy and in percent excess deviation from the optimized policy for the other policies. U and I stand for the unintended and intended regime, respectively.

EDLT and the gains in stabilizing the economy are therefore unclear. In my model, fiscal policy attempts to anchor inflation (expectations) in the two regimes. In achieving this objective, the government is however constrained by the debt accumulation and its implications for monetary policy once the ELB stops binding. To illustrate this last point, consider the excessive tax cut (−4 percent) in the third line of the table. While inflation is better stabilized in this case, it is at the cost of accumulating a large amount of debt. As a result, consumption and output drop too much in the intended regime and the welfare loss increases by 1.2 percent.

Notice that a spending cut alone may seem appealing because it increases inflation in the EDLT while consolidating debt and lowering the endogenous response of taxes. However, as witnessed by the last line of the table, it turns out to have the worst effect on welfare. The reason is twofold. First, despite lowering the real rates and stimulating consumption, the spending cut reduces output in the unintended regime because of the negative effect on public demand. Second, in the absence of other policies, the consolidation of debt (−7.5 percent in the unintended regime) implies that inflation is subdued in the intended regime.

Finally, I close the discussion with an important remark on the optimized strategy. The result of improving welfare in a liquidity trap by cutting taxes and government spending admittedly seems far fetched given the large expansionary fiscal policy that we have observed in reality. First of all, this result holds only in an EDLT with a long-lasting intervention. Hence, if the liquidity trap is fundamental, shrinking the size of the state would be counterproductive. To illustrate this point, Appendix G evaluates the optimized rules when the policymaker is uncertain about the type of liquidity trap occurring. To this end, I assume that once in a high state of demand, there is a positive probability to fall in a liquidity trap. However, now this liquidity trap may be either fundamental driven or expectations driven. The optimized strategy in this context is to adopt the status quo (except for a mild spending cut). Since fiscal policy has opposite effects depending on the type of liquidity trap, the government refrains from intervening. Second of all, the duration of the intervention matters for the results. If the policy is not going to outlast the liquidity trap, then it will never be recessionary in an FDLT. As demonstrated in this paper, this affirmation is not true for an

EDLT: a perfectly timed stimulus puts a significant strain on public finances and depresses output during the downturn.

6.   Conclusion

With the COVID-19 crisis unfolding, deficit-financed fiscal stimuli have grown in popularity in the United States and other advanced economies. One of the main insights of the literature on fiscal and monetary policy in a fundamental-driven liquidity trap is that the large multiplier of spending policies tremendously reduces its impact on debt accumulation. However, the soaring debt-to-GDP ratios may be a sign that we are overestimating those self-financing effects. At the same time, central banks are emphasizing the risk of long-lasting liquidity traps caused by self-fulfilling expectations. The reality might be somewhere in between. Nevertheless, this paper shows that financing government spending with debt issuance can be counterproductive in an expectations-driven liquidity trap because it increases real rates both at the effective lower bound and in its aftermath. In this context, reducing the size of the state supports economic activity by reaping the benefits of a tax cut while keeping the accumulation of debt at a manageable level. This policy alleviates the need for a monetary tightening at the exit of the liquidity trap and stimulates consumption of forward-looking households during the downturn by reducing expected real rates.

Appendix A. The Non-linear Economy

A.1 Equilibrium Conditions

The representative household maximizes its expected lifetime utility (1) subject to its budget constraint (2). Attaching multiplier λ_t to the constraint, the first-order necessary conditions (FONCs) of this problem are standard:

$$\nu_h h_t^{\gamma_h} c_t^{\gamma_c} = (1 - \tau_t) w_t$$

$$R_t^{-1} = \beta d_t \mathbb{E}_t \left[\frac{c_t^{\gamma_c}}{\pi_{t+1} c_{t+1}^{\gamma_c}} \right].$$

The problem (4) of the intermediate firm gives rise to the following FONC:

$$w_t = \frac{\theta - 1}{\theta(1 - s)} - \frac{\psi}{\theta(1 - s)}$$
$$\times \left(\pi_t(\pi_t - 1) - \beta d_t \mathbb{E}_t \left[\frac{c_t^{\gamma_c}}{c_{t+1}^{\gamma_c}} \frac{y_{t+1}}{y_t} \pi_{t+1}(\pi_{t+1} - 1) \right] \right).$$

Moreover, the budget constraint of the government in real terms reads

$$\frac{b_t}{R_t} - \frac{b_{t-1}}{\pi_t} - G_t + \tau_t w_t y_t - s(w_t y_t - wy) = 0.$$

Together with the resource constraint, $y_t \left(1 - \frac{\psi}{2}(\pi_t - 1)^2 \right) = c_t + G_t$, those equations can be log-linearized to obtain the system of equations in the text.[13]

A.2 The First-Best Allocation

The first-best allocation solves the problem

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \xi_t \left[\frac{c_t^{1-\gamma_c}}{1 - \gamma_c} + \nu_g \frac{G_t^{1-\gamma_g}}{1 - \gamma_g} - \nu_h \frac{h_t^{1+\gamma_h}}{1 + \gamma_h} + \omega_t(y_t - c_t - G_t) \right]$$

that gives the following FONCs:

$$c_t^{-\gamma_c} = \omega_t, \quad \nu_h y_t^{\gamma_h} = \omega_t, \quad \nu_g G_t^{-\gamma_g} = \omega_t.$$

Hence, at the first best, it holds that $(1 - \tau_t)w_t = 1$.

A.3 The Steady State (Non-efficient and Efficient)

The non-efficient steady state corresponds to the case where $s = 0$. It is characterized by the following set of equations:

$$y = c + G$$

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[13]In the text, the system is reduced to three equations by substituting out output and wages using, respectively, the log-linearized resource constraint and the log-linearized intratemporal consumption-leisure trade-off.

$$R = \beta^{-1}$$

$$w = \frac{\theta - 1}{\theta}$$

$$\tau = (wy)^{-1}[G + b(1 - \beta)]$$

$$\nu_h = y^{-\gamma_h} c^{-\gamma_c} w(1 - \tau)$$

$$\nu_g = G^{\gamma_g} c^{-\gamma_c}.$$

In the *efficient* steady state, the subsidy is set to attain the first best, $(1 - \tau)w = 1$, and is given by

$$s = 1 - \frac{\theta - 1}{\theta}(1 + G + (1 - \beta)by^{-1})^{-1}.$$

Moreover, the equations for the steady-state tax rate and wage become

$$\tau = \frac{\theta s - 1}{\theta - 1} \qquad w = \frac{\theta - 1}{(1 - s)\theta}.$$

The other steady-state equations remain unchanged.

Appendix B. Analytical Derivations in the Economy with Lump-Sum Taxes

In the presence of lump-sum taxes, I can drop the budget constraint from my system of equations. Under the non-linear Taylor rule (9), I can write the system as a collection of four equations: two for the intended regime and two for the unintended regime:

$$\hat{c}_t^i = -\gamma_c^{-1}(\phi_\pi \hat{\pi}_t^i - \mathbb{E}_t^i \hat{\pi}_{t+1}) + \mathbb{E}_t^i \hat{c}_{t+1} \tag{B.1}$$

$$\hat{\pi}_t^i = \kappa_G \hat{G}_t^i + \overline{\kappa}_c \hat{c}_t^i + \kappa_\tau \tilde{\tau}_t^i + \beta \mathbb{E}_t^i \hat{\pi}_{t+1} \tag{B.2}$$

$$\hat{c}_t^u = -\gamma_c^{-1}(-i^* - \mathbb{E}_t^u \hat{\pi}_{t+1}) + \mathbb{E}_t^u \hat{c}_{t+1} \tag{B.3}$$

$$\hat{\pi}_t^u = \kappa_G \hat{G}_t^u + \overline{\kappa}_c \hat{c}_t^u + \kappa_\tau \tilde{\tau}_t^u + \beta \mathbb{E}_t^u \hat{\pi}_{t+1}, \tag{B.4}$$

where $\kappa_G \equiv \frac{\gamma_h(\theta-1)}{\psi} Gy^{-1}$, $\kappa_\tau \equiv \frac{(\theta-1)}{(1-\tau)\psi}$ and $\overline{\kappa}_c \equiv \frac{\gamma_c(\theta-1)}{\psi} + \frac{\gamma_h(\theta-1)}{\psi} cy^{-1}$.

Solving the PC for consumption gives

$$\hat{c}_t^u = \overline{\kappa}_c^{-1}\left(\hat{\pi}_t^u - \kappa_G \hat{G}_t^u - \kappa_\tau \tilde{\tau}_t^u - \beta \mathbb{E}_t^u \hat{\pi}_{t+1}\right).$$

Combining this expression with the EE gives

$$-\hat{\imath}^* = \overline{\kappa}_c^{-1}\left(-\hat{\pi}_t^u + \kappa_G(\hat{G}_t^u - \mathbb{E}_t^u \hat{G}_{t+1}) + \kappa_\tau(\tilde{\tau}_t^u - \mathbb{E}_t^u \tilde{\tau}_{t+1})\right.$$
$$\left. + (\overline{\kappa}_c + 1 + \beta)\mathbb{E}_t^u \hat{\pi}_{t+1} - \beta \mathbb{E}_t^u \hat{\pi}_{t+2}\right).$$

With probability p_u, the economy remains in the unintended regime, in which case next-period inflation is equal to current inflation. Moreover, with probability $(1 - p_u)$, a regime shock hits the economy and inflation is equal to its value in the intended regime, i.e., $\hat{\pi}_t^i = 0$. Notice that the same logic applies to government spending and labor taxes because of the perfectly timed assumption. Then, I can write

$$-\hat{\imath}^* = \overline{\kappa}_c^{-1}\left(-\hat{\pi}_t^u + \kappa_G(\hat{G}_t^u - \mathbb{E}_t^u \hat{G}_{t+1}) + \kappa_\tau(\tilde{\tau}_t^u - \mathbb{E}_t^u \tilde{\tau}_{t+1})\right.$$
$$\left. + (\overline{\kappa}_c + 1 + \beta)p_u \hat{\pi}_t^u - \beta p_u^2 \hat{\pi}_t^u\right),$$

which, solving for inflation, gives Equation (11) in the text.

Appendix C. Solving the Expectations-Driven Liquidity Trap

I denote the coefficients related to the constant terms by $\mathcal{C}_c^r$, $\mathcal{B}_c^r$, $\mathcal{Y}_c^r$, $\mathbf{\Pi}_c^r$, $\mathcal{I}_c^r$ and the coefficients related to lagged debt by $\mathcal{C}_b^r$, $\mathcal{B}_b^r$, $\mathcal{Y}_b^r$, $\mathbf{\Pi}_b^r$, $\mathcal{I}_b^r$. Superscript $r \in \{u, i\}$ indicates the regime. The strategy to recover those coefficients is the following. Gather all the constant terms on the left-hand side of each equation and all the terms pre-multiplying the state variable on the right-hand side of the equation. Then, find the value of the coefficients that implies each side of every equation in the system is equal to zero. This involves two steps. First, solve the system of right-hand-side equations. Second, using the coefficients recovered for lagged debt, solve the system of left-hand-side equations.

More specifically, the system of right-hand-side equations contains a set of equations for the intended regime and a set for the unintended regime. The system for the intended regime reads

$$0 = 1 - \Omega\beta^{-1}\mathbf{\Pi}_b^i + \Omega\mathcal{I}_b^i - w\tau y\Big(\gamma_c\mathcal{C}_b^i + (1+\gamma_h)\mathcal{Y}_b^i + \frac{\phi_\tau}{(1-\tau)\tau}\Big)$$
$$- \beta\mathcal{B}_b^i$$

$$0 = \mathbf{\Pi}_b^i - \kappa_y\mathcal{Y}_b^i - \kappa_c\mathcal{C}_b^i - \kappa_\tau\phi_\tau - \beta\Big(p_i\mathbf{\Pi}_b^i\mathcal{B}_b^i + (1-p_i)\mathbf{\Pi}_b^u\mathcal{B}_b^i\Big)$$

$$0 = \gamma_c\mathcal{C}_b^i - \gamma_c\Big(p_i\mathcal{C}_b^i\mathcal{B}_b^i + (1-p_i)\mathcal{C}_b^u\mathcal{B}_b^i\Big) + \mathcal{I}_b^i$$
$$- \Big(p_i\mathbf{\Pi}_b^i\mathcal{B}_b^i + (1-p_i)\mathbf{\Pi}_b^u\mathcal{B}_b^i\Big)$$

$$0 = \mathcal{I}_b^i - \phi_\pi\mathbf{\Pi}_b^i$$

$$0 = y\mathcal{Y}_b^i - c\mathcal{C}_b^i.$$

The system for the unintended regime reads

$$0 = 1 - \Omega\beta^{-1}\mathbf{\Pi}_b^u + \Omega\mathcal{I}_b^u - w\tau y\Big(\gamma_c\mathcal{C}_b^u + (1+\gamma_h)\mathcal{Y}_b^u + \frac{\phi_\tau}{(1-\tau)\tau}\Big)$$
$$- \beta\mathcal{B}_b^u$$

$$0 = \mathbf{\Pi}_b^u - \kappa_y\mathcal{Y}_b^u - \kappa_c\mathcal{C}_b^u - \kappa_\tau\phi_\tau - \beta\Big(p_u\mathbf{\Pi}_b^u\mathcal{B}_b^u + (1-p_u)\mathbf{\Pi}_b^i\mathcal{B}_b^u\Big)$$

$$0 = \gamma_c\mathcal{C}_b^u - \gamma_c\Big(p_u\mathcal{C}_b^u\mathcal{B}_b^u + (1-p_u)\mathcal{C}_b^i\mathcal{B}_b^u\Big) + \mathcal{I}_b^u$$
$$- \Big(p_u\mathbf{\Pi}_b^u\mathcal{B}_b^u + (1-p_u)\mathbf{\Pi}_b^i\mathcal{B}_b^u\Big)$$

$$0 = \mathcal{I}_b^u$$

$$0 = y\mathcal{Y}_b^u - c\mathcal{C}_b^u.$$

Together, this gives a non-linear system of 10 equations in 10 unknowns that I solve using the routine *fsolve* in MATLAB. Once the coefficients of lagged debt have been recovered, the system of constant terms can be solved. As before, it consists in two sets of equations for the intended and unintended regime. For the intended regime, the system reads

$$0 = -\Omega\beta^{-1}\mathbf{\Pi}_c^i + \Omega\mathcal{I}_c^i - w\tau y(\gamma_c\mathcal{C}_c^i + (1+\gamma_h)\mathcal{Y}_c^i) - \beta\mathcal{B}_c^i$$

$$0 = \mathbf{\Pi}_c^i - \kappa_y\mathcal{Y}_c^i - \kappa_c\mathcal{C}_c^i - \beta\Big(p_i(\mathbf{\Pi}_c^i + \mathbf{\Pi}_b^i\mathcal{B}_c^i) + (1-p_i)(\mathbf{\Pi}_c^u + \mathbf{\Pi}_b^u\mathcal{B}_c^i)\Big)$$

$$0 = \gamma_c\mathcal{C}_c^i - \gamma_c\Big(p_i(\mathcal{C}_c^i + \mathcal{C}_b^i\mathcal{B}_c^i) + (1-p_i)(\mathcal{C}_c^u + \mathcal{C}_b^u\mathcal{B}_c^i)\Big)$$

$$+ \mathcal{I}_c^i - \Big(p_i(\mathbf{\Pi}_c^i + \mathbf{\Pi}_b^i\mathcal{B}_c^i) + (1-p_i)(\mathbf{\Pi}_c^u + \mathbf{\Pi}_b^u\mathcal{B}_c^i)\Big)$$

$$0 = \mathcal{I}_c^i - \phi_\pi\mathbf{\Pi}_c^i$$

$$0 = y\mathcal{Y}_c^i - c\mathcal{C}_c^i.$$

For the unintended regime, the system reads

$$0 = -\Omega\beta^{-1}\mathbf{\Pi}_c^u + G\hat{G}^u + \Omega\mathcal{I}_c^i - w\tau y\Big(\gamma_c\mathcal{C}_c^i + (1+\gamma_h)\mathcal{Y}_c^i + \frac{\tilde{\tau}^u}{(1-\tau)\tau}\Big)$$

$$- \beta\mathcal{B}_c^i$$

$$0 = \mathbf{\Pi}_c^u - \kappa_y\mathcal{Y}_c^u - \kappa_c\mathcal{C}_c^u - \kappa_\tau\tilde{\tau}^u$$

$$- \beta\Big(p_u(\mathbf{\Pi}_c^u + \mathbf{\Pi}_b^u\mathcal{B}_c^u) + (1-p_u)(\mathbf{\Pi}_c^i + \mathbf{\Pi}_b^i\mathcal{B}_c^u)\Big)$$

$$0 = \gamma_c\mathcal{C}_c^u - \gamma_c\Big(p_u(\mathcal{C}_c^u + \mathcal{C}_b^u\mathcal{B}_c^u) + (1-p_u)(\mathcal{C}_c^i + \mathcal{C}_b^i\mathcal{B}_c^u)\Big)$$

$$+ \mathcal{I}_c^u - \Big(p_u(\mathbf{\Pi}_c^u + \mathbf{\Pi}_b^u\mathcal{B}_c^u) + (1-p_u)(\mathbf{\Pi}_c^i + \mathbf{\Pi}_b^i\mathcal{B}_c^u)\Big)$$

$$0 = \mathcal{I}_c^u + log(\beta^{-1})$$

$$0 = y\mathcal{Y}_c^u - c\mathcal{C}_c^u - G\hat{G}^u.$$

Again, this gives a non-linear system of 10 equations in 10 unknowns that I solve using the routine *fsolve* in MATLAB.

Appendix D. Fiscal Policy in the Fundamental-Driven Liquidity Trap

I define a *fundamental-driven liquidity trap* (FDLT) as one that is triggered by a negative demand shock in Equation (6). For the ease of comparison, I assume that the demand shock follows the exogenous process

$$\hat{d}_t = \begin{cases} -0.016, & \text{if } t \leq T \\ 0, & \text{otherwise.} \end{cases} \tag{D.1}$$

Moreover, private agents are uncertain about when period T will actually occur. This uncertainty is captured by a two-state Markov process.[14] Note that the existence of FDLTs requires their expected duration to be much lower than EDLTs (see, e.g., the discussion in Nakata and Schmidt 2019 and Kollmann 2021). As a benchmark calibration, I thus choose

$$\begin{bmatrix} p_h & (1-p_h) \\ (1-p_l) & p_l \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0.5 & 0.5 \end{bmatrix},$$

which implies an expected duration of the low state below two years.[15] The solution of the model is obtained with the same method of undetermined coefficients used for the EDLT (see Appendix C). Consider the same two perfectly timed fiscal stimuli studied in Section 3: a spending stimulus and a tax cut. Figure D.1 compares their respective effect in a FDLT when government debt matters for stabilization policies.

Consider first that the government increases spending to stimulate the economy (dotted red line). The top left panel shows that this strategy is effective to boost output. This result is related to the large fiscal multiplier at the ELB identified by Christiano, Eichenbaum, and Rebelo (2011), Woodford (2011), and Erceg and Lindé (2014). In parallel to the demand effect of government spending on output, larger deficits trigger an endogenous rise in the labor tax rate. As a result, the cost-push effect of taxes reduces real rates at the ELB and crowds in consumption in a virtuous loop. In particular, the bottom left panel shows that debt is reduced in response to higher spending, which indicates that the stimulus is self-financing because the positive effect on consumption widens the tax base.

Turning to the tax cut (dashed blue line), this strategy turns out to be self-defeating. Cutting taxes aggravates the inflation shortfall because of the large accumulation of debt that produces a

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[14]See, e.g., Woodford (2011) for a similar characterization of an FDLT.

[15]Notice that here I refer to the high state and the low state of demand to make a distinction between the intended and unintended regime when liquidity traps are expectations driven.

Figure D.1. Effects of a Fiscal Stimulus in a Fundamental-Driven Liquidity Trap
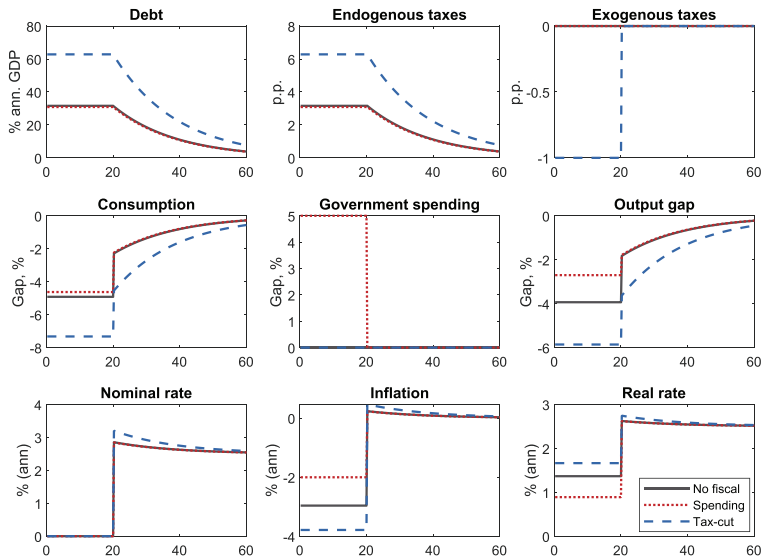
Note: The solid black line corresponds to the absence of fiscal intervention, the dotted red line to a spending increase of 1 percent of GDP, and the dashed blue line to a tax cut of 1 percentage point. Government spending, consumption, and the output gap are expressed in percentage deviations from the steady state. Inflation, the nominal interest rate, and the real interest rate are in annual percentages. Debt is in percentage of annual output and the tax rate in absolute percentages. The economy starts in the unintended regime after debt has converged to its long-run stationary level. The demand shock occurs after 20 years.

monetary tightening upon the exit of the FDLT in response to the cost-push effect of labor taxes when the policy is overturned. Consumption drops due to intertemporal consumption smoothing and the tax base shrinks. Hence, the economy is burdened by higher debt levels and lower output gap.

Appendix E. Sensitivity Analysis

E.1 Expected Duration of Fiscal Policy

Wieland (2018) shows that the multiplier of government spending depends on its duration independently of the type of liquidity trap,

## Figure E.1. Fiscal Multipliers as a Function of Policy Duration
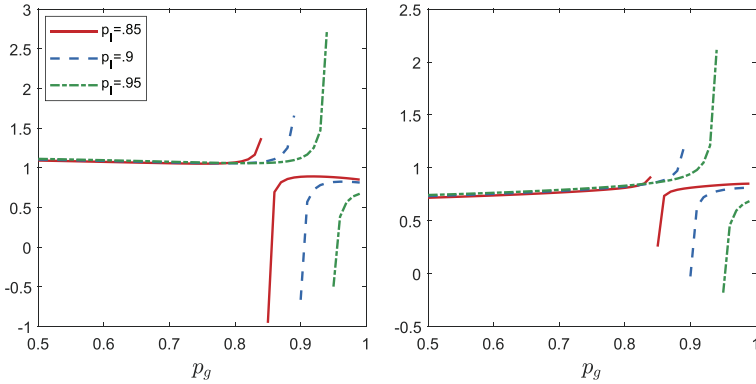
Note: The left panel draws the output multiplier of government spending and the right panel the one of tax cut. The solid red line, the dashed blue line, and the dashed-dotted green line correspond to the output multiplier when the probability of staying in the low confidence regime is respectively 0.85, 0.9, and 0.95. The formula for computing the multipliers is detailed in the text. The horizontal axis is the expected duration of the fiscal experiment in the low confidence regime. For high-enough duration of fiscal policy, the multiplier turns negative.

fundamentally driven or expectations driven. More specifically, the size of the multiplier is decreasing in the duration of the policy intervention.

Figure E.1 shows that this result extends to a spending stimulus when households are non-Ricardian. The figure also displays the multiplier for the tax-cut policy considered previously. Here, I assume the existence of an additional regime, denoted regime n, characterized by a low degree of confidence and a binding ELB but in which fiscal policy is muted. Conditional on the confidence being low, this regime is assumed to be absorbing. The policy regime considered before is now denoted regime g.

This setup allows me to consider fiscal policies of expected duration shorter than the expectations-driven liquidity trap itself and to analyze the resulting multipliers. The marginal multiplier for a generic period of binding ELB and operational policy is computed as $\Delta y_t / \Delta G_t$ and $\Delta y_t / (y_t |\Delta \tau_t|)$ for the spending stimulus and tax cut, respectively. The figure clearly shows that, for an expected duration

Figure E.2. Effects of the Consolidation Pace in an Expectations-Driven Liquidity Trap
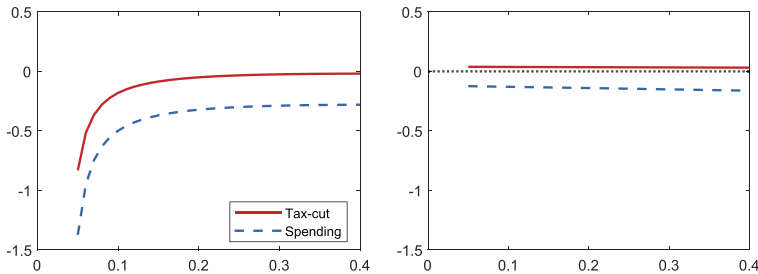
Note: The solid red line and dashed blue line correspond to the output multiplier (left panel) and inflation multiplier (right panel) of the tax cut and spending stimulus, respectively. The formula for computing the multipliers is detailed in the text. The horizontal axis is the endogenous response of labor taxes to lagged debt, ϕ_τ.

of fiscal policy equivalent to the FDLT considered earlier ($p_g = 0.5$), the multiplier of the spending stimulus is positive in the EDLT and superior to the tax cut. Moreover, the multiplier is increasing in the duration of the policy up to a certain point because of the negative effect of cumulative inflation on the real interest rates. However, when the expected duration of the policy is equal to or higher than the expected duration of the EDLT, the multiplier drops, turning negative initially and then increasing until reaching a higher bound.

E.2 Effect of the Consolidation Pace

As explained in Section 4.2, an increase in government spending affects the debt dynamics not only through its direct effect on the budget constraint but also through a reduction in the tax base. The magnitude of the debt accumulation, in turn, depends on the endogenous response of the tax rate governed by the parameter ϕ_τ.

To assess the effect of the consolidation pace on macroeconomic outcomes, Figure E.2 plots the output and inflation multiplier for a 1 percent of GDP increase in government spending (the dashed line) and a 1 pp tax cut (the solid line) for values of ϕ_τ ranging from 0.05 to 0.4. From Section 4.1, we know that the endogenous response of taxes to debt affects inflation in the unintended regime

only marginally because of two opposite effects that cancel out each other: one from the price markup variation and one from the debt accumulation. This low sensitivity of inflation is attested by the flat inflation multipliers in the right panel of Figure E.2. However, the left panel reveals that the output multiplier is less negative when ϕ_τ increases due to the positive effect of bringing down the debt level faster. A government that consolidates at a slow pace finds itself with a high debt burden at the exit of the liquidity trap. Hence, inflation remains above target for a prolonged period of time after the regime shock and this provides an incentive for forward-looking households to decrease their consumption in anticipation of the contractionary monetary policy and subdued economic recovery. This expectation channel provides the incentive for an additional consolidation effort in the unintended regime.

E.3 Size of the Fiscal Intervention

The numerical experiments in Section 4.2 show that output in the unintended regime deteriorates more with an increase in government spending than with a tax cut. One reason for this result is the larger debt accumulation stemming from the spending policy. A natural follow-up exercise performed in Table E.1 is thus to investigate whether this result is sensitive to the relative size of the policy experiments. The table shows the effect of different calibrations for the spending and tax-cut policies on the debt accumulation and on the output multiplier (and its components). The baseline calibration (columns +1 pp and –1 pp) assumes that government spending increases by 1 percentage point (from 20 percent of output to 21 percent) while the tax rate decreases by –1 percentage point. Clearly, the larger the fiscal expansion, the more debt accumulates in the unintended regime. For a larger tax cut of –2 pp, the debt accumulation (measured in deviations from the no-intervention case as a percentage of annual output) becomes larger than the one in the baseline increase in government spending (26.36 percent against 17.42 percent). When compared to the baseline tax cut (–1 pp), the higher debt burden leads to a larger deterioration of output (–0.09 against –0.04). Nevertheless, this deterioration remains lower than the one in the baseline spending policy (–0.12) because the tax cut is associated with a drop of the real interest rate in the unintended

Table E.1. Size of the Fiscal Intervention and Output Multiplier

Fiscal Policy	Gov. Spending			Tax Rate		
	+1 pp	+3 pp	+5 pp	−1 pp	−2 pp	−4 pp
Δb_t	17.42	49.91	79.69	13.18	26.36	52.72
Δy_t (numerator)	−0.12	−0.35	−0.56	−0.04	−0.09	−0.18
ΔG_t (denominator G)	0.24	0.70	1.12	0	0	0
$y_t \lvert \Delta \tau_t \rvert$ (denominator τ)	0	0	0	0.25	0.50	0.99
$\Delta y_t / \Delta G_t$ or $\Delta y_t / (y_t \lvert \Delta \tau_t \rvert)$	−0.50	−0.50	−0.50	−0.18	−0.18	−0.18

Note: The table shows the impact of varying the size of the fiscal intervention on debt accumulation and on the numerator and denominator of output multiplier. Sizes of government spending and tax-cut policies are expressed in percentage-point deviations from respectively the steady-state spending-to-output ratio and the steady-state tax rate. All deviations in the core of the table are from the no-intervention case (stationary level in the unintended regime) in percentage of annual output.

regime that crowds in consumption and that alleviates the negative effect of debt accumulation on output (see Section 4.2). This last result can be overturned with a large-enough tax cut (–4 pp). In this case, debt accumulates so much (52.72 percent) that output in the unintended regime falls below that observed in the baseline spending policy (–0.18 against –0.12). Notice however that since this larger output deterioration is proportional to the size of the tax variation, the output multiplier remains unchanged (–0.18) and is less negative than the output multiplier of government spending (–0.5) for any size of the fiscal intervention. This confirms the superiority of the tax-cut policy in the EDLT when government debt dynamics matter for macroeconomic outcomes.

Appendix F. Preference over Safe Assets

I consider a modified version of the model where government bonds enter in the utility function of the representative household. More specifically, the lifetime utility now becomes[16]

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \xi_t \left[\frac{c_t^{1-\gamma_c}}{1-\gamma_c} + \nu_g \frac{G_t^{1-\gamma_g}}{1-\gamma_g} - \nu_h \frac{h_t^{1+\gamma_h}}{1+\gamma_h} + \chi \frac{\left(\frac{b_t}{R_t}\right)^{1-\gamma_b}}{1-\gamma_b} \right]. \quad \text{(F.1)}$$

The log-linear system now reads

$$\beta \tilde{b}_t - \tilde{b}_{t-1} - b(\beta \hat{\imath}_t - \hat{\pi}_t) - \Psi_G^b \hat{G}_t + \Psi_c^b \hat{c}_t + \Psi_\tau^b \tilde{\tau}_t = 0$$

$$\hat{c}_t = -\gamma_c^{-1} \delta(\hat{\imath}_t - \mathbb{E}_t \hat{\pi}_{t+1}) + \delta \mathbb{E}_t \hat{c}_{t+1} + (1-\delta)\gamma_b(b^{-1}\tilde{b}_t - \hat{\imath}_t)$$

$$\hat{\pi}_t = \beta \mathbb{E}_t \hat{\pi}_{t+1} - (\theta - 1)\psi^{-1}\hat{\mu}_t,$$

where $\delta = \beta R$ is the discounting wedge and γ_b is the wealth curvature. Parameter χ governs the degree of preference over safe assets (POSA).

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[16]The reason R_t shows up in the utility is the following. Rannenberg (2021) considers a budget constraint of the form $\bar{b}_t = \frac{R_{t-1}\bar{b}_{t-1}}{\pi_t} + deficit_t$, where $\bar{b}_t$ is the face value of debt. To recover the (mathematically equivalent) budget constraint in this paper, one has to operate a variable change by defining $b_t = R_t \bar{b}_t$. Moreover, Rannenberg (2021) uses the following functional form for POSA: $\chi \frac{\bar{b}_t^{1-\gamma_b}}{1-\gamma_b}$. Applying the variable change, this gives $\chi \frac{(\frac{b_t}{R_t})^{1-\gamma_b}}{1-\gamma_b}$ in my model.

Under this specification, the individual discount rate exceeds the nominal return on the bond. Formally, the non-linear Euler equation reads $1 = R_t \beta \mathbb{E}_t \frac{c_{t+1}^{-\gamma_c}}{\pi_{t+1} c_t^{-\gamma_c}} + \chi \bar{b}_t^{-\gamma_b} c_t^{\gamma_c}$, where $\bar{b}_t = b_t/R_t$ is the face value of debt. The risk-free rate in the benchmark model (without POSA) is given by $R_t^* = \frac{1}{SDF_t}$, where $SDF_t \equiv \beta \mathbb{E}_t \frac{c_{t+1}^{-\gamma_c}}{\pi_{t+1} c_t^{-\gamma_c}}$ represents the stochastic discount factor of the households. Defining $\Theta_t \equiv \chi \bar{b}_t^{-\gamma_b} c_t^{\gamma_c}$, the spread can be written as $\frac{R_t}{R_t^*} = 1 - \Theta_t$. Thus, when $\chi > 0$, the risk-free rate with POSA is lower than the one in the benchmark model ($R_t < R_t^*$). This spread is interpreted as a *convenience yield* on the risk-free bond, i.e., a premium that the representative household is willing to pay for the additional safety and liquidity services attributed to this type of asset.[17] To calibrate the additional parameters, I draw on the POSA literature. As in Campbell et al. (2017), I assume that the discounting wedge is $\delta = 0.99$. Given my steady-state gross rate of $R = 1.0063$ (which corresponds to an annualized interest rate of 2.5 percent), this gives me an individual discount factor of $\beta = 0.9839$. For the same discounting wedge, Rannenberg (2019) sets the wealth curvature to $\gamma_b = 1/3$. I take this value as an upper bound and choose $\gamma_b \in [0, 1/3]$. The POSA parameter can be recovered as a residual from the steady-state Euler equation, $\chi = (1 - \delta)(\frac{b}{R})^{\gamma_b} c^{-\gamma_c}$.

Appendix G. Optimized Rules with Regime Uncertainty

Section 5 on optimized rules assumed that the economy is plagued with rare episodes of EDLTs. In reality, it might be difficult for the government to identify the true nature of a liquidity trap: fundamental driven or expectations driven. Since the perfectly timed stimuli studied in this paper have contradictory effects depending on the nature of the liquidity trap, it is interesting to evaluate the impact of regime uncertainty on the optimized policy. Intuitively, if FDLTs may arise with some probability, then cutting taxes or spending may be less desirable because it sometimes would have recessionary consequences. Hence, I simulate again the economy, but this time

---

[17]For a similar interpretation see, e.g., Krishnamurthy and Vissing-Jorgensen (2012).

Table G.1. Macroeconomic Outcomes with Regime Uncertainty

	$\widehat{G}_u$	$\widetilde{\tau}_u$	$\mathcal{L}$	$\widehat{\pi}$			$\widehat{c}$			$\widehat{b}$		
				U	L	H	U	L	H	U	L	H
Optimized	-1	0	0.16	-2.39	-3.99	-0.25	0.25	-2.92	0.10	-2.00	-0.71	-0.70

Note: Government spending and consumption are expressed in percentage deviations from the steady state. Inflation is in annual percentages. Debt is in percentage of annual output and the tax rate in absolute percentages. Welfare loss is in percentage of permanent consumption equivalent. U, L, and H stand for the unintended regime, low regime, and high regime, respectively.

assuming three regimes: an unintended regime (U) that is expectations driven, a low regime (L) that is caused by a large demand shock, and a high regime (H) with high demand and non-binding ELB. The transition probability matrix is the following:

$$
\begin{bmatrix} p_{UU} & p_{UL} & p_{UH} \\ p_{LU} & p_{LL} & p_{LH} \\ p_{HU} & p_{HL} & p_{HH} \end{bmatrix} = \begin{bmatrix} 0.99 & 0 & 0.01 \\ 0 & 0.5 & 0.5 \\ 0.003 & 0.1 & 0.897 \end{bmatrix}.
$$

On the one hand, this distribution implies that it is impossible to switch from one binding regime to the other. On the other hand, once in the non-binding regime, it is possible to switch to a binding regime of both kind with a higher probability of fundamental regime.

Table G.1 shows that the optimized outcome still consists in a 1 percent spending cut although now no tax cut is warranted. This policy almost corresponds to a neutral stance of fiscal policy. This result is intuitive. Since expansionary fiscal policy has opposite effects depending on the type of liquidity trap, the best strategy becomes to refrain from intervening. Notice that inflation is lower in the low regime because the spending cut is deflationary in this case. The opposite is true for the unintended regime.

Appendix H. Derivation of the Loss Function

A second-order approximation of the representative households' utility around the efficient steady state yields

$$
U(c_t, y_t, G_t) \approx c^{1-\gamma_c} \hat{c}_t + \frac{1}{2}(1 - \gamma_c)c^{1-\gamma_c} \hat{c}_t^2 - \nu_h y^{1+\gamma_h} \hat{y}_t
$$

$$
- \frac{1}{2}\nu_h (1 + \gamma_h) y^{1+\gamma_h} \hat{y}_t^2 + \nu_g G^{1-\gamma_g} \hat{G}_t
$$

$$
+ \frac{1}{2}\nu_g (1 - \gamma_g) G^{1-\gamma_g} \hat{G}_t^2 + tip.
$$

At the efficient steady state, we have $\nu_g = G^{\gamma_g} c^{-\gamma_c}$ and $\nu_h = y^{-\gamma_h} c^{-\gamma_c}$, thus we can write

$$U(c_t, y_t, G_t) \approx c^{-\gamma_c}\left(c\hat{c}_t + \frac{1}{2}(1-\gamma_c)c\hat{c}_t^{\,2} - y\hat{y}_t - \frac{1}{2}(1+\gamma_h)y\hat{y}_t^2\right.$$

$$\left. + G\hat{G}_t + \frac{1}{2}(1-\gamma_g)G\hat{G}_t^{\,2}\right) + tip.$$

Next, a second-order approximation of the resource constraint $y_t\left(1 - \frac{\psi_\pi}{2}(\pi_t - 1)^2\right) = c_t + G_t$ gives

$$RC(c_t, G_t, \pi_t, \pi_{w,t}, y_t) \approx c\hat{c}_t + \frac{1}{2}c\hat{c}_t^2 + G\hat{G}_t + \frac{1}{2}G\hat{G}_t^2 + \frac{1}{2}\psi_\pi y\pi^2\hat{\pi}_t^2$$

$$= y\hat{y}_t + \frac{1}{2}y\hat{y}_t^2.$$

Solving for $c\hat{c}_t + \frac{1}{2}c\hat{c}_t^{\,2}$, substituting in the approximated utility and using $\pi = 1$, we arrive at the loss function in the text.

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