Seemingly Irresponsible but Welfare Improving Fiscal Policy at the Lower Bound*

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Abstract

We evaluate super-active fiscal policy rules that cut taxes or increase spending as the government's debt level rises. Using a standard New Keynesian model subject to an occasionally-binding zero lower bound on the monetary policy interest rate and a model-consistent measure of welfare, we show that such seemingly irresponsible fiscal rules can improve economic welfare. While sensible fiscal policy and active monetary policy performs best away from the ZLB, the fiscal rules we analyze significantly reduce the time spent at the ZLB and produce overall welfare gains. Super-active fiscal policies are most effective with a high debt target and when debt is short-term. However, when private expectations are characterized by cognitive discounting, the performance of super-active fiscal rules deteriorates. Fiscal rules calibrated to the U.S. response during both the Great Recession and COVID recession, combined with a weak monetary policy response to inflation, outperform a monetary policy that responds strongly to inflation and reduce the frequency of ZLB episodes under rational expectations, but not under cognitive discounting.

Keywords: automatic stabilizers, cognitive discounting, fiscal and monetary interactions, government debt.

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1 Introduction

We use a stylized, calibrated New Keynesian model to study the role that active fiscal policies in the form of debt-financed fiscal expansions might play in stabilizing inflation and output when the zero lower bound (ZLB) on nominal interest rates can render monetary policy ineffective. In line with the recent research on new monetary-policy frameworks to deal with the ZLB, which assumes that central banks can commit to rules responding to inflation, we extend the standard approach by incorporating simple fiscal rules governing purchases and taxes net of transfers in response to the government debt level. In contrast to the standard approach, however, we consider policy regimes in which monetary policy responds weakly (or not at all) to inflation while fiscal policy might appear to threaten the sustainability of the government's debt. We find that, in the face of contractionary aggregate-demand shocks that occasionally drive the nominal interest rate to the ZLB, a regime of passive monetary policy and active fiscal policy in which rising debt levels trigger an *increase* in government purchases and/or a *cut* in taxes net of transfers can reduce both the frequency of the ZLB and the welfare costs of inflation fluctuations.

The relevance of policies that reduce the primary surplus as debt levels rise is suggested by the policies adopted in the U.S. following the 2008-09 global financial crisis and the COVID induced recession of early 2020. During these recessions, large fiscal expansions occurred accompanied by increases in debt-to-GDP levels. As is well-known, the U.S. federal debt held by the public as a percent of GDP has been rising steadily since 2007; it was 35% at the start of the Great Recession (2007Q4) and had risen to 80% at the onset of the COVID recession (2019Q4).[1] Figure 1 illustrates the size and composition of the U.S. federal response during these recessions by showing the change in government *purchases* and *net taxes* as a share of GDP, divided by the change in debt as a share of GDP.[2] Also shown is the change in the *primary surplus* (net taxes minus purchases) relative to the change in debt. The bars on the left refer to the fiscal response during the Great Recession (2007Q4 to 2009Q2), while the bars on the right show the response in the COVID recession (2019Q4 to 2020Q2).

[1] The peak to trough dates for the Great Recession in the U.S. are 2007Q4–2009Q2, while for the COVID recession the peak to trough dates are 2019Q4–2020Q2, according to the NBER's Business Cycle Dating Committee (`https://www.nber.org`). Because we interpret the budget constraint (4) as applying to the consolidated government sector, the relevant definition of debt in the model is government debt held outside the government sector, i.e. federal debt held by the public.

[2] The data source is the Federal Reserve Bank of St. Louis FRED database (`https://fred.stlouisfed.org`). The variables we use (and their FRED identifiers) are the following: U.S. federal government receipts (FGRECPT), expenditures (FGEXPND), interest payments (A091RC1Q027SBEA), transfer payments (W014RC1Q027SBEA), debt held by the public as a percent of GDP (FYGFGDQ188S), and GDP (GDP). *Net taxes* are equal to receipts minus transfers, while government *purchases* are equal to expenditures minus transfers minus interest payments. And the *primary surplus* is equal to net taxes minus government purchases. In Figure 1, for example, the bar shown for government purchases is given by (g(end) - g(start))/(debt(end) - debt(start)), where g and debt are expressed as a percent of GDP and where 'start' and 'end' refer to the quarter in which the recession begins and ends.

As the figure reports, most of the fiscal response in the U.S. during the Great Recession took the form of tax cuts and increases in transfers, with the fall in net taxes equaling 42% of the rise in debt. Government purchases (consumption plus investment) rose by only 6% of the change in debt, implying the primary surplus fell by 48% of the rise in debt. During the COVID recession, the fiscal response was *larger overall* measured relative to the debt level, with the primary surplus falling by 91% of the rise in debt *and* with the debt level at the end of 2019 much higher than during the Great Recession. Government purchases rose notably more during COVID (24% of the rise in debt) and cuts in net taxes were larger (67% of the rise in debt) compared to the previous recession.

Understanding the implications of fiscal policies that increase borrowing as debt levels rise motivates our paper, which makes four primary contributions. First, we evaluate the consequences of adopting simple fiscal rules that would normally be viewed as prescribing "irresponsible" fiscal behavior: debt-financed fiscal expansions unbacked by any promise of future tax increases or spending cuts. We refer to these policies as *super-active* fiscal policies. The resulting debt expansions generate expectations of higher future inflation. If combined with a weak monetary policy response to inflation, the rise in expected inflation lowers the real interest rate and boosts aggregate demand. To ensure a unique, stationary rational-expectations equilibrium, such fiscal rules must be combined with monetary policy responses to inflation that violate the Taylor principle.

Importantly, the ZLB places no constraint on the government's ability to tax less and spend more to offset contractionary shocks to aggregate demand. In contrast, an active monetary policy seeking to stabilize current inflation will fail to raise inflation expectations if the ZLB binds; active monetary policy becomes ineffective. Away from the ZLB, however, active monetary policy can stabilize inflation and output without any fiscal stimulus. Thus, a welfare comparison of whether monetary policy or fiscal policy should be active will depend on their relative performances both at the ZLB and away from it and on the frequency of the ZLB under each policy alternative.

Our second contribution is to carry out such a welfare comparison employing a model-consistent measure of the welfare costs of fluctuations. We show that super-active fiscal policies can dominate less active fiscal policies as well as active monetary policies. This remains the case when the debt target is increased and when the government issues long-term debt. However, super-active fiscal policies are most effective with a high debt target and when debt is short-term. The normative assessment suggests that both the existing literature and policy discussions based on conventional wisdom have focused too exclusively on the role of active monetary policies in the face of the ZLB.

Our third contribution is to provide an evaluation of active monetary/passive fiscal (AM/PF) and passive monetary/active fiscal (PM/AF) policy regimes when expectations are not rational. Given that the performance of policy rules depends heavily on their impact on future expectations, an important question is whether our findings are robust to deviations from rational expectations. To address this issue, we replace the assumption of rational expectations and instead assume bounded rationality, in the form of cognitive discounting, that causes less weight to be placed on future events. While reducing the impact of expected future output and inflation on the current equilibrium, cognitive discounting also leads to deviations from Ricardian equivalence. Under a passive fiscal policy, an increase in debt comes with increases in the expected future primary surpluses necessary to ensure debt sustainability. When those future surpluses are discounted, the debt level has wealth effects that are absent under rational expectations. As far as we are aware, ours is the first analysis of alternative monetary and fiscal rules under cognitive discounting. We find that deviating from rational expectations has significant implications for equilibrium determinacy; some policies that would normally be classified as regimes of passive monetary and active fiscal policies are inconsistent with a stable equilibrium. Cognitive discounting also leads to a large deterioration in the performance of PM/AF regimes.

Our fourth contribution is to calibrate the fiscal rules to reflect the size of the fiscal responses seen in the U.S. during the Great Recession and the COVID recession, and thus show that super-active fiscal policies are effective in stabilizing inflation and output in the face of the ZLB. Accounting for the ZLB, the welfare costs of fluctuations under these policies are slightly lower than achieved by active monetary policy. The fiscal response during the Great Recession was concentrated on tax cuts and transfer increases, while that in 2020 during the COVID pandemic represented a more balanced increase in purchases and cut in net taxes. In the model simulations, the COVID response reduced inflation volatility and resulted in a welfare improvement relative to the fiscal response during the Great Recession. Both examples of super-active fiscal policies are particularly effective if they are combined with a passive monetary policy that pegs the nominal interest rate to its steady state, eliminating the occurrence of the ZLB. These results, however, are reversed under cognitive discounting.

The paper is organized as follows. Section 2 reviews the relevant literature and highlights our contribution therein. We employ a simple New Keynesian model for our analysis, and this is set out in Section 3, which also discusses the policy rules we consider, reviews the intuition for why active fiscal polices might improve outcomes facing the ZLB, and discusses the calibration of the model. We use the model in Section 4 to investigate the effects of active fiscal polices in the face of a contractionary shock to aggregate demand. In Section 5 we investigate whether our results depend on the debt-to-GDP target and on the introduction of long-term debt. Section 6 analyzes how bounded rationality, in the form of cognitive discounting of the future, affects the relative performance of monetary and fiscal rules. Section 7 evaluates the impact of a negative demand shock when the fiscal responses are calibrated to those seen in the U.S.

during the Great Recession and COVID recession. Conclusions are summarized in Section 8.

2 Related Literature

Our paper contributes to the large literature on designing policies to achieve macroeconomic stability in the face of the ZLB. This literature has been prompted by the extended periods of low and even negative interest rates experienced in many countries and by evidence of a declining natural rate of interest (see for example Holston, Laubach and Williams (2017)), which increases the likelihood of future ZLB episodes. A large literature has focused on optimal monetary policy at the ZLB. Work by Eggertsson and Woodford (2003, 2006), Adam and Billi (2006), and Nakov (2008), showed that central banks should promise to keep their policy rate at zero for longer, not raising rates as soon as doing so might become feasible. If credible, such promises to make-up for past target misses induce expectations of higher future inflation, helping to mitigate the policy limitations arising from the ZLB.[3]

The research on new monetary policy rules and goals to deal with the ZLB has, however, generally ignored the role of fiscal policy.[4] Nevertheless, monetary policy actions have implications for the government's budget, and the central bank's ability to achieve its inflation target depends on the behavior of the fiscal authority. Standard analyses of monetary policy assume, in the terminology of Leeper (1991), an *active monetary* policy (AM) aimed at controlling inflation, implicitly combined with a *passive fiscal* policy (PF) that ensures debt sustainability.[5] The Fed's policy framework review that led to the adoption of average inflation targeting in 2020, for example, took as given that any candidate framework would involve just such an AM/PF arrangement.[6]

Several authors have emphasized the role that active fiscal policy might play at the ZLB. According to Sims (2016), p. 315, the key question is: "Can fiscal deficit finance replace

[3]Policy rules consistent with price-level targeting or average inflation targeting lead expectations to adjust in ways that mimic optimal policy at the ZLB. The ZLB and its implications for the choice of central-bank goals are investigated in Billi (2017, 2018, 2020), Billi, Söderström and Walsh (2020), and Budianto, Nakata and Schmidt (2022), among others.

[4]As part of the FOMC's review of its policy framework, in June 2019 a research conference was held at the Federal Reserve Bank of Chicago. The papers from the conference were published in the *International Journal of Central Banking*, vol. 16(1), February 2020. However, none of the papers discussed the interactions between monetary and fiscal policies, or the role fiscal rules might play if monetary policy is limited in achieving its goals due to the ZLB.

[5]Leeper and Leith (2016) discuss the literature on interactions between monetary and fiscal policies and their role in determining macroeconomic outcomes, particularly the aggregate price level. Sablik (2019) provides a discussion of active and passive policies, budget deficits and inflation, linking active fiscal policies to the fiscal theory of the price level (FTPL) and to modern monetary theory (MMT). For a detailed introduction to FTPL and its relation to New Keynesian analysis, see Cochrane (2022).

[6]Liu, Miao and Su (2022) examine the relative performance of average inflation targeting (AIT) in AM/PF and PM/AF regimes. However, their focus, as is that of Beck-Friis and Willems (2017) and Hills and Nakata (2018), is on the implications for fiscal multipliers associated with exogenous fiscal shocks.

ineffective monetary policy" at the ZLB? He concludes the answer is yes, but stresses that "fiscal expansion is not the same thing as deficit finance. It requires deficits aimed at, and conditioned on, generating inflation. The deficits must be seen as financed by future inflation, not future taxes or spending cuts." Hence, monetary policy that is ineffective at controlling inflation requires fiscal expansion that is not accompanied by any promise to generate future primary surpluses to finance those deficits; "budget balancing can become bad policy" (Sims (2000), p. 970). Similarly, Eggertsson (2006) calls for the government to "commit to being irresponsible" during periods at the ZLB by creating money to fund a fiscal expansion, inducing expectations of higher future inflation. At the ZLB, creating money and debt financing a fiscal expansion are equivalent, see Galí (2020).

Thus, an era with frequent periods at the ZLB may require a more fundamental change in policy than simply maintaining an AM/PF regime while adopting a make-up rule based on a price-level target or average inflation. Passive monetary policy and active fiscal policy (PM/AF) regimes also need to be considered. There is some evidence that switches between policy regimes in the U.S. have occurred in the past. Kim (2003) argued that VAR evidence from the U.S. on inflation and output responses is consistent with a PM/AF regime during the 1940s and 1950s. Davig and Leeper (2011) estimate a regime switching model and find the U.S. has alternated between active and passive regimes.[7] Jacobson, Leeper and Preston (2019) offer an historical example of active fiscal policy in President Franklin Roosevelt's distinction between the *regular* budget, which was governed by conventional budget-balancing concerns, and the temporary *emergency* budget, for which there was no promise that future taxes would be raised to fund the deficit. Bianchi, Faccini and Melosi (2020) analyze temporary shock-specific polices (emergency budgets and temporary inflation targets) that can also be interpreted as capturing Roosevelt's distinction between the regular and emergency budgets.

While emergency budgets represent temporary adoption of an active fiscal policy, we examine the welfare implications of permanently adopting a PM/AF regime in an environment in which episodes at the ZLB are frequent under a standard inflation-targeting AM/PF regime.[8] Our analysis is therefore consistent with most of the recent work investigating alternative monetary rules for dealing with the ZLB, where regimes are analyzed as permanent choices among a variety of policy frameworks.[9] To rank alternatives, we use a model-consistent wel-

[7] Davig and Leeper (2011) use an estimated model to explore the impact of shocks to government purchases (such as the 2008 American Recovery and Reemployment Act) in different policy regimes, where the regimes are determined by the properties of policy rules for the nominal interest rate and lump-sum taxes net of transfers. Ascari, Florio and Gobbi (2020) also employ a regime-switching framework that allows for "timid" departures from regimes, ensuring determinacy as long as private agents anticipate a future return to either an AM/PF or PM/AF regime. They define fiscal rules in terms of lump-sum taxes, and their focus is primarily on issues of determinacy and the effects of regimes on the impact of fiscal-spending shocks.

[8] Bhattarai, Lee and Park (2014) provide an analytical characterization of inflation dynamics under AM/PF and PM/AF when not constrained by the ZLB.

[9] An exception is the proposal of *temporary* price-level targeting of Bernanke, Kiley and Roberts (2019). We also focus on regimes consistent with a unique, stationary equilibrium; Bianchi and Melosi (2019) considered

fare measure of the costs of economic fluctuations. Thus, our measure of the performance of AM/PF and PM/AF policies will depend on their respective welfare costs at the ZLB and away from it, as well as on the incidence of ZLB episodes.

In related work, Ascari, Florio and Gobbi (2021) examine the relative performance of inflation targeting (IT) and price-level targeting (PLT) in AM/PF and PM/AF regimes.[10] They employ a quadratic loss function to evaluate alternative outcomes with instrument rules for the nominal interest rate and for net taxes (short for *lump-sum taxes net of transfers*). They find that AM/PF dominates PM/AF under PLT, while the comparison of AM/PF and PM/AF under IT depends on the size of the interest rate response to inflation. They show that with an active fiscal policy, in which the primary surplus is fixed, performance under IT is improved if monetary policy responds *negatively* to inflation. Our paper is complementary in that they consider a seemingly irresponsible IT regime (raising rates as inflation falls) under active fiscal policy, while our focus is on super-active fiscal policies that reduce the primary surplus as debt levels rise. Bianchi, Faccini and Melosi (2020) consider emergency budgets and temporary inflation targets and analyze a transfer shock based on the 2020 CARES Act with nominal interest rates positive throughout the experiment. Instead, we focus on the role of fiscal rules in contributing to macroeconomic stabilization in the face of aggregate demand shocks that can push the economy to the ZLB, employing fiscal rules for both net taxes and government purchases in a stylized, calibrated New Keynesian model with a ZLB constraint.

While we follow much of the literature on active fiscal policy in assuming one-period debt, we also generalize the analysis to consider the role of long-term government debt. Caramp and Silva (2021) and Leeper (2021) emphasize how the presence of long-term debt implies revaluation effects on existing debt that affect the wealth channel of monetary policy under active fiscal policies. Leeper and Zhou (2021) investigate optimal commitment policies when debt is long-term, while Leeper, Leith and Liu (2021) consider discretionary policies, as does Harrison (2021), who highlights how debt sustainability becomes a constraint on the actions of the central bank when fiscal policy is active. Harrison's work is complementary to ours in that he uses, as we do, a model-consistent quadratic loss function to rank outcomes and specifies fiscal policy as setting an exogenous primary surplus, which as he notes, is one of the specifications we investigate. We differ in adopting a simple rule for monetary policy, while he derives optimal monetary policy, and we consider super-active fiscal policies.

Policy rules assume the central bank has committed to follow the rule in the future. Thus,

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the consequences of a conflict between active fiscal policy and active monetary policy.

[10]They define monetary policy in terms of an interest rate rule that respond to the price level or average inflation. Defining regimes in terms of what variables appear in an instrument rule contrasts with approaches that define regimes in terms of the objectives or goals adopted by the central bank. IT and PLT are defined in terms of the objectives in Vestin (2006) and Billi (2017, 2018); see also Svensson (2003) and the analysis of AIT in Walsh (2003, 2019). For a discussion of the choice between rules and goals in the context of monetary policy design, see Walsh (2015).

the performance of different rules depends importantly on the way a rule shapes future expectations. A number of authors have analyzed the implications of deviations from rational expectations for the issues that arise at the ZLB such as the forward guidance puzzle (e.g., Gabaix (2020)) and the performance of monetary policy frameworks such as average inflation targeting (e.g., Budianto, Nakata, and Schmidt (2022)). We discuss some of the macroeconomic evidence supporting cognitive discounting in Appendix A. However, the literature comparing active fiscal policy has maintained the assumption of rational expectations. Our paper is, therefore, the first to employ the cognitive discounting model due to Gabaix (2020) to analyze the relative performance of AM/PF and PM/AF policy regimes.

3 The Model

We conduct our analysis using a simple version of the New Keynesian model, augmented with a ZLB constraint and with fiscal policy rules in which net taxes and purchases respond to the level of government debt. In this section, we introduce the equations describing the model's equilibrium, discuss how the fiscal rules affect inflation stabilization in a regime of passive monetary policy and active fiscal policy, and then calibrate the model to recent U.S. data.

3.1 Private Sector

The behavior of the private sector is described by the equilibrium conditions that correspond to the closed-economy New Keynesian model with staggered price setting à la Calvo, flexible wages, and without capital accumulation. Government purchases are financed through lump-sum taxes and the issuance of debt. All equations are log-linearized around a steady state with no trend growth, zero price inflation, and with a subsidy that exactly offsets the steady-state distortions arising from price markups. The micro foundations of the model and the derivations of its reduced form are well known and can be found in the textbooks of Galí (2015) chapter 3, or Walsh (2017) chapter 8. Our notation generally follows Galí (2020).

The supply side of the economy is described by a New Keynesian Phillips curve:

$$\pi_t = \beta E_t \{\pi_{t+1}\} + \kappa \tilde{y}_t, \tag{1}$$

where π_t is the rate of price inflation between periods $t-1$ and t. The parameter β denotes the household's discount factor. $\tilde{y}_t \equiv \hat{y}_t - \hat{y}_t^n$ denotes the output gap, where $\hat{y}_t \equiv \log(Y_t/Y)$ denotes (log) output in deviation from its steady state, and where $\hat{y}_t^n \equiv \log(Y_t^n/Y)$ represents the (log) deviation of the natural level of output, i.e. output's equilibrium level in the absence of nominal rigidities, as a deviation around its steady state.

The natural (flexible-price) level of output is given by $\hat{y}_t^n \equiv \Gamma \hat{g}_t$, where $\Gamma \equiv \frac{\bar{\sigma}(1-\alpha)}{\alpha+\varphi+\bar{\sigma}(1-\alpha)}$ and

$\hat{g}_t \equiv (G_t - G)/Y$ denotes the deviation of (real) government purchases from its steady state as a share of steady-state output. Note that $\bar{\sigma} \equiv \sigma(Y/C)$. The parameters α, σ and φ denote the degree of decreasing returns to labor in production, the household's coefficient of relative risk aversion and the curvature of labor disutility, respectively. The goods-market equilibrium condition is given by $Y_t = C_t + G_t$ or approximately $\hat{y}_t = (C/Y)\hat{c}_t + \hat{g}_t$, where $\hat{c}_t \equiv \log(C_t/C)$ denotes (log) private consumption expressed as a deviation from its steady state. In addition, the slope of the Phillips curve is given by $\kappa \equiv \lambda\left(\bar{\sigma} + \frac{\alpha+\varphi}{1-\alpha}\right)$, where $\lambda \equiv \frac{(1-\theta)(1-\beta\theta)(1-\alpha)}{\theta(1-\alpha+\alpha\epsilon)}$. The parameter $\theta \in [0, 1)$ denotes the Calvo index of price rigidity (the probability that a firm does not reset its price in a given period), and $\epsilon > 1$ denotes the elasticity of substitution among varieties of goods.

The demand side of the economy is described by a dynamic IS equation:

$$\tilde{y}_t = E_t\{\tilde{y}_{t+1}\} - \frac{1}{\bar{\sigma}}\left(\hat{\imath}_t - E_t\{\pi_{t+1}\} - \hat{r}_t^n\right), \tag{2}$$

where $\hat{\imath}_t \equiv i_t - \rho$ denotes the short-term nominal interest rate expressed as a deviation from its steady state, and the latter corresponds to the discount rate $\rho \equiv 1/\beta - 1 > 0$. The short-term real interest rate is given by $\hat{r}_t \equiv \hat{\imath}_t - E_t\{\pi_{t+1}\}$. The natural rate of interest is given by $\hat{r}_t^n \equiv (1-\rho_z)z_t - \bar{\sigma}(1-\Gamma)E_t\{\Delta\hat{g}_{t+1}\}$, where z_t is a preference shifter (aggregate-demand shock) which follows an exogenous $AR(1)$ process with autoregressive coefficient ρ_z and standard deviation σ_z.[11]

A key objective of our analysis is the evaluation of fiscal and monetary policy from a welfare perspective. For that purpose, we use as a welfare metric the second-order approximation of the average welfare loss experienced by the representative household as a consequence of fluctuations around an efficient steady state with zero inflation. We express this social welfare loss as a fraction of steady-state consumption:

$$\mathbb{L} = \frac{1}{2}\left[\frac{\epsilon}{\lambda}var(\pi_t) + \frac{\kappa}{\lambda}var(\tilde{y}_t) + \frac{\gamma\kappa}{\lambda}var(\hat{g}_t)\right], \tag{3}$$

where $\gamma \equiv \Gamma\left(1 - \Gamma + \frac{\bar{\delta}}{\bar{\sigma}}\right)$, where $\bar{\delta} \equiv \delta(Y/G)$ and δ denotes the curvature of utility from government purchases. The welfare loss has three components, respectively associated with the volatilities of inflation, the output gap, and government purchases. A discussion can be found in Woodford (2011).

[11] This shock's innovation is an i.i.d. normally distributed process with zero mean and standard deviation given by $\sigma_{ez} = \sigma_z\sqrt{1-\rho_z^2}$. Furthermore, z_t is interpreted as a shock to the effective discount factor; it affects the household's marginal utility of consumption and marginal value of leisure, while leaving unaffected the marginal rate of substitution between consumption and leisure. Thus, z_t affects $\hat{r}_t^n$ but not $\hat{y}_t^n$ in the model.

3.2 Government Budget and Policy Regimes

The fiscal authority finances its spending through two sources: net taxes (*lump-sum taxes net of transfers*) and the issuance of nominally riskless one-period bonds with a nominal yield i_t. Section 5 extends the model to include long-term debt. After log-linearization around a steady state with no trend growth and zero inflation, the following difference equation describes the evolution of real government debt as a share of steady-state output, thereby representing the government's flow-budget constraint:[12]

$$\hat{b}_t = \beta^{-1}\hat{b}_{t-1} + \beta^{-1}b\left(\hat{\imath}_{t-1} - \pi_t\right) + \hat{g}_t - \hat{\tau}_t, \tag{4}$$

where $\hat{b}_t \equiv \left(B_t - B\right)/Y$ and $\hat{\tau}_t \equiv \left(T_t - T\right)/Y$ denote, respectively, deviations of (real) government debt and net taxes from their steady state, expressed as a fraction of steady-state output. B_t denotes the (real) market value of government debt. The parameter $b \equiv B/Y$ denotes the long-run debt target as a share of steady-state output.

In (4) the government debt issuance for the current period, $\hat{b}_t$, is determined by three cost components expressed as deviations from their steady state. The first part is the cost to refinance (roll over) the outstanding debt, $\beta^{-1}\hat{b}_{t-1}$. The second part is the (real) interest cost to service the debt outstanding, $\beta^{-1}b\left(\hat{\imath}_{t-1} - \pi_t\right)$. And the third part captures the "*primary surplus*" (defined in official statistics as the fiscal balance net of any interest payments) which may be in surplus or deficit. Let $\hat{s}_t \equiv \hat{\tau}_t - \hat{g}_t$ denote the primary surplus, then $\hat{s}_t < 0$ (i.e. $\hat{\tau}_t < \hat{g}_t$) indicates that the fiscal balance excluding interest payments is in *deficit* rather than surplus.

The fiscal authority controls the primary balance with rules that specify how both net taxes and government purchases respond to deviations of the outstanding stock of government debt from its steady state. When log-linearized, the fiscal rules we analyze take the form:

$$\hat{\tau}_t = \psi_\tau \hat{b}_{t-1}, \tag{5}$$

$$\hat{g}_t = \psi_g \hat{b}_{t-1}. \tag{6}$$

These fiscal policy rules together imply a rule for the primary surplus in response to the debt level, $\hat{s}_t = \psi_s \hat{b}_{t-1}$, where $\psi_s \equiv \psi_\tau - \psi_g$. Moreover, combining (4) through (6), we obtain:

$$\hat{b}_t = \left(\beta^{-1} - \psi_s\right)\hat{b}_{t-1} + \beta^{-1}b\left(\hat{\imath}_{t-1} - \pi_t\right). \tag{7}$$

Hence, as this combined version of the government's flow budget shows, the choice of coefficients in the fiscal rules, ψ_τ and ψ_g, allows the fiscal authority to affect directly the accumulation of government debt through the response of the primary surplus $\psi_s \equiv \psi_\tau - \psi_g$.

[12] See, for example, Walsh (2017) chapter 4 and Galí (2020) for a discussion.

In particular, a lower ψ_τ and/or a higher ψ_g increase the outstanding debt from period $t-1$ that must be refinanced. All else equal, the lower ψ_s would lead to a higher debt issuance in period t to satisfy the government's budget. The government debt issuance, however, is not determined by fiscal policy alone; rather it is the result of the joint behavior of the fiscal authority and the central bank that will determine inflation and the nominal interest rate. To close the model economy, we need also a description of monetary policy.

We adopt a standard rule for the nominal interest rate, namely a truncated Taylor-type rule that incorporates explicitly a ZLB constraint ($i_t \geq 0$ implying $\hat{\imath}_t \geq -\rho$):

$$\hat{\imath}_t = \max\left[-\rho, \phi\pi_t\right]. \tag{8}$$

In our analysis we have two policy regimes, characterized by the configuration of the response coefficients ϕ, ψ_g and ψ_τ in the above monetary and fiscal rules. Namely, in the terminology of Leeper and Leith (2016), we study regimes M and F. Under *regime M*, active monetary policy (AM) aimed at controlling inflation is combined with a passive fiscal policy (PF) ensuring debt sustainability: $\phi > 1$ and $\psi_s \equiv \psi_\tau - \psi_g > \rho$. That is, in regime M, with $\phi > 1$ in rule (8), the nominal interest rate responds more than one-for-one to movement in inflation and therefore the Taylor principle is satisfied. With $\psi_s > \rho$, the coefficient on the lagged debt stock in (7) is smaller than unity, $\beta^{-1} - \psi_s = 1 + \rho - \psi_s < 1$, which ensures the debt level converges to its long-run target. Conversely, in *regime F*, active fiscal policy (AF) controls inflation and monetary policy responds passively (PM) to ensure debt sustainability: $\phi < 1$ and $\psi_s < \rho$.[13]

Consistent with the standard analysis of policy rules in the monetary policy literature, we assume that both the fiscal authority and the central bank are able to credibly commit to follow the policy rules (5), (6), and (8). At the same time, private agents in the economy form expectations knowing that the policy authorities will abide by those policy rules. A discussion of the feasibility of implementing such a set of policy rules is postponed until our concluding section.[14]

We next discuss how active fiscal policy in regime F and the choice of fiscal instrument

[13] The determinacy conditions for ϕ and ψ_τ are well known; see Leeper (1991). Because stationarity depends on the absolute value of the eigenvalues, active fiscal policy would also arise if $1/\beta - \psi_s < -1$, or $\psi_s > 2 + \rho$. Given our focus on super-active fiscal policies, we rule out such large tax increases or spending cuts in the face of rising debt levels. The previous literature has focused on tax policies, generally treating spending as an exogenous process. For this reason, online appendix B.1 discusses determinacy for the spending rule (6).

[14] One could add exogenous stochastic components to the policy rules (5), (6), and (8) without qualitatively affecting our results. We restrict attention to simple rules for both fiscal and monetary policy. Burgert and Schmidt (2014) show that government spending and debt rise under the optimal discretionary policy at the ZLB, with the increase depending negatively on the initial debt level. Nakata (2017) studies the optimal commitment policy in a similar environment. He finds that the ability to commit to future policies implies a higher initial debt level leads to a larger spending response. In both these papers, fiscal and monetary instruments are optimally chosen by a single policymaker.

affects the response of inflation to demand shocks.

3.3 Inflation Stabilization in Regime F

To discuss inflation stabilization under regime F, we investigate how the fiscal rules for net taxes and government purchases influence the economy's adjustment to a negative demand shock. Under regime F, $\phi < 1$ and $\psi_s < \rho$ in the policy rules (PM/AF). It will simplify the discussion to set $\phi = 0$ in the monetary policy rule, implying the nominal interest rate is pegged to its steady state and does not react at all to inflation: $\hat{\imath}_t = 0$ and $i_t = \rho > 0$ for all t. We relax this assumption in Section 4 when we report simulation results for passive monetary policy with $0 \leq \phi < 1$. Because our focus is on the consequences of negative aggregate-demand shocks, we briefly review the key mechanism through which debt dynamics affect the inflation response to such shocks.

The equilibrium conditions for regime F consist of the Phillips curve and IS equation, (1) and (2), together with the debt accumulation equation, (7). As is well-known, with the nominal interest rate pegged, (1) and (2) fail the Blanchard-Kahn conditions and are consistent with multiple stationary equilibria (see Leeper (1991)). However, (7) pins down the unique equilibrium level of inflation consistent with stationarity of the government debt level as a share of output.

A negative demand shock causes a fall in the output gap and inflation. The fall in π_t increases the (real) interest expense to service the outstanding debt, $-\beta^{-1}b\pi_t$ rises, worsening the fiscal authority's debt outlook. Moreover, the impact of inflation on the debt outlook, conditional on the lagged debt stock, is increasing in the debt target b. The implications for future inflation are seen most clearly if regime F involves setting $\psi_\tau = \psi_g = 0$. That is, neither net taxes nor government purchases respond to deviations of debt from its steady state.[15] As a consequence, with the nominal interest rate pegged, $\hat{\imath}_t = 0$ for all t, the debt accumulation equation (7) reduces to

$$\hat{b}_t = \beta^{-1}\hat{b}_{t-1} - \beta^{-1}b\pi_t. \tag{9}$$

Because $\beta^{-1} > 1$, we solve the debt equation forward to obtain

$$\hat{b}_{t-1} = b\sum_{i=0}^{\infty}\beta^i\pi_{t+i} + \lim_{i\to\infty}\beta^{i+1}\hat{b}_{t+i}. \tag{10}$$

[15] This is equivalent to making fiscal policy exogenous and is the active fiscal policy considered by Ascari, Florio and Gobbi (2021) and by Harrison (2021).

For a stationary equilibrium, the discounted future debt level must converge to zero, implying

$$\hat{b}_{t-1} = b\left[\pi_t + \sum_{i=1}^{\infty} \beta^i \pi_{t+i}\right]. \tag{11}$$

With monetary policy nonreactive ($\hat{\imath}_{t+j} = 0$ for $j \geq 0$), the present discounted value of inflation is fixed at $\hat{b}_{t-1}/b$. The fall in current inflation, $\pi_t < 0$, due to the negative demand shock, must therefore generate higher future inflation to ensure a stationary debt process. This reasoning is similar to the "unpleasant monetarist arithmetic" of Sargent and Wallace (1981), though they focused on the need for future seigniorage revenue to rise to balance the intertemporal government budget, while here debt sustainability is accomplished through the impact of inflation on the real value of the outstanding debt.[16] In the face of a negative demand shock, however, raising expectations of future inflation helps to stabilize the economy when the nominal interest rate fails to adjust. For this reason, regime F may help stabilize the economy when monetary policy is unable to respond.

In an active monetary policy regime, the rise in real debt holdings of households resulting from the fall in inflation is offset by the negative wealth effect generated as households anticipate a rise in the present value of future tax payments. Under active fiscal policy with $\psi_s = 0$, there is no negative wealth effect from future taxes offsetting the rise in the real value of household debt holdings.

By extension, a super-active fiscal policy that causes the primary surplus to fall as the debt level rises will require a larger rise in future inflation to ensure debt sustainability. This increase in expected future inflation acts to partially offset the initial fall in inflation, serving to help stabilize inflation and the output gap in the face of contractionary aggregate-demand shocks.

A rule-based, active fiscal policy—that is, a credible commitment to behave in ways that to many academics and policymakers would appear to be irresponsible and shortsighted—can endogenously generate movement in expected inflation that serves to stabilize the economy. This is an advantage if, due to the ZLB, monetary policy's response is limited. However, the economy is likely to experience periods when the ZLB binds and periods when it doesn't. Even if the PM/AF policy of regime F performs best when at the ZLB, it may perform much worse than AM/PF when the ZLB is not a constraint on monetary policy. To assess under which policy regime social welfare is highest, we turn to a calibrated version of the model that can be used to conduct stochastic simulations.

[16] A discussion can be found in Bhattarai, Lee and Park (2014).

3.4 Baseline Calibration

The simulations of the model reported in the next sections use the following baseline parameter values. We set the discount factor $\beta = 0.995$ which implies a steady-state real interest rate ρ equal to 2% annual. We set $\sigma = 1$, $\varphi = 5$ and $\alpha = 0.25$. Setting $\delta = 1$ implies the utility of government purchases decreases at the same rate as the marginal utility of private consumption. Setting $\epsilon = 9$ implies a steady-state price markup of 12.5%. And we set $\theta = 0.75$ which is consistent with an average duration of price spells of one year (four periods in the model). As we normalize Y to 1, we set $C = 0.8$ and $G = 0.2$.

In the policy rules, *under a standard regime M*, we set $\phi = 2$ for AM policy. We set $\psi_\tau = 0.3$ and $\psi_g = 0$ for PF, implying any increase in the debt-to-GDP ratio above its target is corrected about three quarters in one year by future taxes, in the absence of further deficits.[17] We set $b = 2.4$, which corresponds to a debt target equal to 60% of annual GDP. This value of b is chosen to be quantitatively comparable to the onset of the Great Recession and COVID recession, as we discuss later in Section 7. Finally, we calibrate the aggregate-demand shock in this benchmark AM/PF regime, by setting $\rho_z = 0.8$ to generate persistence and $\sigma_z = 0.028$ to obtain a frequency of the ZLB near 25%. Our baseline calibration of regime M is summarized in Table 1. We next present the outcomes of the model's stochastic simulations.

4 The Effects of Irresponsible Fiscal Stimulus Facing the ZLB

We use the stylized, calibrated New Keynesian model, given by equations (1) through (8), as a framework to study whether, as argued by Sims (2016), fiscal deficit finance can replace ineffective monetary policy when the economy faces frequent periods at the ZLB. We examine the implications of permanently adopting a rule-based PM/AF regime that would appear to be "fiscally irresponsible" but serves as an automatic stabilizer that helps to offset aggregate-demand shocks when monetary policy is unable to respond. We compare the model's outcomes, with and without the ZLB, under fiscal rules that cut net taxes as the debt level rises, raise government purchases as debt levels rise, or hold the primary surplus constant as debt levels rise. Under each of these policy alternatives, we analyze the economy's adjustment to a contractionary shock that pushes down the natural rate of interest, aggregate demand and inflation. To rank the policy alternatives, we use (3), the model-consistent welfare measure of the costs of economic fluctuations arising from shocks buffeting the economy. In the following section, we also analyze whether the government's long-run debt target and the presence of long-term debt matter for the predictions of the model.

[17] That is, given $\beta = 0.995$, $\psi_\tau = 0.3$, and $\psi_g = 0$, the debt condition (7) implies $\left(\beta^{-1} - \psi_\tau + \psi_g\right)^4 \approx 0.25$.

4.1 Effects of Regime F and ZLB without a Fiscal Response

The various policy scenarios we investigate are summarized in Table 2. Scenario 1 is our benchmark representation of regime M (the baseline calibration from Section 3.4). Monetary policy is active with a response to inflation given by $\phi = 2$. With $\psi_\tau = 0.3$ and $\psi_g = 0$, passive fiscal policy ensures net taxes adjust positively to movements in the level of debt. Given the discount factor β is 0.995, the coefficient on the lagged debt stock in the debt accumulation equation (7) is then smaller than unity, $\beta^{-1} - \psi_s \approx 0.7$, which ensures the debt level converges to the government's long-run debt target for any stationary inflation path. Scenario 2 represents a PM/AF policy that holds both fiscal instruments constant. It sets $\phi = 0.8$ so monetary policy responds less than one-for-one to movement in inflation. We assume no fiscal response to the debt level by setting $\psi_\tau = \psi_g = 0$, implying $\psi_s = 0$. Hence, the coefficient on the lagged debt stock in the debt accumulation equation is larger than unity, $\beta^{-1} \approx 1.005$, implying an "irresponsible" debt outlook that will endogenously generate movement in expected inflation to ensure debt sustainability.

To illustrate the implications of these policy scenarios, we report the dynamic responses when the economy experiences a negative three standard-deviation demand shock, with and without the ZLB constraint in the model. Figure 2 shows the responses of key variables without the ZLB constraint.[18] Not surprisingly, regime M succeeds in stabilizing both inflation and the output gap much better than the PM/AF policy of scenario 2. This difference in the responses of those variables can be seen in the top row of the figure. The superior performance of regime M is reflected in a much-lower welfare loss from fluctuations, measured as a fraction of permanent consumption reported in Table 3. Without the ZLB in the model, the total welfare loss in regime M is about a quarter of that in scenario 2 (0.31% versus 1.19%). Of note in the figure, however, under scenario 2 inflation first becomes negative in the face of the contractionary demand shock but then rises and turns positive before converging to zero (its steady state). It overshoots, and the higher expected inflation this generates serves to ensure debt remains stationary. By contrast, in regime M inflation falls and then converges to zero from below. The inflation overshooting in scenario 2 means that expected future inflation will eventually be higher than in regime M.

Higher expected inflation is desirable at the ZLB, because it helps to stabilize the economy. This suggests that scenario 2 may deliver improved performance relative to regime M once the ZLB is taken into account. As Figure 3 shows, when the ZLB is accounted for, both inflation and the output gap fall much *less* in the face of the negative demand shock in scenario 2 than in scenario 1 (regime M). Under scenario 2, inflation recovers more quickly and overshoots. In the second row of the figure, the nominal interest rate hits the ZLB, but it remains there for a much-shorter period of time in scenario 2. As a result, the real interest rate rises much

[18] In all the figures, variable are shown in quarterly rates (not annualized).

less in scenario 2 than in regime M. Regarding the welfare implications of these policies, as Table 3 reports, regime M still performs better than scenario 2 but the difference becomes much smaller when facing the ZLB. Under regime M, the total welfare loss nearly triples when accounting for the ZLB (from 0.31% to 0.79%). Instead in scenario 2, the total welfare loss *falls* moderately due to the ZLB (from 1.19% to 1.06%); the reason is that, at the ZLB, monetary policy is effectively constrained and so unable to offset the expectations of higher future inflation generated by active fiscal policy to ensure debt sustainability.

Policy scenario 2 held both fiscal instruments constant by setting $\psi_\tau = \psi_g = 0$. We next examine how the model outcomes are affected when these response coefficients are allowed to differ from zero in ways that would normally be considered "fiscally irresponsible," such as committing to cut net taxes and/or increase government purchases as the level of debt increases.

4.2 Seemingly Irresponsible Tax Cuts and Spending Hikes

We begin with two examples of super-active fiscal responses, scenarios 3 and 4 in Table 2. One involves cutting net taxes as the level of debt rises; the other involves increasing government purchases as debt increases. To focus on the differences between using taxes or spending as the fiscal instrument, scenario 3 sets $\psi_\tau = -0.3$ and $\psi_g = 0$, while scenario 4 sets $\psi_\tau = 0$ and $\psi_g = 0.3$. In both cases, the primary surplus is then given by $\hat{s}_t = \left(\psi_\tau - \psi_g\right) \hat{b}_{t-1} = -0.3\hat{b}_{t-1}$. These values of ψ_τ and ψ_g are chosen to make them quantitatively comparable to the fiscal responses seen during the Great Recession and COVID recession, as we discuss later in Section 7. Both scenario 3 and 4 result in the primary surplus falling as the debt level rises, the opposite of conventional wisdom that seeks to stabilize the level of debt by increasing the primary surplus if debt increases. When debt levels rise, the two scenarios correspond, therefore, to using further debt issuance to finance the endogenous cut in taxes or increase in spending. We pair these active fiscal rules with a passive monetary policy; $\phi = 0.8$, the same PM policy as in scenario 2 in the previous section.

Figure 4 shows the dynamic effects of these policies with the ZLB. Regime M is also shown for comparison. Despite the effect of government purchases on the natural interest rate, these "irresponsible" tax and spending rules lead to very similar effects on inflation and the output gap.[19] Inflation falls only 1% under either AF rule, compared to a fall of around 4% in regime M; the output gap declines less than 5%, compared to around 8% in regime M. The superior performance of both AF rules is due to the behavior of the real interest rate. Under regime M, a negative demand shock that drives the nominal interest rate to the ZLB, combined with the resulting fall in inflation, leads to a sharp rise in the real interest rate near 2%. The ZLB further contracts demand and amplifies the decline in the output gap and inflation. In contrast,

[19] For our calibration, $\bar{\sigma} = 1.25$ and $\Gamma = 0.1515$, which implies $\Delta\hat{r}^n_t / E_t\left\{\Delta\hat{g}_{t+1}\right\} = -\bar{\sigma}\left(1-\Gamma\right) = -1.0606$.

under the AF rules, the nominal interest rate immediately rises from the ZLB. Combined with the smaller decline in inflation, the real interest rate falls below its steady state. By keeping the real interest rate low, the AF rules help to stabilize both inflation and the output gap when the economy experiences a large, contractionary demand shock. As a result, despite a modest decline in the primary surplus of 0.6% necessary to fuel the debt-financed fiscal expansion, the AF rules actually help to *stabilize* the level of debt. In the bottom row of the figure, the debt-to-GDP ratio rises only 2.5% under the AF rules, while it rises above 11% in regime M.

The welfare implications of policy scenarios 3 and 4 are reported in Table 3. If the ZLB is taken into account, both these super-active fiscal policies *reduce* the welfare costs arising from fluctuations in inflation and the output gap. Of the two polices, the welfare costs are lower in scenario 4, that is, when government purchases rather than net taxes are employed as the fiscal instrument. The main source of the gain is due to the significantly improved inflation stability relative to regime M, particularly when government purchases are the fiscal instrument. That is, when the ZLB is frequently binding under regime M, the welfare costs of inflation are notably *lower* if active fiscal policy replaces active monetary policy as the means of controlling inflation. With the ZLB, the total welfare loss is almost one-fifth *lower* in scenario 4 than in regime M (0.64% versus 0.79%). This welfare improvement is achieved from the better stabilizing effects at the ZLB. Furthermore, active fiscal policy leads to a *reduced* incidence of episodes at the ZLB. As the last column of the table reports, the frequency of the ZLB falls from 25.0% in regime M to only 10.1% in scenario 4.

So far in the analysis, tax cuts and spending hikes were debt financed, causing a fall in the primary surplus. As a further example, we consider a balanced-budget rule in which any spending is tax financed.[20] Scenario 5 sets $\psi_g = \psi_\tau = 0.3$, again paired with $\phi = 0.8$ for PM policy. In this case, given that both fiscal instruments adjust positively to movement in the level of debt, the primary surplus is held constant, $\psi_s = 0$. Figure 5 shows the dynamic effects of scenario 5 with the ZLB, compared to the previous scenario 4 in which government purchases are debt financed in the face of a contractionary demand shock. Not surprisingly, under scenario 5, the combination of expansionary spending and contractionary taxes does a worse job in stabilizing inflation and the output gap than debt-financed spending. Preventing the primary surplus from falling, and the expectations of inflation from rising, leads to a larger increase in the debt level. The debt-to-GDP ratio rises 2% in scenario 4 and near 5% in scenario 5. Regarding the welfare implications of such a policy, as Table 3 reports, scenario 5 performs worse than scenario 4. With the ZLB, the total welfare costs of fluctuations increase by one tenth (from 0.64% to 0.69%) if net taxes are used to finance the endogenous movement in government purchases. Thus, budget-balancing is less effective than debt-financing of the fiscal expansion. Put differently, the more "irresponsible" fiscal policy performs better.

[20] Given that PM/AF policy breaks Ricardian equivalence, spending financed by taxes or by debt may not have the same impact on output and inflation.

5 The Role of the Debt Level and Its Duration

In this section, we evaluate the robustness of our results to the long-run debt target and extend the model to include long-term debt. We find that, in the face of contractionary aggregate-demand shocks that occasionally drive the nominal interest rate to the ZLB, a regime of active fiscal and passive monetary policy can become more effective when the government adopts a high debt target and issues debt of short duration.

5.1 Does the Debt Target Matter?

We next analyze whether the government's long-run debt target affects the predictions of the model. Recall, from the debt accumulation equation, the effect of the real interest rate on the debt process depends on the long-run debt target, b. As (9) showed, when the nominal interest rate is pegged, the impact of inflation on debt, conditional on the lagged debt stock, is increasing in b. This observation suggests that, under an active fiscal and passive monetary policy, the fluctuations in the inflation rate necessary to ensure debt remains stationary may be smaller when the debt target is higher.

With the ZLB, Figure 6 compares the responses to a negative demand shock for scenarios 4 and 6 which differ only in the calibrated value of b. In both cases, the policy regime sets $\psi_\tau = 0$ and $\psi_g = 0.3$ for AF, combined with $\phi = 0.8$ for PM. In scenario 4 the baseline value of $b = 60\%$ as a share of annual GDP, whereas scenario 6 sets $b = 200\%$ as a share of annual GDP. Despite the much-higher debt target in scenario 6, the output gap responds similarly under either scenario. However, the responses of inflation differ slightly, with inflation overshooting less when b is higher. With a higher b, the debt-to-GDP ratio is more volatile and, as a consequence, so are government purchases. The larger increase in debt, given that the inflation responses are very similar for the first five quarters after the shock, is due to the larger coefficient on the real interest rate in the debt accumulation equation. That is, with a fall in inflation, the larger stock of debt amplifies the (real) interest expense to service the debt. From a welfare perspective, the higher debt target *improves* stabilization policy, due to the lower inflation volatility, as Table 3 reports. With the ZLB, the total welfare costs of fluctuations *fall* one quarter (from 0.64% to 0.48%) if the debt target takes the higher value. Moreover, because the higher debt target renders the active fiscal policy more effective in stabilizing inflation, the frequency of the ZLB is *reduced* (from 10.1% to 6.6%).

Overall, not surprisingly, a higher debt target increases debt volatility. However, the implications for inflation stability are quite the opposite of conventional wisdom that seeks to stabilize the level of debt by increasing the primary surplus if debt increases. Under a credible commitment to an "irresponsible" fiscal rule that raises government purchases when debt levels rise, a higher debt target helps to stabilize inflation and to improve welfare both at the ZLB and away from it.

5.2 Does the Presence of Long-Term Debt Matter?

The previous analysis was based on the assumption that all government debt took the form of one-period discount bonds. We next investigate whether the conclusions are affected if the government issues long-term debt. Harrison (2021), for example, finds that the presence of long-term debt can lessen the recessionary impact of a negative demand shock. Following Woodford (2001), we assume government bonds are perpetuities whose coupon declines at rate $\eta \in [0, 1]$ in each period.[21] We denote the price of the bond by Q_t.

In addition to these perpetuities, assume there are one-period bonds in zero net supply. The representative household's first-order conditions for the two types of bond imply

$$1 = \beta \mathrm{E}_t \left(\frac{1 + i_t}{1 + \pi_{t+1}} \right) \left(\frac{MUC_{t+1}}{MUC_t} \right) = \beta \mathrm{E}_t \left(\frac{1 + \eta Q_{t+1}}{Q_t} \right) \left(\frac{1}{1 + \pi_{t+1}} \right) \left(\frac{MUC_{t+1}}{MUC_t} \right), \tag{12}$$

where MUC_t denotes the marginal utility of consumption at time t. When these two Euler conditions are linearized around a zero inflation steady state, the relationship between the deviation of the one-period rate from its steady state, $\hat{\imath}_t$, and the deviation from steady-state of the one-period holding return on the perpetuity is given by

$$\hat{\imath}_t = \eta \beta \mathrm{E}_t \left\{ \hat{Q}_{t+1} \right\} - \hat{Q}_t, \tag{13}$$

where $\hat{Q}_t \equiv (Q_t - Q)/Q$ denotes the percent deviation of the bond price from its steady state, and the steady-state bond price is given by $Q \equiv \beta/(1 - \eta\beta)$. The average duration of the bond is $1/(1 - \eta\beta)$, which is increasing in η. The recent literature typically assumes the average duration of U.S. government debt is 5 years. Given that our model is calibrated at a quarterly frequency and $\beta = 0.995$, this implies a value for η of 0.955.

In addition, the flow budget constraint for the government, when log-linearized around a steady state with no trend growth and zero inflation, now takes the more general form:

$$\hat{b}_t = \beta^{-1} \hat{b}_{t-1} + \beta^{-1} b \left(\eta \beta \hat{Q}_t - \hat{Q}_{t-1} - \pi_t \right) + \hat{g}_t - \hat{\tau}_t. \tag{14}$$

When all debt is one-period, as in the previous analysis, $\eta = 0$ and $\hat{\imath}_{t-1} = -\hat{Q}_{t-1}$, implying (14) reduces to (4).

When $\eta > 0$, there are two key difference that distinguish (14) from (4). First, the (real) interest cost to service the debt outstanding is *increasing* in η. Namely, while a rise in the past bond price reflects a fall in the nominal yield, a rise in the current bond price results

[21] Declining perpetuities of this form have been used by, for example, Chen, Cúrdia and Ferrero (2012), Bianchi, Faccini and Melosi (2020), Caramp and Silva (2021), and Harrison (2021), among others.

in a revaluation of long-term debt that increases the government's liabilities. Second, long-term debt also *amplifies* the impact of monetary policy on the bond price itself. Solving (13) forward gives

$$\hat{Q}_t = -\sum_{i=0}^{\infty} (\eta\beta)^i \, \hat{\imath}_{t+i}, \tag{15}$$

which shows that the current bond price depends negatively on the future path of the short-term nominal interest rate. But this relationship reduces to $\hat{Q}_t = -\hat{\imath}_t$ when $\eta = 0$.

With the ZLB, Figure 7 shows the dynamic effects of a negative demand shock under scenario 4 (G with one-period debt) and scenario 7 (G with long-term debt). With one-period debt, the nominal interest rate rises and remains above its steady-state level before converging back to the steady state. The bond price $\hat{Q}_t$ mirrors (with opposite sign) the path of the nominal interest rate. With long-term debt, the bond price falls more to reflect the discounted value of the entire path of the nominal interest rate, see (15). The lower bond price generates a revaluation effect that initially reduces the value of outstanding debt. This initial decline in the debt-to-GDP ratio, in turn, implies less fiscal spending, so inflation and the output gap fall more. The ZLB becomes more of a constraint with long-term debt, leading to an initial rise in the real interest rate and, like the lower fiscal spending, contributes to the larger fall in inflation and the output gap when debt is long-term. Regarding the welfare consequences of long-term debt, as Table 3 reports, scenario 7 performs *worse* than scenario 4 due to the ZLB constraint. Facing the ZLB, the total welfare costs of fluctuations *increase* by one fifth (from 0.64% to 0.77%) if debt is long-term. However, scenario 7 with long-term debt still performs better than regime M, the AM/PF regime (which generates a welfare loss of 0.79%).[22]

In sum, facing the ZLB, the presence of long-term debt can increase the recessionary impact of adverse demand shocks in a regime of active fiscal and passive monetary policy. This outcome is the opposite of conventional wisdom that seeks to stabilize the government's burden of debt repayments by issuing debt instruments with longer maturity. Long-term debt renders the unfunded fiscal expansion less effective, because long-term debt dampens the wealth effects generated by rising debt levels in the face of the ZLB.

[22] As Table 3 shows, the presence of long-term debt *improves* welfare if the ZLB is ignored. Removing this constraint prevents the rise in the real interest rate that occurs in scenario 7. Harrison (2021) finds that with an active fiscal policy setting an exogenous primary surplus ($\psi_g = \psi_\tau = 0$) and assuming prices are extremely rigid (average duration of price spells near two years), long-term debt leads to a welfare improvement regardless of the ZLB.

6 Deviating from Rational Expectations: Cognitive Discounting

The analysis so far has assumed rational expectations. In this section, we explore the implications of dropping the rational expectations assumption in the basic model of Section 3. The performance of alternative monetary and fiscal policy regimes depends critically on how expectations of future policy actions affect the current equilibrium, and therefore on the way agents are assumed to form their expectations. In place of rational expectations, we adopt a form of cognitive discounting developed by Gabaix (2020). We discuss how cognitive discounting of future events modifies the model, before turning to its implications for determinacy and the ranking of AM/PF and PM/AF policy regimes.

Modifying the New Keynesian Phillips curve to incorporate cognitive discounting is straightforward. Details can be found in the online appendix B.2.1 and in Gabaix (2020). Letting $\bar{m} \in [0,1]$ be the micro-cognitive discounting factor, the New Keynesian Phillips curve with cognitive discounting is

$$\pi_t = \beta M^f E_t \{\pi_{t+1}\} + \kappa \tilde{y}_t, \tag{16}$$

where M^f is the aggregate equilibrium discount factor given by

$$M^f \equiv \bar{m} \left[\theta + (1-\theta)\left(\frac{1-\beta\theta}{1-\beta\theta\bar{m}}\right)\right] \leq \bar{m}.$$

Note that the elasticity of inflation with respect to the output gap κ is unchanged from the basic model. The factor M^f captures the discounting of future expectations that occurs under cognitive discounting. Under rational expectations, $\bar{m} = 1$, implying $M^f = 1$, and (16) reduces to (1).

Cognitive discounting affects the IS equation by modifying the role of expected future output and inflation. However, it also leads to deviations from Ricardian equivalence, generating an additional channel through which government debt affects aggregate demand. Under an active fiscal policy and rational expectations, Ricardian equivalence does not hold because agents do not expect the government to raise future taxes when, for example, current taxes are cut. With cognitive discounting, *even if future taxes are expected to be raised*, these future taxes are discounted by $\bar{m} < 1$. This generates an additional reason for Ricardian equivalence to fail. Specifically, Gabaix (2020) argues that a debt-financed increase in transfer payments puts money in the pockets of households, but households then discount the future taxes implied by the higher government debt. On net, households feel wealthier; they spend more and work less, raising the natural interest rate. Details can be found in the online appendix B.2.2.[23]

[23] See section XI.G.1, p. 11, of Gabaix's online appendix for a version of his model with government purchases.

The IS equation under cognitive discounting becomes, with $M \equiv \bar{m}$,[24]

$$\tilde{y}_t = ME_t\left\{\tilde{y}_{t+1}\right\} - \frac{1}{\bar{\sigma}}\left(\hat{\imath}_t - ME_t\left\{\pi_{t+1}\right\} - \hat{r}_t^{BR}\right), \tag{17}$$

where

$$\hat{r}_t^{BR} \equiv \left(z_t - ME_t\left\{z_{t+1}\right\}\right) - \bar{\sigma}\left(1-\Gamma\right)\left(ME_t\left\{\hat{g}_{t+1}\right\} - \hat{g}_t\right) + \bar{\sigma} b_d \hat{b}_t, \tag{18}$$

and the parameter b_d is given by

$$b_d \equiv \left(1 - M\right)\beta\rho\left(\frac{C}{Y}\right)\left(\frac{\varphi}{\varphi + (1-\alpha)\bar{\sigma}}\right) \geq 0.$$

The presence of $\hat{b}_t$ inside $\hat{r}_t^{BR}$ reflects the impact of deviations from Ricardian equivalence. Debt has no effect when $M = 1$.[25]

Note that $\hat{r}_t^{BR}$ also depends on $ME_t\left\{\hat{g}_{t+1}\right\}$. Given our fiscal policy rule (6), $E_t\left\{\hat{g}_{t+1}\right\} = \psi_g \hat{b}_t$. Thus $\hat{g}_{t+1}$ is known by agents at time t and therefore, once we impose our fiscal rules, is not affected by cognitive discounting. Under rational expectations, $M = \bar{m} = 1$, (17) and (18) reduce to (2) and to the earlier definition of the natural interest rate in Section 3.

The debt accumulation equation given by (4) does not involve expectations and so is unaffected under cognitive discounting. The model's equilibrium conditions are now (4) and (16)-(18). We set $\bar{m} = 0.85$ as in Gabaix (2020).[26] We summarize some of the empirical evidence on $\bar{m}$ in Appendix A. Other parameter values remain those of our baseline calibration (Section 3.4).

6.1 Equilibrium Determinacy Under Cognitive Discounting

Gabaix (2020) shows that the presence of cognitive discounting affects the standard conditions for equilibrium determinacy in a basic New Keynesian model with passive fiscal policy. Specifically, when $\bar{m} < 1$, the Taylor Principle is affected and a policy response that is "too weak" according to the normal Taylor Principle can still be consistent with determinacy. The intuition is straightforward. As $\bar{m}$ falls towards zero, the role of future expectations diminishes. In the limit, if $\bar{m} = 0$, the model would be completely static and a unique equilibrium exists for any response to inflation.

Determinacy conditions under cognitive discounting have not previously been explored

[24] Gabaix (2020), p. 2282, appeals to "a fringe of rational financial arbitrageurs with vanishing small consumption" to argue that inflation expectations in the definition of the real return are rational. We assume, instead, that households have access to nominal assets only and thus the relevant expected real return includes cognitive discounting of inflation in the equation for aggregate demand.

[25] If debt has a wealth effect, households respond by increasing their consumption of goods and of leisure. The term $\varphi / \left(\varphi + (1-\alpha)\bar{\sigma}\right) < 1$ captures the net effect on goods consumption.

[26] See section E of Gabaix (2020), p. 2285, for a discussion of the empirical relevance of the value of $\bar{m} = 0.85$, which as he notes could be viewed as conservative.

when both monetary and fiscal rules are governing policy. Consistent with Gabaix, we find that, when $\bar{m} = 0.85$, the conditions on the monetary policy response to inflation consistent with active policy are affected significantly. In contrast, those that determine whether fiscal policy is active or passive are much less affected.

With $\bar{m} = 0.85$, Figure 8 shows regions of determinacy, indeterminacy, and no stable equilibrium as functions of the parameters ϕ and ψ_τ in the top panels, and ϕ and ψ_g in the bottom panels. The left column shows results when ψ_τ and ψ_g range from -0.4 to 0.4, while the right column narrows the range to -0.02 to 0.02 so to highlight the boundaries between active and passive fiscal policies. Areas in white denote parameter regions with a unique, stationary equilibrium, in dark grey denote multiple equilibria, and in light grey denote no stationary equilibrium. Recall that under rational expectations, $\psi_s \equiv \psi_\tau - \psi_g > \rho$ and $\phi > 1$ define passive fiscal and active monetary policy respectively; the dashed lines in the figure use these standard values to divide the space into the traditional regions of determinacy, indeterminacy, and no stable equilibrium.

Consistent with Gabaix's result, monetary policy can be significantly less responsive to inflation than required by the Taylor principle and still be consistent with determinacy when fiscal policy is passive. There are now regions in which, when $\bar{m} = 1$, both monetary and fiscal policy would be viewed as passive, yet a unique equilibrium is obtained for $\bar{m} < 1$. For example, this is the case when $\psi_\tau = 0.02 > \rho$ or $\psi_g = -0.02 < -\rho$ and $\phi = 0.8$; a unique equilibrium occurs when taxes are increased or spending is reduced as the debt level rises to ensure debt sustainability, while monetary policy responds weakly to inflation. Some policies normally thought of as involving active fiscal and passive monetary policy, for example $\psi_\tau = 0 < \rho$ or $\psi_g = 0 > -\rho$ combined with, for example, $\phi = 0.8$ would, under the standard criterion, be classified as PM/AF, ensuring determinacy. However, under cognitive discounting, these policy combinations generate an unstable equilibrium.

Compared to the case of rational expectations, it is primarily the dividing line between active and passive monetary policy that is affected. Under our baseline calibration, as fiscal policy becomes more active, weaker and weaker monetary policy responses are still "active." With super-active fiscal policy, the critical value of ϕ defining active monetary policy falls towards 0.6. The reduced impact of future expectations extends towards zero the range of monetary policy responses consistent with active monetary policy. It is the deviation from Ricardian equivalence due to cognitive discounting that accounts for policies normally viewed as PM/PF to support determinacy. If $b_d = 0$, then passive fiscal policy is defined by $\psi_s \equiv \psi_\tau - \psi_g > \rho$, just as in the standard analysis under rational expectations, and active monetary policy requires $\phi > 0.6$ under our calibration, regardless of the fiscal rule.[27] For example, consider a policy in which $\psi_s \equiv \psi_\tau - \psi_g = 0.006 > \rho$ and $\phi < 0.6$. Under rational expectations,

[27] See online appendix B.2.3 for a discussion of determinacy with cognitive discounting.

this would represent a PM/PF regime and there would be multiple equilibria; under cognitive discounting, this policy supports a determinate equilibrium.

To understand why cognitive discounting affects the regions of determinacy, consider a positive shock to inflation expectations. Under a weak monetary policy response, this results in a lower real interest rate and an expansion of aggregate demand that risks making the expectation of higher inflation self-fulfilling. However, the rise in inflation reduces the real value of outstanding debt. Under a fiscal policy in which the primary surplus responds by more than ρ to the debt level but only weakly so, the initial fall in the debt level lowers household wealth because with cognitive discounting Ricardian equivalence fails. This, in turn, reduces aggregate demand. This feedback of the debt level to demand can ensure determinacy even with a weak monetary policy response to inflation. This is also why the value of ϕ consistent with determinacy falls as the primary surplus responds more negatively to the debt level, strengthening the feedback from the debt level to demand, as seen in the right panels of Figure 8.

Expectations do not appear directly in the government's budget equation. This accounts for the result that the condition for fiscal policy to be active or passive is less affected by the introduction of cognitive discounting than are the conditions for monetary policy.

6.2 Effects of Regime F with Cognitive Discounting

In Section 4, we analyzed a PM/AF regime by setting $\phi = 0.8$. With cognitive discounting this value for ϕ would represent an active monetary policy. To compare AM/PF and PM/AF regimes when the cutoff value of ϕ separating active from passive monetary policies can be much lower under cognitive discounting, we now set $\phi = 0.4$ when we assess passive monetary policy. As previously, we set $\phi = 2$, $\psi_\tau = 0.3$, and $\psi_g = 0$ under regime M. Responses under regime M are compared to the PM/AF regime with $\phi = 0.4$ and the Tax policy with $\psi_\tau = -0.3$, while keeping $\psi_g = 0$.[28]

With the ZLB, Figure 9 shows the responses when $\bar{m} = 0.85$ to a negative demand shock in regime M and the Tax policy under rational expectations (RE) and with cognitive discounting (CD). Under regime M, cognitive discounting does dampen the impact effect on inflation slightly and this is reflected in a smaller rise in the debt ratio. Overall however, the AM/PF regime M is very similar regardless of the assumption about expectations. This similarity is driven in part because the nominal rate is at the ZLB for 8 quarters under both RE and CD.

The responses under the PM/AF regime differ considerably from the AM/PF regime M and are more affected by the assumption made about expectations. In particular, the primary surplus falls under CD more that it does with rational expectations, and, as a result the debt-to-GDP ratio rises more and continues to rise for almost two years after the shock.

[28] The results when $\psi_\tau = 0$ and $\psi_g = 0.3$ are similar.

When future expectations are discounted, fiscal measures (debt-to-GDP, purchases, net taxes, and the primary surplus) in the super-active fiscal regime all display greater volatility than under rational expectations. Because the higher debt level generates a positive wealth effect on aggregate demand, the output gap eventually rises above its steady-state value before converging back to steady state. This contrasts with the effects under rational expectations where the output gap converges to its steady-state value without overshooting. This greater volatility under CD is even more pronounced if the ZLB constraint is ignored.

Table 4 reports the welfare costs of fluctuations under regimes M and F with cognitive discounting; this table can be compared to Table 3 which reported the welfare costs with rational expectations. When the ZLB is ignored, cognitive discounting has little effect on welfare under regime M, with the total welfare loss rising slightly (from 0.31% to 0.39%). The welfare loss also rises under all the F regimes but it does so much more significantly. Under the Tax and G policies, the total welfare loss rises by more than 100% compared to the case in which expectations were assumed to be rational. As under rational expectations, however, regime M dominates the fiscal regimes when the ZLB is ignored. In contrast to the results from Table 3 under rational expectations, regime M continues to dominate the fiscal regimes under cognitive discounting even when the ZLB is accounted for. The fiscal regimes lead to significant increases in the welfare loss due to inflation volatility and to output gap volatility compared to the outcomes under rational expectations. This is the case even though all the F regimes significantly reduce the frequency of the ZLB. For example, while this frequency is 27% under regime M, it is less than 10% under each of the F regimes, and falls to as low as 4% under the balanced G policy.[29]

Some intuition for the deterioration of outcomes under PM/AF policy with cognitive discounting can be provided by considering the case of an interest rate peg, $\phi = 0$. This case was shown previously to lead to (11). Under cognitive discounting, (11) becomes

$$\hat{b}_{t-1} = b\left[\pi_t + \sum_{i=1}^{\infty} \beta^i E_t^{BR} \pi_{t+i}\right] = b\left[\pi_t + E_t \sum_{i=1}^{\infty} \beta^i \bar{m}^i \pi_{t+i}\right]. \tag{19}$$

Starting from a zero-inflation steady state, and with the right hand side given, the path of inflation in response to a shock requires that

$$\pi_t = -E_t \sum_{i=1}^{\infty} \beta^i \bar{m}^i \pi_{t+i}.$$

With future inflation more heavily discounted relative to the case of rational expectations,

[29] These results on active fiscal policies are consistent with the findings of Budianto, Nakata, and Schmidt (2022) that cognitive discounting can lead price-level and average inflation targeting to perform worse than inflation targeting under passive fiscal policies.

future inflation must increase more in response to a fall in π_t generated by a negative demand shock.[30] This is what one sees in Figure 9 and in Table 4; the welfare loss under PM/AF policies rises significantly under cognitive discounting because of the large increase in the loss due to greater inflation volatility. Employing lower values of $\bar{m}$ would further exacerbate our finding that cognitive discounting leads to a large deterioration in the performance of PM/AF regimes.

7 Irresponsible Policy Responses in Recent Recessions

In this section, we use the data underlying Figure 1 to calibrate the fiscal policy parameters ψ_τ and ψ_g to study the consequences of "irresponsible" fiscal policies during the two recessions through the lens of our basic model of Section 5.2 with long-term debt. We consider outcomes under rational expectations and then under cognitive discounting.[31] Table 5 summarizes the experiments. The Great Recession (GR) scenario sets $\psi_\tau = -0.42$ and $\psi_g = 0.06$, combined with a passive monetary policy described by $\phi = 0.4$. The COVID scenario sets $\psi_\tau = -0.67$ and $\psi_g = 0.24$, maintaining $\phi = 0.4$.[32] We calibrate the debt target b to the debt-to-GDP level in the data at the start of each recession episode; this implies $b = 35\%$ for GR and $b = 80\%$ for COVID, each as a share of annual GDP. In both scenarios, the debt duration is set to five years ($\eta = 0.955$).

Figure 10 compares the responses to a negative demand shock for the GR and COVID specifications of the fiscal rules under rational expectations and with the ZLB constraint. Measured by the fall in the primary surplus as debt rises, the GR policy, with $\psi_s = -0.48$, might be expected to be less expansionary than the COVID policy, with $\psi_s = -0.91$. However, the two policies do a very similar job in stabilizing inflation and the output gap. Differences appear in the behavior of the fiscal variables themselves. Under the COVID policy, debt and the primary surplus move more. The reason is that a higher debt target increases the volatility in debt and government purchases, which serves to stabilize inflation under an active fiscal and passive monetary policy (see Section 5.1). The first two rows of Panel A in Table 6 report the welfare implications under rational expectations of the GR and COVID policies when $\phi = 0.4$, with and without the ZLB. As expected, the higher debt target of the COVID policy serves

[30] Cochrane (2016) discusses how the dynamics of the New Keynesian model are affected by cognitive discounting.

[31] When the model with long-term debt is modified to incorporate cognitive discounting, (13) is replaced with

$$\hat{\imath}_t = \eta\beta M \mathrm{E}_t \left\{ \hat{Q}_{t+1} \right\} - \hat{Q}_t.$$

[32] The Coronavirus Aid, Relief, and Economic Security (CARES) Act of 2020 was enacted during the COVID recession that ended in 2020Q2, while the American Rescue Plan (ARP) of 2021 was enacted after the recession ended. If the COVID period is extended to 2021Q2 to include the ARP, the calibration of the COVID scenario would be $\psi_\tau = -0.38$ and $\psi_g = 0.15$, implying $\psi_s = -0.53$, which is overall quite similar to the GR scenario.

to reduce inflation volatility, and therefore improves welfare regardless of the ZLB.

Macroeconomic outcomes depend on the fiscal rules *and* on the monetary policy rule, that is, on the value of ϕ, the response of the nominal interest rate to inflation. The GR and COVID scenarios considered so far set $\phi = 0.4$, implying that when the economy is away from the ZLB, the nominal interest rate adjusts with inflation but by much less than one-for-one. While this behavior constitutes a passive monetary policy, it will have consequences for the economy when at the ZLB. The expectation of a future recovery from the ZLB will also generate expectations of a rise in the nominal interest rate, which, in turn, will *weaken* the current expansionary impact of higher expected inflation. In rows 3 and 4 of Table 5, therefore, we consider scenarios that set $\phi = 0$ to investigate the consequences of the central bank pegging the nominal interest rate.[33]

Imposing the ZLB, Figure 11 shows the responses to a negative demand shock for the COVID policy with $\phi = 0.4$ and with $\phi = 0$. The latter scenario is labeled "COVID no MP" to indicate no response of monetary policy. The impact of the nominal rate peg on inflation is large. While inflation falls 2% when $\phi = 0.4$, it declines only 0.3% and returns to zero more quickly when $\phi = 0$. Under the nominal rate peg, the output gap also falls less and returns more quickly to zero. Because the nominal interest rate cannot adjust under the peg, the bond price remains at its steady state—that is, the duration of government debt plays no role under the peg. The resulting larger (real) interest expense to service the debt causes a larger rise in the debt-to-GDP ratio. With a larger rise in debt, government purchases rise more and net taxes fall more under the peg. Rows 3 and 4 of Panel A in Table 6 report the welfare implications under rational expectations of the nominal rate peg for both the GR and COVID fiscal policies. Under either set of fiscal rules, a monetary policy that pegs the nominal interest rate results in a large welfare improvement, due to the lower inflation volatility. As a result, the GR and COVID fiscal rules achieve the same welfare when the nominal interest rate is pegged. The nominal rate peg, by definition, also eliminates the occurrence of the ZLB.

These results lead us to a final question that brings us back to our benchmark policy. Would an active fiscal policy combined with a peg on the nominal interest rate perform better than a standard regime of active monetary policy and passive fiscal policy? As we discussed earlier in this paper, scenario 1 is a standard representation of AM/PF policy, or regime M. The welfare results of that policy were reported in Table 3. Under regime M, the total welfare loss from fluctuations was 0.79% and 0.31% respectively with and without the ZLB. The total welfare loss is reduced to only 0.17% under both the GR and COVID fiscal rules when the nominal interest rate is pegged (Table 6 panel A). Hence, even if the ZLB is ignored in the

[33] With $\phi = 0$, (15) pins the bond price to its steady state value, $\hat{Q}_t = \hat{\imath}_t = 0$ for all t, so the debt condition (14) reduces to (4), which means that the duration of government debt is irrelevant for the outcomes under the nominal rate peg. Ascari, Florio and Gobbi (2021) find that with an active fiscal policy in which $\psi_g = \psi_\tau = 0$, setting $\phi < 0$ can lead to a welfare improvement.

analysis, an active fiscal policy combined with a peg results in a large welfare improvement relative to regime M. The welfare gain achieved by an active fiscal policy and a peg is *several times larger* once the consequences of the ZLB are taken into account. Furthermore, while the ZLB inexorably binds frequently under an AM/PF regime, an active fiscal policy combined with a peg on the nominal interest rate would rule out episodes at the ZLB.

These results are, however, significantly affected if rational expectations are replaced by cognitive discounting. Even when the ZLB is ignored in the analysis, the GR and COVID fiscal rules under cognitive discounting lead to significant increases in the welfare loss due to inflation volatility and to output gap volatility compared to the outcomes under rational expectations (Table 6 panel B). The loss under the GR policy increases from 0.33% to 2.33% (from 0.31% to 2.57% under the COVID policy) when expectations are subject to cognitive discounting. Losses are lower when accompanied by an interest rate peg, but are again much larger with cognitive discounting. Thus, the implications of a comparison of Tables 3 and 4 and of panels A and B of Table 6 suggest super-active fiscal policies are much more dependent on the assumption of rational expectation than is regime M.

8 Concluding Remarks

The challenges facing central banks in a low interest rate environment, when episodes at the ZLB may be frequent and long lasting, are well known. Much is also known about the relative performance of alternatives to inflation targeting such as price-level targeting and average inflation targeting. The research on alternative policy frameworks has typically assumed the central bank can credibly commit to a policy rule and has *almost always* assumed that the broad framework of policy is one of active monetary policy and passive fiscal policy (AM/PF). It is this last assumption that we question. We show that, in the face of aggregate demand shocks and the ZLB, a *credible commitment* to active fiscal policy and passive monetary policy (AF/PM) can yield welfare gains. The superior performance of such a policy regime when monetary policy is constrained by the ZLB outweighs the advantages of active monetary policy when the ZLB is not a threat.

Absent the ZLB constraint, the traditional framework of AM/PF dominates, but this is no longer the case when the constraint is present. In fact, we find that the incidence of the ZLB is reduced to zero *and* the welfare costs of economic fluctuations are the lowest under an active fiscal policy and a nominal interest rate peg among the scenarios we consider, if private agents form expectations rationally.

The model we employ and the policy rules we analyze are stylized, but we think the results call into question the exclusive focus on monetary policy as the means of achieving inflation targets and maintaining macroeconomic stability. The fiscal rules we study involve seemingly irresponsible fiscal actions, that is, raising spending or cutting taxes as debt levels rise. Such actions generate expectations of the higher inflation necessary to ensure the government's real debt level remains stationary. Higher expected inflation helps offset a negative demand shock by reducing the real interest rate. At the ZLB, monetary policy is limited in its ability to generate higher expected inflation; central banks can talk, but they cannot backup their statements if their primary policy instrument cannot be reduced. In contrast, the fiscal authority can always act because its instruments are not constrained by the ZLB.

These results were robust to whether the government's long-run debt target was calibrated to equal 60% of annual GDP or to the much higher level of 200% of annual GDP. They were also robust to whether government debt was assumed to be of one-period duration or calibrated to match an average duration of 5 years. The advantage of super-active fiscal policy over active monetary policy was greatest when the debt target was high and the maturity of debt was short.

Rational expectations are key to why seemingly irresponsible fiscal actions may generate stabilizing movement in inflation expectations; they are also key to the performance of active monetary policy under "make-up" strategies such as price-level targeting or average inflation targeting. Replacing rational expectations with a model of cognitive discounting, which reduced the role of future expectations and introduced a new channel through which Ricardian equivalence fails to hold even with passive fiscal policy, had a significant effect on the results. Under cognitive discounting, the combination of AM/PF policies produce a smaller welfare loss than the PM/AF policies we examined. This outcome highlights the crucial role expectations play in evaluating alternative monetary and fiscal policies and emphasizes the importance of investigating the impact of deviations from rational expectations when assessing policy frameworks.

As is common in the literature, we assume for both AM/PF and PM/AF that policymakers can commit to simple, implementable rules. While this assumption is widely accepted for independent central banks, a host of political issues arise in the case of fiscal policy. Changes in taxes and spending raise the issue of which taxes and which spending will be adjusted. The resulting choices have distributional implications whose political consequences may limit the ability to precommit to future fiscal actions. The debates over debt limits in the Euro area and in the U.S. are well known. Cutting taxes or raising spending when debt levels rise in a recession may gain more political popularity than implementing austerity as debt levels rise. However, the fiscal rules we analyze would call for tax increases and spending cuts when debt levels fall. Such policies might be feasible if debt levels are falling during economic booms. Regardless, one can question the ability of fiscal authorities to credibly commit to the types of policies we find would perform well in an environment of low interest rates and frequent episodes at the ZLB.

At a minimum, our results suggest the need for further analysis of passive monetary and active fiscal regimes in a low-inflation, low interest rate environment.

References

Adam, K., and R. M. Billi (2006): "Optimal Monetary Policy under Commitment with a Zero Bound on Nominal Interest Rates," *Journal of Money, Credit and Banking*, 38(7), 1877–1905.

Andrade, J., P. Cordeiro, and G. Lambais (2019): "Estimating a Behavioral New Keynesian Model," *Working Paper*.

Ascari, G., A. Florio, and A. Gobbi (2020): "Controlling Inflation With Timid Monetary-Fiscal Regime Changes," *International Economic Review*, 61(2), 1001–1024.

——— (2021): "Price Level Targeting under Fiscal Dominance," *Working Paper*.

Beck-Friis, P., and T. Willems (2017): "Dissecting Fiscal Multipliers Under the Fiscal Theory of the Price Level," *European Economic Review*, 95, 62–83.

Bernanke, B. S., M. T. Kiley, and J. M. Roberts (2019): "Monetary Policy Strategies for a Low-Rate Environment," *AEA Papers and Proceedings*, 109, 421–426.

Bhattarai, S., J. W. Lee, and W. Y. Park (2014): "Inflation Dynamics: The Role of Public Debt and Policy Regimes," *Journal of Monetary Economics*, 67, 93–108.

Bianchi, F., R. Faccini, and L. Melosi (2020): "Monetary and Fiscal Policies in Times of Large Debt: Unity is Strength," *NBER Working Paper No. 27112*.

Bianchi, F., and L. Melosi (2019): "The Dire Effects of the Lack of Monetary and Fiscal Coordination," *Journal of Monetary Economics*, 104, 1–22.

Billi, R. M. (2017): "A Note on Nominal GDP Targeting and the Zero Lower Bound," *Macroeconomic Dynamics*, 21(8), 2138–2157.

——— (2018): "Price Level Targeting and Risk Management," *Economic Modelling*, 73(6), 163–173.

——— (2020): "Unemployment Fluctuations and Nominal GDP Targeting," *Economics Letters*, 188, 108970.

Billi, R. M., U. Söderström, and C. E. Walsh (2020): "The Role of Money in Monetary Policy at the Lower Bound," *Sveriges Riksbank Working Paper No. 390*.

Budianto, F., T. Nakata, and S. Schmidt (2022): "Average Inflation Targeting and the Interest Rate Lower Bound," *Working Paper*.

Burgert, M., and S. Schmidt (2014): "Dealing with a Liquidity Trap when Government Debt Matters: Optimal Time-Consistent Monetary and Fiscal Policy," *Journal of Economic Dynamics and Control*, 47, 282–299.

Caramp, N., and D. H. Silva (2021): "Fiscal Policy and the Monetary Transmission Mechanism," *Working Paper*.

Chen, H., V. Curdia, and A. Ferrero (2012): "The Macroeconomic Effects of Large-Scale Asset Purchase Programmes," *Economic Journal*, 122(564), 289–315.

Cochrane, J. H. (2016): "Comments on "A Behavioral New-Keynesian Model" by Xavier Gabaix," *Working Paper*.

——— (2022): *The Fiscal Theory of the Price Level*. Book Draft, Princeton University Press, Princeton NJ.

Davig, T., and E. M. Leeper (2011): "Monetary-Fiscal Policy Interactions and Fiscal Stimulus," *European Economic Review*, 55(2), 211–227.

Eggertsson, G. B. (2006): "The Deflation Bias and Committing to Being Irresponsible," *Journal of Money, Credit and Banking*, 38(2), 283-321.

Eggertsson, G. B., and M. Woodford (2003): "The Zero Bound on Interest Rates and Optimal Monetary Policy," *Brookings Papers on Economic Activity*, 34(1), 139–235.

——— (2006): "Optimal Monetary and Fiscal Policy in a Liquidity Trap," *NBER International Seminar on Macroeconomics 2004*, pp. 75–144.

Fuhrer, J. C., and G. D. Rudebusch (2004): "Estimating the Euler Equation for Output," *Journal of Monetary Economics*, 51(6), 1133–1153.

Gabaix, X. (2020): "A Behavioral New Keynesian Model," *American Economic Review*, 110(8), 2271–2327.

Galí, J., and M. Gertler (1999): "Inflation Dynamics: A Structural Econometric Analysis," *Journal of Monetary Economics*, 44(2), 195–222.

Galí, J. (2015): *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and its Applications*. Princeton University Press, Princeton NJ, second edn.

——— (2020): "The Effects of a Money-Financed Fiscal Stimulus," *Journal of Monetary Economics*, 115, 1–19.

Harrison, R. (2021): “Flexible Inflation Targeting with Active Fiscal Policy,” *Bank of England Working Paper No. 928.*

Hills, T. S., and T. Nakata (2018): “Fiscal Multipliers at the Zero Lower Bound: The Role of Policy Inertia,” *Journal of Money, Credit and Banking*, 50(1), 155–172.

Hirose, Y., H. Iiboshi, M. Shintani, and K. Ueda (2022): “Estimating a Behavioral New Keynesian Model with the Zero Lower Bound,” *CARF Working Paper F-535.*

Holston, K., T. Laubach, and J. C. Williams (2017): “Measuring the Natural Rate of Interest: International Trends and Determinants,” *Journal of International Economics*, 108(S1), 59–75.

Ilabaca, F., G. Meggiorini, and F. Milani (2020): “Bounded Rationality, Monetary Policy, and Macroeconomic Stability,” *Economics Letters*, 186, 108522.

Jacobson, M. M., E. M. Leeper, and B. Preston (2019): “Recovery of 1933,” *NBER Working Paper No. 25629.*

Kim, S. (2003): “Structural Shocks and the Fiscal Theory of the Price Level in the Sticky Price Model,” *Macroeconomic Dynamics*, 7(5), 759–782.

Leeper, E. M. (1991): “Equilibria under ‘Active’ and ‘Passive’ Monetary and Fiscal Policies,” *Journal of Monetary Economics*, 27(1), 129–147.

——— (2021): “Shifting Policy Norms and Policy Interactions,” *Federal Reserve Bank of Kansas City, Jackson Hole Symposium Proceedings*, pp. 1–20.

Leeper, E. M., and C. Leith (2016): “Understanding Inflation as a Joint Monetary-Fiscal Phenomenon,” in *Handbook of Macroeconomics*, ed. by J. B. Taylor, and H. Uhlig, vol. 2, chap. 30, pp. 2305–2415. Amsterdam: Elsevier B.V.

Leeper, E. M., C. Leith, and D. Liu (2021): “Optimal Time-Consistent Monetary, Fiscal and Debt Maturity Policy,” *Journal of Monetary Economics*, 117, 600–617.

Leeper, E. M., and X. Zhou (2021): “Inflation’s Role in Optimal Monetary-Fiscal Policy,” *Journal of Monetary Economics*, 124, 1–18.

Lindé, J. (2005): “Estimating New-Keynesian Phillips Curves: A Full Information Maximum Likelihood Approach,” *Journal of Monetary Economics*, 52(6), 1135–1149.

Liu, Z., J. Miao, and D. Su (2022): “Fiscal Stimulus Under Average Inflation Targeting,” *Federal Reserve Bank of San Francisco Working Paper 2022-22.*

NAKATA, T. (2017): "Optimal Government Spending at the Zero Lower Bound: A Non-Ricardian Analysis," *Review of Economic Dynamics*, 23, 150–169.

NAKATA, T., R. OGAKI, S. SCHMIDT, AND P. YOO (2019): "Attenuating the Forward Guidance Puzzle: Implications for Optimal Monetary Policy," *Journal of Economic Dynamics and Control*, 105, 90–106.

NAKOV, A. (2008): "Optimal and Simple Monetary Policy Rules with Zero Floor on the Nominal Interest Rate," *International Journal of Central Banking*, 4(2), 73–127.

SABLIK, T. (2019): "Do Budget Deficits Matter?," *Federal Reserve Bank of Richmond, Econ Focus*, Second/Third Quarter, 4–6.

SARGENT, T. J., AND N. WALLACE (1981): "Some Unpleasant Monetarist Arithmetic," *Federal Reserve Bank of Minneapolis, Quarterly Review*, 5(Fall), 1–17.

SIMS, C. A. (2000): "Comment on Three Lessons for Monetary Policy in a Low-Inflation Era," *Journal of Money, Credit and Banking*, 32(4), 967–972.

——— (2016): "Fiscal Policy, Monetary Policy and Central Bank Independence," *Federal Reserve Bank of Kansas City, Jackson Hole Symposium Proceedings*, pp. 313–325.

SVENSSON, L. E. O. (2003): "What Is Wrong with Taylor Rules? Using Judgment in Monetary Policy through Targeting Rules," *Journal of Economic Literature*, 41(2), 426–477.

VESTIN, D. (2006): "Price-Level Versus Inflation Targeting," *Journal of Monetary Economics*, 53(7), 1361–1376.

WALSH, C. E. (2003): "Speed Limit Policies: The Output Gap and Optimal Monetary Policy," *American Economic Review*, 93(1), 265–278.

——— (2015): "Goals and Rules in Central Bank Design," *International Journal of Central Banking*, 11(4), 295–352.

——— (2017): *Monetary Theory and Policy*. MIT Press, Cambridge MA, fourth edn.

——— (2019): "Alternatives to Inflation Targeting in Low Interest Rate Environments," *Bank of Japan, Monetary and Economic Studies*, 37, 41–70.

WOODFORD, M. (2001): "Fiscal Requirements for Price Stability," *Journal of Money, Credit and Banking*, 33(3), 669–728.

——— (2011): "Simple Analytics of the Government Expenditure Multiplier," *American Economic Journal: Macroeconomics*, 3(1), 1–35.

Table 1: Baseline calibration of regime M.

Parameter	Description	Value
β	Discount factor	0.995
σ	Curvature of consumption utility	1
δ	Curvature of government purchases utility	1
φ	Curvature of labor disutility	5
ϵ	Elasticity of substitution of goods	9
α	Index of decreasing returns to labor	0.25
θ	Calvo index of price rigidities	0.75
G	Government purchases share of output	0.2
ϕ	Monetary policy response to inflation	2
ψ_τ	Fiscal policy, net taxes response to debt	0.3
ψ_g	Fiscal policy, purchases response to debt	0
b	Debt-to-GDP target	2.4
η	Bond coupon decay rate	0
ρ_z	Persistence of aggregate-demand shock	0.8
σ_z	Std. deviation of aggregate-demand shock	0.028

Notes: Values are shown in quarterly rates.

Table 2: Policy scenarios under regimes M and F.

Scenario	Policy coefficients					Regime	Implications for a rise in debt
	ϕ	ψ_τ	ψ_g	b	η		
1. Regime M	2	0.3	0	2.4	0	M	$\hat{\tau}_t$ hike
2. No tax or G	0.8	0	0	2.4	0	F	No fiscal response
3. Tax	0.8	-0.3	0	2.4	0	F	$\hat{\tau}_t$ cut, debt financed
4. G	0.8	0	0.3	2.4	0	F	$\hat{g}_t$ hike, debt financed
5. G balanced	0.8	0.3	0.3	2.4	0	F	$\hat{g}_t$ and $\hat{\tau}_t$ hike, balanced budget
6. G high b	0.8	0	0.3	8.0	0	F	$\hat{g}_t$ hike, debt financed
7. G long debt	0.8	0	0.3	2.4	0.955	F	$\hat{g}_t$ hike, debt financed

Notes: In regime F, $\phi < 1$ and $\psi_s \equiv \psi_\tau - \psi_g \leq 0$, i.e. super-active fiscal. The debt duration is one quarter if $\eta = 0$ and 5 years if $\eta = 0.955$.

Table 3: Welfare loss under regimes M and F.

Scenario	$\mathbb{L}(\%)$ no ZLB				$\mathbb{L}(\%)$ with ZLB				ZLB freq. (%)
	Tot.	π_t	$\tilde{y}_t$	$\hat{g}_t$	Tot.	π_t	$\tilde{y}_t$	$\hat{g}_t$	
1. Regime M	0.31	0.30	0.01	0.00	0.79	0.74	0.05	0.00	25.0
2. No tax or G	1.19	1.11	0.08	0.00	1.06	0.98	0.08	0.00	14.3
3. Tax	0.94	0.90	0.04	0.00	0.76	0.71	0.04	0.00	11.8
4. G	0.78	0.73	0.04	0.00	0.64	0.60	0.04	0.00	10.1
5. G balanced	0.75	0.67	0.07	0.01	0.69	0.62	0.07	0.01	10.3
6. G high b	0.54	0.48	0.04	0.02	0.48	0.42	0.04	0.02	6.6
7. G long debt	0.72	0.66	0.06	0.00	0.77	0.70	0.07	0.00	12.8

Notes: $\mathbb{L}$ is the permanent consumption loss from fluctuations. The total loss may differ from the sum of its components due to rounding.

Table 4: Welfare loss under regimes M and F with cognitive discounting.

Scenario	$\mathbb{L}(\%)$ no ZLB				$\mathbb{L}(\%)$ with ZLB				ZLB freq. (%)
	Tot.	π_t	$\tilde{y}_t$	$\hat{g}_t$	Tot.	π_t	$\tilde{y}_t$	$\hat{g}_t$	
1. Regime M	0.39	0.36	0.03	0.00	0.81	0.72	0.09	0.00	27.0
2. No tax or G	1.96	1.76	0.21	0.00	1.99	1.77	0.21	0.00	8.3
3. Tax	2.39	2.25	0.13	0.00	2.07	1.94	0.12	0.00	8.6
4. G	2.13	1.94	0.14	0.04	1.92	1.74	0.14	0.04	7.6
5. G balanced	1.33	1.07	0.19	0.08	1.35	1.08	0.19	0.08	4.0

Notes: $\mathbb{L}$ is the permanent consumption loss from fluctuations. The total loss may differ from the sum of its components due to rounding. We set $\phi = 0.4$ in regime F to ensure equilibrium determinacy with $\bar{m} = 0.85$.

Table 5: Great Recession and COVID, regime F scenarios.

Scenario	Policy coefficients ϕ	ψ_τ	ψ_g	b	η	Regime	Implications for a rise in debt
1) GR	0.4	-0.42	0.06	1.4	0.955	F	$\hat{\tau}_t$ cut and $\hat{g}_t$ hike, debt financed
2) COVID	0.4	-0.67	0.24	3.2	0.955	F	Idem
3) GR no MP	0	-0.42	0.06	1.4	0.955	F	Idem
4) COVID no MP	0	-0.67	0.24	3.2	0.955	F	Idem

Notes: In regime F, $\psi_s \equiv \psi_\tau - \psi_g \leq 0$, i.e. super-active fiscal. The debt duration is five years. The label "no MP" indicates no monetary policy response ($\phi = 0$). We set $\bar{m} = 0.85$ under cognitive discounting.

Table 6: Welfare loss under Great Recession and COVID, regime F scenarios.

	$\mathbb{L}$(%) no ZLB Tot.	π_t	$\tilde{y}_t$	$\hat{g}_t$	$\mathbb{L}$(%) with ZLB Tot.	π_t	$\tilde{y}_t$	$\hat{g}_t$	ZLB freq. (%)
A. Rational expectations									
1) GR	0.33	0.29	0.04	0.00	0.33	0.29	0.04	0.00	0
2) COVID	0.31	0.27	0.04	0.00	0.31	0.27	0.04	0.00	0
3) GR no MP	0.17	0.15	0.02	0.00	0.17	0.15	0.02	0.00	0
4) COVID no MP	0.17	0.15	0.02	0.00	0.17	0.15	0.02	0.00	0
B. Cognitive discounting									
1) GR	2.33	2.20	0.13	0.00	2.13	2.00	0.13	0.00	9.4
2) COVID	2.57	2.41	0.14	0.02	2.35	2.19	0.14	0.02	10.4
3) GR no MP	0.87	0.80	0.07	0.00	0.87	0.80	0.07	0.00	0
4) COVID no MP	1.00	0.93	0.07	0.01	1.00	0.93	0.07	0.01	0

Notes: $\mathbb{L}$ is the permanent consumption loss from fluctuations. The total loss may differ from the sum of its components due to rounding. If no MP, $\phi = 0$ implies the policy rate is pegged to its steady state and therefore the ZLB has no effects.

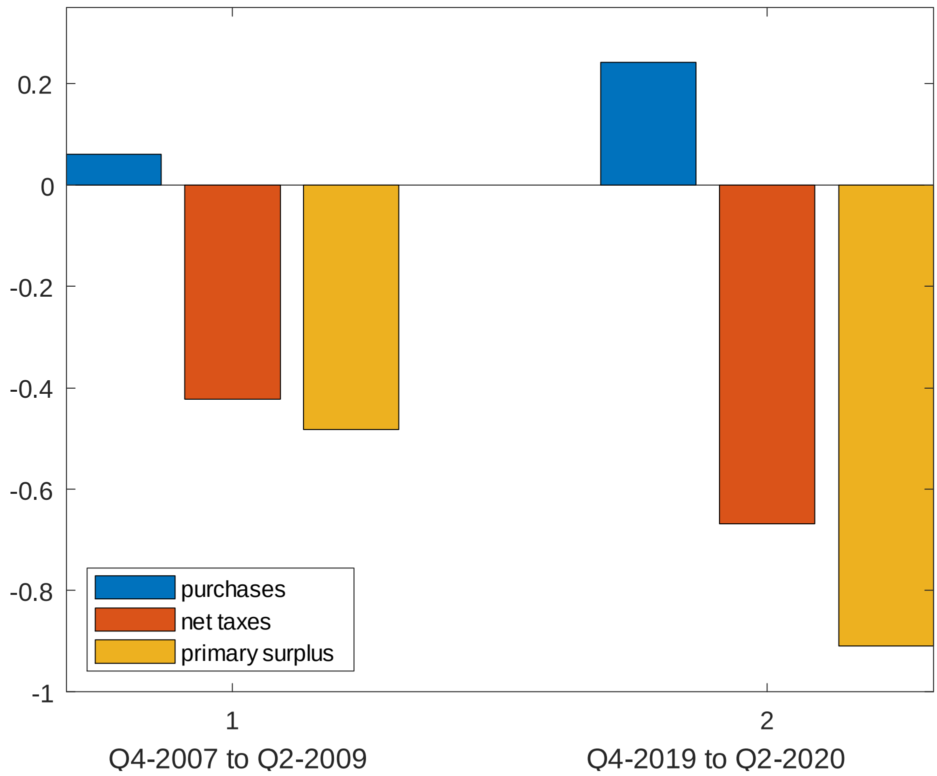

Figure 1: Composition of U.S. federal responses during the Great Recession (1) and COVID induced recession (2). Each bar is the change in category divided by change in debt held by the public. Data source FRED.

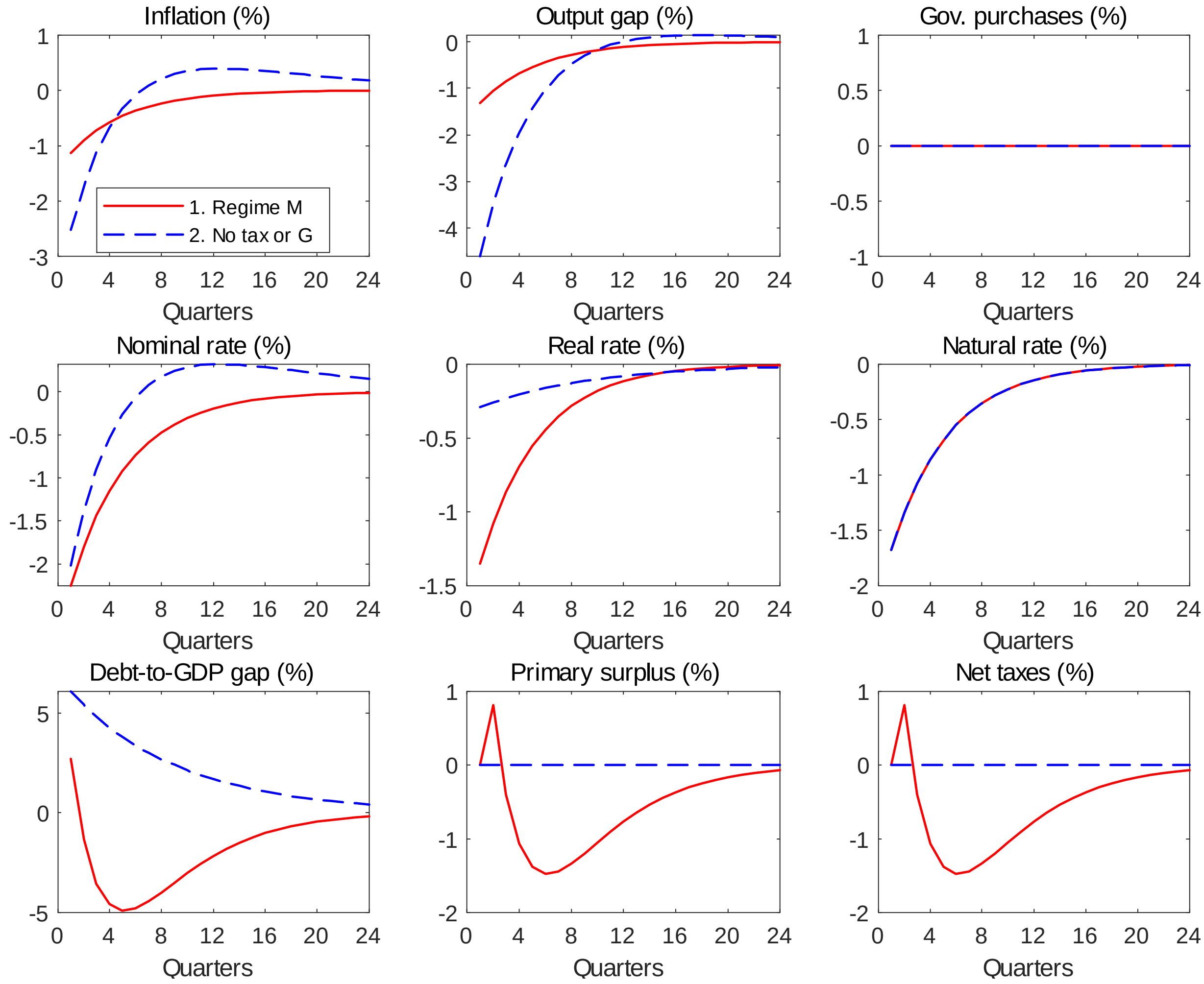

Figure 2: Dynamic effects of regime F (no tax or G; $\psi_\tau = \psi_g = 0$) without ZLB. Deviation from steady state in response to $-3sd$ demand shock.

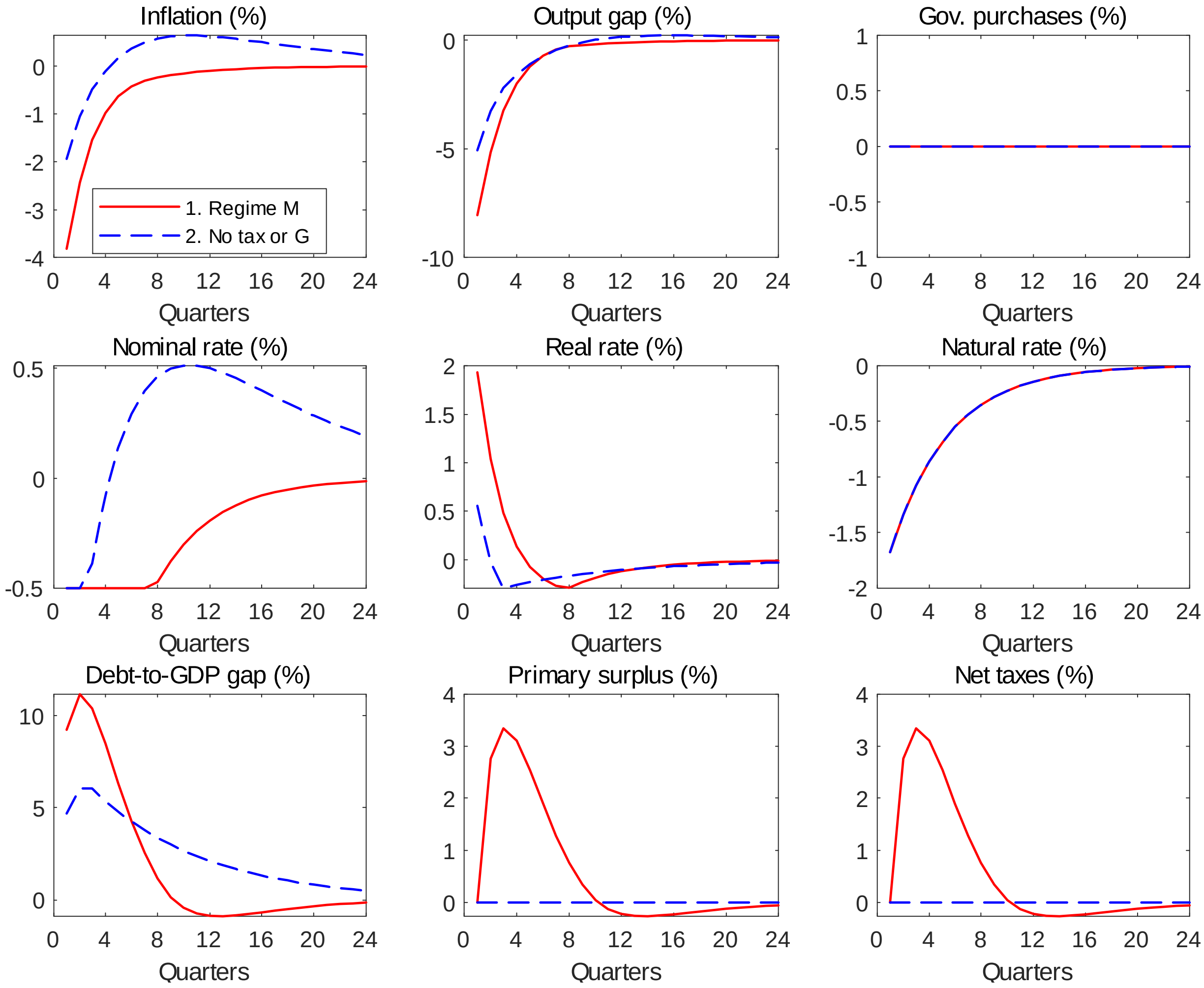

Figure 3: Dynamic effects of regime F (no tax or G; $\psi_\tau = \psi_g = 0$) with ZLB. Deviation from steady state in response to $-3sd$ demand shock.

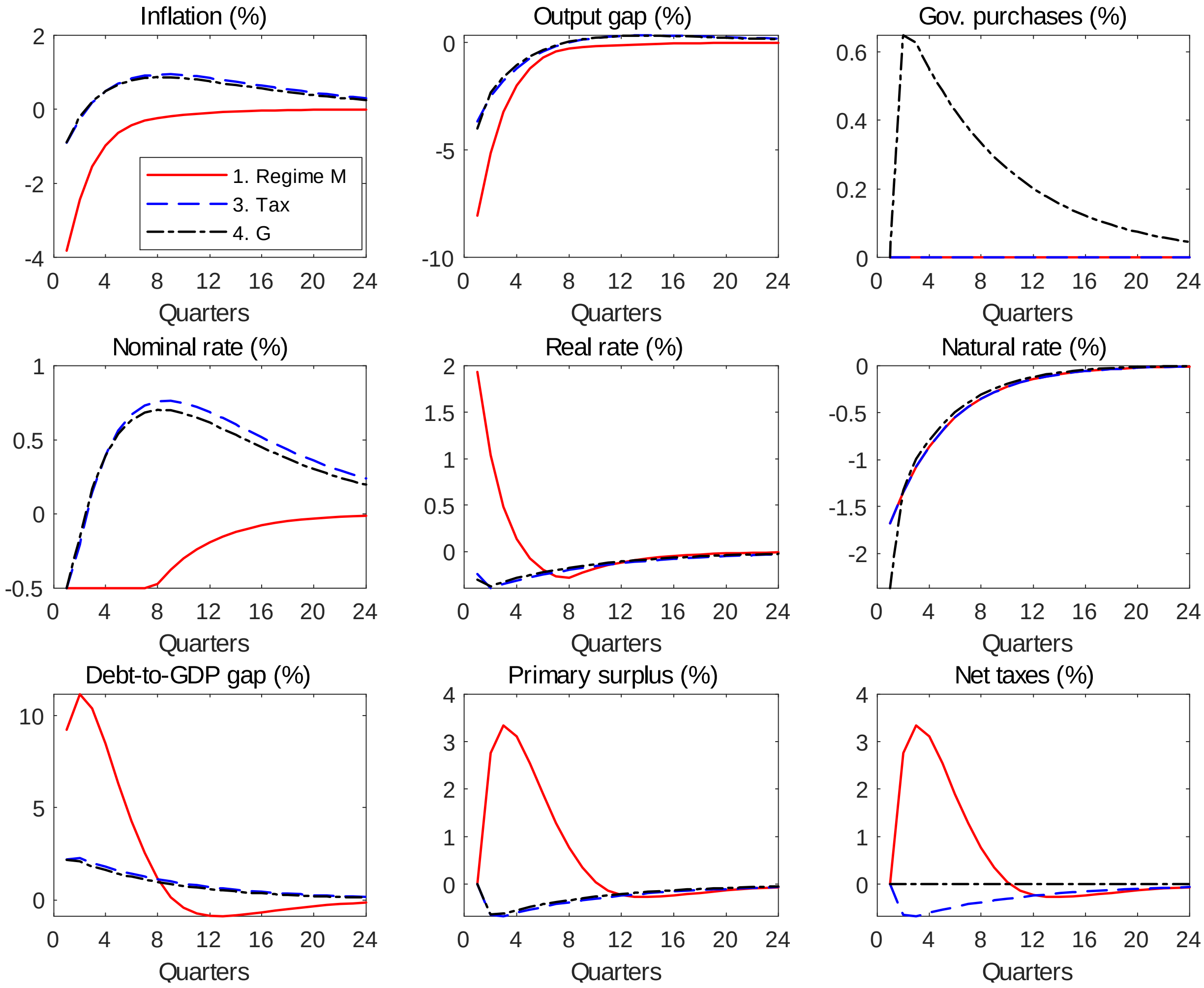

Figure 4: Dynamic effects of a tax cut ($\psi_\tau = -0.3$, $\psi_g = 0$) or G hike ($\psi_\tau = 0$, $\psi_g = 0.3$) with ZLB. Deviation from steady state in response to $-3sd$ demand shock.

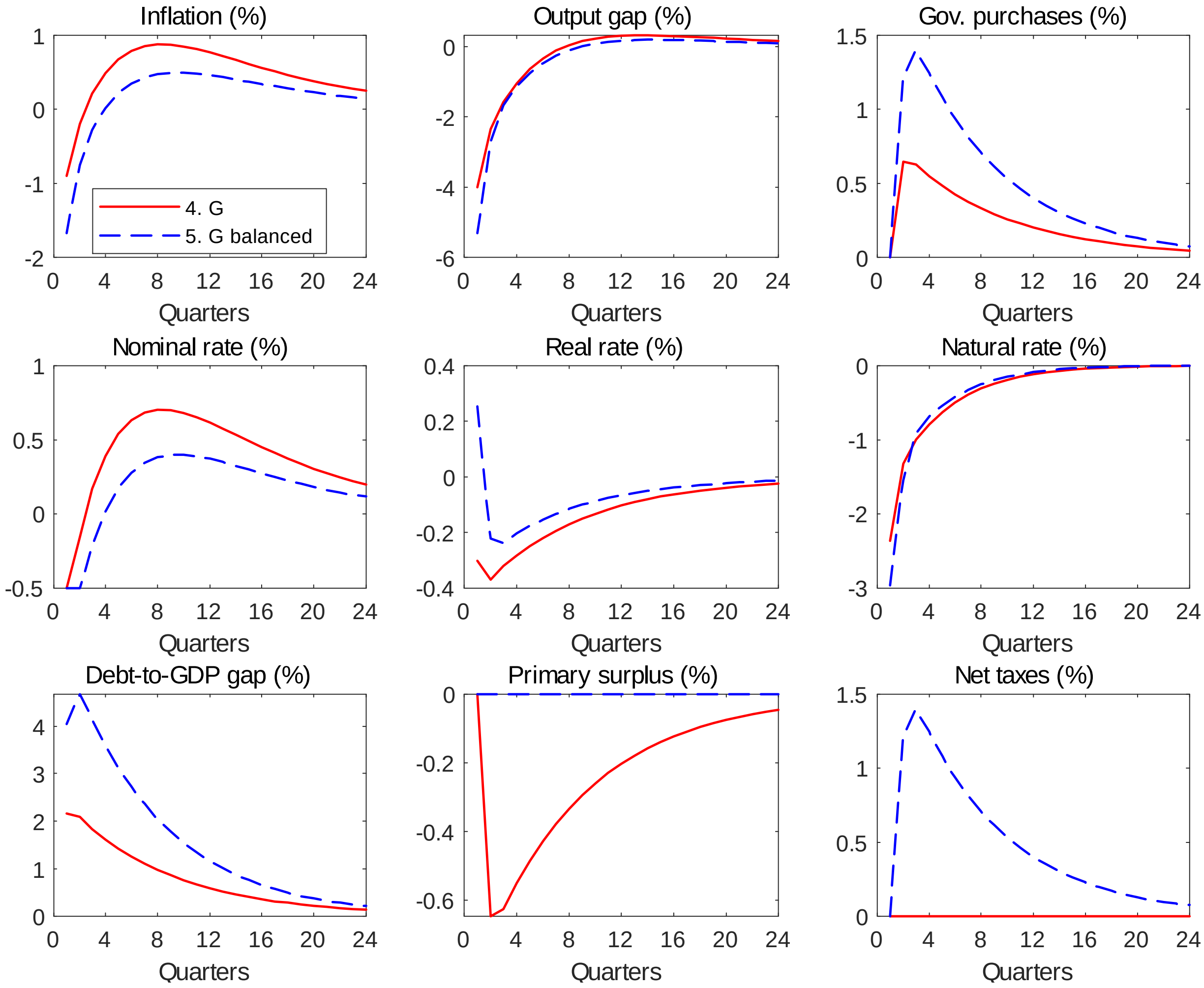

Figure 5: Dynamic effects of G under balanced budget ($\psi_\tau = \psi_g = 0.3$) with ZLB. Deviation from steady state in response to $-3sd$ demand shock.

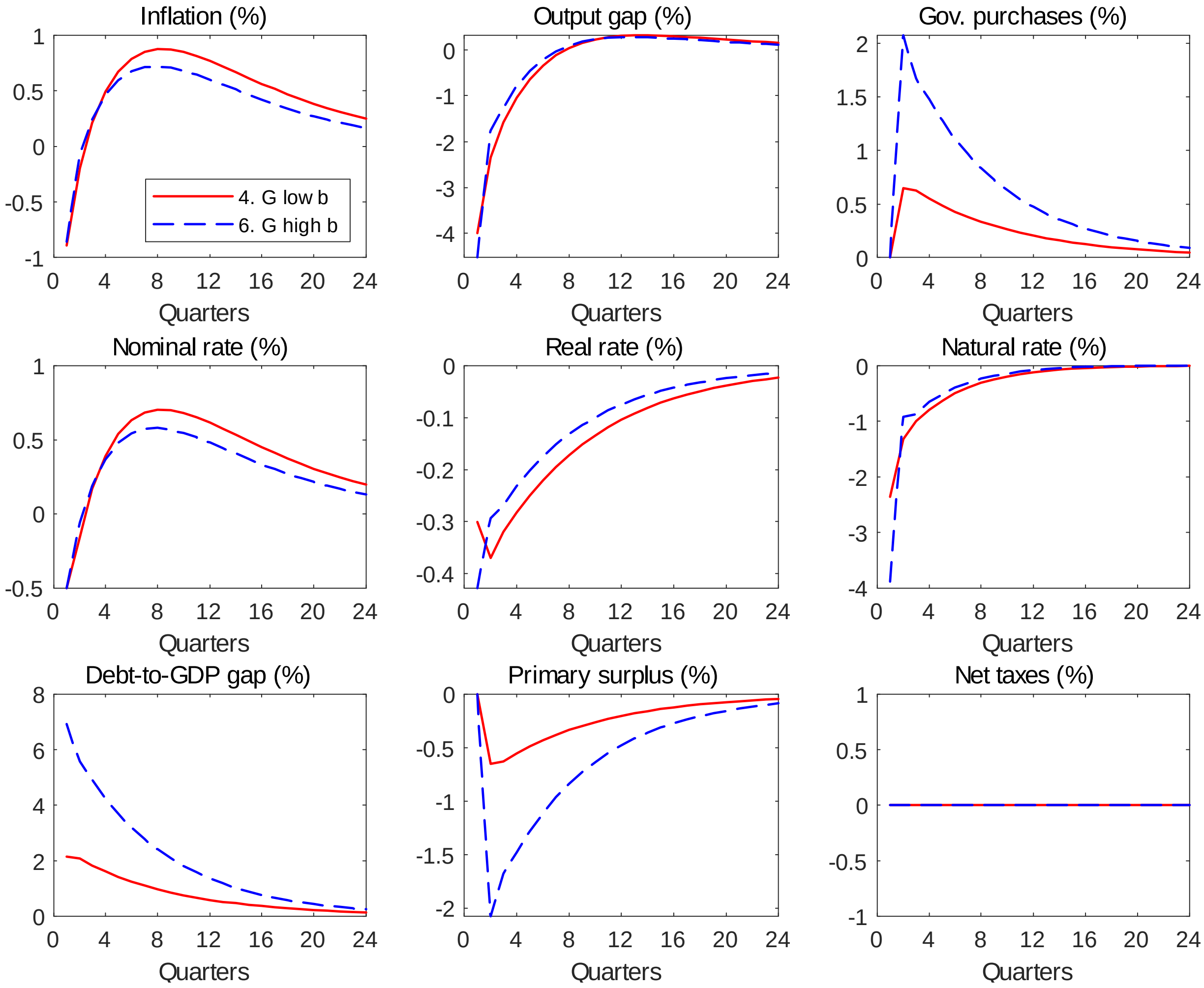

Figure 6: Dynamic effects of G and higher debt target ($b = 60\%$ versus 200% annual) with ZLB. Deviation from steady state in response to $-3sd$ demand shock.

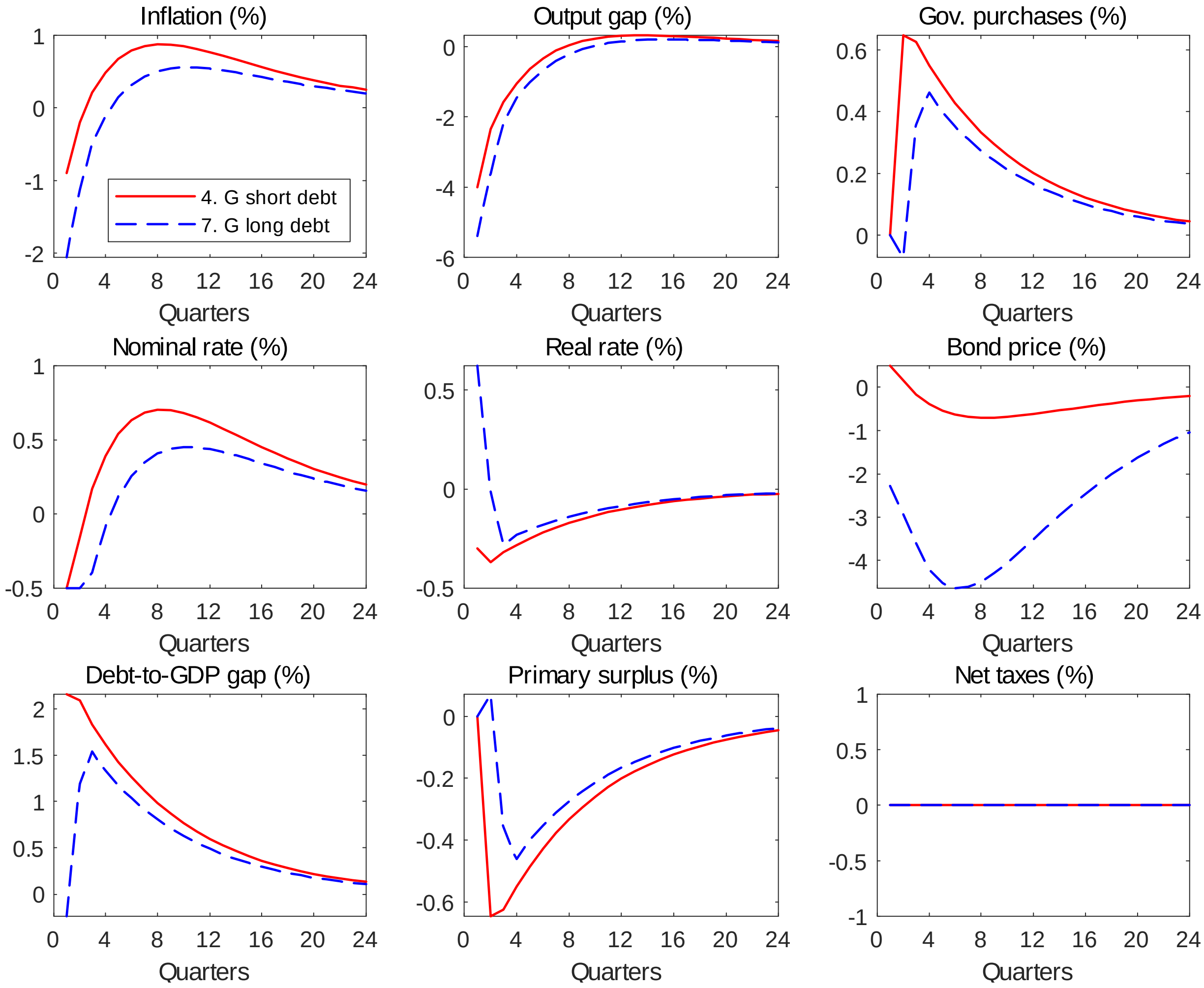

Figure 7: Dynamic effects of G and long-term debt (one-quarter versus five-year duration) with ZLB. Deviation from steady state in response to $-3sd$ demand shock.

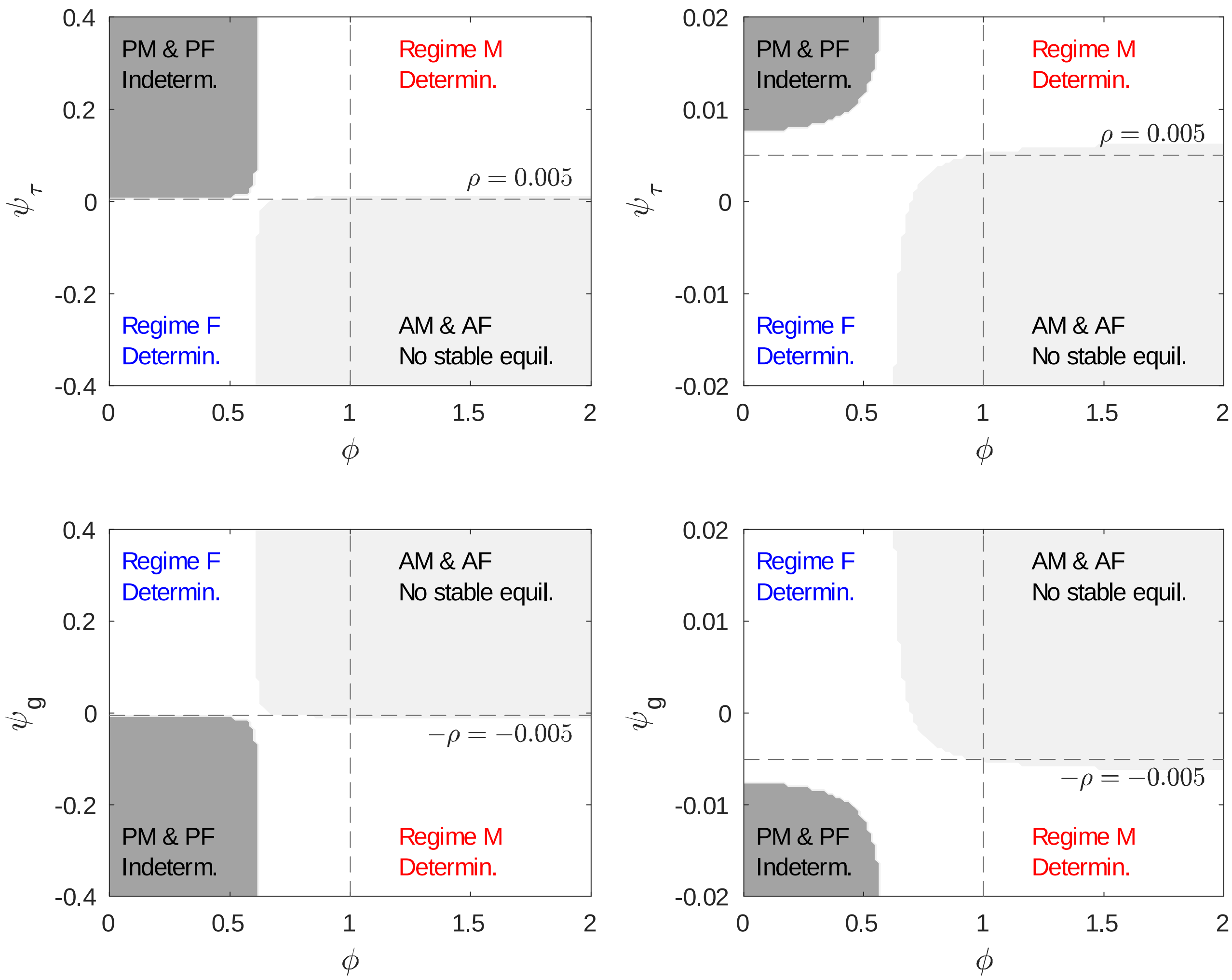

Figure 8: Equilibrium determinacy in regimes M and F with cognitive discounting ($\bar{m} = 0.85$). In the top row $\psi_g = 0$, while in the bottom row $\psi_\tau = 0$. The right column provides a close-up of the left column (note the change in the range for the fiscal parameter).

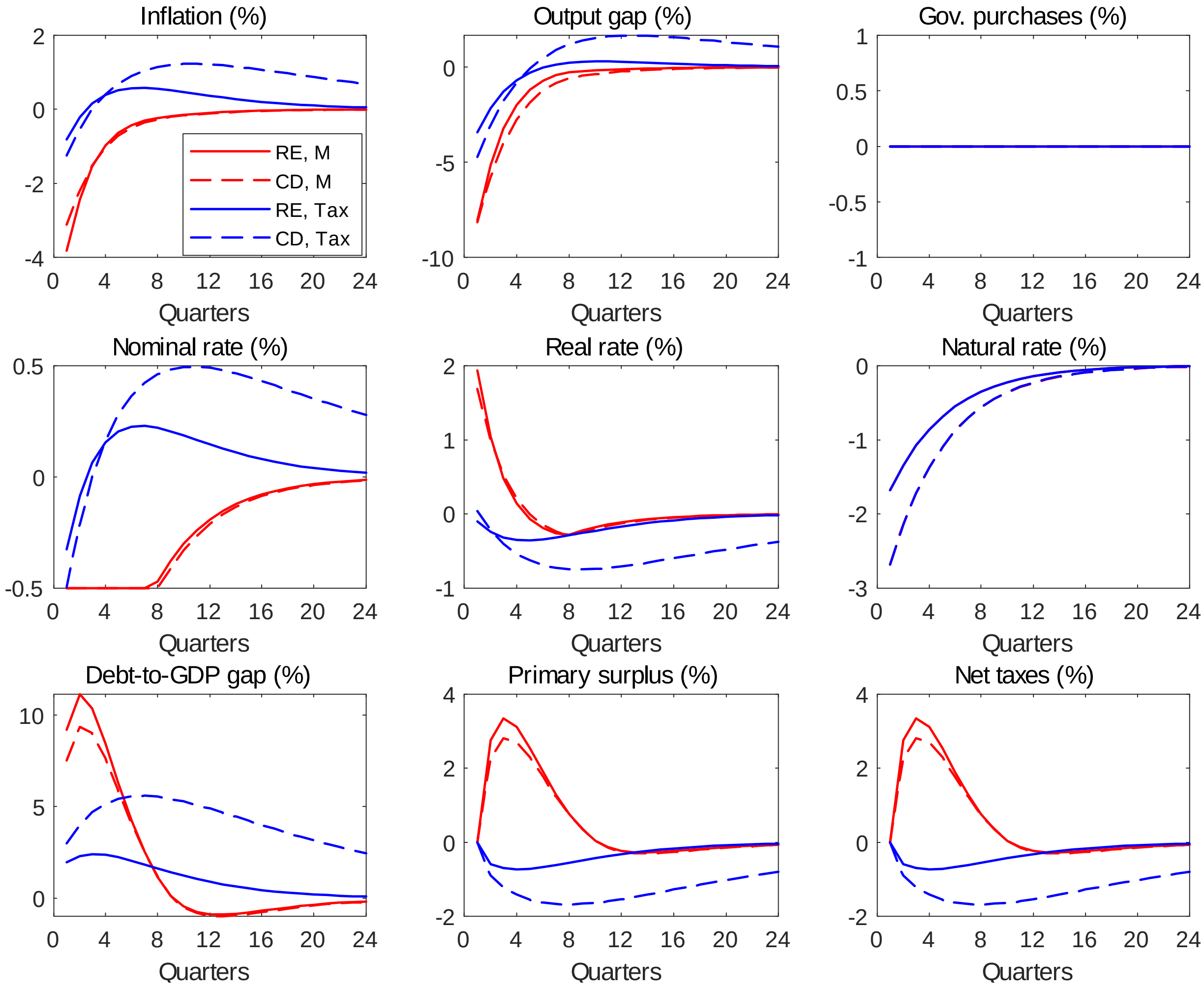

Figure 9: Dynamic effects of a tax cut ($\psi_\tau = -0.3$, $\psi_g = 0$, and $\phi = 0.4$) and cognitive discounting ($\bar{m} = 0.85$) with ZLB. RE (CD) indicates outcomes under rational expectations (cognitive discounting). Deviation from steady state in response to $-3sd$ demand shock.

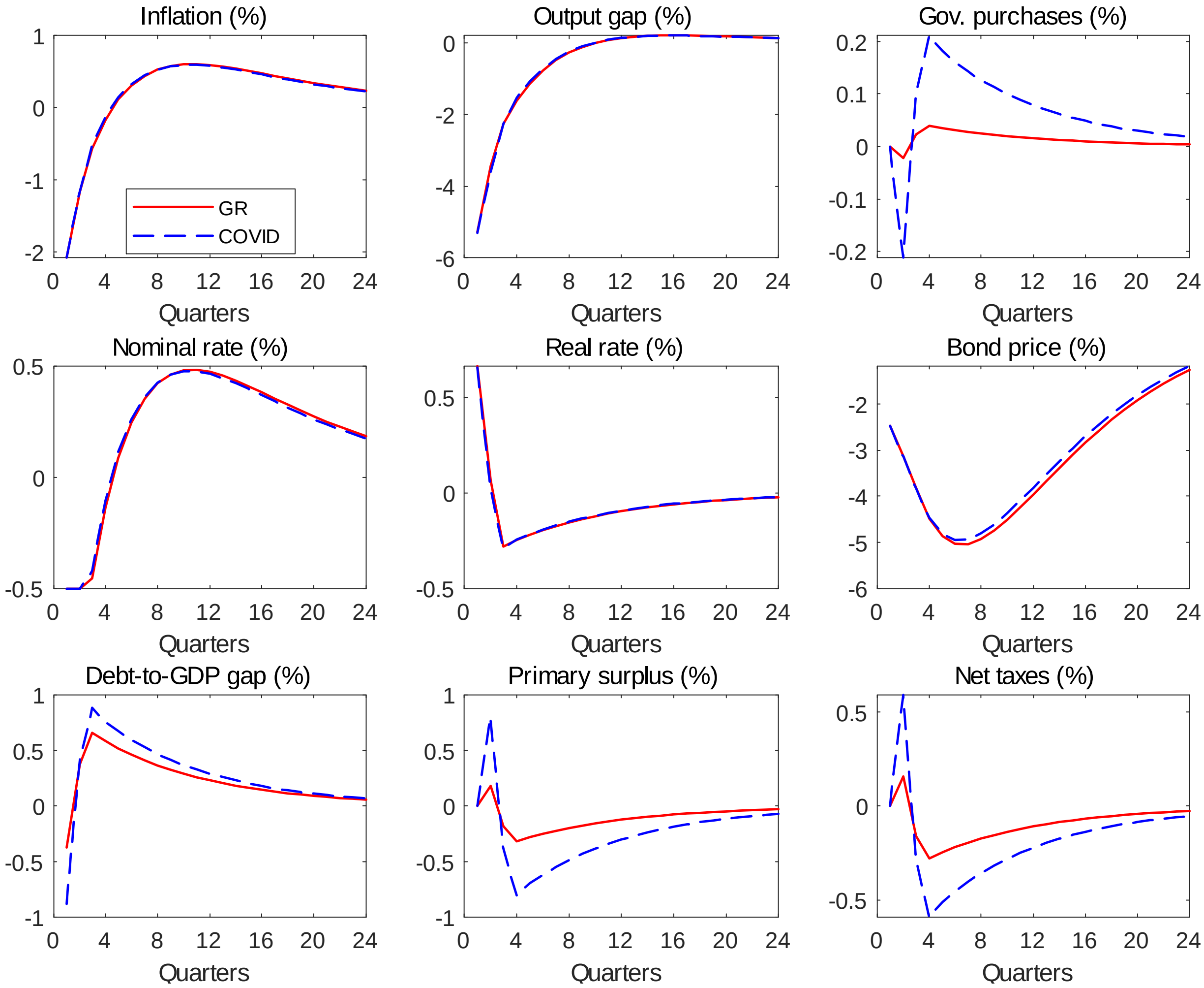

Figure 10: Dynamic effects of irresponsible fiscal stimulus as during Great Recession and COVID facing the ZLB. Deviation from steady state in response to $-3sd$ demand shock.

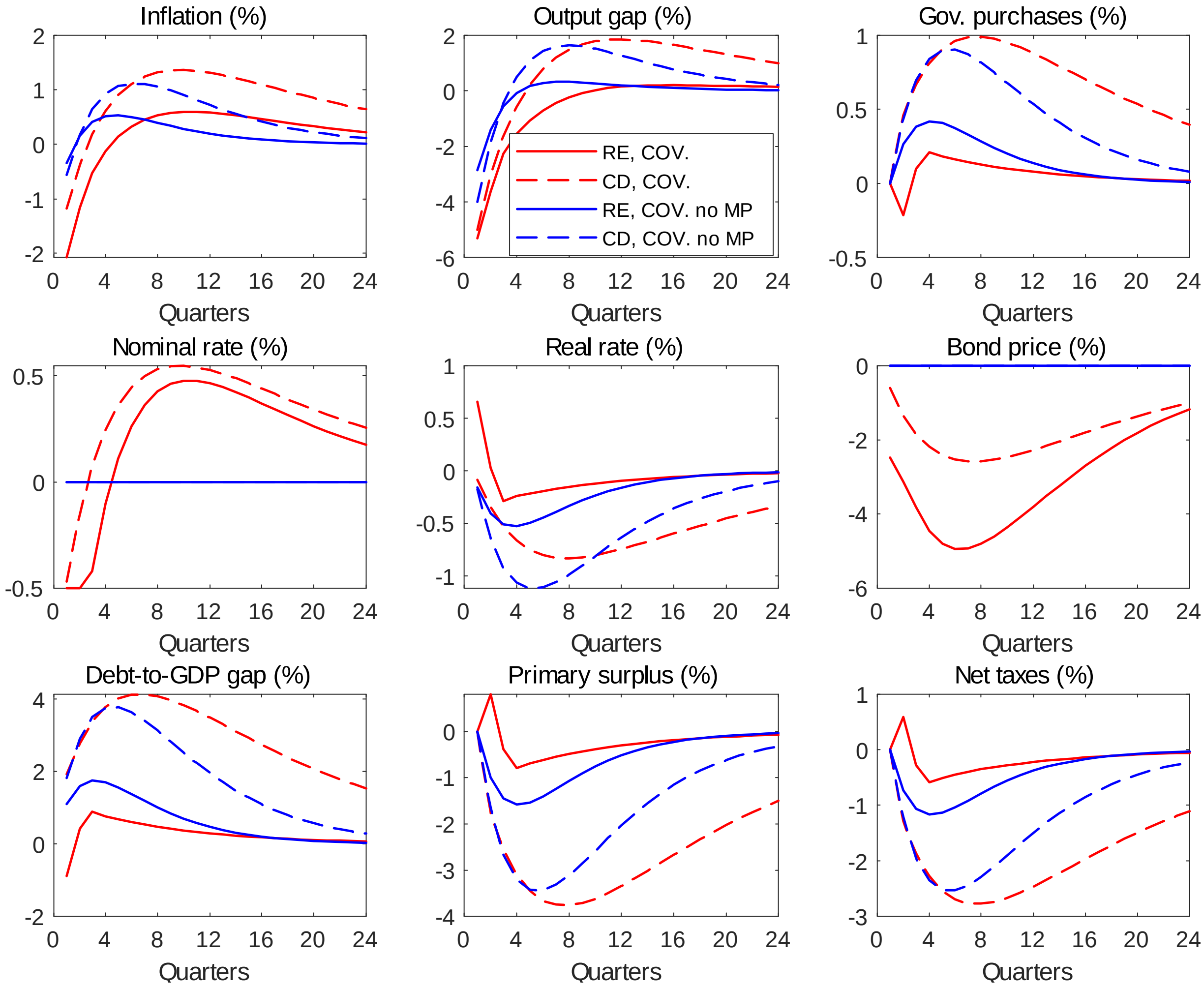

Figure 11: Dynamic effects of irresponsible fiscal stimulus as during COVID facing the ZLB, with and without a monetary policy response. RE (CD) indicates outcomes under rational expectations (cognitive discounting). Deviation from steady state in response to $-3sd$ demand shock.

A Appendix: Macroeconomic Evidence on Cognitive Discounting in New Keynesian Models

We briefly review here some of the macroeconomic evidence on the value of the cognitive discounting parameter $\bar{m}$. Gabaix (2020), p. 2285, bases his calibration of $\bar{m}$ to 0.85 with reference to matching the inertia in the Phillips curve and IS curve found in Galí and Gertler (1999), Lindé (2005), and Fuhrer and Rudebusch (2004).

Those papers do not estimate $\bar{m}$ directly, but there have been attempts to estimate directly the degree of cognitive discounting in New Keynesian models. For example, Andrade, Coredeiro, and Lambais (2019) provide maximum likelihood estimates for Gabaix's behavioral New Keynesian model and obtain a point estimate for $\bar{m}$ of 0.68 (standard deviation 0.07). This is significantly less than 1. They also employ estimation methods that are robust to weak identification. They find that $\bar{m}$ has an upper bound of 0.84 that rises to 0.95 when the wider confidence intervals associated with a robust estimator are used. Ilabaca, Meggiorini, and Milani (2020) estimate the behavioral New Keynesian model using U.S. macro data. Their estimates for the period 1982–2007 imply $\bar{m} = 0.71$ and $M^f = 0.41$ ($\bar{m} = 0.85$ and $M^f = 0.60$ for their pre-1979 sample).

Perhaps most relevant for our calibration, given our focus on the ZLB, is the work of Hirose et al. (2022). They incorporate the ZLB and estimate the resulting non-linear New Keynesian model under the assumption of cognitive discounting. Their Bayesian estimation yields posterior means for $\bar{m}$ of 0.856 and 0.861 depending on the way the monetary policy rule is specified.[34]

These results are broadly consistent with the literature on approaches used to solve the forward guidance puzzle reviewed in Nakata et al. (2019).

[34] They assume a policy rule of the form $R_t = \max[R_t^*, 1]$ for the gross nominal rate where R^* is described by a Taylor rule with inertia. When the lagged nominal rate in the rule is R_{t-1}^*, they estimate $\bar{m}$ to be 0.856; when R_{t-1} is in the rule, the estimate of $\bar{m}$ is 0.861.

B Online Appendix to "Seemingly Irresponsible but Welfare Improving Fiscal Policy at the Lower Bound"; Not For Publication

In this appendix, we discuss equilibrium determinacy with a fiscal spending rule under rational expectations in the basic New Keynesian model of Section 3 with one-period debt, and then introduce cognitive discounting into the model. After modifying the New Keynesian Phillips curve (NKPC) and the IS equation, we discuss the effects of cognitive discounting on the model's determinacy conditions.

B.1 Determinacy with a Fiscal Spending Rule

The literature on active fiscal policy has focused on rules for lump-sum taxes. Conditions for determinacy in this case are well-known from Leeper (1991). Spending rules of the form (6) are less commonly analyzed. Because $\hat{g}_t$ appears in the definition of $\hat{r}_t^n$ and therefore directly affects aggregate demand (2), the determinacy conditions for spending rules potentially differ from those for tax rules.

When the definition of $\hat{r}_t^n$ and the policy rules for $\hat{\imath}_t$, $\hat{g}_t$ and $\hat{\tau}_t$ are substituted into (1), (2) and (4), the model under rational expectations takes the form

$$\pi_t = \beta E_t \pi_{t+1} + \kappa \tilde{y}_t,$$

$$\tilde{y}_t = E_t \tilde{y}_{t+1} - \frac{1}{\bar{\sigma}} \left(\phi \pi_t - E_t \pi_{t+1}\right) + \frac{1}{\bar{\sigma}} \left(1 - \rho_z\right) z_t - \left(1 - \Gamma\right) \psi_g \left(\hat{b}_t - \hat{b}_{t-1}\right),$$

and

$$\beta \hat{b}_t = \hat{b}_{t-1} + b \left(\phi \pi_{t-1} - \pi_t\right) + \beta \left(\psi_g - \psi_\tau\right) \hat{b}_{t-1}.$$

To assess the restrictions on the policy parameters that ensure a unique, stationary rational-expectations equilibrium, i.e. equilibrium determinacy, set the exogenous preference shock z_t to zero and write the model as

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \beta & 0 & 0 \\ 0 & \frac{1}{\sigma} & 1 & -\left(1-\Gamma\right)\psi_g \\ 0 & 0 & 0 & \beta \end{bmatrix} \begin{bmatrix} \pi_t \\ E_t \pi_{t+1} \\ E_t \tilde{y}_{t+1} \\ \hat{b}_t \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 1 & -\kappa & 0 \\ 0 & \frac{\phi}{\sigma} & 1 & -\left(1-\Gamma\right)\psi_g \\ b\phi & -b & 0 & 1+\beta\left(\psi_g - \psi_\tau\right) \end{bmatrix} \begin{bmatrix} \pi_{t-1} \\ \pi_t \\ \tilde{y}_t \\ \hat{b}_{t-1} \end{bmatrix}, \tag{20}$$

or

$$\begin{bmatrix} \pi_t \\ E_t\pi_{t+1} \\ E_t\tilde{y}_{t+1} \\ \hat{b}_t \end{bmatrix} = C \begin{bmatrix} \pi_{t-1} \\ \pi_t \\ \tilde{y}_t \\ \hat{b}_{t-1} \end{bmatrix},$$

where

$$C = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & \frac{1}{\beta} & -\frac{\kappa}{\beta} & 0 \\ \frac{b}{\beta}\phi(1-\Gamma)\psi_g & \frac{1}{\sigma}\phi - \frac{1}{\sigma\beta} - \frac{b}{\beta}(1-\Gamma)\psi_g & \frac{\kappa}{\sigma\beta}+1 & \sigma(1-\Gamma)\psi_g\left(\psi_g - \psi_\tau + \frac{1}{\beta} - 1\right) \\ \frac{b}{\beta}\phi & -\frac{b}{\beta} & 0 & \psi_g - \psi_\tau + \frac{1}{\beta} \end{bmatrix}.$$

With two forward-looking variables, the Blanchard-Kahn conditions for determinacy require that two eigenvalues of C lie outside the unit circle.

The standard analysis of monetary and fiscal interactions assumes fiscal spending is exogenous and taxes follow a simple rule such as (5). Setting $\psi_g = 0$, the characteristic equation for the system is obtained by solving

$$\det \begin{bmatrix} -\lambda & 1 & 0 & 0 \\ 0 & \frac{1}{\beta}-\lambda & -\frac{\kappa}{\beta} & 0 \\ 0 & \frac{1}{\sigma}\left(\phi - \frac{1}{\beta}\right) & \frac{\kappa}{\sigma\beta}+1-\lambda & 0 \\ \frac{b}{\beta}\phi & -\frac{b}{\beta} & 0 & -\psi_\tau + \frac{1}{\beta} - \lambda \end{bmatrix} = 0.$$

This determinant can be written as

$$-\lambda\left(-\psi_\tau + \frac{1}{\beta} - \lambda\right)\det\begin{bmatrix} \frac{1}{\beta}-\lambda & -\frac{\kappa}{\beta} \\ \frac{1}{\sigma}\left(\phi-\frac{1}{\beta}\right) & \frac{\kappa}{\sigma\beta}+1-\lambda \end{bmatrix} = 0. \tag{21}$$

One eigenvalue is $\lambda = 0$, another is $\lambda = 1/\beta - \psi_\tau$. The other two are determined by the determinant of the 2×2 matrix in (21), which is exactly that obtained in the basic New Keynesian model when debt is ignored; it has one eigenvalue outside the unit circle if $\phi < 1$ and two if $\phi > 1$. The condition for active fiscal policy is $|1/\beta - \psi_\tau| > 1$, or $\psi_\tau < \rho$.[35] Importantly, the conditions on ϕ for active and passive monetary policy do not depend on the fiscal policy parameter ψ_τ, and the conditions on fiscal policy do not depend on the monetary policy parameter ϕ.

The situation is different when $\psi_\tau = 0$ and $\psi_g \neq 0$. Now, the characteristic equation is

[35] Note that because it is the absolute value of the eigenvalues that matters, $1/\beta - \psi_\tau < -1$, or $\psi_\tau > 1/\beta + 1 = 2 + \rho$ is also consistent with an active fiscal policy. We rule out such a large positive tax response to debt and focus on $\psi_\tau < 2 + \rho$.

obtained from

$$\det\begin{bmatrix} -\lambda & 1 & 0 & 0 \\ 0 & \frac{1}{\beta}-\lambda & -\frac{\kappa}{\beta} & 0 \\ \frac{b}{\beta}\phi\left(1-\Gamma\right)\psi_g & \frac{1}{\sigma}\phi-\frac{1}{\sigma\beta}-\frac{b}{\beta}\left(1-\Gamma\right)\psi_g & \frac{\kappa}{\sigma\beta}+1-\lambda & \sigma\left(1-\Gamma\right)\psi_g\left(\psi_g+\frac{1}{\beta}-1\right) \\ \frac{b}{\beta}\phi & -\frac{b}{\beta} & 0 & \psi_g+\frac{1}{\beta}-\lambda \end{bmatrix}=0. \tag{22}$$

The term $\left(1-\Gamma\right)\psi_g$ reflects the presence of $\left(\hat{b}_t-\hat{b}_{t-1}\right)$ in the aggregate demand equation. However, the determinate on the left side of (22) equals

$$\left(\psi_g+\frac{1}{\beta}-\lambda\right)\det\begin{bmatrix} -\lambda & 1 & 0 \\ 0 & \frac{1}{\beta}-\lambda & -\frac{\kappa}{\beta} \\ \frac{b}{\beta}\phi\left(1-\Gamma\right)\psi_g & \frac{1}{\sigma}\phi-\frac{1}{\sigma\beta}-\frac{b}{\beta}\left(1-\Gamma\right)\psi_g & \frac{\kappa}{\sigma\beta}+1-\lambda \end{bmatrix}$$
$$-\left[\sigma\left(1-\Gamma\right)\psi_g\left(\psi_g+\frac{1}{\beta}-1\right)\right]\det\begin{bmatrix} -\lambda & 1 & 0 \\ 0 & \frac{1}{\beta}-\lambda & -\frac{\kappa}{\beta} \\ \frac{b}{\beta}\phi & -\frac{b}{\beta} & 0 \end{bmatrix}. \tag{23}$$

One can order the four eigenvalues from smallest (λ_1) to largest (λ_4) in absolute value; $|\lambda_1|<1$ and $|\lambda_4|>1$. Note that when $\psi_g+1/\beta=1$, $\lambda=1$ ensures the value of (23) is zero. If λ is increasing in ψ_g, then one eigenvalue would exceed 1 if $\psi_g+1/\beta>1$. Figure A1 shows $|\lambda_2|$ and $|\lambda_3|$ as a function of ψ_g. When $\phi=0.8$, monetary policy is passive and $|\lambda_2|$ is always less than 1 (blue dotted line). Determinacy then requires $|\lambda_3|>1$ which occurs for $\psi_g+1/\beta>1$ (heavy blue dotted line). Thus, one has determinacy with passive monetary policy when fiscal policy is active with $\psi_g>1-(1/\beta)=-\rho$. When monetary policy is active ($\phi=2.0$, shown in red), determinacy requires $\psi_g<-\rho$ (so that $|\lambda_2|<1$, $|\lambda_3|>1$), while no stationary equilibrium exists when $\psi_g>-\rho$ (so that $|\lambda_2|>1$, $|\lambda_3|>1$).

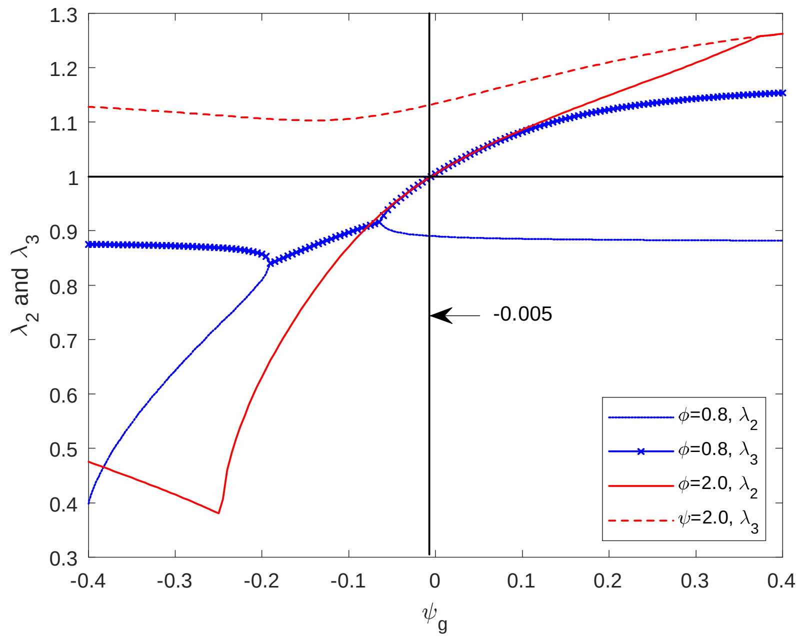

Figure A1: Eigenvalues λ_2 and λ_3 as a function of ψ_g for $\phi = 0.8$ (blue) and $\phi = 2.0$ (red). The vertical line is at $\psi_g = -\rho = -0.005$.

B.2 Introducing Cognitive Discounting

This section provides details of the model under cognitive discounting.

B.2.1 Derivation of the NKPC with Cognitive Discounting

The New Keynesian Phillips curve under cognitive discounting is derived by Gabaix (2020) for the case of constant returns to scale ($\alpha = 0$). We adapt the proofs of Lemma 2 and Proposition 2 in appendix X.B of Gabaix (2020), p. 2322, to deal with the case of decreasing returns to scale ($\alpha < 1$). This generalization only affects the mapping from real marginal cost to the output gap.

With rational expectations, Galí (2015) shows that the first-order condition for a price-setting firm under Calvo pricing takes the form

$$p_t^* - p_{t-1} = (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t \left[\Theta\mu_{t+k} + (p_{t+k} - p_{t-1})\right], \tag{24}$$

where μ is real marginal cost and $\Theta \equiv (1 - \alpha) / (1 - \alpha + \alpha\epsilon)$. Note that p_{t-1} has a coefficient of 1 on both sides, so add p_{t-1} and subtract p_t from each side to obtain

$$p_t^* - p_t = (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t \left[\Theta\mu_{t+k} + (p_{t+k} - p_t)\right]. \tag{25}$$

In addition, $p_t = \theta p_{t-1} + (1-\theta)\, p_t^*$, implying $\pi_t \equiv p_t - p_{t-1} = (1-\theta)\left(p_t^* - p_{t-1}\right)$. Rearranging, $\pi_t = \left(\frac{1-\theta}{\theta}\right)\left(p_t^* - p_t\right)$.

Let $\bar{m}$ be the cognitive discounting factor, and replace rational expectations with the behavioral expectations operator E_t^{BR} (i.e. $E_t^{BR} x_{t+k} \equiv \bar{m}^k E_t x_{t+k}$ for any variable x_t) in (25) to obtain

$$\begin{aligned} p_t^* - p_t &= (1-\beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t^{BR}\left[\Theta \mu_{t+k} + (p_{t+k} - p_t)\right] \\ &= (1-\beta\theta)\,\Theta \sum_{k=0}^{\infty} (\beta\theta\bar{m})^k E_t \mu_{t+k} + (1-\beta\theta) \sum_{k=0}^{\infty} (\beta\theta\bar{m})^k E_t\left(p_{t+k} - p_t\right). \qquad (26) \end{aligned}$$

Note that

$$p_{t+k} - p_t = \pi_{t+k} + \pi_{t+k-1} + \ldots + \pi_{t+1.}$$

Thus, the second summation in (26) can be written as

$$\begin{aligned} \sum_{k=0}^{\infty} (\beta\theta\bar{m})^k (p_{t+k} - p_t) &= 0 + \beta\theta\bar{m}\,(\pi_{t+1}) + (\beta\theta\bar{m})^2 (\pi_{t+2} + \pi_{t+1}) + (\beta\theta\bar{m})^3 (\pi_{t+3} + \pi_{t+2} + \pi_{t+1}) + \ldots \\ &= \left(\frac{1}{1-\beta\theta\bar{m}}\right)\left[\beta\theta\bar{m}\pi_{t+1} + (\beta\theta\bar{m})^2 \pi_{t+2} + (\beta\theta\bar{m})^3 \pi_{t+3} + \ldots\right] \\ &= \left(\frac{1}{1-\beta\theta\bar{m}}\right) \sum_{k=1}^{\infty} (\beta\theta\bar{m})^k \pi_{t+k}. \end{aligned}$$

Therefore,

$$\begin{aligned} \pi_t &= \left(\frac{1-\theta}{\theta}\right)(p_t^* - p_t) \\ &= \left(\frac{1-\theta}{\theta}\right)(1-\beta\theta)\,\Theta \sum_{k=0}^{\infty} (\beta\theta\bar{m})^k E_t \mu_{t+k} + \left(\frac{1-\theta}{\theta}\right)\left(\frac{1-\beta\theta}{1-\beta\theta\bar{m}}\right) \sum_{k=1}^{\infty} (\beta\theta\bar{m})^k \pi_{t+k}. \end{aligned}$$

Using the forward operator F (i.e. $F x_t \equiv x_{t+1}$), the first summation the right of the equal sign is

$$\begin{aligned} E_t \sum_{k=0}^{\infty} (\beta\theta\bar{m})^k \mu_{t+k} &= E_t \sum_{k=0}^{\infty} (\beta\theta\bar{m}F)^k \mu_t \\ &= \left(\frac{1}{1-\beta\theta\bar{m}F}\right) \mu_t, \end{aligned}$$

while the second summation is

$$\sum_{k=1}^{\infty} (\beta\theta\bar{m})^k \pi_{t+k} = \sum_{k=0}^{\infty} (\beta\theta\bar{m}F)^k \beta\theta\bar{m}F\pi_t$$
$$= \left(\frac{1}{1-\beta\theta\bar{m}F}\right)\beta\theta\bar{m}F\pi_t.$$

Thus,

$$\pi_t = \left(\frac{1-\theta}{\theta}\right)(1-\beta\theta)\,\Theta\left(\frac{1}{1-\beta\theta\bar{m}F}\right)\mu_t + \left(\frac{1-\theta}{\theta}\right)\left(\frac{1-\beta\theta}{1-\beta\theta\bar{m}}\right)\left(\frac{1}{1-\beta\theta\bar{m}F}\right)\beta\theta\bar{m}F\pi_t.$$

Multiplying both sides by $\theta(1-\beta\theta\bar{m}F)$ yields

$$\theta(1-\beta\theta\bar{m}F)\,\pi_t = (1-\theta)(1-\beta\theta)\,\Theta\mu_t + (1-\theta)\left(\frac{1-\beta\theta}{1-\beta\theta\bar{m}}\right)\beta\theta\bar{m}F\pi_t.$$

Collecting terms, this yields the New Keynesian Phillips curve with cognitive discounting as

$$\pi_t = \beta M^f E_t\pi_{t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta}\Theta\mu_t, \tag{27}$$

where

$$M^f \equiv \bar{m}\left[\theta + (1-\theta)\left(\frac{1-\beta\theta}{1-\beta\theta\bar{m}}\right)\right],$$

and where real marginal cost is proportional to the output gap, $\mu_t = \left(\bar{\sigma} + \frac{\alpha+\varphi}{1-\alpha}\right)\tilde{y}_t$, and the factor of proportionality depends on the returns to scale parameter α.

B.2.2 Derivation of the IS equation with Cognitive Discounting

To incorporate cognitive discounting into the IS equation, we initially simplify by ignoring the preference shock z_t that appeared in $\hat{r}_t^n$ below (2). We use the results of Proposition 18, equation (133) on p. 5 of the online appendix to Gabaix (2020) and express current consumption as a function of current assets b_{t-1} and the expected future path of the real interest rate, consumption and transfers $\mathcal{T}_{t+k}$.

$$\hat{c}_t = \beta\rho\chi b_{t-1} + \beta E_t^{BR}\sum_{k=0}^{\infty}\beta^k\left[-\frac{1}{\sigma}\left(\hat{\imath}_{t+k} - E_t\pi_{t+k+1}\right) + \rho\hat{c}_{t+k} + \rho\chi\mathcal{T}_{t+k}\right], \tag{28}$$

where $\chi \equiv \varphi/(\varphi+\tilde{\sigma})$, $\tilde{\sigma} \equiv \sigma(\omega h/c)$ arises from the endogenous response of labor hours to a transfer (which depends on the importance of wage income relative to total consumption) and

$\beta^{-1} = R = 1 + \rho$.[36]

We consider the case in which debt reverts to a steady-state level b. Assume households correctly foresee the future taxes needed to service the interest cost of the steady-state level of debt b, so that

$$\mathcal{T}_{t+k} = -\beta\rho b + \hat{\mathcal{T}}_{t+k},$$

where $\hat{\mathcal{T}}_t^{BR}$ represents transfers that may depend on deviations of debt from its steady-state value. In this case, terms that involve b in (28) are

$$\beta\rho\chi \left[b - b\beta\rho \sum_{k=0}^{\infty} \beta^k \right] = \beta\rho\chi \left(1 - \frac{\beta\rho}{1-\beta} \right) b = 0,$$

and the steady-state debt level does not appear in the IS equation.

Applying cognitive discounting, (28) can now be written in terms of $\hat{b}_t = b_t - b$ as[37]

$$\hat{c}_t = \beta\rho\chi\hat{b}_{t-1} + \beta E_t \sum_{k=0}^{\infty} \bar{m}^k \beta^k \left[-\frac{1}{\sigma} \left(\hat{\imath}_{t+k} - \bar{m}\pi_{t+k+1} \right) + \rho\hat{c}_{t+k} + \rho\chi\hat{\mathcal{T}}_{t+k} \right].$$

Using the forward operator F, this can be written as

$$\hat{c}_t = \beta\rho\chi\hat{b}_{t-1} + \beta E_t \left(1 - \beta\bar{m}F \right)^{-1} \left(-\frac{1}{\sigma} \left(\hat{\imath}_t - \bar{m}\pi_{t+1} \right) + \rho\hat{c}_t + \rho\chi\hat{\mathcal{T}}_t \right).$$

Premultiplying through by $1 - \beta\bar{m}F$, collecting terms involving $\hat{c}_t$, rearranging after noting that $1 - \beta\rho = 1 - \rho/\left(1+\rho\right) = 1/(1+\rho) = \beta$, and finally dividing by β gives

$$\hat{c}_t = \bar{m}E_t\hat{c}_{t+1} - \frac{1}{\sigma} \left(\hat{\imath}_t - \bar{m}E_t\pi_{t+1} \right) + \rho\chi \left(\hat{b}_{t-1} - \beta\bar{m}\hat{b}_t + \hat{\mathcal{T}}_t \right). \tag{29}$$

Let the lump-sum net transfer to households equal

$$\hat{\mathcal{T}}_t = b \left(\hat{\imath}_{t-1} - \pi_t \right) - \beta\hat{s}_t,$$

implying that the debt evolution equation (4) becomes

$$\hat{b}_t = \beta^{-1} \left[\hat{b}_{t-1} + b \left(\hat{\imath}_{t-1} - \pi_t \right) - \beta\hat{s}_t \right] = \beta^{-1} \left(\hat{b}_{t-1} + \hat{\mathcal{T}}_t \right).$$

[36] Gabaix has the real interest rate multiplied by $-1/\sigma R^2$ as he approximates βR_t as $\beta R \left(1 + \hat{r}_t/R\right) = 1 + \hat{r}_t/R$ after using the fact that $\beta R = 1$. We instead use $\beta R_t = \beta\left(1 + r_t\right) = \left(1 + r_t\right)/\left(1 + r\right) \approx 1 + \hat{r}_t$. Thus, he obtains $-\left(1/\sigma R\right)\left(\hat{r}_t/R\right) = -\left(1/\sigma R^2\right)\hat{r}_t$ while we have $-\left(1/\sigma R\right)\hat{r}_t$.

[37] Note that for $k = 0$, $E_t^{BR}\pi_{t+1} = \bar{m}E_t\pi_{t+1}$ which accounts for the $\bar{m}\pi_{t+k+1}$ term in brackets.

Using this equation for $\hat{b}_t$ in (29), one obtains

$$\hat{c}_t = \bar{m}E_t\hat{c}_{t+1} - \frac{1}{\sigma}\left(\hat{\imath}_t - \bar{m}E_t\pi_{t+1}\right) + \rho\chi\left(1-\bar{m}\right)\left(\hat{b}_{t-1} + \hat{\mathcal{T}}_t\right).$$

or

$$\hat{c}_t = \bar{m}E_t\hat{c}_{t+1} - \frac{1}{\sigma}\left(\hat{\imath}_t - \bar{m}E_t\pi_{t+1}\right) + \beta\rho\chi\left(1-\bar{m}\right)\hat{b}_t. \tag{30}$$

The final step is to re-express (30) in terms of the output gap $\tilde{y}_t \equiv \hat{y}_t - \Gamma\hat{g}_t$. To do so, replace $\hat{c}_t$ with $(Y/C)\left(\hat{y}_t - (1-\Gamma)\hat{g}_t\right)$ to obtain

$$\left(\frac{Y}{C}\right)\left[\tilde{y}_t - (1-\Gamma)\hat{g}_t\right] = \bar{m}E_t\left(\frac{Y}{C}\right)\left[\tilde{y}_{t+1} - (1-\Gamma)\hat{g}_{t+1}\right] - \frac{1}{\sigma}\left(\hat{\imath}_t - \bar{m}E_t\pi_{t+1}\right) + \beta\rho\chi\left(1-\bar{m}\right)\hat{b}_t,$$

which can be written as

$$\tilde{y}_t = \bar{m}E_t\tilde{y}_{t+1} - \frac{1}{\bar{\sigma}}\left(\hat{\imath}_t - \bar{m}E_t\pi_{t+1} - \hat{r}_t^{BR}\right), \tag{31}$$

where, after adding back the preference shock z_t that appears in $\hat{r}_t^n$,

$$\hat{r}_t^{BR} \equiv \left(z_t - \bar{m}E_t z_{t+1}\right) + \bar{\sigma}\left(1-\Gamma\right)\left(\hat{g}_t - \bar{m}E_t\hat{g}_{t+1}\right) + \bar{\sigma}b_d\hat{b}_t, \tag{32}$$

and, using $\chi = \varphi/\left(\varphi + \tilde{\sigma}\right) = \varphi/\left(\varphi + \bar{\sigma}(1-\alpha)\right)$,[38]

$$b_d \equiv \left(1-\bar{m}\right)\beta\rho\left(\frac{C}{Y}\right)\left(\frac{\varphi}{\varphi + \bar{\sigma}(1-\alpha)}\right).$$

B.2.3 Equilibrium Determinacy with Cognitive Discounting

Under cognitive discounting, the model now consists of equation (27), (31), the debt equation (4), and the policy rules for the nominal interest rate, taxes and government spending. Substituting out the policy variables and using the definition of $\hat{r}_t^{BR}$, yields the following three equations:

$$\pi_t = \beta M^f E_t\pi_{t+1} + \kappa\tilde{y}_t,$$

$$\tilde{y}_t = \bar{m}E_t\tilde{y}_{t+1} - \frac{1}{\bar{\sigma}}\left(\phi\pi_t - \bar{m}E_t\pi_{t+1}\right) + \frac{1}{\bar{\sigma}}\left(1-\bar{m}\rho_z\right)z_t + \left(1-\Gamma\right)\psi_g\left(\hat{b}_{t-1} - \bar{m}\hat{b}_t\right) + b_d\hat{b}_t,$$

$$\hat{b}_t = \left(\beta^{-1} - \psi_\tau + \psi_g\right)\hat{b}_{t-1} + \beta^{-1}b\left(\phi\pi_{t-1} - \pi_t\right).$$

[38]Note that $\omega h/c = \left((1-\alpha)h^{1-\sigma}\right)/c = (1-\sigma)(Y/C)$ so $\tilde{\sigma} = (1-\sigma)\bar{\sigma}$.

Ignoring shocks, this system can be written as

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \beta M^f & 0 & 0 \\ 0 & \frac{1}{\sigma}\bar{m} & \bar{m} & b_d - (1-\Gamma)\,\psi_g \bar{m} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \pi_t \\ E_t\pi_{t+1} \\ E_t\tilde{y}_{t+1} \\ \hat{b}_t \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 1 & -\kappa & 0 \\ 0 & \frac{1}{\sigma}\phi & 1 & -(1-\Gamma)\,\psi_g \\ \beta^{-1}b\phi & -\beta^{-1}b & 0 & \beta^{-1} - \psi_\tau + \psi_g \end{bmatrix} \begin{bmatrix} \pi_{t-1} \\ \pi_t \\ \tilde{y}_t \\ \hat{b}_{t-1} \end{bmatrix}.$$

Under rational expectations ($\bar{m} = M^f = 1$ and $b_d = 0$). If $\psi_g = 0$ as in the usual analysis of lump-sum taxes only, the model becomes

$$\begin{bmatrix} \pi_t \\ E_t\pi_{t+1} \\ E_t\tilde{y}_{t+1} \\ \hat{b}_t \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & \frac{1}{\beta} & -\frac{\kappa}{\beta} & 0 \\ 0 & \frac{1}{\sigma}\phi - \frac{1}{\sigma\beta} & \frac{\kappa}{\sigma\beta}+1 & 0 \\ \frac{b}{\beta}\phi & -\frac{b}{\beta} & 0 & \frac{1}{\beta} - \psi_\tau \end{bmatrix} \begin{bmatrix} \pi_{t-1} \\ \pi_t \\ \tilde{y}_t \\ \hat{b}_{t-1} \end{bmatrix}.$$

This yields the standard result that one root is $\beta^{-1} - \psi_\tau$ which is stable if $\beta^{-1} - \psi_\tau < 1$ (i.e. $\psi_\tau > \rho$) and unstable if $\psi_\tau < \rho$.

When $\bar{m} < 1$ and $\psi_g \neq 0$, define $\Phi \equiv \left[b_d - (1-\Gamma)\,\psi_g \bar{m}\right]$ and $\psi_s = \psi_\tau - \psi_g$. The system becomes

$$\begin{bmatrix} \pi_t \\ E_t\pi_{t+1} \\ E_t\tilde{y}_{t+1} \\ \hat{b}_t \end{bmatrix} = C \begin{bmatrix} \pi_{t-1} \\ \pi_t \\ \tilde{y}_t \\ \hat{b}_{t-1} \end{bmatrix},$$

where

$$C = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & \frac{1}{M^f\beta} & -\frac{1}{M^f}\frac{\kappa}{\beta} & 0 \\ -\frac{b}{\bar{m}\beta}\phi\Phi & \frac{\beta\phi-1}{\bar{m}\beta\sigma} + \frac{b}{\bar{m}\beta}\Phi & \frac{1}{\bar{m}} + \frac{1}{\bar{m}}\frac{\kappa}{\sigma\beta} & \frac{1}{\bar{m}}\psi_g(\Gamma-1) + \frac{1}{\bar{m}}\Phi\left(\psi_s - \frac{1}{\beta}\right) \\ \frac{b}{\beta}\phi & -\frac{b}{\beta} & 0 & \frac{1}{\beta} - \psi_s \end{bmatrix}.$$

When $\psi_g = 0$, $\Phi = b_d$ and

$$C = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & \frac{1}{M^f\beta} & -\frac{1}{M^f}\frac{\kappa}{\beta} & 0 \\ -\frac{b}{\bar{m}\beta}\phi b_d & \frac{\beta\phi-1}{\bar{m}\beta\sigma} + \frac{b}{\bar{m}\beta}b_d & \frac{1}{\bar{m}} + \frac{1}{\bar{m}}\frac{\kappa}{\sigma\beta} & \frac{1}{\bar{m}}b_d\left(\psi_\tau - \frac{1}{\beta}\right) \\ \frac{b}{\beta}\phi & -\frac{b}{\beta} & 0 & \frac{1}{\beta} - \psi_\tau \end{bmatrix},$$

The characteristic equation is obtained from

$$\det \begin{bmatrix} -\lambda & 1 & 0 & 0 \\ 0 & \frac{1}{M^f \beta} - \lambda & -\frac{1}{M^f}\frac{\kappa}{\beta} & 0 \\ -\frac{b}{\bar{m}\beta}\phi b_d & \frac{\beta\phi - 1}{\bar{m}\beta\sigma} + \frac{b}{\bar{m}\beta} b_d & \frac{1}{\bar{m}} + \frac{1}{\bar{m}}\frac{\kappa}{\sigma\beta} - \lambda & \frac{1}{\bar{m}} b_d \left(\psi_\tau - \frac{1}{\beta}\right) \\ \frac{b}{\beta}\phi & -\frac{b}{\beta} & 0 & \frac{1}{\beta} - \psi_\tau - \lambda \end{bmatrix} = 0.$$

The determinant on the left is equal to

$$\left(\frac{1}{\beta} - \psi_\tau - \lambda\right) \det \begin{bmatrix} -\lambda & 1 & 0 \\ 0 & \frac{1}{M^f \beta} - \lambda & -\frac{1}{M^f}\frac{\kappa}{\beta} \\ -\frac{b}{\bar{m}\beta}\phi b_d & \frac{\beta\phi - 1}{\bar{m}\beta\sigma} + \frac{b}{\bar{m}\beta} b_d & \frac{1}{\bar{m}} + \frac{1}{\bar{m}}\frac{\kappa}{\sigma\beta} - \lambda \end{bmatrix}$$
$$+\frac{1}{\bar{m}} b_d \left(\psi_\tau - \frac{1}{\beta}\right) \left(\frac{1}{M^f}\frac{\kappa}{\beta}\right) \frac{b}{\beta} (\lambda - \phi).$$

Thus, even when only lump-sum taxes are employed as the fiscal policy instrument, the deviation from Ricardian equivalence resulting from cognitive discounting, as reflected in $b_d \neq 0$, implies there is no longer a clear separation in which the condition for active and passive fiscal (monetary) policy is independent of the monetary (fiscal) policy parameter. See Figure 8 of the paper for an illustration.