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Optimal Monetary and Fiscal Policy under Limited Foresight*

Martin Bodenstein† and Junzhu Zhao‡

Abstract: We investigate Barro's random walk hypothesis according to which distortionary labor taxes should follow a random walk for any stochastic process of government expenditures, see Barro (1979). When agents experience cognitive discounting as in Gabaix (2020), they perceive government debt as wealth, and the random walk result breaks down except for knife-edge combinations of limited rationality by policymakers and the private sector. For these specific parameter values, the result can reemerge, but minor deviations from these knife-edge combinations lead to stationary equilibrium dynamics, reflecting the wealth effect of government debt. However, the dynamics turn explosive when policymakers discount the future excessively. Our results extend to other models with limited foresight such as Blanchard (1985), Weil (1989), or Woodford (2019).

Keywords: monetary policy, fiscal policy, limited foresight

JEL classifications: D91, E12, E52, E62, E63, E70

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1 Introduction

According to Barro (1979), optimally chosen labor tax rates and debt levels should follow random walks, regardless of the stochastic process for government expenditures.[1] Barro's random walk (tax-smoothing) hypothesis has not remained unchallenged. Lucas and Stokey (1983) and Chari, Christiano, and Kehoe (1991) show that the optimal labor tax rate will inherit the serial correlation structure of government expenditures when government debt is state contingent.[2] However, Aiyagari, Marcet, Sargent, and Seppala (2002) demonstrate that if the government is confined to issuing only real non-state-contingent debt, distortionary tax rates and debt levels will optimally increase permanently after an adverse fiscal shock, affirming Barro's hypothesis. Benigno and Woodford (2004), Schmitt-Grohe and Uribe (2004), and Siu (2004) extend the Barro-Aiyagari et al. result to New Keynesian (NK) models with distortionary labor taxes and non-state-contingent nominal debt. Although, in principle, unexpected inflation could be used to make real debt returns state-contingent in these models, the high welfare costs of inflation render this option undesirable.

In this paper, we challenge the random walk hypothesis from a new angle as we depart from the assumption of fully rational economic agents in the very same NK models that were used to support the result of Barro-Aiyagari et al. Following Gabaix (2020), we rely on the concept of cognitive discounting, which suggests that individuals only partially understand future events, especially those far into the future. Under this form of bounded rationality, agents perceive government debt as wealth, implying inflationary effects from long-term debt. In turn, the martingale and unit-root properties of the Barro-Aiyagari et al. world do not emerge as the general optimal policy outcomes in this setting, except for knife-edge parameterizations. We show that these findings extend to models with finite planning horizons arising from either bounded rationality (Woodford 2019) or overlapping generations (Blanchard 1985; Weil 1989).

Our findings have particularly important policy implications in an era of elevated global public debt. U.S. federal debt has increased from its level of approximately $10 trillion prior

[1] Sargent (1986) links Barro's tax-smoothing result to the permanent income hypothesis: with distortionary taxes and non-state-contingent debt, policymakers smooth tax rates over time much as households smooth consumption against income fluctuations, with debt serving as the shock absorber.

[2] Lucas and Stokey (1983) assume complete Arrow-Debreu markets. Chari, Christiano, and Kehoe (1991) and Chari and Kehoe (1999) utilize the fact that unanticipated inflation can turn non-state-contingent nominal debt returns into state-contingent real returns—optimality of this approach requires the welfare costs of inflation to be negligible. Angeletos (2002) points to managing the overall debt maturity structure as an alternative approach to render the overall returns from (individually) non-state-contingent assets state-contingent.

to the Global Financial Crisis to more than \$36 trillion by the end of 2024, with the debt-to-GDP ratio reaching approximately 122 percent—nearly at its highest level since World War II. According to the 2025 IMF World Economic Outlook, global public debt surpassed \$100 trillion in 2024. Against this backdrop of historically elevated debt levels, a critical policy question emerges: should governments reverse the large accumulation of debt? We argue that maintaining the debt level stable over time, with governments continually rolling it over without reducing the principal, is not optimal. Because debt optimally reverts toward its initial path following a shock in our model, the substantial debt accumulation of the past two decades should now be wound down. Our reason for reducing government debt is complementary to concerns about debt sustainability and rollover risks when debt-to-GDP ratios are high.

To gain intuition for our result, consider first the optimal policy in a model with fully rational, infinitely-lived, and identical households. Government expenditures are financed by non-state-contingent nominal debt and distortionary labor taxes—rather than lump-sum taxes—a departure from Ricardian equivalence.[3] In this case, policymakers need to balance the benefits of absorbing shocks against the costs from resource misallocation when relying on inflation as a shock absorber. Since the benefits from employing variations in inflation to induce state-contingency of real debt are relatively small, price stability remains the primary objective of the optimal policy. Absent insurance through financial markets, innovations in fiscal conditions are optimally spread over time, implying that debt levels and tax rates exhibit unit-root behavior.

By contrast, under bounded rationality, real debt holdings stimulate aggregate demand, with both current and expected future real government debt exerting upward pressure on inflation. Debt accumulation generates more significant and persistent changes in welfare-costly inflation, even across medium and longer horizons, thereby amplifying the inflationary effects of exogenous disturbances. Consequently, to mitigate the long-term welfare costs associated with inflationary distortions, optimal policy dictates that, contrary to the Barro-Aiyagari et al. result, debt levels and tax rates eventually revert to their initial values.

In greater detail, we develop our theory in a standard NK model with sticky nominal prices, one-period nominal non-state-contingent government debt, and distortionary taxes similar to the model in Benigno and Woodford (2004). As in Gabaix (2020), agents experience cognitive discounting, which means that they discount future events by more than

[3] Note that under lump-sum taxes, there is no rationale for tax-smoothing: Under Ricardian equivalence, the government's intertemporal budget constraint dictates the sum of taxes and debt, but the individual timing choices for taxes and debt are indeterminate.

under full rationality.[4]

We adopt the cognitive discounting approach as our baseline specification of bounded rationality for three key reasons. First, recent studies provide empirical support for cognitive discounting (Ilabaca, Meggiorini, and Milani 2020; Pfäuti and Seyrich 2022; Hirose, Iiboshi, Shintani, and Ueda 2024; Eichenbaum, Guerreiro, and Obradovic 2026). Second, while there are alternative specifications of bounded rationality or lack of common knowledge—including finite planning horizons (Woodford 2019; Woodford and Xie 2022), level-k thinking (Bianchi-Vimercati, Eichenbaum, and Guerreiro 2024), and imperfect knowledge (Angeletos and Lian 2018; Eusepi and Preston 2018), the cognitive discounting approach of Gabaix (2020) offers a gain in tractability relative to these alternatives.[5] Third, and relatedly, the extensions of overlapping generations (OLG) models in the tradition of Blanchard (1985) and Weil (1989) to OLG-NK models (Nisticò 2016; Galí 2021; Del Negro, Giannoni, and Patterson 2023; Aguiar, Amador, and Arellano 2024; Angeletos, Lian, and Wolf 2024) are technically more complex and require implausibly short lifespans in quantitative applications. Crucially, our findings are not exclusive to bounded rationality models characterized by cognitive discounting but instead extend broadly across these alternative model specifications, some of which—finite planning horizons, OLG-NK—we analyze explicitly for sensitivity.

Our model implies a *behavioral* IS Equation for which future changes in the real interest rate gap have a weaker effect on current real activity compared to the model with fully rational agents, i.e., the IS Equation features discounting. Furthermore, real government debt is perceived as wealth and directly stimulates aggregate demand. These two features—discounting in the IS Equation and the perception of government debt as wealth—constitute, alongside distortionary labor taxation, a second and distinct departure from Ricardian equivalence in our model, one arising from limited foresight rather than from the tax code. Similarly, in the *behavioral* NK Phillips Curve (NKPC), the effects of future output gaps on current inflation are diminished because firms are less forward-looking compared to the case of full rationality. The NKPC also features a term in the distortionary labor tax rate; this term is present independently of cognitive discounting, and under full rationality it is the channel through which our model nests the Barro-Aiyagari et al. result, as in Benigno and Woodford (2004). Cognitive discounting affects the government budget constraint indirectly

[4] Models of bounded rationality (and related approaches) have recently enjoyed much attention in monetary economics because they offer a path to resolving the forward guidance puzzle highlighted in Del Negro, Giannoni, and Patterson (2023).

[5] See also Angeletos, Guerreiro, and Zhang (2025) on a comparison between cognitive discounting and related behavioral and informational approaches.

via interest rate dynamics. Last, policymakers may also experience cognitive discounting.

Under cognitive discounting, the two features of *discounting in the IS Equation* and the perception of *government debt as wealth* always arise jointly. To understand which of the two drives the breakdown of the Barro-Aiyagari et al. result, we pursue two approaches. The first approach, departing from the actual model, removes one of the two features at a time from the equilibrium system. The second approach, detailed below, proposes an OLG-NK model in which an appropriately chosen transfer system between agents can switch off the discounting in the IS Equation while leaving the wealth effect of government debt in place. Together, this analysis suggests that for the equilibrium dynamics to be stationary, households must perceive government debt as wealth. Discounting in the IS Equation is neither necessary nor sufficient to induce stationary dynamics of labor taxes and debt. Absent the wealth effect of government debt, the equilibrium dynamics follow a unit root or are explosive.

Cognitive discounting and finite planning horizons are closely related to OLG models with finite lives (Blanchard 1985; Weil 1989). Specifically, we extend the OLG model with an intergenerational transfer system in Nisticò (2016) to feature distortionary labor taxes and then derive an approximation of the welfare criterion. This setting allows us to distinguish more clearly the roles of discounting in the IS Equation from the perception of government debt as wealth. If the intergenerational transfer system equalizes consumption across households in the steady state but not away from it, then the IS Equation features no discounting. Yet, government debt is still viewed as wealth. The resulting dynamics of the model are stationary—the Barro-Aiyagari et al. result breaks down. If the intergenerational transfer system is not sufficient to equalize consumption across households in the steady state, the IS Equation features discounting, and government debt is viewed as wealth. The model dynamics are again stationary.

We also explore other approaches that limit the extent of forward-looking behavior. First, habit persistence in household consumption and price indexation by firms play an important role in quantitative macroeconomics as they introduce backward-looking dynamics. However, these features cannot break the unit-root dynamics of debt and taxes by themselves, which clarifies that backward-looking behavior differs qualitatively from limited foresight. Second, we consider a model with finite planning horizons as proposed in Woodford (2019), Woodford and Xie (2022), and Gust, Herbst, and López-Salido (2022). With agents projecting forward only a finite number of periods into the future, households perceive real government debt as wealth, and the Barro-Aiyagari et al. result breaks down in the same manner as under cognitive discounting.

A possible shortcoming of most models of bounded rationality concerns the assumption that the degree of rationality is constant over time and insensitive to policy. Ilut and Valchev (2023) develop a novel bounded rationality framework that models imperfect reasoning as an interaction between automatic intuitive thought and deliberate analytical thinking. A key insight of their work is that the degree of bounded rationality can be policy-dependent. In light of their work, it is important to stress two aspects of ours. First, because our results extend to the OLG-NK framework with fully rational agents, it is not necessary for agents to experience bounded rationality to break the Barro-Aiyagari et al. result—what is needed is that agents perceive government debt as wealth in addition to labor taxes being distortionary. Second, when we allow for exogenous switching between two regimes—one with a high and one with a low degree of cognitive discounting—the presence of a "more rational regime" slows the speed with which variables approach the steady state while agents are in the less rational regime, but the qualitative results continue to apply.

The remainder of our paper proceeds as follows. In Section 2, we construct an NK model incorporating a fiscal block and cognitive discounting and present the behavioral equations that characterize the equilibrium. Section 3 delves into the analysis of optimal monetary and fiscal policy. In Section 4, we show the optimal responses under bounded rationality. We study the roles of discounting of forward-looking variables and the wealth effect from government debt for our findings in Section 5, for our benchmark model, and Section 6, for an OLG-NK model. Section 7 further explores the robustness of our findings with respect to various modeling assumptions. Concluding remarks are offered in Section 8. An extensive appendix detailing our work is provided separately.

2 The Behavioral Model

We study joint optimal monetary and fiscal policy under bounded rationality in a variant of the textbook NK model that embeds a fiscal block with distortionary labor taxes, as in Benigno and Woodford (2004) and Schmitt-Grohe and Uribe (2004). To incorporate bounded rationality, we follow the cognitive discounting approach developed in Gabaix (2020) which assumes that agents are unable to properly process the implications of economic events. We start by presenting an outline of the model leaving details to Appendix A. We then present the linearized model with details provided in Appendices B and C.

2.1 Brief Model Description

We depart from the framework in Benigno and Woodford (2004) along a single dimension: the formation of expectations by households, firms, and policymakers. Let $\mathbb{E}^{BR}$ stand for the expectation under bounded rationality and X_t be the state vector of the economy. Gabaix (2020) shows that for any variable $\mathbb{k}(X_t)$, the beliefs of behavioral agents satisfy:

$$\mathbb{E}_t^{BR}[\mathbb{k}(X_{t+s})] = \bar{m}^s \mathbb{E}_t[\mathbb{k}(X_{t+s})], \tag{1}$$

where $\mathbb{E}_t[.]$ represents rational expectations. The parameter $\bar{m}$ captures the degree of cognitive discounting. Under full rationality $\bar{m} = 1$. Cognitive discounting, i.e., $\bar{m} < 1$, implies that the impact of an innovation that is expected to occur in period $t+s$ shrinks by a factor of $\bar{m}^s$; events far in the future are heavily discounted, which limits the extent of forward-looking behavior of agents.

Apart from the formation of expectations the model is mostly standard. Households maximize lifetime utility by choosing paths for consumption, c_t, and labor, n_t, subject to their budget constraint. They trade in a nominal non-state-contingent bond, B_t, issued by the government and consume out of post-tax labor income, $(1 - \tau_t)W_t n_t$, with τ_t denoting the tax rate. Under an elastic labor supply, the taxation of labor income distorts labor supply decisions—a feature typically not present in NK models.

Perfectly competitive firms combine differentiated varieties via the Dixit-Stiglitz aggregator to produce the final good, y_t. The varieties are produced by retail firms with labor as the sole input and with stochastic aggregate productivity $\xi_{A,t}$. Firms' pricing of these varieties follows Calvo (1983) with the probability of adjustment $1-\xi_p$; non-adjusting firms raise prices by the steady-state inflation rate $\bar{\Pi}$. An aggregate markup shock, $\mu_{p,t}$, impacts the pricing decisions. Finally, just as households, firms experience cognitive discounting.

Government consumption, g_t, follows an exogenous stochastic process and is financed by labor taxes and debt. The implied flow budget constraint is:

$$\tau_t W_t n_t + B_t = R_{t-1} B_{t-1} + P_t g_t. \tag{2}$$

For generality, we do *not* assume any subsidy scheme that offsets distortions from monopolistic competition or distortionary labor taxation in the steady state. Hence, when the model is linearized, the approximation is around a *distorted steady state*. Next, we turn to the resulting *behavioral* IS Equation, *behavioral* NKPC, and government budget constraint with details given in Appendix C.

2.2 The Behavioral IS Equation

The implied *behavioral* IS Equation is given by:

$$\hat{X}_t = \bar{m}\mathbb{E}_t\hat{X}_{t+1} - \frac{1}{\sigma_C^*}\left(\hat{R}_t - \bar{m}\mathbb{E}_t\hat{\Pi}_{t+1} - \hat{r}_t^n\right) + \beta\mathcal{E}_b\hat{\tilde{b}}_t - \beta\mathcal{E}_b\tilde{b}_y\hat{R}_t, \tag{3}$$

with the natural interest rate $\hat{r}_t^n$:

$$\begin{aligned}\hat{r}_t^n = & -\sigma_C^* q_{ya}\left(\hat{\xi}_{A,t} - \bar{m}\mathbb{E}_t\hat{\xi}_{A,t+1}\right) + \sigma_C^*(1-q_{yg})\left(\hat{g}_t - \bar{m}\mathbb{E}_t\hat{g}_{t+1}\right) \\ & -\sigma_C^* q_{y\theta}\left(\hat{\mu}_{p,t} - \bar{m}\mathbb{E}_t\hat{\mu}_{p,t+1}\right).\end{aligned} \tag{4}$$

The following definitions apply: $\sigma_C^* = \frac{\sigma_C}{s_C}$, where $s_C = \frac{c_{ss}}{y_{ss}}$ represents the steady-state consumption-to-output ratio; $\tilde{b}_y = \frac{\tilde{b}_{ss}}{y_{ss}}$ is the steady-state ratio of the maturity value of real government debt to output; and the composite parameter $\mathcal{E}_b = (1-\beta)\frac{s_C\sigma_L}{\sigma_L+\tilde{\sigma}_C}(1-\bar{m})$ with $\tilde{\sigma}_C = \sigma_C\left(\frac{w_{ss}n_{ss}}{c_{ss}}\right)$. The composite parameters q_{ya}, q_{yg}, and $q_{y\theta}$ are defined in Appendix B as part of deriving the welfare-based loss function under a distorted steady state. Variables with hats represent log deviations from their steady-state values with the exception of $\hat{\tilde{b}}_t = \frac{\tilde{b}_t - \tilde{b}_{ss}}{y_{ss}}$, the deviation of the maturity value of real government debt from its steady state as a fraction of steady-state output, and $\hat{g}_t = \frac{g_t - g_{ss}}{y_{ss}}$, the deviation of real government purchases from steady state as a fraction of steady-state output. The output gap is defined as the deviation of actual output from its target level, i.e., $\hat{X}_t = \hat{y}_t - \hat{y}_t^*$.

Compared to the textbook IS Equation, the *behavioral* IS Equation features "discounting" with the degree of discounting determined by the departure of the coefficient $\bar{m}$ from 1. Cognitive discounting weakens the impact of future output gaps and real rate gaps on the current value of the output gap. The anticipation effect of future events diminishes with the horizon s and fades eventually. These behavioral effects also manifest in the natural rate of interest.

Notice that the channels through which cognitive discounting weakens forward-looking behavior also alter how agents perceive government debt: government debt has a direct and positive stimulative effect on aggregate demand via the term $\mathcal{E}_b\hat{\tilde{b}}_t$. Decomposing $\mathcal{E}_b$, note that as in Gabaix (2020) and Billi and Walsh (2022) $\frac{s_C\sigma_L}{\sigma_L+\tilde{\sigma}_C}$ reflects the endogenous response of labor supply to transfers/payments and $(1-\bar{m})$ governs the perceived value of payments that occur at different points in time. When agents experience cognitive discounting, i.e.,

$\bar{m} < 1$, they discount future transfers/payments more steeply than according to their time preference. The presence of the term $\mathcal{E}_b \hat{\hat{b}}_t$ in the IS Equation is unrelated to the taxation scheme (lump-sum or distortionary). The consequences of $\mathcal{E}_b \hat{\hat{b}}_t$ for optimal policy, however, depend on the tax instrument available to the fiscal authority, as we discuss in Section 3.6.2. When agents are fully rational, i.e., $\bar{m} = 1$, $\mathcal{E}_b = 0$, debt is not perceived as wealth, and this channel is inactive.

2.3 The Behavioral NKPC

The implied *behavioral* NKPC is given by:

$$\hat{\Pi}_t = \beta M^f \mathbb{E}_t \hat{\Pi}_{t+1} + \kappa_p \left(\sigma_C^* + \sigma_L\right) \hat{X}_t + \frac{\kappa_p \bar{\tau}}{1-\bar{\tau}} \left(\hat{\tau}_t - \hat{\tau}_t^*\right). \tag{5}$$

Here, $\kappa_p = \frac{\left(1-\xi_p\right)\left(1-\beta\xi_p\right)}{\xi_p}$ represents the slope of the NKPC and the composite parameter $M^f = \bar{m}\left[\xi_p + \frac{(1-\xi_p)(1-\beta\xi_p)}{1-\beta\xi_p\bar{m}}\right] \leq 1$ governs the degree of discounting.[6] Additionally, $\bar{\tau}$ denotes the steady-state tax rate on household wage income, $\hat{\tau}_t = \frac{\tau_t - \bar{\tau}}{\bar{\tau}}$ represents the log deviation of the tax rate from its steady state, and the *desired* tax rate is defined as:

$$\begin{aligned} \hat{\tau}_t^* \quad = \quad & -\frac{1-\bar{\tau}}{\bar{\tau}} \Big\{ \left[\left(\sigma_C^* + \sigma_L\right) q_{ya} - \left(1+\sigma_L\right)\right] \hat{\xi}_{A,t} + \left[\left(\sigma_C^* + \sigma_L\right) q_{yg} - \sigma_C^*\right] \hat{g}_t \\ & + \left[\left(\sigma_C^* + \sigma_L\right) q_{y\theta} + \frac{\theta_p}{1+\theta_p}\right] \hat{\mu}_{p,t} \Big\}. \end{aligned} \tag{6}$$

The *behavioral* NKPC relates inflation to its one-period-ahead forecast and the output gap, where the extent of forward-looking behavior of boundedly rational firms is limited by the composite parameter M^f. Since $\frac{\partial M^f}{\partial \bar{m}} > 0$, a greater degree of cognitive discounting, i.e., $\bar{m}$ further below 1, results in a lower value of M^f and less forward-looking behavior.[7]

With distortionary taxation, an increase in the tax rate above the desired tax rate exerts upward pressure on inflation via the increase in firms' marginal costs. This tax term is an independent departure from Ricardian equivalence in our model. It is present regardless of the degree of cognitive discounting, $\bar{m}$. For $\bar{m} = 1$, the model collapses to the full rationality benchmark of Benigno and Woodford (2004), in which this term is the key determinant of

[6] To see that $M^f \leq 1$, note that $\bar{m} \leq 1$ implies $\frac{(1-\beta\xi_p)}{1-\beta\xi_p\bar{m}} \leq 1$. Thus, $\frac{(1-\xi_p)(1-\beta\xi_p)}{1-\beta\xi_p\bar{m}} \leq (1-\xi_p)$, which in turn implies $\left[\xi_p + \frac{(1-\xi_p)(1-\beta\xi_p)}{1-\beta\xi_p\bar{m}}\right] \leq 1$ and $M^f = \bar{m}\left[\xi_p + \frac{(1-\xi_p)(1-\beta\xi_p)}{1-\beta\xi_p\bar{m}}\right] \leq 1$.

[7] The derivative of M^f with respect to $\bar{m}$ is: $\frac{\partial M^f}{\partial \bar{m}} = \left[\xi_p + \frac{(1-\xi_p)(1-\beta\xi_p)}{1-\beta\xi_p\bar{m}}\right] + \beta\xi_p\bar{m}\frac{(1-\xi_p)(1-\beta\xi_p)}{\left(1-\beta\xi_p\bar{m}\right)^2} > 0$.

the joint dynamics of taxes and debt.

Finally, in addition to the markup shock, both technology and government spending shocks have direct inflationary effects when the steady state is distorted via $\hat{\tau}_t^*$, defined in Equation (6).

2.4 The Government Budget Constraint

The log-linearized government budget constraint satisfies:

$$\beta\hat{\tilde{b}}_t = \hat{\tilde{b}}_{t-1} + \tilde{b}_y\beta\hat{R}_t - \tilde{b}_y\hat{\Pi}_t - \frac{\bar{\tau}}{(1-\bar{\tau})^2}\hat{\tau}_t - \frac{\bar{\tau}}{1-\bar{\tau}}\left(1+\sigma_C^*+\sigma_L\right)\hat{X}_t + \Psi_t, \tag{7}$$

with the composite fiscal shock Ψ_t given by:

$$\begin{aligned}\Psi_t \;\; = \;\; & \left[\frac{\bar{\tau}}{1-\bar{\tau}}\left(1+\sigma_C^*+\sigma_L\right)q_{ya} + \frac{\bar{\tau}}{1-\bar{\tau}}\left(1+\sigma_L\right)\right]\hat{\xi}_{A,t} \\ & + \left[\frac{\bar{\tau}}{1-\bar{\tau}}\left(1+\sigma_C^*+\sigma_L\right)q_{yg} + \left(1+\frac{\bar{\tau}}{1-\bar{\tau}}\sigma_C^*\right)\right]\hat{g}_t \\ & + \frac{\bar{\tau}}{1-\bar{\tau}}\left(1+\sigma_C^*+\sigma_L\right)q_{y\theta}\hat{\mu}_{p,t}.\end{aligned} \tag{8}$$

Substituting out $\hat{R}_t$ in Equation (7) using the *behavioral* IS Equation, forward iteration delivers the *behavioral* government solvency condition in terms of the output gap and the tax gap:

$$\begin{aligned}& \left[\hat{\tilde{b}}_{t-1} + \Omega_t\right] - \frac{\tilde{b}_y\sigma_C^*\bar{m}}{\left(1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y\right)}\hat{X}_t - \frac{\tilde{b}_y\bar{m}}{\left(1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y\right)}\hat{\Pi}_t \\ = \;\; & \mathbb{E}_t\sum_{s=0}^{\infty}\beta^s\Bigg\{-\beta\left(1-\frac{1}{\left(1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y\right)}\right)\hat{\tilde{b}}_{t+s} + \tilde{b}_y\left(1-\frac{\bar{m}}{\left(1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y\right)}\right)\hat{\Pi}_{t+s} \\ & + \left[\frac{\bar{\tau}}{1-\bar{\tau}}\left(1+\sigma_C^*+\sigma_L\right) - \frac{\tilde{b}_y\sigma_C^*\left(\bar{m}-\beta\right)}{\left(1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y\right)}\right]\hat{X}_{t+s} + \frac{\bar{\tau}}{(1-\bar{\tau})^2}\left(\hat{\tau}_{t+s}-\hat{\tau}_{t+s}^*\right)\Bigg\},\end{aligned} \tag{9}$$

where the composite measure of "fiscal stress" Ω_t is defined as:

$$\Omega_t = \mathbb{E}_t\sum_{s=0}^{\infty}\beta^s\left(\Psi_{t+s} + \tilde{b}_y\beta\frac{1}{\left(1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y\right)}\hat{r}_{t+s}^n - \frac{\bar{\tau}}{(1-\bar{\tau})^2}\hat{\tau}_{t+s}^*\right). \tag{10}$$

Fiscal stress Ω_t stems from three sources of disturbances, including the composite fiscal shock, the natural rate, and the *desired* tax rate.

In an NK model with fiscal and monetary policy, full stabilization of inflation and the output gap requires $\hat{\hat{b}}_{t-1}+\Omega_t=0$, with fiscal policy closing the tax gap by setting $\hat{\tau}_t=\hat{\tau}_t^*$ and monetary policy setting $\hat{R}_t=\frac{1}{\left(1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y\right)}\hat{r}_t^n$. However, in the presence of fiscal stress Ω_t, full stabilization of inflation and the output gap, while ensuring the intertemporal government solvency condition, is generally infeasible. All shocks generate a trade-off between stabilizing inflation, the output gap, and real public debt through Ω_t.

3 Optimal Monetary and Fiscal Policy

To explore the joint determination of optimal monetary and fiscal policy under bounded rationality, we first introduce the policymakers' objective function. We then characterize the state-contingent paths for endogenous variables under the optimal policy from the timeless perspective.[8]

3.1 Welfare-Based Loss Function

Drawing on the work of Rotemberg and Woodford (1997) and Woodford (2003), we derive the objective function of policymakers as the second-order approximation to the utility function of the representative household as detailed in Appendix B. To preserve generality, we abstract from subsidies that remove the steady-state distortions associated with monopolistic competition and distortionary taxes.

Consistent with the focus on bounded rationality, we allow for the possibility that policymakers may also exhibit cognitive discounting, resulting in the approximated welfare-based loss function:

$$\mathbb{W} = \mathbb{E}_0\sum_{t=0}^{\infty}\left(\beta m^\star\right)^t\left[\frac{1}{2}q_y\hat{X}_t^2+\frac{1}{2}q_\pi\hat{\Pi}_t^2+q_{\tau\theta}\hat{\tau}_t\hat{\mu}_{p,t}\right]. \tag{11}$$

The composite parameters q_y, q_π, and $q_{\tau\theta}$ are defined in Appendix B. The measured loss responds to current and future (squared) deviations of inflation from its long-run target and (squared) deviations of the output gap from zero. Compared with the findings in Benigno

[8] See Benigno and Woodford (2012) and Bodenstein, Guerrieri, and LaBriola (2019) for discussions on the concept of "optimality from the timeless perspective" and its role in obtaining the objective function of policymakers as a quadratic loss function.

and Woodford (2004) and Leeper and Zhou (2021), our welfare loss function includes a third term capturing the interaction between taxation and the markup shock, due to the fact that wage taxation directly affects firms' marginal cost of production. Notice that tax-smoothing does not enter explicitly as a motive into the loss function. The incentive to smooth taxes arises from the behavioral NKPC through the fact that higher-than-desired taxes exert downward pressure on the output gap.

Finally, policymakers discount future outcomes more steeply under cognitive discounting than under full rationality with the factor $\beta m^\star \leq \beta$, where $m^\star \leq 1$ measures the degree of cognitive discounting specific to policymakers.

3.2 Optimal State-Contingent Paths

The optimal commitment policy sets state-contingent paths $\{\hat{X}_t, \hat{\Pi}_t, \hat{R}_t, \hat{\tau}_t, \hat{\tilde{b}}_t\}_{t=0}^{\infty}$ to minimize the welfare-based loss function (11), subject to the IS Equation (3), the NKPC (5), and the intertemporal government solvency constraint (9), given an initial value for the state variable $\hat{\tilde{b}}_{-1}$. The policy formulation is constrained by the requirement that $\hat{\Pi}_0$ and $\hat{X}_0$ conform to specific pre-commitment values.[9]

Let λ_t^b be the Lagrange multiplier associated with Condition (9). As shown in Appendix D, the equilibrium state-contingent paths for $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{\Pi}_t, \hat{X}_t, \hat{\tau}_t\}$ satisfy:

$$
\begin{aligned}
\lambda_t^b \;=\;& -\frac{\mathcal{H}_\lambda}{m^\star \mathcal{I}_\lambda}\lambda_{t-1}^b + \frac{1}{\mathcal{I}_\lambda}\hat{\tilde{b}}_{t-1} \\
& + \frac{1}{\mathcal{I}_\lambda}\Bigg[\Omega_t - \beta\frac{\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y}{\left(1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y\right)}\mathbb{E}_t\sum_{s=0}^{\infty}\left(\frac{\beta}{1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y}\right)^s\Omega_{t+1+s} \\
& - \mathbb{E}_t\sum_{s=0}^{\infty}\left(\frac{\beta}{1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y}\right)^s\left(\Theta_1\hat{\mu}_{p,t+1+s} + \Theta_2\hat{\mu}_{p,t+s} + \Theta_3\hat{\mu}_{p,t-1+s}\right)\Bigg], \qquad (12)\\
\hat{\tilde{b}}_t \;=\;& -\mathbb{E}_t\Omega_{t+1} + \beta\frac{\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y}{\left(1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y\right)}\mathbb{E}_t\sum_{s=0}^{\infty}\left(\frac{\beta}{1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y}\right)^s\Omega_{t+2+s} \\
& + \mathbb{E}_t\sum_{s=0}^{\infty}\left(\frac{\beta}{1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y}\right)^s\left(\Theta_1\hat{\mu}_{p,t+2+s} + \Theta_2\hat{\mu}_{p,t+1+s} + \Theta_3\hat{\mu}_{p,t+s}\right) \\
& + \left(\mathcal{I}_\lambda\frac{1}{m^\star\left(1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y\right)} + \frac{\mathcal{H}_\lambda}{m^\star}\right)\lambda_t^b, \qquad (13)
\end{aligned}
$$

[9] As in the underlying model with fully rational agents, the optimal plans are not time consistent; thus, we assume the existence of an unspecified commitment device that the general public deems credible; the pre-commitments prevent discretionary policy moves at time zero.

$$
\begin{aligned}
\hat{\Pi}_t &= \frac{1}{q_\pi}\left[\left(\frac{1}{\kappa_p(1-\bar{\tau})}+\tilde{b}_y\right)\lambda_t^b-\left(\frac{1}{m^\star}\right)\left(\frac{M^f}{\kappa_p(1-\bar{\tau})}+\frac{\tilde{b}_y\bar{m}}{1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y}\right)\lambda_{t-1}^b\right] \\
&\quad -\frac{1-\bar{\tau}}{\kappa_p\bar{\tau}}\frac{q_{\tau\theta}}{q_\pi}\left(\hat{\mu}_{p,t}-\frac{M^f}{m^\star}\hat{\mu}_{p,t-1}\right), \qquad (14)\\
\hat{X}_t &= -\frac{1}{q_y}\left((\sigma_C^*+\sigma_L)-\frac{\tilde{b}_y\sigma_C^*\beta}{\left(1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y\right)}-\frac{\bar{\tau}}{1-\bar{\tau}}\right)\lambda_t^b \\
&\quad -\frac{1}{q_y}\frac{\tilde{b}_y\sigma_C^*\bar{m}}{m^\star\left(1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y\right)}\lambda_{t-1}^b+\frac{1-\bar{\tau}}{\bar{\tau}}(\sigma_C^*+\sigma_L)\frac{q_{\tau\theta}}{q_y}\hat{\mu}_{p,t}, \qquad (15)\\
\hat{\tau}_t-\hat{\tau}_t^* &= \left(\frac{1-\bar{\tau}}{\kappa_p\bar{\tau}}\right)\left[\hat{\Pi}_t-\beta M^f\mathbb{E}_t\hat{\Pi}_{t+1}-\kappa_p(\sigma_C^*+\sigma_L)\hat{X}_t\right]. \qquad (16)
\end{aligned}
$$

Equations (12) and (13) determine the evolution of real government debt, $\hat{\tilde{b}}_t$, and the Lagrange multiplier, λ_t^b, given the exogenous path of the composite fiscal stress measure $\{\Omega_t\}_{t=0}^\infty$ defined in Equation (10) and the exogenous path of the markup shock $\{\hat{\mu}_{p,t}\}_{t=0}^\infty$. Equations (14) and (15) describe the optimal paths for inflation and the output gap, respectively, as functions of λ_t^b. Finally, Equation (16) gives the optimal path for distortionary labor taxes, $\hat{\tau}_t$, which responds to changes in the *desired* tax rate and adjusts positively to inflation but negatively to the output gap.

3.3 Equilibrium Properties

Turning to the dynamic properties of the equilibrium, we note that the optimal state-contingent paths of the endogenous variables in our behavioral NK model can exhibit unit-root behavior, stationarity, or explosiveness depending on the extent and pervasiveness of cognitive discounting.

Theorem 1 *In a behavioral NK model with distortionary taxes, where monetary and fiscal policy are jointly determined under commitment, the time-series properties of the equilibrium trajectories for* $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{\Pi}_t, \hat{X}_t, \hat{\tau}_t\}$ *are determined by the size of the term* $m^\star(1+\Upsilon_m(1-\bar{m}))$, *where* $\Upsilon_m = (1-\beta)\, b_y\left(\frac{\sigma_C\sigma_L}{\sigma_L+\tilde{\sigma}_C}\right) \equiv \frac{\mathcal{E}_b\sigma_C^*}{1-\bar{m}}b_y$*:*

- ***Case I: Unit Roots.*** *If*

$$
m^\star(1+\Upsilon_m(1-\bar{m})) = 1, \qquad (17)
$$

then the Lagrange multiplier λ_t^b *is a martingale, and the optimal state-contingent evolutions of* $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{X}_t, \hat{\tau}_t\}$ *exhibit unit-root behavior. Additionally,* $\hat{\Pi}_t$ *follows a stationary* *process if both policymakers and the private sector are fully rational ($m^\star = \bar{m} = 1$), but a unit-root process if both policymakers and the private sector are boundedly rational ($m^\star < 1, \bar{m} < 1$).*

- ***Case II: Stationarity.*** *If*

$$m^\star \left(1 + \Upsilon_m \left(1 - \bar{m}\right)\right) > 1, \tag{18}$$

then the Lagrange multiplier λ_t^b follows a supermartingale, and the optimal state-contingent paths of $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{\Pi}_t, \hat{X}_t, \hat{\tau}_t\}$ are all stationary processes.

- ***Case III: Explosiveness.*** *If*

$$m^\star \left(1 + \Upsilon_m \left(1 - \bar{m}\right)\right) < 1, \tag{19}$$

then the Lagrange multiplier λ_t^b follows a submartingale, and the optimal state-contingent dynamics of $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{\Pi}_t, \hat{X}_t, \hat{\tau}_t\}$ are all explosive.

Proof: See Appendix D.2.

The term $\Upsilon_m(1 - \bar{m})$ is central to Theorem 1 and can be decomposed into the factors $\mathcal{E}_b$, b_y, and σ_C^*. The first factor reflects the endogenous response of the labor supply to transfers under cognitive discounting in the behavioral IS Equation, recall Equation (3). The second factor is the steady-state holding of government debt. The third factor, σ_C^*, is a scaled version of the intertemporal elasticity of substitution. Thus, the term $\Upsilon_m(1 - \bar{m})$ is a measure of the strength of the wealth effect of government debt in the steady state. The theorem underscores the significance of cognitive discounting in determining the equilibrium properties of our model. We discuss the various cases in turns next.

3.4 Fully Flexible Prices

In the limit of flexible prices, the probability of each firm resetting its price, $1 - \xi_p$, is equal to 1, implying a vertical NKPC ($\kappa_p = \infty$) and zero weight on inflation stabilization in the loss function. The following lemma applies:

Lemma 1 *In a behavioral NK model with distortionary taxes, when prices are flexible, the optimal policy dictates that the tax rate gap and the output gap follow:*

$$\hat{\tau}_t - \hat{\tau}_t^* \quad = \quad - \left[\frac{1 - \bar{\tau}}{\bar{\tau}} \left(\sigma_C^* + \sigma_L\right)\right]^2 \frac{q_{\tau\theta}}{q_y} \hat{\mu}_{p,t}, \tag{20}$$

$$\hat{X}_t = \frac{1-\bar{\tau}}{\bar{\tau}} \left(\sigma_C^* + \sigma_L\right) \frac{q_{\tau\theta}}{q_y} \hat{\mu}_{p,t}. \quad (21)$$

Proof: See Appendix D.3.

Absent markup disturbances, i.e., $\hat{\mu}_{p,t} = 0$, our framework implies that the tax rate gap, $\hat{\tau}_t - \hat{\tau}_t^*$, is closed under flexible prices, a finding that is consistent with Lucas and Stokey (1983) and Benigno and Woodford (2004). It is optimal for the labor tax rate to adjust in response to the desired tax rate, $\hat{\tau}_t^*$. In addition, the optimal policy also dictates $\hat{X}_t = 0$ at all times, signifying full stabilization of the output gap. This result aligns with findings in the NK model with fully rational agents, as in Benigno and Woodford (2004) and Leeper and Zhou (2021). In the face of markup shocks, i.e., $\hat{\mu}_{p,t} \neq 0$, full stabilization of the output gap is not desirable since the flexible price output is not efficient in our setting.

Overall, under flexible prices, optimal tax rate variations are stationary and share the same persistence properties as the underlying shock processes. In addition, optimal output gap variations are also stationary.

3.5 Sticky Prices

Turning to the model with sticky prices, the implications for the joint determination of monetary and fiscal policy change significantly. Using the parameterization in Table 1, Figure 1a illustrates the equilibrium properties for the optimal policy for different assumptions on the rationality of private and public agents.

Table 1: Parameter Values for the Behavioral NK Model

Parameter			Parameter		
$\bar{\Pi}$	s.s. inflation rate	1	σ_C	inverse int. elast.	2
β	discount factor	0.99	σ_L	inverse Frisch elast.	2
ϵ_p	elast. subs. among good varieties	6	$g_y = \bar{g}/\bar{y}$	s.s. gov. purchase to output ratio	0.2
$s_C = \bar{c}/\bar{y}$	s.s. consumption to output ratio	0.8	$\bar{m}$	cognitive discounting, private sector	[0,1]
$b_y = \bar{b}/\bar{y}$	s.s. public debt to output ratio	2.4	$m^\star$	cognitive discounting, policymakers	[0,1]
ξ_p	nom. price rigidity	0.75			

Note: Table 1 presents the parameterization of the behavioral NK model.

3.5.1 Full Rationality: $m^\star = \bar{m} = 1$

With both policymakers and the private sector fully rational, $m^\star = \bar{m} = 1$, debt financing has no impact on aggregate demand and

$$m^\star \left(1 + \Upsilon_m \left(1 - \bar{m}\right)\right) = 1. \tag{22}$$

Hence, Theorem 1, Case I applies and the optimal state-contingent paths of $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{X}_t, \hat{\tau}_t\}$ exhibit unit-root behavior: A transitory change in composite fiscal stress leads to a permanent change in both the Lagrange multiplier λ_t^b and real government debt $\hat{\tilde{b}}_t$, consistent with the findings of Benigno and Woodford (2004).

The first-order condition for the output gap:

$$\begin{aligned}\hat{X}_t &= -\frac{1}{q_y}\left[\left(\left(\sigma_C^* + \sigma_L\right) - \tilde{b}_y \sigma_C^* \beta - \frac{\bar{\tau}}{1-\bar{\tau}}\right)\lambda_t^b + \tilde{b}_y \sigma_C^* \lambda_{t-1}^b\right] \\ &\quad + \frac{1-\bar{\tau}}{\bar{\tau}}\left(\sigma_C^* + \sigma_L\right)\frac{q_{\tau\theta}}{q_y}\hat{\mu}_{p,t},\end{aligned} \tag{23}$$

implies that the permanent change in the Lagrange multiplier leads to a permanent change in the output gap.

The first-order condition for inflation states:

$$\hat{\Pi}_t = \frac{1}{q_\pi}\left(\frac{1}{\kappa_p\left(1-\bar{\tau}\right)} + \tilde{b}_y\right)\left(\lambda_t^b - \lambda_{t-1}^b\right) - \frac{1-\bar{\tau}}{\kappa_p \bar{\tau}}\frac{q_{\tau\theta}}{q_\pi}\left(\hat{\mu}_{p,t} - \hat{\mu}_{p,t-1}\right), \tag{24}$$

implying that the permanent change in the Lagrange multiplier changes the price level permanently—different from the textbook NK model without a fiscal block which implies price-level stationarity. Inflation, by contrast, is stationary with:

$$\mathbb{E}_t \hat{\Pi}_{t+1} = \frac{1-\bar{\tau}}{\kappa_p \bar{\tau}}\frac{q_{\tau\theta}}{q_\pi}\left(1 - \rho_p\right)\hat{\mu}_{p,t}. \tag{25}$$

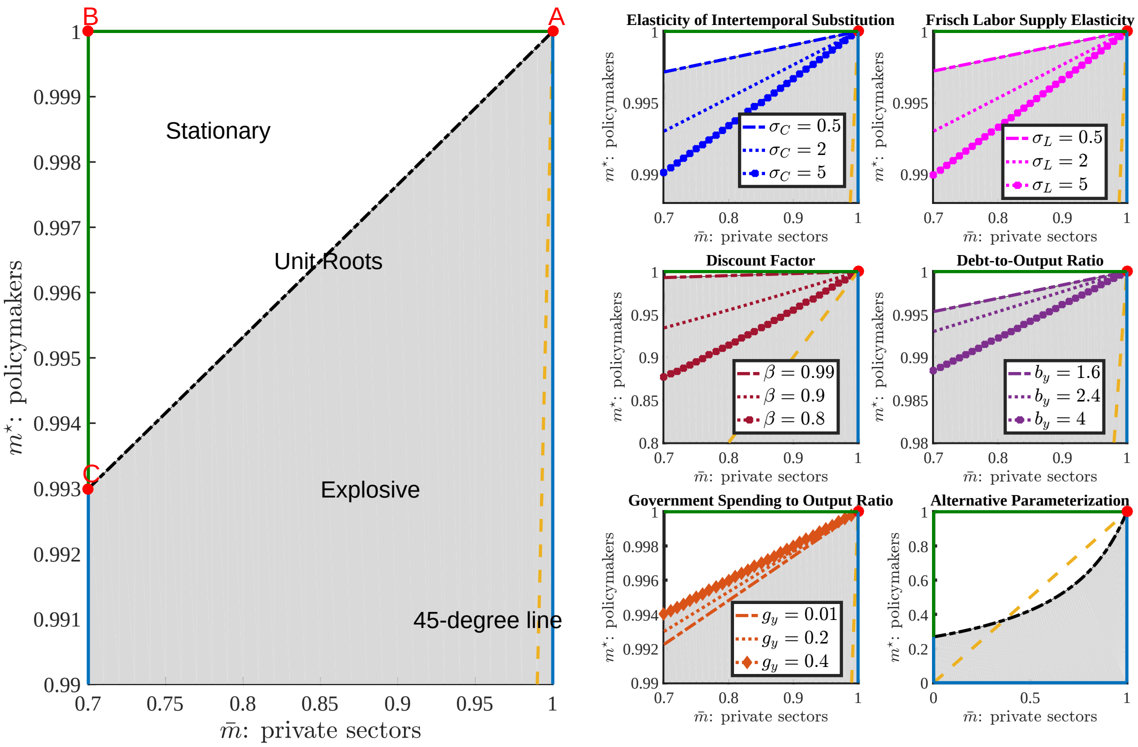
Under full rationality, the optimal policy seeks to anchor inflation expectation as in Benigno and Woodford (2004) and Leeper and Zhou (2021).

Finally, the equilibrium path of the tax rate is also nonstationary:

$$\hat{\tau}_t - \hat{\tau}_t^* = \left(\frac{1-\bar{\tau}}{\kappa_p \bar{\tau}}\right)\left[\hat{\Pi}_t - \kappa_p\left(\sigma_C^* + \sigma_L\right)\hat{X}_t\right] - \beta M^f \left(\frac{1-\bar{\tau}}{\kappa_p \bar{\tau}}\right)^2 \frac{q_{\tau\theta}}{q_\pi}\left(1 - \rho_p\right)\hat{\mu}_{p,t}. \tag{26}$$

In sum, under fully rational policymakers and private agents, marked by Point A in

Figure 1a, the shadow price of the government budget constraint, real government debt, the output gap, the price level, and tax rates follow unit-root processes in line with Barro (1979), Aiyagari, Marcet, Sargent, and Seppala (2002), Benigno and Woodford (2004), Schmitt-Grohe and Uribe (2004), and Siu (2004).



(a) Benchmark Calibration

(b) Alternative Calibrations

Figure 1: Equilibrium Properties of the Behavioral NK Model

Note: The white areas correspond to the stationary regions, while the grey areas refer to the explosive regions. The yellow dashed line represents the 45-degree line.

3.5.2 Bounded Rationality Private Sector: $m^\star = 1$ and $\bar{m} < 1$

With $m^\star = 1$ and $\bar{m} < 1$, we obtain:

$$m^\star \left(1 + \Upsilon_m \left(1 - \bar{m}\right)\right) = 1 + \Upsilon_m \left(1 - \bar{m}\right) > 1. \tag{27}$$

Since $\Upsilon_m \left(1 - \bar{m}\right) = \mathcal{E}_b \sigma_C^* b_y > 0$, real government debt is considered wealth and has a stimulative effect on aggregate demand. Following Theorem 1, Case II applies under bounded rationality of the private sector and full rationality of policymakers. Hence, $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{\Pi}_t, \hat{X}_t, \hat{\tau}_t\}$ all follow stationary processes.

Given a transitory disturbance to the fiscal stress measure, both λ_t^b and $\hat{\tilde{b}}_t$ are stationary. The optimality conditions for the output gap and inflation are:

$$\begin{aligned}
\hat{X}_t &= -\frac{1}{q_y}\left[\left(\sigma_C^* + \sigma_L - \frac{\tilde{b}_y \sigma_C^* \beta}{1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y} - \frac{\bar{\tau}}{1-\bar{\tau}}\right)\lambda_t^b + \frac{\tilde{b}_y\sigma_C^*\bar{m}}{1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y}\lambda_{t-1}^b\right] \\
&\quad + \frac{1-\bar{\tau}}{\bar{\tau}}\left(\sigma_C^* + \sigma_L\right)\frac{q_{\tau\theta}}{q_y}\hat{\mu}_{p,t}, \qquad (28)\\
\hat{\Pi}_t &= \frac{1}{q_\pi}\left[\left(\frac{1}{\kappa_p(1-\bar{\tau})} + \tilde{b}_y\right)\lambda_t^b - \left(\frac{M^f}{\kappa_p(1-\bar{\tau})} + \frac{\tilde{b}_y\bar{m}}{1+\beta\sigma_C^*\mathcal{E}_b\tilde{b}_y}\right)\lambda_{t-1}^b\right] \\
&\quad - \frac{1-\bar{\tau}}{\kappa_p\bar{\tau}}\frac{q_{\tau\theta}}{q_\pi}\left(\hat{\mu}_{p,t} - M^f\hat{\mu}_{p,t-1}\right). \qquad (29)
\end{aligned}$$

Stationarity of λ_t^b implies stationary output gap, inflation, and tax rate.

When policymakers are fully rational but the private sector is boundedly rational, optimal monetary and fiscal policy results in an equilibrium where the shadow price of the government budget constraint, real government debt, output gap, and tax rates no longer follow unit-root processes; instead, they become stationary variables. The points on the green line connecting Point A and Point B in Figure 1a (excluding Point A) summarize the values of $\bar{m}$ for which the optimal equilibrium paths are stationary.

3.5.3 Bounded Rationality Public Sector: $m^\star < 1$ and $\bar{m} = 1$

With $m^\star < 1$ and $\bar{m} = 1$, it is:

$$m^\star\left(1 + \Upsilon_m\left(1 - \bar{m}\right)\right) = m^\star < 1. \qquad (30)$$

Following Theorem 1, Case III applies and the optimal dynamics of $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{\Pi}_t, \hat{X}_t, \hat{\tau}_t\}$ are all explosive. The blue vertical line on the far right in Figure 1a ending in Point A depicts the situation when only the public sector is boundedly rational.

3.5.4 Bounded Rationality Both Sectors: $m^\star < 1$ and $\bar{m} < 1$

The case of both policymakers and the private sector being boundedly rational is the most general one and explores the remainder of the $(\bar{m}, m^\star)$ plane. As depicted in Figure 1a, the three cases stated in Theorem 1 emerge depending on the values assumed by $\bar{m}$ and $m^\star$.

Martingale and Unit Roots: As discussed in Section 3.5.1, Point A represents the case of both policymakers and the private sector being fully rational, i.e., $(m^\star, \bar{m}) = (1, 1)$.

Under these conditions, the equilibrium paths of $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{X}_t, \hat{\tau}_t\}$ all follow unit-root processes. However, the martingale and unit-root features can also emerge when both policymakers and the private sector are not fully rational. As shown in Theorem 1 Case I, all combinations $(m^\star, \bar{m})$ satisfying Condition (17) give rise to martingale and unit-root behavior. In Figure 1a, the black dot-dashed curve connecting the points A and C depicts all these parameter combinations. Note, that the greater the degree of cognitive discounting for the private sector—signifying a greater departure from full rationality and a stronger stimulating effect from government debt—the greater is the extent of cognitive discounting by policymakers that is consistent with unit-root behavior of the endogenous variables.

Stationarity: As discussed in Section 3.5.2 and depicted by the line AB in Figure 1a, when policymakers are fully rational and the private sector is boundedly rational, the equilibrium paths of $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{\Pi}_t, \hat{X}_t, \hat{\tau}_t\}$ are all stationary processes. But, stationarity also emerges when both policymakers and the private sector feature cognitive discounting. Following Theorem 1, Case II, all combinations $(m^\star, \bar{m})$ satisfying Condition (18) yield stationary dynamics. In Figure 1a, these combinations fall into the area marked by the points A, B, and C.

Explosiveness: As discussed in Section 3.5.3 and depicted by the blue vertical line ending in Point A in Figure 1a, when policymakers are boundedly rational and the private sector is fully rational, the equilibrium paths of $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{\Pi}_t, \hat{X}_t, \hat{\tau}_t\}$ are all explosive. As shown in Theorem 1, all combinations $(m^\star, \bar{m})$ satisfying Condition (19) imply explosive dynamics. In Figure 1a, these combinations fall into the gray area below the curve connecting the points A and C.

3.5.5 Equal Degree of Bounded Rationality: $m^\star = \bar{m}$

The dashed yellow line in Figure 1a depicts all situations in which policymakers and the private sector feature the same degree of cognitive discounting. For our calibration of the model, the 45-degree line falls strictly within the explosive region with the exception of Point A.

3.6 Sensitivity Analysis

3.6.1 Parameterization

Structural parameters affect the equilibrium dynamics in the behavioral NK model as follows:

- Increases in σ_C, σ_L, and b_y all enhance the stimulative effect of real bond holdings, expanding the region with stationary equilibrium dynamics and shrinking the region with explosive dynamics.

- Conversely, increases in β (when moderate or high) and g_y dampen the stimulative effect of real bond holdings, shrinking the region with stationary equilibrium dynamics and expanding the region with explosive dynamics.

For analytical results see Appendix D.4. Figure 1b illustrates these findings.

The bottom right panel of Figure 1b shows an extreme calibration with the discount factor set to $\beta = 0.9$, the inverse of the intertemporal elasticity of substitution for consumption $\sigma_C = 5$, the inverse of Frisch labor supply elasticity $\sigma_L = 5$, the steady-state government spending-to-output ratio $g_y = 0$, and the steady-state debt-to-output ratio $b_y = 10$. In this case, the region with stationary equilibrium dynamics is significantly enlarged and, provided that public and private sectors are sufficiently rational, we can identify cases with stationary equilibrium dynamics for $m^\star = \bar{m}$.

3.6.2 Tax Instrument

The literature on optimal monetary policy usually assumes the availability of lump-sum taxes. In this case, policymakers do not impose distortionary labor taxes, i.e., $\tau_t = 0$ $\forall t$. Gabaix (2020) discusses the optimal policy under lump-sum taxation and cognitive discounting by the private sector.

As shown in Appendix D.5, the equilibrium conditions that govern the dynamics of inflation and the output gap, $\{\hat{\Pi}_t, \hat{X}_t\}$, can be summarized as:

$$\hat{\Pi}_t = -\frac{1}{\kappa_p \left(\sigma_C^* + \sigma_L\right) \frac{q_\pi}{q_y}} \left(\hat{X}_t - \frac{M^f}{m^\star}\hat{X}_{t-1}\right), \tag{31}$$

$$\hat{\Pi}_t = \beta M^f \mathbb{E}_t \hat{\Pi}_{t+1} + \kappa_p \left(\sigma_C^* + \sigma_L\right) \hat{X}_t - \frac{\kappa_p \bar{\tau}}{1-\bar{\tau}} \hat{\tau}_t^*. \tag{32}$$

This is the same set of conditions that emerge in a model without a fiscal block despite the fact that, in principle, under bounded rationality, government debt can affect economic activity through the behavioral IS Equation.

In contrast to the model with distortionary labor taxes, the evolution of $\{\hat{\Pi}_t, \hat{X}_t\}$ is independent of the fiscal authority's policy choices when lump-sum taxes are available. As in the standard NK model with fully rational agents, inflation and the output gap are fully stabilized in response to shocks to the natural rate; only markup shocks induce policy trade-offs. The optimal evolution of $\{\hat{\tilde{b}}_t, \hat{\tau}^l_t, \hat{R}_t\}$ is indeterminate, but the three endogenous variables must satisfy the government solvency condition and the behavioral IS Equation. This constitutes a weaker form of Ricardian equivalence: as under the textbook benchmark, the timing of lump-sum taxes and debt is not pinned down, but here the indeterminacy is constrained by the interaction of debt and taxes with the policy rate via the wealth effect of debt in the behavioral IS Equation.

However, the model with cognitive discounting and lump-sum taxes does not share all the policy implications of the standard NK model with fully rational agents. Although Equation (31) and Equation (32) closely resemble the equilibrium conditions under full rationality, the presence of discounting in the NKPC ($M^f < 1$) and the policymakers' loss function ($m^\star < 1$) implies that price level targeting is generally not optimal under bounded rationality even with lump-sum taxation: the sum of past and current inflation rates using Equation (31),

$$\hat{P}_t = \sum_{i=0}^{t} \hat{\Pi}_i \quad = \quad -\frac{1}{\kappa_p \left(\sigma_C^* + \sigma_L\right) \frac{q_\pi}{q_y}} \left(\hat{X}_t + \left(1 - \frac{M^f}{m^\star}\right) \sum_{i=0}^{t-1} \hat{X}_i\right), \tag{33}$$

does not mean-revert unless $\frac{M^f}{m^\star} = 1$; past output gaps are permanently reflected in the price level.

4 Optimal Policy Responses

This section examines the role of bounded rationality in shaping the dynamic responses under optimal policy. The *behavioral* equilibrium solvency condition can be stated as:

$$\begin{aligned}
& \left[\hat{\tilde{b}}_{t-1} + \Omega_t\right] + \mathbb{E}_t \sum_{s=0}^{\infty} \beta \left(\beta m^\star\right)^s \left(1 - \frac{1}{1 + \beta \sigma_C^* \mathcal{E}_b \tilde{b}_y}\right) \hat{\tilde{b}}_{t+s} \\
= \quad & \tilde{b}_y \hat{\Pi}_t + \mathbb{E}_t \sum_{s=1}^{\infty} \left(\beta m^\star\right)^s \tilde{b}_y \left(1 - \frac{\bar{m}}{1 + \beta \sigma_C^* \mathcal{E}_b \tilde{b}_y}\right) \hat{\Pi}_{t+s} \\
& + \mathbb{E}_t \sum_{s=0}^{\infty} \left(\beta m^\star\right)^s \frac{\bar{\tau}}{(1-\bar{\tau})^2} \left(\hat{\tau}_{t+s} - \hat{\tau}^*_{t+s}\right) \\
& + \left[\frac{\bar{\tau}}{1-\bar{\tau}} \left(1 + \sigma_C^* + \sigma_L\right) + \frac{\tilde{b}_y \sigma_C^* \beta}{1 + \beta \sigma_C^* \mathcal{E}_b \tilde{b}_y}\right] \hat{X}_t \\
& + \mathbb{E}_t \sum_{s=1}^{\infty} \left(\beta m^\star\right)^s \left[\frac{\bar{\tau}}{1-\bar{\tau}} \left(1 + \sigma_C^* + \sigma_L\right) + \frac{\tilde{b}_y \sigma_C^* \left(\beta - \bar{m}\right)}{1 + \beta \sigma_C^* \mathcal{E}_b \tilde{b}_y}\right] \hat{X}_{t+s}
\end{aligned} \tag{34}$$

with fiscal stress Ω_t as defined in Equation (10).

Under full rationality and flexible prices, Equation (34) reduces to:

$$\hat{\tilde{b}}_{t-1} + \Omega_t = \tilde{b}_y \hat{\Pi}_t. \tag{35}$$

Current inflation absorbs all disturbances arising from fiscal stress Ω_t. With flexible prices, inflation volatility generates no welfare costs. However, distortionary taxes create wedges between the marginal rate of substitution and the marginal rate of transformation, making fiscal policy itself a source of distortions. Consequently, inflation serves as a fiscal financing tool that fully absorbs fiscal stress; tax rates stay unchanged. See also Chari, Christiano, and Kehoe (1991), Chari and Kehoe (1999), and Benigno and Woodford (2004).

Under full rationality and sticky prices, Equation (34) becomes:

$$\begin{aligned}\left[\hat{\tilde{b}}_{t-1} + \Omega_t\right] \quad = \quad & \tilde{b}_y \hat{\Pi}_t + \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \frac{\bar{\tau}}{(1-\bar{\tau})^2} \left(\hat{\tau}_{t+s} - \hat{\tau}^*_{t+s}\right) \\ & + \left[\frac{\bar{\tau}}{1-\bar{\tau}} \left(1 + \sigma^*_C + \sigma_L\right) + \tilde{b}_y \sigma^*_C \beta\right] \hat{X}_t \\ & + \mathbb{E}_t \sum_{s=1}^{\infty} \beta^s \left[\frac{\bar{\tau}}{1-\bar{\tau}} \left(1 + \sigma^*_C + \sigma_L\right) + \tilde{b}_y \sigma^*_C \left(\beta - 1\right)\right] \hat{X}_{t+s}. \end{aligned} \tag{36}$$

With sticky prices, inflation is welfare costly as relative price dispersion causes resource misallocation. Thus, policymakers need to balance the benefits of absorbing shocks via inflation against the costs of creating resource misallocation when relying on inflation as a shock absorber. In turn, this decision has implications for the government's need to rely on distortionary labor taxes.

Benigno and Woodford (2004) demonstrate that optimally chosen taxes, real government debt and output gap all exhibit unit roots when prices are sticky. Inflation, by contrast, is stationary just as in models with non-distortionary lump-sum taxation. Schmitt-Grohe and Uribe (2004) find that small deviations from full price flexibility induce near random walk behavior in government debt and tax rates. Siu (2004) establishes that with sticky prices, tax rates and real government debt display behavior similar to a random walk. Hence, sticky prices revive the Barro-Aiyagari et al. result.

Under sticky prices with bounded rationality, several tensions emerge: (a) Trade-off between debt- and tax-financing: Positive real government debt stimulates aggregate demand, which in turn makes debt-financing inflationary. Thus, the optimal policy relies more on taxes to balance the government budget compared to the model with fully rational agents. The greater the degree of cognitive discounting in the private sector, the more pronounced is this shift. (b) Trade-off between current and future inflation: This trade-off emerges due to discounting in the aggregate demand equation. The higher the degree of cognitive discounting in the private sector, the greater is the trade-off between inflation today and tomorrow.[10] (c) Trade-off between current and future variables: Greater cognitive discounting for policymakers leads to stronger discounting of future variables, reducing the stimulating effect of real debt holdings. (d) The inflationary effect of real debt holdings under cognitive discounting in the private sector results in a stronger overall response of inflation compared to full rationality. By contrast, cognitive discounting by policymakers weakens the inflation response. Thus, the overall effect on inflation depends on the relative extent of cognitive discounting by policymakers and the private sector.

Under cognitive discounting, real government debt holdings stimulate aggregate demand, rendering debt-financing inflationary through the NKPC. This behavioral phenomenon leads to a distinctive dynamic pattern where the accumulation of real debt induces more significant and persistent welfare-costly inflationary pressures that persist across medium and longer horizons. In contrast to the random walk behavior characteristic of models with fully rational agents, the optimal policy in this bounded rationality framework requires debt and tax rates to eventually revert to their steady-state values. This mean-reverting property represents an optimal response to mitigate the cumulative welfare losses that would otherwise arise from sustained inflationary pressures.

4.1 Numerical Illustrations

Figure 2 plots the optimal responses of real government debt, inflation, labor income tax rate, and output gap to an exogenous government spending shock under different degrees of cognitive discounting for policymakers and the private sector. The parameterization follows Table 1 and the shock is transitory.

With fully rational agents (green solid line), real government debt, the output gap, and tax rates display unit-root behavior. While inflation is stationary, the price level follows a random walk. However, when the private sector exhibits bounded rationality but policy-makers are fully rational (pink dashed line), all variables become stationary and eventually revert to their initial values. As illustrated, cognitive discounting by the private sector causes

[10] In the rational expectations NK model with long-term bonds, Leeper and Zhou (2021) show that the maturity structure of debt also allows the government to trade off inflation today against future inflation under the optimal policy. They elaborate that the longer the average maturity, the farther into the future inflation can be postponed.

current and future real government debt to positively influence inflation dynamics, resulting in less pronounced changes in real government debt. Due to the wealth effect from debt accumulation, inflation fluctuations become more pronounced under bounded rationality compared to full rationality. Policymakers respond by smoothing the inflation trajectory—reducing initial responses at the expense of greater future inflation adjustments—leading to gradual convergence toward its long-run target.

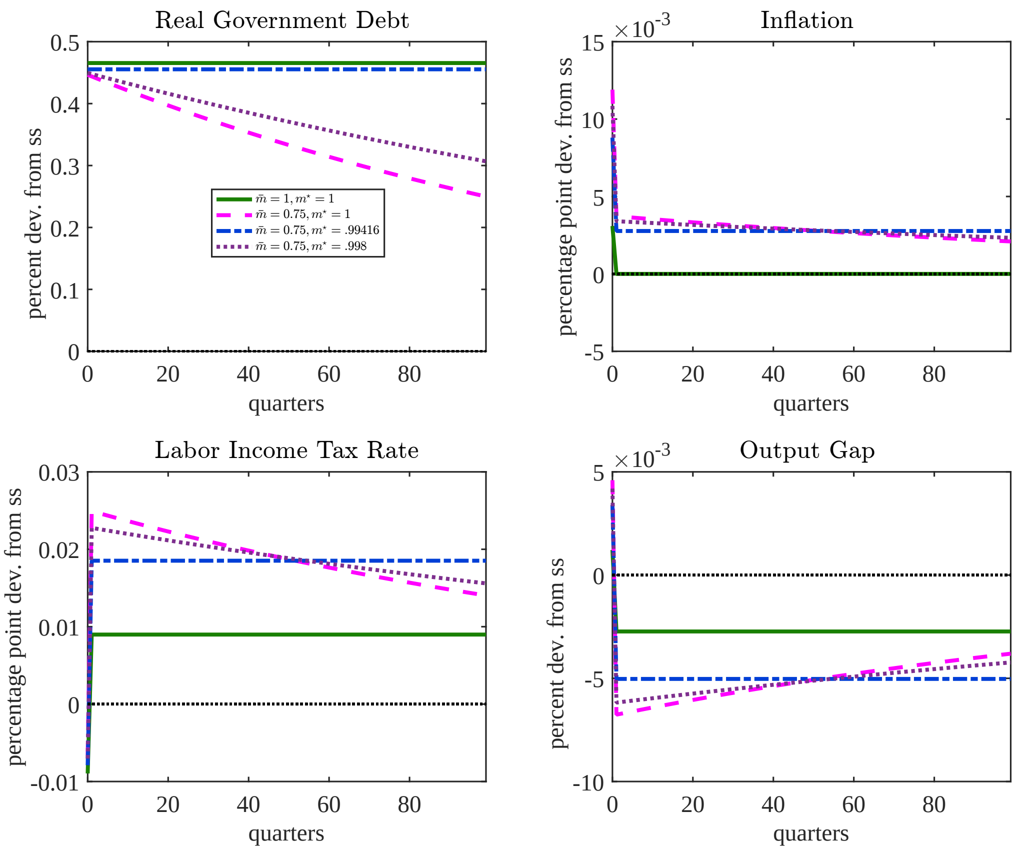


Figure 2: Impulse Responses Gov. Spending

Note: Figure 2 plots the impulse responses to a one-standard deviation shock to government spending in the behavioral NK model under different degrees of cognitive discounting by the private and public sectors.

When, in addition, we also decrease policymakers' degree of rationality (purple dotted line), real government debt, the output gap, and tax rates stay stationary as long as Condition (18) holds, that is Case II applies. Compared to the scenario represented by the pink dashed line, policymakers' discounting weakens the wealth effect of real debt holdings which reduces the long-run inflation costs associated with debt accumulation. Thus, real government debt reverts to its steady state more gradually, and the overall responses in inflation and the output gap are less pronounced. Decreasing policymakers' rationality further so that

Table 2: Macroeconomic Volatility under Optimal Policy

Model \Variable	$\tilde{b}_t$	Π_t	τ_t	X_t
$\bar{m} = 1$, $m^\star = 1$	1.2264	0.0003	0.0249	0.0076
$\bar{m} = 0.75$, $m^\star = 1$	0.5560	0.0015	0.0357	0.0099
$\bar{m} = 0.75$, $m^\star = 0.9942$	0.8339	0.0014	0.0355	0.0098
$\bar{m} = 0.75$, $m^\star = 0.998$	0.6174	0.0014	0.0348	0.0096

Note: Table 2 reports average of standard deviations from 1000 simulations each of 400 periods length after discarding the first 100 periods following Schmitt-Grohe and Uribe (2004). Simulations feature three AR(1) shock processes: productivity ($\rho_a = 0.9$, $\sigma_a = 0.02$), government expenditure ($\rho_g = 0.9$, $\sigma_g = 0.03$), and markup ($\rho_u = 0.9$, $\sigma_u = 0.02$), where ρ governs persistence and σ the standard deviation of innovations.

Condition (17) holds (blue dot-dashed line), that is Case I applies, real government debt, the output gap, and tax rates experience permanent changes again. Compared to the full rationality case, changes in real government debt become less pronounced, tax rate adjustments strengthen, and the responses in inflation and the output gap become more pronounced.

We explore the implications for macroeconomic volatility in more detail next. Table 2 presents standard deviations under optimal policy for the four model specifications. Specifically, the volatility of real government debt decreases, while the volatilities of inflation and output gaps increase under bounded rationality.

Figure 3 investigates the role of cognitive discounting in the private sector further. Assuming full rationality of policymakers, the figure plots the ratio of standard deviations under bounded rationality ($\bar{m} < 1$) and full rationality ($\bar{m} = 1$), for different values of the cognitive discounting parameter ($\bar{m}$). Values above (below) 1.0 indicate increased (decreased) volatility relative to the rational benchmark. The more agents experience cognitive discounting, the greater is the volatility of inflation, the output gap, and the tax rate while government debt becomes less volatile.

5 Identifying the Key Mechanism

Under cognitive discounting, the two features of *discounting in the IS Equation* and the perception of *government debt as wealth* arise jointly. Both are manifestations of the same underlying departure from Ricardian equivalence—limited foresight—as distinct from the departure introduced by distortionary taxation. There is no parameterization of the model that shuts down one feature without also shutting down the other one. To understand which of the two drives the breakdown of the Barro-Aiyagari et al. result, we remove one of the

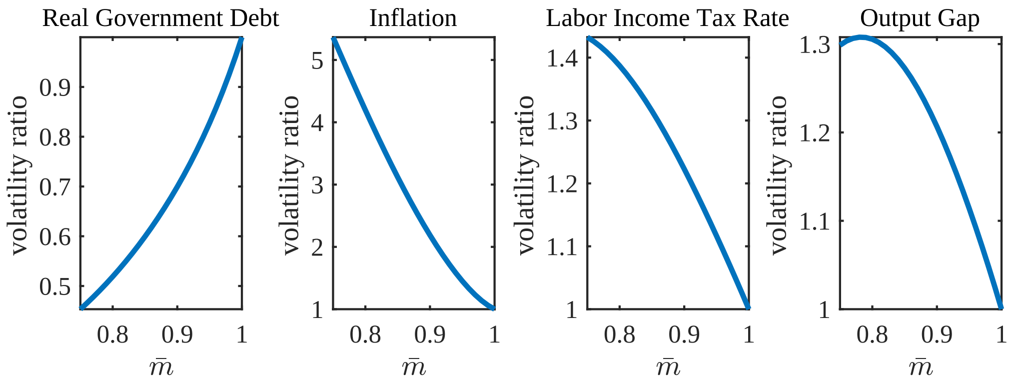


Figure 3: Relative Macroeconomic Volatility

Note: Figure 3 reports the standard deviations for varying degrees of cognitive discounting by the private sector ($\bar{m} < 1$) relative to full rationality. Policymakers are assumed to be fully rational ($m^\star = 1$).

two features at a time from the equilibrium system.

5.1 The Role of the Wealth Effect

To isolate the role of the wealth effect, we remove discounting for both the private sector and policymakers in an ad hoc manner. We obtain the following result:

Lemma 2 *When monetary and fiscal policy are jointly determined under commitment in a behavioral NK model with distortionary taxes, eliminating the discounting of forward-looking variables in the IS Equation while maintaining the wealth effect of debt holdings, the time-series properties of the equilibrium trajectories for* $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{\Pi}_t, \hat{X}_t, \hat{\tau}_t\}$ *exhibit stationarity. That is, the Lagrange multiplier* λ_t^b *follows a supermartingale, and the optimal state-contingent paths of* $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{\Pi}_t, \hat{X}_t, \hat{\tau}_t\}$ *are all stationary processes.*

Proof: See Appendix E.1.

5.2 The Role of Discounting

To isolate the role of discounting, we shut down the wealth effect of government debt. We obtain the following result:

Lemma 3 *When monetary and fiscal policy are jointly determined under commitment in a behavioral NK model with distortionary taxes, eliminating the wealth effect of debt holdings while maintaining discounting of forward-looking variables in the IS Equation, the time-series properties of the equilibrium trajectories for* $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{\Pi}_t, \hat{X}_t, \hat{\tau}_t\}$ *exhibit either unit roots* *or explosiveness, depending on the degree of cognitive discounting by policymakers, $m^\star$. More specifically:*

- *If policymakers are fully rational, i.e., $m^\star = 1$, then the Lagrange multiplier λ_t^b is a martingale, and the optimal state-contingent paths of $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{X}_t, \hat{\tau}_t\}$ exhibit unit-root behavior. Additionally, $\hat{\Pi}_t$ follows a stationary process if the private sector is also fully rational, but a unit-root process if the private sector is boundedly rational.*

- *If policymakers are boundedly rational, i.e., $m^\star < 1$, the Lagrange multiplier λ_t^b follows a submartingale, and the optimal state-contingent dynamics of $\{\lambda_t^b, \hat{\tilde{b}}_t, \hat{\Pi}_t, \hat{X}_t, \hat{\tau}_t\}$ are all explosive.*

Proof: See Appendix E.2.

5.3 Discussion

The lemmas underscore the critical role of the wealth effect of debt holdings in rendering the optimal state-contingent paths stationary. Absent wealth effects, the dynamics either follow Barro-Aiyagari et al. or are explosive. Discounting in the IS Equation is neither necessary nor sufficient to obtain stationarity.[11]

The approach taken here to isolate the roles of discounting and the wealth effects is ad hoc: our model of bounded rationality generates both the perception of government debt as wealth and discounting in the IS Equation simultaneously.[12] For this reason, we turn to an Overlapping Generations New Keynesian (OLG-NK) model next, which can cleanly delineate these features.

6 OLG-NK Model

Our OLG-NK framework incorporates the overlapping generations structure of Blanchard (1985) and Weil (1989) into a New Keynesian model. We follow the work of Nisticò (2016) which provides guidance for obtaining a quadratic approximation of the policymakers' welfare function. In Appendix F, we provide a full description of the model and its solution.

[11] In Appendix E.3, we demonstrate that eliminating myopia for firms alone has no impact on our findings in the behavioral NK model with distortionary taxes. Theorem 1 continues to hold.

[12] The finite planning horizon models of Woodford (2019) and Woodford and Xie (2022) face the same challenge.

The economy features consumers and firms both facing uncertainty about the duration of their lives. Consumers consist of a continuum of cohorts, with each consumer facing mortality risk γ each period. Newborn households start without assets but may receive an intergenerational transfer. On the production side, a continuum of monopolistically competitive firms—each owned by a consumer and thus subject to the same mortality risk—produce distinct varieties of intermediate goods. Competitive final goods producers aggregate these varieties into a composite consumption good. A policymaker designs a joint monetary and fiscal policy.

This setup implies a dynamic IS Equation of the form:

$$\hat{X}_t = \frac{1}{1+\chi_b}\mathbb{E}_t\hat{X}_{t+1} - \frac{s_C}{1+\chi_b}\left[\hat{R}_t - (1-\chi_b)\,\mathbb{E}_t\hat{\Pi}_{t+1} - \tilde{\hat{r}}_t^n\right] + \frac{\frac{\gamma\vartheta}{(1-\gamma)}}{1+\chi_b}\hat{\tilde{b}}_t, \tag{37}$$

with the natural rate being defined as:

$$\tilde{\hat{r}}_t^n = \frac{1}{s_C}\frac{1}{1+\phi_L}\left(\hat{g}_t - \frac{1}{1+\chi_b}\mathbb{E}_t\hat{g}_{t+1}\right) - \frac{1}{s_C}\frac{1+\phi_L s_C}{1+\phi_L}\left(\hat{\xi}_{A,t} - \frac{1}{1+\chi_b}\mathbb{E}_t\hat{\xi}_{A,t+1}\right). \tag{38}$$

The composite parameters are $\chi_b = \frac{\gamma\vartheta}{1-\gamma}\frac{\tilde{b}_y}{s_C}$, the propensity to consume out of total wealth $\vartheta = \frac{1-\tilde{\beta}(1-\gamma)}{1+\phi_L}$, and $\tilde{\beta} = \frac{\beta}{1+\frac{\vartheta\gamma}{1-\gamma}\frac{\tilde{b}_y}{s_C}}$. As in the model with cognitive discounting, the IS Equation in the OLG-NK model, Equation (37), generally features discounting of future variables and a wealth effect from government debt.

Under finite lives, the replacement of existing consumers with wealth by newborns without wealth distorts the intertemporal consumption paths, making the dynamics of aggregate bonds crucial for the equilibrium evolution of real output. Intuitively, when government debt rises, the relative wealth of the current generation increases compared to future generations, because current households anticipate that they may not be alive when the elevated public debt ultimately needs to be repaid. Through this channel wealth is reallocated between currently living and future generations. The strength of this wealth effect on aggregate consumption is greater for a higher replacement rate γ.

Turning to the firms' problem, the NKPC is given by:

$$\hat{\Pi}_t = \tilde{\beta}\,(1-\gamma)\,\mathbb{E}_t\hat{\Pi}_{t+1} + \kappa_p\frac{1}{s_C}\left(1+\frac{1}{\phi_L}\right)\hat{X}_t + \frac{\kappa_p\bar{\tau}}{1-\bar{\tau}}\left(\hat{\tau}_t - \hat{\tau}_t^*\right), \tag{39}$$

where the slope of the NKPC is $\kappa_p = \frac{(1-\xi_p)\left(1-\tilde{\beta}(1-\gamma)\xi_p\right)}{\xi_p}$ and the *desired* tax rate follows $\hat{\tau}_t^* = -\frac{1-\bar{\tau}}{\bar{\tau}}\frac{\theta_p}{1+\theta_p}\hat{\mu}_{p,t}$. As in the IS Equation, forward-looking behavior of firms is attenuated by the survival probability $(1-\gamma)$. Additionally, steady-state inefficiency reduces the effective discount factor ($\tilde{\beta} < \beta$), further attenuating the degree of forward-looking behavior in the NKPC. The reduced-form NKPC in the OLG-NK model resembles its counterpart under cognitive discounting.

Finally, the government budget constraint is given by:

$$\tilde{\beta}\hat{\tilde{b}}_t = \hat{\tilde{b}}_{t-1} + \tilde{\beta}\tilde{b}_y\hat{R}_t - \tilde{b}_y\hat{\Pi}_t - \frac{\bar{\tau}}{(1-\bar{\tau})^2}\hat{\tau}_t - \frac{\bar{\tau}}{1-\bar{\tau}}\left(1 + \frac{1}{s_C} + \frac{1}{s_C\phi_L}\right)\hat{X}_t + \Psi_t, \tag{40}$$

where the fiscal stress is defined as:

$$\Psi_t = -\frac{\bar{\tau}}{1-\bar{\tau}}\frac{1+s_C\phi_L}{1+\phi_L}\hat{\xi}_{A,t} + \left(1 - \frac{\bar{\tau}}{1-\bar{\tau}}\frac{\phi_L}{1+\phi_L}\right)\hat{g}_t. \tag{41}$$

6.1 With Transfer Mechanism

To remove all distortions in the steady state, we assume a wage subsidy that offsets monopolistic competition and distortionary wage income taxation, and an *intergenerational transfer scheme* that via a static payment to newborns equalizes steady-state consumption across generations. Equal consumption across generations in the steady state does not imply, however, that consumption is equal across generations away from the steady state.

Under these assumptions, the equilibrium conditions simplify to:

$$\hat{X}_t = \mathbb{E}_t\hat{X}_{t+1} - s_C\left[\hat{R}_t - (1-\chi_b)\,\mathbb{E}_t\hat{\Pi}_{t+1} - \tilde{\tilde{r}}_t^n\right] + \frac{\gamma\vartheta}{(1-\gamma)}\hat{\tilde{b}}_t, \tag{42}$$

$$\hat{\Pi}_t = \beta(1-\gamma)\,\mathbb{E}_t\hat{\Pi}_{t+1} + \kappa_p\frac{1}{s_C}\left(1+\frac{1}{\phi_L}\right)\hat{X}_t + \frac{\kappa_p\bar{\tau}}{1-\bar{\tau}}\left(\hat{\tau}_t - \hat{\tau}_t^*\right), \tag{43}$$

$$\beta\hat{\tilde{b}}_t = \hat{\tilde{b}}_{t-1} + \tilde{b}_y\beta\hat{R}_t - \tilde{b}_y\hat{\Pi}_t - \frac{\bar{\tau}}{(1-\bar{\tau})^2}\hat{\tau}_t - \frac{\bar{\tau}}{1-\bar{\tau}}\left(1+\frac{1}{s_C}+\frac{1}{s_C\phi_L}\right)\hat{X}_t + \Psi_t, \tag{44}$$

with the composite parameters $\vartheta = \frac{1-\beta(1-\gamma)}{1+\phi_L}$, and $\kappa_p = \frac{\left(1-\xi_p\right)\left(1-\beta(1-\gamma)\xi_p\right)}{\xi_p}$.

This version of the model no longer features discounting of forward-looking variables, but still features a wealth effect from government debt. Contrary to the behavioral NK model, the OLG-NK model can separate the roles of discounting and wealth effects in driving the departure from the Barro-Aiyagari et al. result. In terms of Ricardian equivalence, the transfer scheme isolates the wealth-effect channel from the discounting-in-IS-equation channel while distortionary taxation, the first departure, remains active throughout—confirming that stationarity of the equilibrium dynamics requires only the wealth effect.

The welfare loss function can be approximated as:

$$\mathbb{W} = \frac{1}{2s_C}\mathbb{E}_{t_0}\sum_{t=t_0}^{\infty}\beta^{t-t_0}\left\{\left(\frac{1}{s_C}+\frac{1}{\phi_L s_C}\right)\hat{X}_t^2+\frac{1+\theta_p}{\theta_p\kappa_p}\hat{\Pi}_t^2+\Lambda_d\left(\hat{\tilde{b}}_{t-1}-\tilde{b}_y\hat{\Pi}_t\right)^2\right\} \tag{45}$$

where $\Lambda_d = s_C\left(1+\phi_L\right)\left(\frac{1}{1-\beta(1-\gamma)}\right)\left(\frac{\gamma}{1-\gamma}\right)\left(\frac{\vartheta}{s_C}\right)^2$. The function includes a new term for debt which captures the dispersion of welfare-costly consumption and employment across generations. To understand the nexus between debt and consumption dispersion, recall that newborns are born with non-financial wealth only. The static intergenerational transfer equalizes wealth and consumption across generations in the steady state, but away from the steady state existing households hold different wealth levels from newborns. Because households consume out of financial and non-financial wealth, the differences in asset holdings induce cross-cohort consumption heterogeneity.

The strength of the wealth effect of government debt on consumption heterogeneity scales proportionally with the mortality rate. Under greater mortality risk, the effective planning horizon contracts, strengthening households' preference for current over future consumption. Furthermore, elevated mortality rates increase the population share of newborns who remain completely insulated from existing bond holdings, thereby expanding the consumption wedge between surviving agents and newborn cohorts.

Appendix F.6 formulates the optimal control problem for the OLG-NK model with distortionary labor taxes when the steady state is efficient. As illustrated by the red dash-dotted lines in Figure 4, the equilibrium paths of government debt, labor taxes, inflation, and output do not feature a unit root—the Barro-Aiyagari et al. result breaks down.

6.2 No Transfer Mechanism

Absent intergenerational transfers, the steady state of the model is inefficient regardless of the assumptions about a subsidy scheme targeting the distortions from monopolistic competition and labor taxes. This version of the model is given by the structural equations (37)-(41) and features both discounting in the IS Equation and a wealth effect of government debt.

It is no longer tractable to derive a purely quadratic welfare-based loss function for this model. Instead, we solve for the joint determination of optimal monetary and fiscal policy in a nonlinear framework numerically. As shown by the blue dashed lines in Figure 4, the equilibrium paths of government debt, labor taxes, inflation, and output are again all stationary.

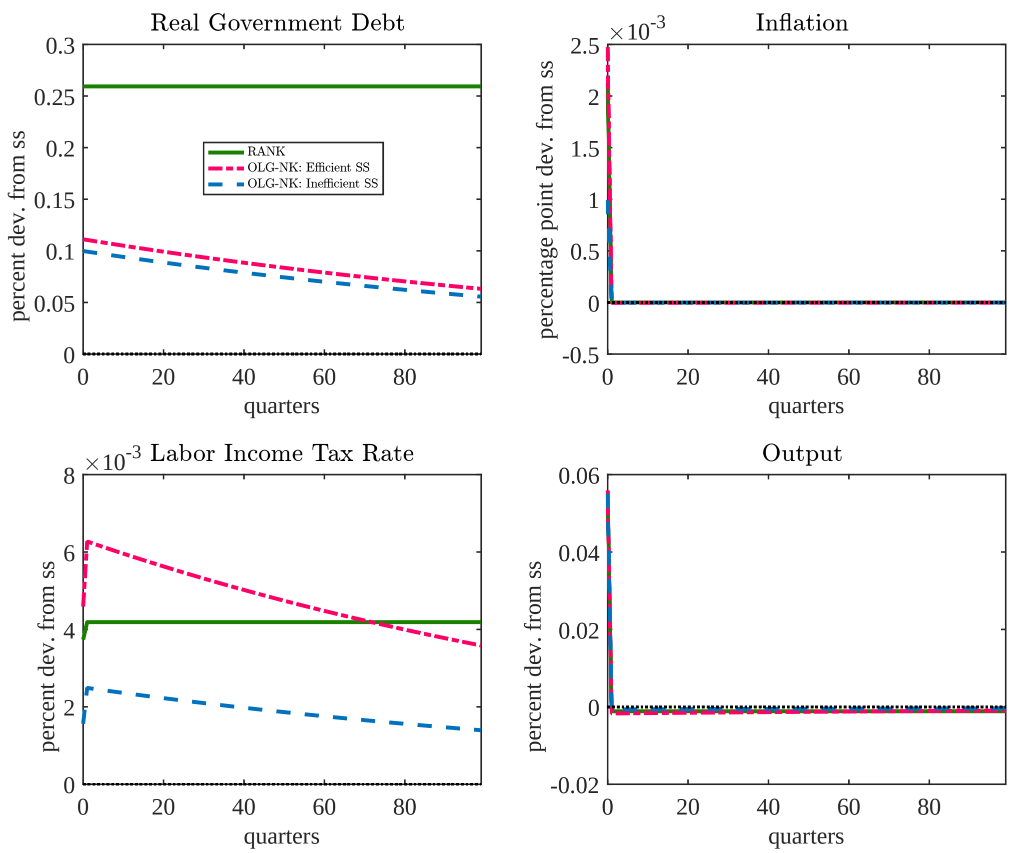


Figure 4: Impulse Responses Gov. Spending

Note: Figure 4 plots the impulse responses to a one-standard deviation shock to government spending for alternative parameterizations of the OLG-NK models—with and without transfers.

In summary, the analysis in the OLG-NK model confirms the claim in Section 5 regarding the role of the wealth effects from government debt in obtaining stationary model dynamics. Discounting of forward-looking variables is not needed to obtain this specific departure from the Barro-Aiyagari et al. result.

7 Further Explorations

We briefly comment on three themes: (i) the distinction between bounded rationality and backward-looking behavior, (ii) finite planning horizons as an alternative to cognitive discounting, and (iii) the possibility that agents could be more rational in the future. Appendix G offers details on each theme.

To improve empirical fit, macroeconomic models often include backward-looking features such as habit persistence and price indexation. Assuming that, apart from these ad hoc features, agents form expectations under full rationality, the tax rate, government debt, and the output gap continue to follow a unit root in equilibrium. Backward-looking behavior does not introduce discounting or wealth effects into the IS Equation. Once cognitive discounting is introduced, we obtain the same findings regarding the equilibrium dynamics as in the textbook NK model with cognitive discounting—the dynamics are stationary, display unit-root behavior or are explosive. This exercise highlights that limiting the extent of forward-looking behavior via bounded rationality is qualitatively different from doing so via backward-looking expectations.

An alternative to the approach taken by Gabaix (2020) to modeling bounded rationality is the model of finite planning horizons proposed in Woodford (2019) and Woodford and Xie (2022). This setup implies discounting of future variables in the IS Equation and the NKPC, respectively, and features a wealth effect of government debt. As in the model with cognitive discounting, these features arise simultaneously—contrary to the OLG-NK model which allows for such separation. The dynamics under the optimal monetary and fiscal policy in the finite-planning-horizons model are stationary when policymakers are fully rational but the private sector does not have an infinite planning horizon.

Finally, we pick up the concern raised in Ilut and Valchev (2023) that the degree of rationality could be sensitive to policy which in turn may influence policy choices. As an initial exploration of this issue, we consider a simple Markov-switching environment with exogenous transition probabilities in which the fully rational policymaker is aware that agents could become more forward-looking at some point in the future. Compared to a world with a constant degree of cognitive discounting, the presence of a "more rational regime" slows the speed with which variables approach the steady state while agents are in the "less rational regime." Qualitatively, however, our results continue to apply.

8 Conclusion

Under distortionary labor taxation, non-state-contingent nominal debt, and full-information rational expectations, the joint determination of optimal monetary and fiscal policy leads to the Barro-Aiyagari et al. result, suggesting that the equilibrium paths of taxes and debt exhibit martingale and unit-root behaviors—a fiscal analogue to the permanent income hypothesis where policymakers optimally smooth distortionary tax rates using debt as a shock absorber. We demonstrate, however, that these properties can break down under bounded rationality. While there are combinations of limited rationality of policymakers and the private sector under which the Barro-Aiyagari et al. result reemerges, such cases represent only knife-edge scenarios, rather than general results. Even minor deviations in the degree of cognitive discounting on the part of either policymakers or the private sector lead to the breakdown of the Barro-Aiyagari et al. result. Additionally, when policymakers exhibit too much cognitive discounting, the resulting equilibrium dynamics may become explosive.

In terms of policy responses, our analysis reveals that optimal policy necessitates the eventual return of debt and tax rates to their initial values. This convergence serves to mitigate the long-term welfare costs associated with inflationary distortions that arise from debt accumulation. Under bounded rationality, the wealth effect of government debt stimulates aggregate demand, rendering debt accumulation inflationary. Consequently, optimal policy shifts away from debt-financing toward greater reliance on tax-financing compared to the rational benchmark, as policymakers seek to balance the government budget while limiting the inflationary pressures induced by elevated debt levels. These findings have important implications in an era of historically elevated public debt: the substantial debt accumulation of the past two decades should now be wound down. This conclusion is complementary to traditional concerns about debt sustainability and rollover risks when debt-to-GDP ratios are high.

More broadly, our analysis contributes to understanding the interaction between monetary and fiscal policy in environments with multiple departures from Ricardian equivalence. Our model features two distinct departures: the first arises from distortionary labor taxation combined with non-state-contingent debt, which under full rationality yields the Barro-Aiyagari et al. unit-root result; the second arises from limited foresight through the wealth effect of government debt. Whether limited foresight is modeled through cognitive discounting, finite planning horizons, or overlapping generations, the resulting IS Equation features both discounting and a wealth effect from government debt. However, our analysis reveals that only the wealth effect—not discounting *per se*—is essential for breaking the unit-root result. The breakdown of the martingale and unit-root properties requires the wealth effect to be operative in the presence of distortionary taxation—the setting where the Barro-Aiyagari et al. result would otherwise emerge under full rationality.

References

Aguiar, M., M. Amador, and C. Arellano (2024). Pareto Improving Fiscal and Monetary Policies: Samuelson in the New Keynesian Model.

Aiyagari, S. R., A. Marcet, T. J. Sargent, and J. Seppala (2002). Optimal Taxation without

State-Contingent Debt. *Journal of Political Economy 110*(6), 1220–1254.

Angeletos, G.-M. (2002). Fiscal Policy with Noncontingent Debt and the Optimal Maturity Structure. *The Quarterly Journal of Economics 117*(3), 1105–1131.

Angeletos, G.-M., J. Guerreiro, and D. R. Zhang (2025, Dec). From RANK to HANK, without FIRE. NBER Working Papers 34596, National Bureau of Economic Research, Inc.

Angeletos, G.-M. and C. Lian (2018). Forward Guidance without Common Knowledge. *American Economic Review 108*(9), 2477–2512.

Angeletos, G.-M., C. Lian, and C. K. Wolf (2024). Can Deficits Finance Themselves? *Econometrica 92*(5), 1351–1390.

Barro, R. J. (1979). On the Determination of the Public Debt. *Journal of Political Economy 87*(5), 940–971.

Benigno, P. and M. Woodford (2004). Optimal Monetary and Fiscal Policy: A Linear-Quadratic Approach. In *NBER Macroeconomics Annual 2003, Volume 18*, NBER Chapters, pp. 271–364.

Benigno, P. and M. Woodford (2012). Linear-Quadratic Approximation of Optimal Policy Problems. *Journal of Economic Theory 147*(1).

Bianchi-Vimercati, R., M. Eichenbaum, and J. Guerreiro (2024). Fiscal Stimulus with Imperfect Expectations: Spending vs. Tax Policy. *Journal of Economic Theory 217*, 105814.

Billi, R. M. and C. E. Walsh (2022). Seemingly Irresponsible but Welfare Improving Fiscal Policy at the Lower Bound. Working Paper Series 410, Sveriges Riksbank (Central Bank of Sweden).

Blanchard, O. J. (1985). Debt, Deficits, and Finite Horizons. *Journal of Political Economy 93*(2), 223–247.

Bodenstein, M., L. Guerrieri, and J. LaBriola (2019). Macroeconomic Policy Games. *Journal of Monetary Economics 101*(C), 64–81.

Calvo, G. A. (1983). Staggered Prices in a Utility-Maximizing Framework. *Journal of Monetary Economics 12*(3), 383–398.

Chari, V. and P. J. Kehoe (1999). Optimal Fiscal and Monetary Policy. Volume 1 of *Handbook of Macroeconomics*, Chapter 26, pp. 1671–1745.

Chari, V. V., L. J. Christiano, and P. J. Kehoe (1991). Optimal Fiscal and Monetary Policy: Some Recent Results. *Journal of Money, Credit and Banking 23*(3), 519–539.

Del Negro, M., P. Giannoni, Marc, and C. Patterson (2023). The Forward Guidance Puzzle. *Journal of Political Economy Macroeconomics 1*(1), 43–79.

Eichenbaum, M. S., J. Guerreiro, and J. Obradovic (2026, Jan). Ricardian Non-Equivalence. NBER Working Papers 34691, National Bureau of Economic Research, Inc.

Eusepi, S. and B. Preston (2018). Fiscal Foundations of Inflation: Imperfect Knowledge. *American Economic Review 108*(9), 2551–2589.

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

Galí, J. (2021). Monetary Policy and Bubbles in a New Keynesian Model with Overlapping Generations. *American Economic Journal: Macroeconomics 13*(2), 121–67.

Gust, C., E. Herbst, and D. López-Salido (2022). Short-Term Planning, Monetary Policy, and Macroeconomic Persistence. *American Economic Journal: Macroeconomics 14*(4), 174–209.

Hirose, Y., H. Iiboshi, M. Shintani, and K. Ueda (2024). Estimating a Behavioral New Keynesian Model with the Zero Lower Bound. *Journal of Money, Credit and Banking 56*(8), 2185–2197.

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

Ilut, C. and R. Valchev (2023, None). Economic Agents as Imperfect Problem Solvers. *The Quarterly Journal of Economics 138*(1), 313–362.

Leeper, E. M. and X. Zhou (2021). Inflation's Role in Optimal Monetary-Fiscal Policy. *Journal of Monetary Economics 124*(C).

Lucas, R. J. and N. L. Stokey (1983). Optimal Fiscal and Monetary Policy in an Economy without Capital. *Journal of Monetary Economics 12*(1), 55–93.

Nisticò, S. (2016, October). Optimal Monetary Policy And Financial Stability In A Non-Ricardian Economy. *Journal of the European Economic Association 14*(5), 1225–1252.

Pfäuti, O. and F. Seyrich (2022). A Behavioral Heterogeneous Agent New Keynesian Model. CRC TR 224 Discussion Paper Series, University of Bonn and University of Mannheim, Germany.

Rotemberg, J. J. and M. Woodford (1997). An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy. In *NBER Macroeconomics Annual 1997, Volume 12*, pp. 297–361.

Sargent, T. J. (1986). Interpreting the Reagan deficits. *Economic Review*, 5–12.

Schmitt-Grohe, S. and M. Uribe (2004). Optimal Fiscal and Monetary Policy under Sticky Prices. *Journal of Economic Theory 114*(2), 198–230.

Siu, H. E. (2004). Optimal Fiscal and Monetary Policy with Sticky Prices. *Journal of Monetary Economics 51*(3), 575–607.

Weil, P. (1989). Overlapping Families of Infinitely-Lived Agents. *Journal of Public Economics 38*(2), 183–198.

Woodford, M. (Ed.) (2003). *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton University Press.

Woodford, M. (2019). Monetary Policy Analysis when Planning Horizons Are Finite. *NBER Macroeconomics Annual 33*(1), 1–50.

Woodford, M. and Y. Xie (2022). Fiscal and Monetary Stabilization Policy at the Zero Lower Bound: Consequences of Limited Foresight. *Journal of Monetary Economics 125*(C), 18–35.