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The Fiscal Limit and Non-Ricardian Consumers

Alexander Richter

Auburn University

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Alexander W. Richter†

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Abstract

The U.S. faces exponentially rising entitlement obligations. I introduce a fiscal limit—a point where higher taxes are no longer a feasible financing mechanism—into a Perpetual Youth model to assess how intergenerational redistributions of wealth and the maturity of government debt impact the consequences of fiscal stress. Intergenerational transfers of wealth strengthen the expectational effects of the fiscal limit and magnify the likelihood of stagflation. A longer average maturity of debt weakens these effects in the short/medium-runs but still increases stagflation in the long-run. Delaying reform increases the severity and duration of the stagflationary period.

Keywords: Finite lifetime, long-term debt, policy uncertainty, fiscal limit, entitlement reform
JEL Classifications: E62, E63, H60, E43

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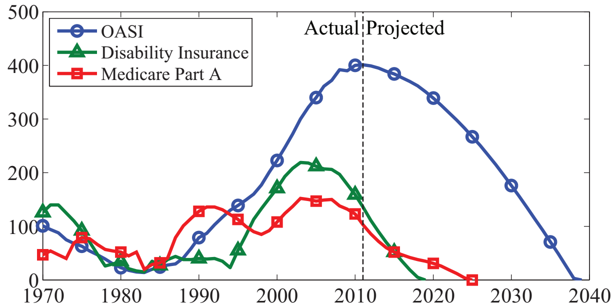
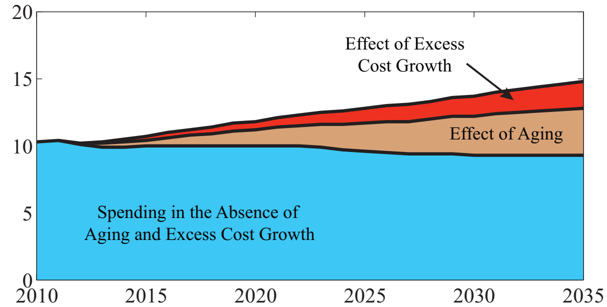
†Correspondence: Department of Economics, Auburn University, Hayley Center 0332, Auburn, AL 36849, USA. Phone: +1(334)844-8638; Fax: +1(334)844-4615; E-mail: arichter@auburn.edu.



(a) Projected outlook for the Social Security and Medicare trust funds: Assets as a percentage of annual expenditures. Source: Social Security Administration (2011)



(b) Factors contributing to future federal spending on entitlements as a percentage of GDP. Source: Congressional Budget Office (2011)

Figure 1: Factors contributing to the fiscal stress of entitlement programs. See the online appendix for further details.

1 INTRODUCTION

The amount of public discourse about fiscal policy is unprecedented. Despite the heightened concern about current deficits, many policymakers have begun to recognize that the real problem is projected future deficits, which are driven by the growth in entitlement spending. By 2035, the Congressional Budget Office (CBO) projects total spending on entitlement programs will rise from 10.4 to 15.5 percent of GDP, of which nearly 75 percent is attributable to growth in Medicare spending. These projections, which are due to an aging population and "excess" growth in health care costs, imply government entitlement programs will soon become insolvent (figure 1).[1]

There is an extensive and compelling literature that uses sophisticated overlapping generations (OLG) models with features such as inter- and intra-generational heterogeneity, life-cycle and population dynamics, bequest motives, stochastic income levels, and several program-specific components to study the effects of policy adjustments and the consequences of fiscal stress [Auerbach and Kotlikoff (1987); De Nardi et al. (1999); Huggett and Ventura (1999); İmrohoroğlu et al. (1995); Kotlikoff et al. (1998, 2007); Smetters and Walliser (2004)]. These models assess distributional and generational effects but do not account for monetary policy or deal with the degree of uncertainty that actually surrounds monetary and fiscal policies.

In models with forward-looking agents, ignoring uncertainty pushes the effects of future policy adjustments toward the present, which is inconsistent with current observations. Recognizing this drawback, another segment of the literature uses a representative agent model to build-in the complex aspects of monetary and fiscal policy uncertainty [Davig and Leeper (2011b); Davig et al. (2010, 2011); Eusepi and Preston (2010a); Fernández-Villaverde et al. (2011)] but with the limitation of not being able to account for specific program features or generational effects.[2]

This paper advances the literature on fiscal uncertainty in several ways. First, it adopts a Perpetual Youth Model [Blanchard (1985); Yaari (1965)] to bridge the gap between OLG and representative agent models and show how intergenerational transfers of wealth impact the consequences of explosive government transfers. This approach is a first pass at combining heterogeneity with aggregate policy uncertainty, two components that are computationally difficult, but essential to

[1] Many other countries are heading into similar periods of fiscal stress [International Monetary Fund (2009)]. Moreover, the projected increases in the debt-to-GDP ratio are larger than any developed countries have experienced in the post-World War II era [Congressional Budget Office (2009)].

[2] Also see Cochrane (2011), Sims (2011), and Daniel and Shiamptanis (2011).

understanding the impact of fiscal stress. Second, it introduces long-term government debt, which impacts the timing of debt and inflation. Thus, this paper shows how the Fed's recent program to reweight its portfolio of government bonds toward longer maturities and suppress borrowing costs impacts the costs of rising debt and inflation. Finally, it studies the costs of delaying reform—legislation that places entitlement spending back on a stable path. Given the degree of political gridlock, this paper serves as warning sign to policymakers of the consequences of inaction.

The policy framework allows for a wide range of potential outcomes, which accounts for the uncertain nature of monetary and fiscal policy. At some unknown date, promised government transfers switch from a stable to an explosive trajectory to mimic the demographics and medical inflation underlying the CBO's debt projections. Each period the economy maintains explosive transfers, there is upward pressure on debt, which increases taxes. As taxes rise, policymakers face increasing political resistance and a rising probability of hitting the fiscal limit—the point where higher taxes are no longer feasible. At the fiscal limit, either the fiscal authority must renege on its transfers commitments or the monetary authority must adjust its policy to stabilize debt.

Reneging on transfers places policymakers in a bind. On the one hand, they face the economic constraints posed by rising debt. On the other hand, entitlement recipients (current and prospective) constitute a large voting block and any reduction in benefits may be politically toxic. This is why I allow for the possibility that the monetary authority stabilizes debt instead of the fiscal authority reneging on transfers. In this policy mix, the monetary authority adjusts nominal interest rates less than one-for-one with inflation. Without any adjustment in taxes, growing transfers obligations increase the price level until the real value of debt stabilizes. It is the expectation of this surprise increase in inflation that makes the economic consequences of fiscal stress dangerous.

The Perpetual Youth model differs from commonly adopted representative agent models in that it assigns all agents a constant probability of death each period. As agents face a higher probability of death, their expected lifetimes become increasingly misaligned with the government's infinite planning horizon. This increases the likelihood that current generations, who benefit from increases in (net) government expenditures, will die before taxes come due. The expected shift of the tax burden onto future generations produces positive wealth effects for current generations, but the threat of rising inflation reduces expected real government liabilities and quickly offsets the positive effects of growing promised transfers. Thus, intergenerational transfers of wealth strengthen the expectational effects of the fiscal limit and magnify the likelihood of stagflation. The representative agent models that have been exclusively used to study aggregate policy uncertainty fail to capture these wealth effects [Davig and Leeper (2011b); Davig et al. (2010, 2011)].

Following Woodford (2001) and Eusepi and Preston (2010b), the maturity structure is parameterized to allow longer-term government debt in the baseline model that only includes one-period debt. A longer average maturity of debt increases the slope of the yield curve and pushes the financing of government liabilities into the future. This weakens the expectational effects of the fiscal limit in the short/medium-runs but still induces stagflation when taxes come due in the long-run.

2 ECONOMIC MODEL

I employ a stochastic discrete-time variant of the Blanchard (1985)-Yaari (1965) Perpetual Youth model. This model includes an endogenous labor supply decision and a choice of money holdings. Agents face uncertainty regarding the duration of their lifetimes, the trajectory of their economic variables, and monetary and fiscal policy. Consumption goods are supplied under monopolistic competition, and firms are subject to costly (Rotemberg) price adjustments. The government finances discretionary spending and delivered lump-sum transfers through seigniorage revenues, long-term nominal debt, and distortionary taxes on capital and labor income.

2.1 INDIVIDUALS

All agents are subject to identical probabilities of death, ϑ.[3] Since higher probabilities of death are isomorphic to adding population growth, population dynamics are not included in the current model even though they may seem like a natural extension. The size at birth of generation s is normalized to ϑ, which implies the size of generation s at time t is $\vartheta(1-\vartheta)^{t-s}$ and the total population size over all generations is one. The average lifetime of a member of generation s is given by $\sum_{t-s=1}^{\infty}(t-s)\vartheta(1-\vartheta)^{t-s-1} = 1/\vartheta$. When $\vartheta \to 0$, this model reduces to the more traditional representative agent model where agents are infinitely lived.

In period t, each member of generation $s \leq t$ maximizes expected lifetime utility of the form[4]

$$E_t \sum_{k=t}^{\infty} [\beta(1-\vartheta)]^{k-t} \{\log c_{s,k} + \kappa \log(m_{s,k}/P_k) + \chi \log(1-n_{s,k})\}, \quad \kappa, \chi > 0, \tag{1}$$

where $\beta \in (0,1)$ is the discount rate, P_t is the aggregate price index, and $c_{s,t}$, $m_{s,t}$, and $n_{s,t}$ are consumption of the final good, nominal money balances, and the labor supplied at time t by an agent born at time s. Following Dixit and Stiglitz (1977), $c_{s,t} \equiv [\int_0^1 c_{s,t}(i)^{(\theta-1)/\theta} di]^{\theta/(\theta-1)}$ is a consumption bundle composed of a continuum of differentiated goods, where $\theta > 1$ measures the price elasticity of demand. The demand function for good i, $c_{s,t}(i) = [p_t(i)/P_t]^{-\theta} c_{s,t}$, corresponds to the agent's maximum attainable consumption bundle given a specific level of expenditures, where $P_t = [\int_0^1 p_t(i)^{1-\theta} di]^{1/1-\theta}$. Log preferences ensure linearity in wealth and preserve aggregation.

Agents have no bequest motive and, instead, sell contingent claims on their assets to insurance companies. Assets are collected each period from ϑ agents who died and transferred to the remaining survivors. With a perfectly competitive life insurance industry, each surviving agent receives a premium payment of $\vartheta/(1-\vartheta)$. Incorporating the gross return on the insurance contract, $1 + \vartheta/(1-\vartheta) = 1/(1-\vartheta)$, into the per-period budget constraint of a surviving agent yields

$$c_{s,t} + k_{s,t} + \frac{m_{s,t}}{P_t} + \frac{P_t^S b_{s,t}^S}{P_t} + \frac{P_t^M b_{s,t}^M}{P_t} \leq \omega_{s,t} + (1-\vartheta)^{-1} a_{s,t}, \tag{2}$$

where $k_{s,t}$ is the stock of capital carried into period $t+1$. Human income is given by

$$\omega_{s,t} \equiv (1-\tau_{s,t}) w_{s,t} n_{s,t} + \lambda_t z_{s,t} + d_{s,t}, \tag{3}$$

where $w_{s,t}$ is the real wage, $\tau_{s,t}$ is the proportional tax rate levied against capital and labor income, $z_{s,t}$ are promised real government transfers, λ_t is the fraction of promised transfers received, and $d_{s,t}$ is the share of real firm profits. Beginning of the period financial wealth is given by

$$a_{s,t} \equiv \left[(1-\tau_{s,t}) R_t^k + 1 - \delta\right] k_{s,t-1} + \frac{m_{s,t-1}}{P_t} + \frac{b_{s,t-1}^S}{P_t} + \frac{(1+\rho P_t^M) b_{s,t-1}^M}{P_t}, \tag{4}$$

where δ is the depreciation rate and R_t^k is the real price rate of capital. There are two types of government debt—one-period government bonds, $b_{s,t}^S$, in zero net supply with price P_t^S, and a

[3] A constant death parameter implies all agents have identical planning horizons, which is required for aggregation.

[4] A nonstochastic continuous-time monetary version of the Perpetual Youth model was first introduced by van der Ploeg and Marini (1988). For a discrete-time variant see Cushing (1999). Stochastic monetary models are developed in Annicchiarico et al. (2006), Piergallini (2006), and Annicchiarico et al. (2008).

more general portfolio of government bonds, $b^M_{s,t}$, in non-zero net supply with price P^M_t. The price of short-term nominal bonds satisfies $P^S_t = R^{-1}_t$, where R_t is the gross nominal interest rate. Following Woodford (2001) and Eusepi and Preston (2010b), long-term debt issued at time t pays ρ^j dollars $j+1$ periods in the future, for $j \geq 0$ and $0 \leq \rho < \beta^{-1}$. The payment parameter, ρ, controls the average maturity of government debt, $1/(1-\beta\rho)$.

Necessary and sufficient conditions for optimality require that each individual's first-order conditions hold in every period, the budget constraint binds, and the transversality condition,

$$\lim_{T\to\infty} E_t\left\{(1-\vartheta)^{T-t} q_{t,T}(s) a_{s,T}\right\} = 0, \tag{5}$$

holds, where $q_{t,t+1}$ is the real stochastic discount factor (SDF) and $q_{t,T}(s) \equiv \prod_{k=t+1}^{T} q_{k-1,k}(s)$.

To derive the law of motion for consumption, first use generation s's first-order conditions to rewrite (2) in terms of the period-t price of the their portfolio, which has random value $a_{s,t+1}$ in the next period. Then solve the resulting budget constraint forward and impose the transversality condition, (5), to obtain

$$c_{s,t} = \xi[a_{s,t}/(1-\vartheta) + h_{s,t}], \tag{6}$$

where $\xi \equiv [1-\beta(1-\vartheta)]/(1+\kappa)$ and $h_{s,t} \equiv \sum_{T=t}^{\infty}(1-\vartheta)^{T-t} E_t[q_{t,T}(s)\omega_{s,T}]$ is human wealth. An increase in the probability of death, ϑ, increases current generations' marginal propensity to consume and the return on financial wealth but reduces the present value of future labor income.

2.2 Aggregation

I obtain aggregate values by summing across all generations and weighting by their relative sizes. Thus, the aggregate counterpart of a generic economic variable, $x_{s,t}$, is given by $X_t \equiv \sum_{s=-\infty}^{t} \vartheta(1-\vartheta)^{t-s} x_{s,t}$. Since agents are born with zero assets and government policies are equally distributed, the aggregate budget constraint is given by

$$C_t + K_t + \frac{M_t}{P_t} + \frac{P^S_t B^S_t}{P_t} + \frac{P^M_t B^M_t}{P_t} = \Omega_t + A_t, \tag{7}$$

where $\Omega_t \equiv (1-\tau_t)W_t N_t + \lambda_t Z_t + D_t$ is aggregate human income and

$$A_t = \left[(1-\tau_t)R^k_t + 1 - \delta\right] K_{t-1} + \frac{M_{t-1}}{P_t} + \frac{B^S_{t-1}}{P_t} + \frac{(1+\rho P^M_t)B^M_{t-1}}{P_t} \tag{8}$$

is aggregate financial wealth. The aggregate counterpart of (6) is given by

$$C_t = \xi(A_t + H_t), \tag{9}$$

where $H_t = \sum_{T=t}^{\infty}(1-\vartheta)^{T-t} E_t[Q_{t,T}\Omega_T]$ is aggregate human wealth and $Q_{t,T}$ is the aggregate SDF.

To derive the dynamic equation for aggregate consumption, rewrite (7) in terms of the period-t price of the aggregate portfolio and substitute the resulting budget constraint into (9) to obtain a consolidated law of motion for consumption. Then move the original version of (9) forward, apply expectations, and combine with the consolidated law of motion for consumption to obtain[5]

$$C_t = \frac{1}{\beta} E_t\{Q_{t,t+1} C_{t+1}\} + \frac{1}{\beta}\frac{\vartheta\xi}{1-\vartheta} E_t\{Q_{t,t+1} A_{t+1}\}. \tag{10}$$

When $\vartheta \neq 0$ higher real government liabilities push the financing of government expenditures onto future generations and increase consumption by living generations. This new relationship breaks Ricardian equivalence and alters the aggregate impacts of fiscal stress.

[5] See the online appendix for a complete derivation of equations (6) and (10).

2.3 FIRMS The production sector consists of a continuum of monopolistically competitive intermediate goods producers and a representative final goods producer.

2.3.1 INTERMEDIATE GOODS PRODUCING FIRMS Firm $i \in [0,1]$ in the intermediate goods sector produces a differentiated good, $y_t(i)$, with production function, $y_t(i) = k_{t-1}(i)^\alpha n_t(i)^{1-\alpha}$, where $k(i)$ and $n(i)$ are the amounts of capital and labor the firm rents and hires. The firm chooses its capital and labor inputs to minimize total cost, $W_t n_t(i) + R_t^k k_{t-1}(i)$, subject to its production function. Optimality implies

$$\frac{k_{t-1}(i)}{n_t(i)} = \frac{\alpha}{1-\alpha}\frac{W_t}{R_t^k}, \tag{11}$$

which shows that the capital-labor ratio is identical across intermediate goods producing firms and equal to the aggregate capital-labor ratio. Hence each firm's marginal cost function is given by

$$\Psi_t = W_t^{1-\alpha}(R_t^k)^\alpha(1-\alpha)^{-(1-\alpha)}\alpha^{-\alpha}. \tag{12}$$

2.3.2 PRICE SETTING The representative final goods producing firm purchases inputs from intermediate goods producers to produce a composite good according to CES technology, $Y_t \equiv [\int_0^1 y_t(i)^{(\theta-1)/\theta} di]^{\theta/(\theta-1)}$, where Y_t denotes aggregate output. Profit-maximization given a specific level of output yields firm i's demand function for intermediate inputs, $y_t(i) = (p_t(i)/P_t)^{-\theta} Y_t$.

Following Rotemberg (1982), each firm faces a quadratic cost to adjusting its nominal price level, which emphasizes the potentially negative effect that price changes have on customer-firm relationships. Given the functional form used in Ireland (1997), real profits of firm i are given by

$$d_t(i) = \left[\left(\frac{p_t(i)}{P_t}\right)^{1-\theta} - \Psi_t\left(\frac{p_t(i)}{P_t}\right)^{-\theta} - \frac{\varphi}{2}\left(\frac{p_t(i)}{\bar\pi p_{t-1}(i)} - 1\right)^2\right] Y_t, \tag{13}$$

where $\varphi \geq 0$ parameterizes the adjustment cost and $\bar\pi$ is the steady state gross inflation rate. Each intermediate goods producer chooses their price level, $p_t(i)$, to maximize the expected discounted present value of real profits, $E_t \sum_{k=t}^{\infty} Q_{t,k} d_k(i)$. In a symmetric equilibrium, all intermediate goods producing firms make identical decisions and the optimality condition reduces to

$$\varphi\left(\frac{\pi_t}{\bar\pi} - 1\right)\frac{\pi_t}{\bar\pi} = (1-\theta) + \theta\Psi_t + \varphi E_t\left[Q_{t,t+1}\left(\frac{\pi_{t+1}}{\bar\pi} - 1\right)\frac{\pi_{t+1}}{\bar\pi}\frac{Y_{t+1}}{Y_t}\right], \tag{14}$$

where $\pi_t = P_t/P_{t-1}$ is the gross inflation rate. In the absence of costly price adjustments (i.e. $\varphi = 0$), real marginal costs equal $(\theta-1)/\theta$, which is the inverse of the firm's markup factor, μ.

2.4 MONETARY AND FISCAL POLICY The fiscal authority finances a constant level of real discretionary spending, $\bar G$, and delivered real government transfers, $\lambda_t Z_t$, through a proportional tax on capital and labor income, seigniorage revenues, and by issuing long-term nominal government debt. The government's flow budget constraint is given by

$$\frac{M_t}{P_t} + \frac{P_t^M B_t^M}{P_t} + \tau_t(W_t N_t + R_t^k K_{t-1}) = \bar G + \lambda_t Z_t + \frac{M_{t-1}}{P_t} + \frac{(1+\rho P_t^M)B_{t-1}^M}{P_t}. \tag{15}$$

The model incorporates several layers of policy uncertainty, which follow Davig et al. (2010).[6] Figure 2 illustrates how the uncertainty unfolds. The economy begins in "normal times" under

[6]This paper omits the possibility of government default. For analysis on the implications of default within the context of a DSGE model with a fiscal limit see Bi and Leeper (2010), Bi (2012), and Bi and Traum (2012). It also omits the possibility of discretionary spending cuts, due to the size of the projected budget shortfalls.

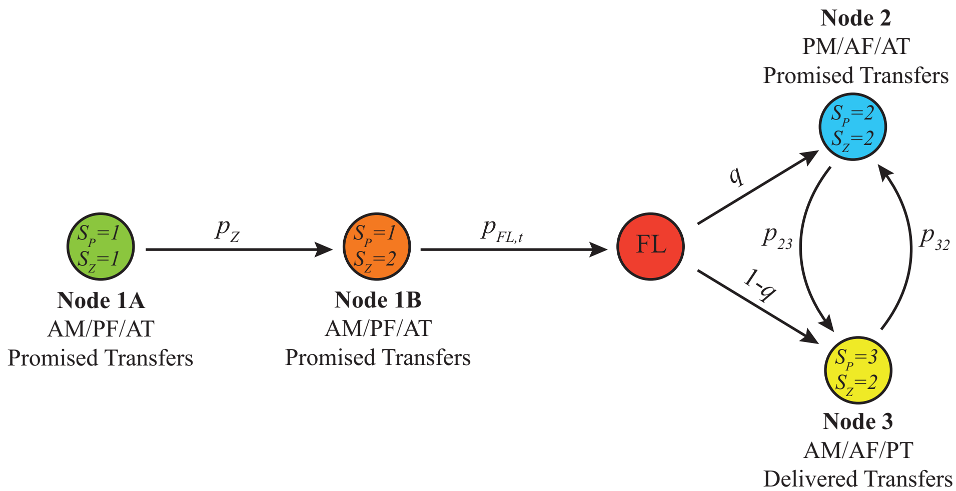


Figure 2: Possible evolution of monetary and fiscal policy regimes. FL: fiscal limit, AM: active monetary policy, PM: passive monetary policy, AF: active fiscal policy, PF: passive fiscal policy, AT: active transfers, PT: passive transfers.

a policy mix where the monetary authority actively targets inflation by following a simplified Taylor rule (AM) and the fiscal authority fully honors its stationary transfers commitments (AT) by passively adjusting the tax rate with the level of real debt, $b^M_{t-1} = B^M_{t-1}/P_{t-1}$ (PF).[7]

Real government transfers initially follow a stationary path and evolve according to a first-order two-state Markov chain given by

$$\begin{bmatrix} \Pr[S_{Z,t}=1|S_{Z,t-1}=1] & \Pr[S_{Z,t}=2|S_{Z,t-1}=1] \\ \Pr[S_{Z,t}=1|S_{Z,t-1}=2] & \Pr[S_{Z,t}=2|S_{Z,t-1}=2] \end{bmatrix} = \begin{bmatrix} 1-p_Z & p_Z \\ 0 & 1 \end{bmatrix},$$

where p_Z is the time-invariant probability of non-stationary transfers. Each period, the economy faces the dilemma that government transfers may begin to follow a perpetually unsustainable path, as the CBO currently projects. Formally, the transfers process is given by

$$Z_t = \begin{cases} (1-\rho_Z^S)\bar{Z} + \rho_Z^S Z_{t-1} + \varepsilon_t, & \text{for } S_{Z,t}=1, \\ \rho_Z^{NS} Z_{t-1} + \varepsilon_t, & \text{for } S_{Z,t}=2, \end{cases} \tag{16}$$

where $\bar{Z}$ are steady state promised transfers, $\rho_Z^{NS} > 1$, $\beta\rho_Z^{NS} < 1$, $|\rho_Z^S| < 1$, and $\varepsilon_t \sim N(0,\sigma_Z^2)$.

Eventually, rising medical inflation rates and falling worker-to-retiree ratios place government transfers on an explosive trajectory and the economy moves from node 1A to node 1B. Government debt mounts and taxes are revised upward. Policymakers face increasing political resistance and the likelihood of hitting the *fiscal limit* (FL) steadily rises. Eventually, either the resistance becomes so great that higher tax rates are no longer politically feasible or the economy reaches the peak of its Laffer curve—the instance where higher taxes no longer yield higher revenues—and the fiscal limit is hit.[8] Once this occurs, taxes are no longer a viable financing mechanism and either the monetary or fiscal authority is forced to adopt an alternative policy that stabilizes government debt.

[7]This terminology follows Leeper (1991). A passive monetary authority weakly adjusts the nominal interest rate with changes in inflation, whereas an active monetary authority targets inflation by sufficiently adjusting nominal interest rates to pin down inflation. Active tax policy implies that the fiscal authority sets the tax rate independently of the size of government debt, while passive tax policy implies that the fiscal authority adjusts taxes to stabilize debt.

[8]Trabandt and Uhlig (2011) find that some countries are already at or near the peaks of their Laffer curve.

The possible policy outcomes are captured by the monetary/tax policy mix ($S_P \in \{1,2,3\}$). Specifically, the monetary authority sets the short-term nominal interest rate according to

$$R_t = \begin{cases} \bar{R}(\pi_t/\pi^*)^{\phi}, & \text{for } S_{P,t} \in \{1,3\}, \\ \bar{R}, & \text{for } S_{P,t} = 2, \end{cases} \tag{17}$$

while the fiscal authority adjusts tax rates according to

$$\tau_t = \begin{cases} \bar{\tau}(b^M_{t-1}/b^*)^{\gamma}, & \text{for } S_{P,t} = 1 \text{ (if the FL does \textit{not} bind)}, \\ \tau^{FL}, & \text{for } S_{P,t} \in \{2,3\} \text{ (if the FL binds)}, \end{cases} \tag{18}$$

where an asterisk corresponds to a policy target and a bar corresponds to a steady state value. The parameters ϕ and γ respectively control the response of the nominal interest rate to changes in inflation and the sensitivity of taxes to real debt. τ^{FL} is the post-fiscal limit tax rate. The policy specification makes explicit the fact that there exists an upper bound to the degree of financing that taxes can provide. Although agents know the post-fiscal limit tax rate, uncertainty about the trajectory of government transfers implies that agents are unable to predict when this rate will bind.

Agents forecast when the fiscal limit will be hit, which captures some of the uncertainty that surrounds government spending programs when they are funded by future revenue streams, such as with pay-as-you-go financing. Following Davig et al. (2010, 2011), the probability of hitting the fiscal limit, $p_{FL,t}$, is endogenously determined by

$$p_{FL,t} = 1 - \frac{\exp(\eta_0 - \eta_1(\tau_{t-1} - \bar{\tau}))}{1 + \exp(\eta_0 - \eta_1(\tau_{t-1} - \bar{\tau}))}, \tag{19}$$

where η_0 and $\eta_1 > 0$ pin down the intercept and slope of the logistic function. At the fiscal limit, tax policy becomes active (AF), and the policy mix must adjust. If the fiscal authority honors its promised transfers (AT), the monetary authority stabilizes debt by switching from active to passive policy (PM) and the economy moves from node 1B to node 2. Under this policy mix, transfers continue to follow an unsustainable path, which leads to continued increases in debt and, without a central bank response, higher inflation. A higher price level reduces the value of real debt and allows the fiscal authority to stave off any reduction in promised transfers ($\lambda = 1$). If the monetary authority continues to target inflation (AM), the fiscal authority cannot fully honor its promised transfers (PT) and the economy moves from node 1B to node 3. Reneging on transfers could come in a variety of forms ($\lambda < 1$), but regardless of the approach, reductions must be sufficient to stabilize real debt, so that both post-fiscal limit regimes produce paths that are consistent with a long-run equilibrium. When the fiscal limit is hit, the monetary authority stabilizes debt with probability q and the fiscal authority reneges on its transfers commitments with probability $1 - q$.

The initial policy adjustment is not permanent. Instead, after the fiscal limit, policy evolves according to a first-order two-state Markov chain given by

$$\begin{bmatrix} \Pr[S_{P,t} = 2 | S_{P,t-1} = 2] & \Pr[S_{P,t} = 3 | S_{P,t-1} = 2] \\ \Pr[S_{P,t} = 2 | S_{P,t-1} = 3] & \Pr[S_{P,t} = 3 | S_{P,t-1} = 3] \end{bmatrix} = \begin{bmatrix} p_{22} & p_{23} \\ p_{32} & p_{33} \end{bmatrix},$$

so that each period either the monetary or fiscal authority stabilizes debt when the fiscal limit binds. This forces agents to always condition on the possibilities of debt revaluation and entitlements reductions. These policy adjustments are marked by movements between nodes 2 and 3 in figure 2.

2.5 EQUILIBRIUM The aggregate amounts of labor and capital supplied by the agent are defined as $N_t = \int_0^1 n_t(i)di$ and $K_t = \int_0^1 k_t(i)di$. Equilibrium requires all goods and asset markets to clear each period. The former is satisfied by the aggregate resource constraint,

$$C_t + I_t + \bar{G} = \left[1 - \frac{\varphi}{2}\left(\frac{\pi_t}{\bar{\pi}} - 1\right)^2\right] Y_t, \tag{20}$$

where capital evolves according to $K_t = I_t + (1-\delta)K_{t-1}$. The latter requires that one-period bonds are in zero net supply, $B_t^S = 0$, since they are not issued by the government. A competitive equilibrium consists of a sequence of prices, $\{P_t, W_t, R_t^k, P_t^M, \Psi_t, Q_{t,t+1}\}_{t=0}^{\infty}$, quantities, $\{C_t, K_t, M_t, N_t, B_t^S, B_t^M, Y_t, I_t, A_t\}_{t=0}^{\infty}$, and government policies, $\{R_t, \bar{G}, \tau_t, Z_t\}_{t=0}^{\infty}$, that satisfy the aggregate (over all generations) optimality conditions, the representative firm's optimality conditions, the government's budget constraint, the monetary and fiscal policy rules, the asset, labor, and goods markets' clearing conditions, and the transversality condition.

3 ANALYTICAL INTUITION: LONG-TERM DEBT AND FINITELY-LIVED AGENTS

Before solving the model in section 2, I analytically show how long-term debt and finitely-lived agents affect the equilibrium price level in the AM/PF and PM/AF regimes.[9]

Consider a cashless Perpetual Youth model where labor is inelastically supplied and agents receive the same constant endowment, face the same fiscal policies (transfers and lump-sum taxes), and are subject to identical probabilities of death, $\vartheta > 0$.

Each member of generation $s \leq t$ chooses sequences $\{c_{s,t}, b_{s,t}^S, b_{s,t}^M\}_{t=0}^{\infty}$ to maximize their expected lifetime utility, $E_t \sum_{k=0}^{\infty} [\beta(1-\vartheta)]^k \ln c_{s,t+k}$, subject to their flow budget constraint,

$$c_{s,t} + \frac{P_t^S b_{s,t}^S}{P_t} + \frac{P_t^M b_{s,t}^M}{P_t} + \tau_{s,t} - z_{s,t} \leq y_{s,t} + \left[\frac{P_t^S b_{s,t-1}^S}{P_t} + \frac{(1+\rho P_t^M) b_{s,t-1}^M}{P_t}\right] (1-\vartheta)^{-1}. \tag{21}$$

After aggregating, the Euler equations for short and longer-term government debt are given by

$$P_t^S = E_t\left\{Q_{t,t+1}\frac{P_t}{P_{t+1}}\right\} \quad \text{and} \quad 1 = E_t\left\{Q_{t,t+1}\frac{1+\rho P_{t+1}^M}{P_t^M}\frac{P_t}{P_{t+1}}\right\}, \tag{22}$$

where $P_t^S = 1/R_t$. In this economy, the aggregate law of motion for consumption, (10), reduces to

$$C_t = \frac{1}{\beta} E_t\{Q_{t,t+1} C_{t+1}\} + \frac{1}{\beta}\frac{\vartheta\xi}{1-\vartheta} E_t\left\{Q_{t,t+1}\left[\frac{B_t^S}{P_{t+1}} + \frac{(1+\rho P_{t+1}^M) B_t^M}{P_{t+1}}\right]\right\}. \tag{23}$$

The government chooses sequences of taxes, lump-sum transfers, and nominal bonds to satisfy

$$\frac{P_t^M B_t^M}{P_t} + \tau_t = Z_t + \frac{(1+\rho P_t^M) B_{t-1}^M}{P_t}. \tag{24}$$

In equilibrium, the goods ($C_t = Y_t = \bar{Y}$) and asset markets ($B_t^S = 0$) must clear and the transversality condition must hold every period. The bond Euler equations imply a no arbitrage condition, $P_t^M = P_t^S E_t\{1 + \rho P_{t+1}^M\}$, that delivers the term structure of interest rates.

[9]The online appendix imposes a fiscal limit and analytically solves for the equilibrium price level. It also simulates the equilibrium paths of real debt and inflation to obtain a clearer picture of how a fiscal limit and intergenerational transfers of wealth affect equilibrium dynamics.

To analytically solve for the equilibrium price level, it is necessary to work with a linear approximation of the model. In equilibrium, the log-linear bond Euler equations, given in (22), imply

$$\hat{P}_t^M = \hat{P}_t^S + \rho \bar{P}^S E_t \hat{P}_{t+1}^M = -\sum_{j=0}^{\infty} (\rho P^S)^j E_t \hat{R}_{t+j}. \tag{25}$$

Given (25), the log-linear aggregate law of motion for consumption, (23), is given by

$$\hat{R}_t = E_t \hat{\pi}_{t+1} + \mu(\hat{P}_t^M + \hat{b}_t^M), \tag{26}$$

where hats denote log-deviations from the deterministic steady state[10] and $\mu \equiv \frac{\vartheta\xi}{1-\vartheta} \frac{(1+\rho\bar{P}^M)\bar{b}^M}{\bar{\pi}\bar{Y}}$ controls the wealth effect from changes in debt. When $\mu > 0$, the market value of real debt impacts real and nominal interest rates. The log-linear government budget constraint, (24), implies

$$\hat{\pi}_t = \hat{b}_{t-1}^M + \rho P^S \hat{P}_t^M - \bar{Q}\left[\hat{P}_t^M + \hat{b}_t^M + \tilde{\tau}\hat{\tau}_t - \tilde{Z}\hat{Z}_t\right], \tag{27}$$

where $\tilde{\tau} = \bar{\tau}/(\bar{P}^M \bar{b}^M)$, $\tilde{Z} = \bar{Z}/(\bar{P}^M \bar{b}^M)$, and $\bar{Q} = \bar{\pi}/\bar{R} = \beta/(1+\mu)$.

3.1 Active Monetary and Passive Fiscal Policy

Monetary and fiscal policy rules are similar to the initial policy rules in section 2 ($S_P = 1$) and are given by

$$\hat{R}_t = \phi \hat{\pi}_t, \tag{28}$$

$$\hat{\tau}_t = \gamma(\hat{P}_{t-1}^M + \hat{b}_{t-1}^M), \tag{29}$$

where ϕ is set to ensure price stability and γ is set to ensure that any increase in the market value of debt is met with the expectation that future taxes will rise by enough to service the higher debt and retire it back to its stationary level. Government transfers are exogenous and follow,

$$\hat{Z}_t = \rho_Z^S \hat{Z}_{t-1} + \varepsilon_t, \tag{30}$$

where $|\rho_Z^S| < 1$ and $\varepsilon_t \sim N(0, \sigma_Z^2)$.

To find conditions on monetary policy that stabilize inflation around its target, combine (26)-(28) to obtain the expected evolution of inflation, given by,

$$E_t \hat{\pi}_{t+1} = (\phi + \mu\bar{Q}^{-1})\hat{\pi}_t - \mu\bar{Q}^{-1}(\hat{b}_{t-1}^M + \rho\bar{P}^S \hat{P}_t^M) + \mu(\tilde{\tau}\hat{\tau}_t - \tilde{Z}\hat{Z}_t). \tag{31}$$

This result reveals that the Taylor principle ($\phi > 1$) is no longer necessary to guarantee a unique bounded solution for inflation. When only short-term debt exists, a sufficient condition for price level stability is $\phi > 1 - \mu/\bar{Q}$.[11] When agents are finitely lived, higher inflation reduces real financial wealth, which imposes negative wealth effects that reduce consumption by current generations. Lower consumption acts as a stabilizer on inflation and implies that the monetary authority no longer needs to adjust nominal interest rates more than one-for-one with inflation to stabilize prices. The existence of long-term government debt further weakens this condition. When the monetary authority raises nominal interest rates in response to inflation, the long-term bond price falls, which reduces consumption demand and acts as an additional stabilizer on inflation.

[10] Steady state values are denoted by a bar. Thus, for some generic variable X, $\hat{X}_t = \ln X_t - \ln \bar{X} \approx (X_t - \bar{X})/\bar{X}$.

[11] This result is discussed in Leith and Wren-Lewis (2000) and Annicchiarico and Piergallini (2007).

Active monetary policy implies the unique bounded solution for inflation is given by

$$\hat{\pi}_t = \frac{\mu}{\phi}\sum_{k=0}^{\infty}\left(\frac{1}{\phi}\right)^k (E_t\hat{P}^M_{t+k} + E_t\hat{b}^M_{t+k}). \tag{32}$$

When $\vartheta > 0$, any change in inflation is proportional to changes in the market value of real debt. This shows that even when the monetary authority aggressively targets inflation, fiscal policy still influences equilibrium inflation dynamics. As debt rises, finitely lived households require higher interest rates to induce them to hold that debt given their finite horizons. The only way this can happen under the monetary policy rule specified in (28) is if inflation rises. Thus, a Taylor rule induces inflation when $\vartheta > 0$. If the central bank adjusts the nominal interest rate with changes in debt by adding μb^M_t to its policy rule, it could accommodate a higher level of debt without compromising its inflation targeting policy, but adding fiscal variables to the monetary feedback rule is anathema to most monetary economists. Moreover, this result is unique to lump-sum taxation.

The central bank can reduce fiscal influence by increasing its response to inflation, but not eliminate it since higher debt will still increase inflation. A longer maturity of debt allows the monetary authority to push inflation into the future and further reduce short-run fiscal interference.

When monetary policy is active, a unique bounded equilibrium requires the fiscal authority to respond to transfers shocks in a way that stabilizes long-run debt levels. To find conditions on fiscal policy that meet this criteria, combine (27) and (29), apply expectations conditional on information at $t-1$, and impose (25) and (26) to obtain the expected evolution of real debt, given by,

$$E_{t-1}[\hat{P}^M_t + \hat{b}^M_t] = (\tilde{\beta}^{-1} - \gamma\tilde{\tau})(\hat{P}^M_{t-1} + \hat{b}^M_{t-1}) + E_{t-1}\tilde{Z}\hat{Z}_t,$$

where $\tilde{\beta} \equiv \beta/(1+\mu)^2 < 1$ accounts for finitely lived agents. The tax rule implies that any increase in the market value of debt will induce higher taxes. If the response is too weak, shocks to transfers will lead to explosive debt dynamics that are not consistent with equilibrium. If, on the other hand, $\tilde{\beta}^{-1} - \gamma\tilde{\tau} < 1$, the effect of any shock to transfers will decay and produce stable debt dynamics.

The intertemporal equilibrium condition, which relates real debt to the present value of primary surpluses, provides further insight about the financing of transfers. To derive this condition, update (27) and impose (25) and (26). Then apply expectations conditional on information at t and solve forward to obtain

$$\hat{P}^M_t + \hat{b}^M_t = \sum_{k=1}^{\infty}\tilde{\beta}^k E_t\left[\tilde{\tau}\hat{\tau}_{t+k} - \tilde{Z}\hat{Z}_{t+k}\right]. \tag{33}$$

To see how the price level is pinned down, use the government budget constraint, (27), to decompose the intertemporal equilibrium condition, (33), and obtain

$$\hat{b}^M_{t-1} + \rho\bar{P}^S\hat{P}^M_t - \hat{\pi}_t = \bar{Q}\sum_{k=0}^{\infty}\tilde{\beta}^k E_t\left[\tilde{\tau}\hat{\tau}_{t+k} - \tilde{Z}\hat{Z}_{t+k}\right]. \tag{34}$$

Since current and future transfers are exogenous and debt is predetermined, transfers shocks propagate entirely through bond prices, inflation, and future taxes. When agents are infinitely lived, the monetary authority consistently meets its inflation target and any debt financed increase in transfers is met by a commensurate increase in the expected present value of taxes. In this case, agents bear the entire burden of higher future taxes and fully discount any short-run benefits from higher transfers, delivering Ricardian equivalence. When agents are finitely lived, there is a chance they will die before taxes come due. Thus, a debt financed increase in transfers produces positive wealth effects that cause inflation to temporarily rise. This means transfers shocks are only partially financed by future taxes when agents are finitely lived. An increase in prices, whose timing is controlled by the maturity of debt, delivers the remaining portion. The interesting question is whether the fiscal authority can exploit this by trading higher transfers for higher inflation.

3.2 PASSIVE MONETARY AND ACTIVE FISCAL POLICY

Monetary and fiscal authorities do not always base policy on the same rules [Davig and Leeper (2006, 2011a)]. Policy fluctuates between active and passive regimes due to political and economic factors. Under active fiscal policy, the fiscal authority does not adjust taxes to stabilize debt and instead bases tax policy on exogenous factors such as re-election, stimulus, or hitting the fiscal limit. The 2001 Bush tax cuts, which cut income and dividend tax rates while the debt-to-GDP ratio rose, serve as recent evidence.

Under passive monetary policy, the monetary authority does not aggressively target inflation and instead focuses on other factors. This policy often arises during economic downturns to reduce the severity of recessions. The pre-Volcker era (1960-1979), which experienced high inflation and output volatility, is an example of this policy [Davig and Leeper (2011a)].

Suppose the fiscal authority fixes taxes at $\bar{\tau}$ while the monetary authority weakly adjusts the nominal interest rate with inflation. To see how the price level gets pinned down, use (34) to obtain

$$\hat{P}_t - \rho \bar{P}^S \hat{P}_t^M = \hat{B}_{t-1}^M + \bar{Q} \sum_{k=0}^{\infty} \tilde{\beta}^k E_t \tilde{Z} \hat{Z}_{t+k}. \tag{35}$$

When fiscal policy is exogenous, the discounted present value of future surpluses is predetermined and fiscal policy determines the overall *change* in prices. To see this, consider two cases. First, suppose there is an unanticipated shock to current government transfers, financed by an increase in nominal debt, B_t^M. Without any response from the fiscal authority, at initial prices agents feel wealthier regardless of their planning horizon. Higher consumption demand drives up prices (either P_t or future prices via P_t^M) until agents are content with their initial consumption plan. Now suppose agents expect transfers to increase at some future date. In this case, there is no change in current debt, but without a fiscal response agents still feel wealthier. Once again, prices rise.

Longer-term government debt allows the monetary authority to influence the *timing* of price changes. Consider two extreme cases. The monetary authority can focus on stabilizing current prices, P_t, but then it must allow expected future inflation to adjust through the price of the maturity, P_t^M. Alternatively, the monetary authority can focus on stabilizing future prices by pegging the nominal interest rate, but then it must allow the current price level to adjust. This tradeoff between current and future inflation makes clear the important role that longer-term debt plays in price level determination. As Cochrane (2001, 2011) emphasizes, a longer average maturity of government debt allows the monetary authority to push inflation into the future.

Finitely lived agents also influence the timing of inflation. Without a response from the fiscal authority, an increase in debt produces positive wealth effects that drive up current inflation. When agents are finitely lived, higher inflation reduces real wealth. Feeling poorer, agents reduce future consumption, which suppresses expected inflation. To see this another way, recall that finitely lived agents require higher returns to hold more debt. When the monetary authority pegs the nominal interest rate, this can only occur if expected inflation falls. Thus, shorter planning horizons push inflation to the present and hinder the monetary authority's ability to delay inflation.

Table 1: Calibration

Baseline Calibration		
Probability of Death	ϑ	0.06*
Price Elasticity of Demand	θ	7.666
Rotemberg Adjustment Cost Coefficient	φ	10
Capital Depreciation Rate	δ	0.10
Cost Share of Capital	α	0.33
Steady State Money Velocity	v	3.80
Steady State Gross Inflation Rate	$\bar{\pi}$	0.02
Steady State Gross Nominal Interest Rate	$\bar{R}$	0.04
Steady State Labor	$\bar{N}$	0.33
Steady State Government Spending Share	$\bar{G}/\bar{Y}$	0.08
Steady State Government Transfers Share	$\bar{Z}/\bar{Y}$	0.09
Steady State Debt-to-GDP ratio	$\bar{b}/\bar{Y}$	0.385
Policy Parameters		
Inflation Coefficient: Active MP Rule	ϕ	1.50
Debt Coefficient: Passive Fiscal Rule	γ	0.15
Prob. of Moving to PM/AF/AT Regime after FL	q	0.50
Initial prob. of the PM/AF/AT Regime after FL	p_{22}	0.90
Prob. of staying in the AM/AF/PT Regime after FL	p_{33}	0.99
Prob. of Non-stationary Transfers Occurring	p_Z	0.20
AR Coefficient: Stationary Transfers Process	ρ_Z^S	0.90
Growth Rate: Non-stationary Transfers Process	ρ_Z^{NS}	1.01
Standard Deviation of the Transfers Shock	σ_Z	0.002
Implied Values		
Steady state Tax Rate	τ	0.19953
Tax Rate After Fiscal Limit	τ^{FL}	0.24
Transaction Services Preference Parameter	κ	0.0101
Leisure Preference Parameter	χ	1.30
Annual Discount Factor	β	0.9824
Bond Payment Parameter	ρ	$0^\dagger$
Logistic Function Slope	η_0	3.8918
Logistic Function Intercept	η_1	23.6018

* Alternative values of the probability of death parameter, given by $\vartheta = \{0, 0.1\}$, are also considered.
† When a maturity structure is embedded into the model, the bond payment parameter, ρ, corresponds to an average maturity of three years. Note that the implied parameters change under alternative calibrations.

4 Calibration and Solution Technique

The model in section 2 is calibrated annually to study the impacts of policy uncertainty over the next several decades. The baseline calibration summarized in table 1 is consistent with Rotemberg and Woodford (1997) and Woodford (2003). The steady state markup, $\mu = \theta/(\theta - 1)$, is set to 15 percent. The annual depreciation rate, δ, is set to 10 percent and the cost share of capital, α, is set to 0.33. Following Sbordone (2002), two-thirds of firms cannot adjust prices each period. Under a quarterly calibration, this implies a costly price adjustment parameter, φ, of about 38.[12] Given that prices are roughly 4 times more flexible at an annual frequency, φ is set to 10.

The leisure preference parameter, χ, implies a steady state share of time spent working of 0.33, which corresponds to a standard eight hour workday. The transaction services preference parameter, κ, is set so steady state velocity, defined as the ratio of nominal consumption expenditures (less durables) to the M1 money aggregate, corresponds to the average U.S. monetary velocity (1959-2009) of 3.8. The baseline model only includes one-period government debt. When longer-term debt is added, the bond payment parameter, ρ, corresponds to an average maturity of three years.

[12] If ω represents the fraction of firms that cannot adjust prices, $\varphi = \omega(\theta - 1)/[(1 - \omega)(1 - \beta\omega)]$.

The probability of death parameter has many interpretations. Under a strict interpretation, it measures agents' expected lifetimes. U.S. life expectancy is about 75 years. Restricting attention to the working age population, agents' expected lifetimes are about 50 years, which corresponds to a 2 percent probability of death. Higher values for the probability of death account for agents who are myopic about fiscal policy. Agents may expect to live 50 years but their planning horizons in response to fiscal shocks are likely much shorter. Regardless of interpretation, ϑ measures the deviation from Ricardian equivalence. The probability of death between consecutive years is set to 0.06 [Leith and Wren-Lewis (2000)]. I compare these results to the results when $\vartheta = 0.1$ [Freedman et al. (2010)] and the results from the representative agent model ($\vartheta = 0$).

The steady state tax rate ensures a debt/output ratio of 0.385, a value consistent with U.S. data from 1954-2009. The ratios of government expenditures/output and transfers/output are set to 8 percent and 9 percent, which matches U.S. data over the same period. The steady state gross nominal interest rate, $\bar{R}$, and gross inflation rate, $\bar{\pi}$, are set to 4 percent and 2 percent. Before the fiscal limit, monetary policy is active and tax policy is passive ($S_P = 1$) with parameters $\phi = 1.5$ and $\gamma = 0.15$. In the stationary transfers regime ($S_Z = 1$), transfers are persistent with an autoregressive coefficient, ρ_Z^S, of 0.9. The expected duration of the stationary transfers regime, $1/(1 - p_Z)$, is set to 5 years, which matches CBO projections. In the non-stationary transfers regime ($S_Z = 2$), transfers grow at 1 percent ($\rho_Z^{NS} = 1.01$), which equals the average projected growth rate of entitlement spending between 2015-2035 [Congressional Budget Office (2011)].

The probability of hitting the fiscal limit, p_{FL}, rises according to the logistic function specified in (19). The parameters of the logistic function are calibrated so there is a 2 percent chance of hitting the fiscal limit when $\tau_t = \bar{\tau}$ and a 5 percent chance when $\tau_t = \tau^{FL}$. The post fiscal-limit tax rate, τ^{FL}, is exogenously set in accordance with a steady state debt/output ratio of 2.3, which is unprecedented in U.S. history and would undoubtedly generate strong political resistance.[13]

With little direction on how Congress might proceed, the potential policy adjustments at the fiscal limit—either debt revaluation or reneging on government transfers—occur with an equal probability ($q = 0.5$). The transition matrix that governs post-fiscal limit policy is set so the regime where the fiscal authority adjusts policy ($S_P = 3$) has an expected duration of 100 years ($p_{33} = 0.99$, $p_{32} = 0.01$) and the regime where the monetary authority adjusts policy ($S_P = 2$) has an expected duration of 10 years ($p_{22} = 0.9$, $p_{23} = 0.1$). These values reflect the political reality that in the long-run some modifications to entitlement benefits will occur, but because of their politically toxic nature, debt revaluation always remains a possible financing outcome.

Solution Technique The prospect of exponential growth in entitlement spending and sudden changes to the policy mix imply that nonlinearity affects the distribution of aggregate outcomes that may transpire. Thus, I solve the aggregate *nonlinear* model using policy function iteration based upon the theory of monotone operators, known as the monotone map (MM). The MM has useful theoretical and numerical properties. It was used to prove existence and uniqueness of equilibrium of non-optimal economies by Coleman (1991) and later developed into an algorithm to approximate the solution to models with regime switching by Davig (2004). This solution technique discretizes the state space and iteratively solves for updated policy functions that satisfy equilibrium until a specified tolerance criterion is reached. The online appendix explains the algorithm used to solve the model in section 2. For additional applications see Richter et al. (2012).

[13] Rising debt is the primary concern of the Tea Party and the main source of their opposition to current tax and spending policies [July 5, 2010 Gallup poll: "Debt, Government Power Among Tea Party Supporters' Top Concerns"].

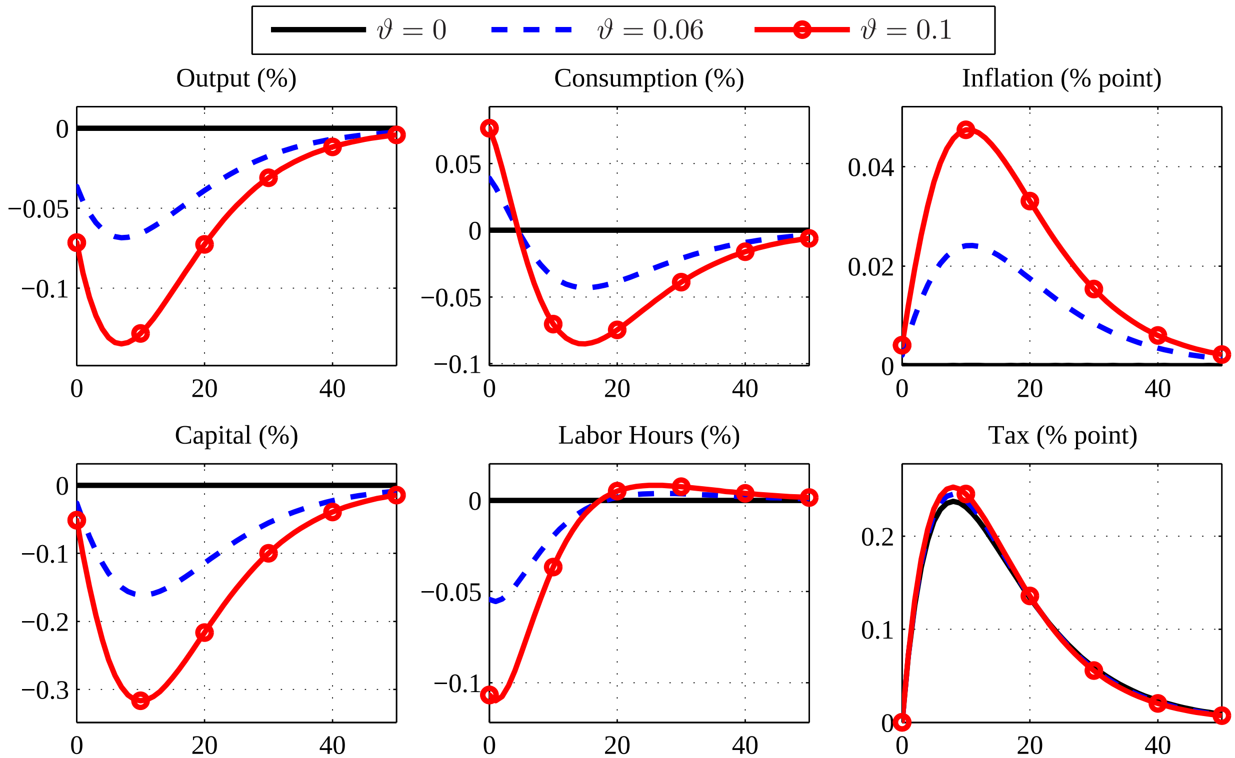


Figure 3: Responses to a 10 percent shock to government transfers conditional on fixed active monetary/passive tax policy and stationary transfers. Policies are financed by *lump-sum* taxes and *one-period* nominal debt. All values represent deviations from the corresponding simulation's stochastic steady state.

5 Numerical Results: No Fiscal Limit

Before solving the complete nonlinear model in section 2, this section first solves the model *without* a fiscal limit to show how finitely-lived agents and long-term debt affect equilibrium dynamics without the effects of policy switching. Conditional on fixed AM/PF policy and stationary transfers, I show how two key adaptations to the model impact impulse responses to a transfers shock. First, I contrast two fiscal financing methods—lump-sum taxes and proportional taxes on capital and labor income—to isolate wealth effects from changes in government liabilities. Second, I add longer-term debt to show how the maturity structure affects the timing of debt and inflation.

5.1 Lump-sum Taxes Figure 3 displays responses to a 10 percent shock to government transfers, which is consistent with the annual change during the Great Recession.[14] Since lump-sum taxes passively respond to changes in debt, a deficit financed transfers shock increases future tax liabilities. When agents are infinitely lived, they bear the entire burden of higher future taxes and fully discount the short-run benefits from higher transfers. Thus, Ricardian equivalence holds.

When agents are finitely lived, a positive transfers shock redistributes wealth from future to current generations, since there is positive probability that living generations will die before taxes come due. This places a higher expected tax burden onto future generations and makes current

[14] Nonlinear impulse responses differ from linear responses. Linear impulse responses report how a shock makes each simulated variable differ from its *deterministic* (calculated) steady state. Nonlinear impulse responses report how a shock makes each simulated path differ from the *stochastic* steady state, defined as a value for the state vector such that $|\Theta_t - \Theta_{t-1}| < \epsilon$, where Θ is a vector of policy functions and $\epsilon > 0$ is a tolerance criterion [Gallant et al. (1993)].

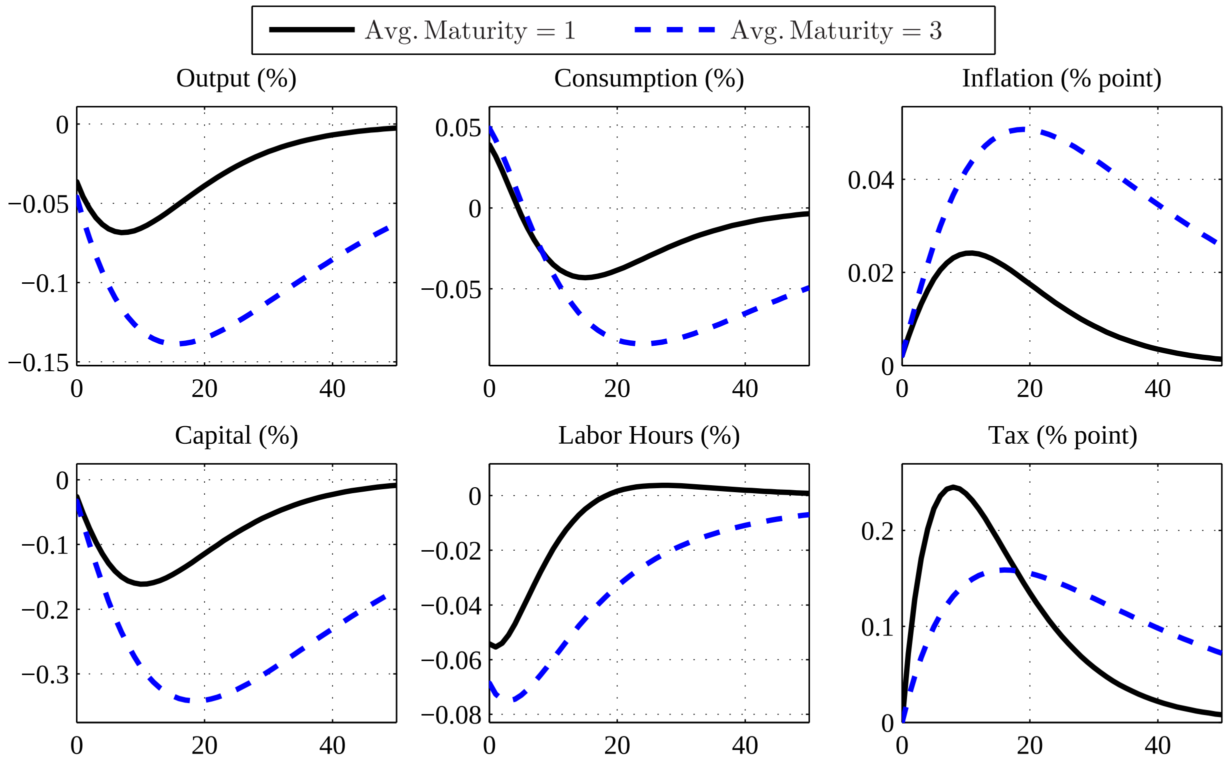


Figure 4: Responses to a 10 percent shock to government transfers conditional on fixed active monetary/passive tax policy and stationary transfers. Policies are financed by *lump-sum* taxes and nominal debt. The probability of death is 6 percent. All values represent deviations from the corresponding simulation's stochastic steady state.

generations feel wealthier. On impact, living generations increase consumption and reduce hours worked. Higher consumption demand crowds out savings and investment in capital and propels inflation. Mounting inflation reduces real government liabilities, causing labor supply to rise and consumption demand to fall. As capital continues to fall, marginal costs rise and induce stagflation.

When agents face a higher probability of death, their expected lifetimes are further misaligned with the government's infinite planning horizon and wealth effects are magnified. The initial positive wealth effects further increase consumption demand and crowd out savings and investment. Inflationary pressures from rising marginal costs mount, and since changes in inflation affect the level of real financial wealth, a higher probability of death imposes more severe stagflation.

As the effect of the transfers shock slowly decays, tax rates and government debt eventually peaks. A smaller stock of debt causes capital investment to rebound and sends inflation back toward its target rate. Increasingly smaller negative wealth effects from inflation propel consumption, capital, and output back toward their stationary levels. These results confirm the intuition in section 3.1—when agents are finitely lived, shocks to transfers cause the monetary authority to temporarily lose control of inflation even when it is aggressively targeted. Moreover, higher inflation is not associated with higher output, contrary to conventional analysis.

Longer-term Government Debt Figure 4 shows how the average maturity of government debt impacts the responses to a 10 percent transfers shock. Longer-term government debt impacts the timing of debt and inflation. When agents are infinitely lived, Ricardian equivalence still holds, since the timing of debt does not impact agents' optimal decisions. In contrast, when agents are finitely lived, a longer average maturity of debt produces higher inflation and a deeper and more persistent contractionary period. As the average maturity of debt rises, the financing of government liabilities is pushed further into the future. This increases the tax burden for future generations and magnifies the transfer of wealth from future to current generations.

On impact, greater wealth effects lead to larger increases in consumption and further reductions in labor. However, higher inflation quickly erases the positive short-run benefits. The monetary authority responds by raising nominal interest rates, which drives down long-term bond prices. The loss in net wealth from higher inflation and lower bond prices causes deeper reductions in consumption, capital, and output, and, since real debt remains well above steady state for a longer period, the degree of stagflation is more severe. These results illustrate the significance of intergenerational redistributions of wealth and the impact of longer-term government debt.

5.2 PROPORTIONAL TAXES

In contrast with lump-sum taxes, higher proportional taxes on capital and labor income reduce incentives to work and invest, breaking Ricardian equivalence even if agents are infinitely lived. On impact, this causes agents to substitute consumption for capital.

When agents are finitely lived, substitution effects are larger, since intergenerational transfers of wealth cause current generations to increase consumption and reduce labor supply and investment on impact. The reduction in savings reduces the marginal product of labor and lowers the real wage. Since wages constitute two-thirds of firms' costs, marginal costs and inflation initially fall.

Rising distortionary taxes cause steady reductions in output, which eventually raise marginal costs and inflation. However, when agents are finitely lived, rising inflation once again creates a negative wealth effect that induces persistent stagflation. Even when transfers are financed with distortionary taxes, intergenerational transfers of wealth significantly impact the trajectories of real and nominal variables. As agents' planning horizons are shortened, the stagflationary period is more severe and the monetary authority's inflation targeting policy is less effective.

Longer-term Government Debt Figure 5 compares the responses to a 10 percent shock to government transfers with a one and three year average maturity of debt.[15] In contrast with the results under lump-sum taxation, a longer average maturity of debt reduces the volatility of real and nominal variables. Regardless of the financing mechanism, longer-term bonds pushes the financing of debt into the future. Once again, this delays tax increases and transfers wealth from future to current generations. However, with proportional taxes, it also implies greater incentives to work and invest, which leads to a smaller reduction in the capital stock and labor supply in the short-run (i.e. the substitution effects dominate the wealth effects in the short-run).

The long-run effect on real variables is more severe. Eventually, the full tax burden comes due and further distort the capital and labor markets. Even though lower labor earnings keep consumption demand low, more persistent reductions in capital increase marginal costs and keep inflation above target longer. With proportional taxes, a longer average maturity of debt reduces the volatility of real and nominal variables but at the steep cost of prolonged stagflation.

6 NUMERICAL RESULTS: FISCAL LIMIT

I now consider the complete model in section 2. Using counterfactual exercises that condition on a particular monetary/tax/transfers policy regime and Monte Carlo simulations, I show how

[15] Monetary and fiscal policy parameters are held constant across maturity lengths, but the response of taxes to government debt, γ, is increased to 0.40 to guarantee stability. Thus, the results are not comparable to earlier ones.

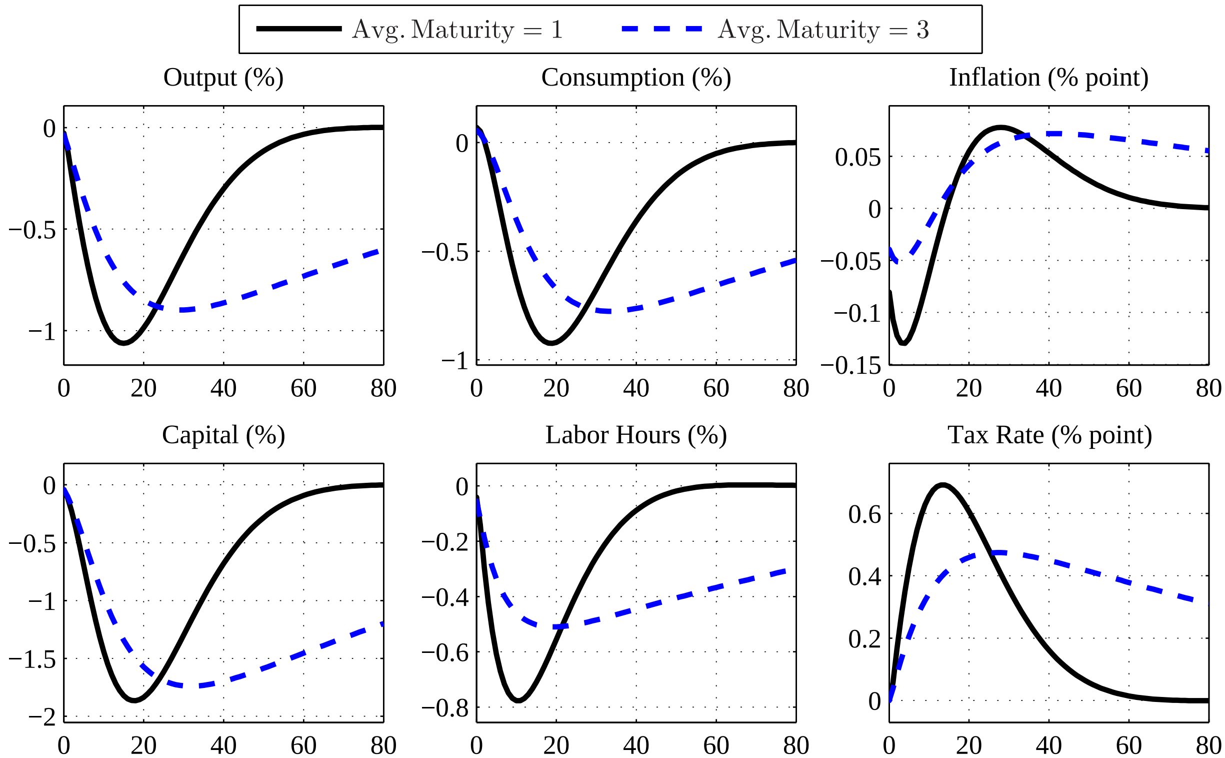


Figure 5: Responses to a 10 percent shock to government transfers conditional on fixed active monetary/passive tax policy and stationary transfers. Policies are financed by *distortionary* taxes and nominal debt. The probability of death is 6 percent. All values represent deviations from the corresponding simulation's stochastic steady state.

alternative planning horizons and average maturities of debt impact the expectational effects of the fiscal limit and the degree of reneging on transfers. I also illustrate the consequences of delaying reform by adding the possibility that transfers permanently return to a stable trajectory.

6.1 EQUILIBRIUM TRANSITION PATHS The economy begins in "normal times", when the monetary authority actively targets inflation and the fiscal authority passively adjusts the tax rate to stabilize debt and fully honor its (stationary) transfers commitments ($S_P = 1$). In period 5, the same policy regime continues to hold, but transfers switch to the non-stationary process ($S_Z = 2$) given in (16). Figure 6 displays counterfactual transition paths, conditional on the initial policy mix and non-stationary transfers remaining in place even after the fiscal limit is hit.[16]

Steadily rising transfers push real debt and taxes continually higher. Higher proportional tax rates levied against capital and labor income decrease incentives to work and invest, reducing labor supply and savings in capital.[17] When agents are finitely lived, growing debt produces positive wealth effects, but these effects are dominated by the reduction in output, which reduces consumption. Although lower consumption tends to reduce inflation, the expectational effects of moving to

[16]This simulation is different from the impulse responses in section 5. Those simulations produce responses to a one-time transfers shock. This simulation is based on a sequence of *policy* regime shocks, where transfers set off on an non-stationary path in period 5 ($S_Z = 2$) and the active monetary/passive tax/active transfers regime ($S_P = 1$) remains in place even after the fiscal limit. Although the initial policy mix is absorbing and no transfers shocks are realized, agents continue to base expectations on the true probability distributions described in section 2.

[17]The tax rates levied against capital and labor income are identical. The online appendix differentiates between these tax rates and shows how the results change when capital and labor taxes hit their limits at different dates.

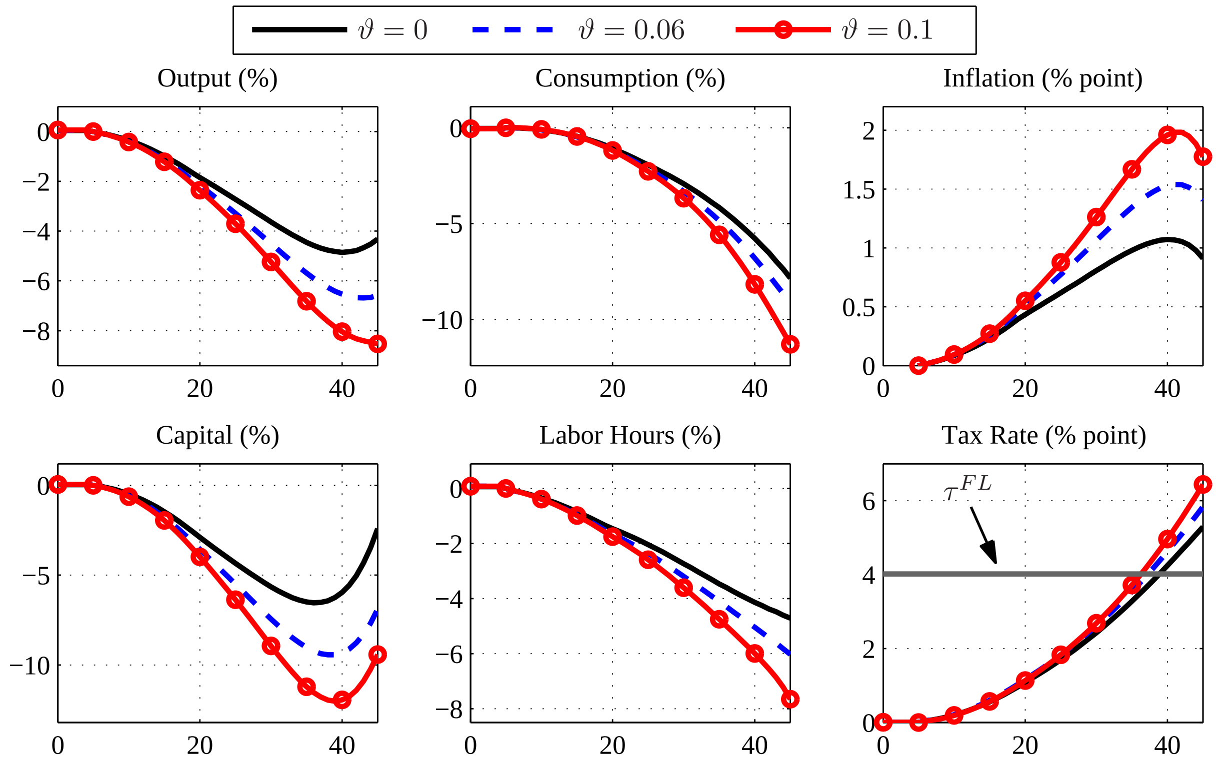


Figure 6: Responses to government transfers switching to a non-stationary path ($S_Z = 2$) in period 5, conditional on active monetary/passive tax/active transfers policy remaining in place after the fiscal limit is hit. All values represent deviations from the corresponding simulation's stochastic steady state.

a regime where debt is revalued ($S_P = 2$), steadily increase expected and realized inflation.[18]

When agents are finitely lived, the expectational effects of hitting the fiscal limit are stronger. Steadily rising inflation shifts real wealth from current to future generations, since it decreases real government liabilities and lowers the tax burden of future generations. Faced with a negative wealth effect, current generations further reduce consumption and investment. Feeling poorer, agents would typically work more, but higher debt levels from a smaller tax base force higher taxes, which reduces incentives to work. A higher probability of hitting the fiscal limit produces higher inflation. Thus, the severity of the stagflationary period rises with the probability of death.[19]

Since taxes continue to respond to increases in debt after they surpass the post-fiscal limit tax rate, τ^{FL}(gray line), agents face persistently positive innovations in taxes. With the expectation that taxes will remain fixed at τ^{FL}, the expected after-tax return on capital and the prospect of reneging rise. Both of these expectational effects increase incentives to invest and lead to steady increases in the capital stock. When agents are finitely lived, these forces are partially offset by the negative wealth effects imposed by higher inflation. Thus, the duration of the contractionary period increases with the probability of death. Nevertheless, lower marginal costs eventually dominate the expectational effect of moving to a regime where debt is revalued and inflation falls. Although the tax base expands, falling inflation and growing transfers continue to push real debt higher.

This counterfactual makes clear the devastating consequences of long-term fiscal stress. Re-

[18]The strength of the expectational effects is dependent on the slope and intercept of the logistic function specified in (19). The online appendix conducts sensitivity analysis on these parameters.

[19]Cochrane (2011) also argues that stagflation is a likely outcome of looming fiscal stress.

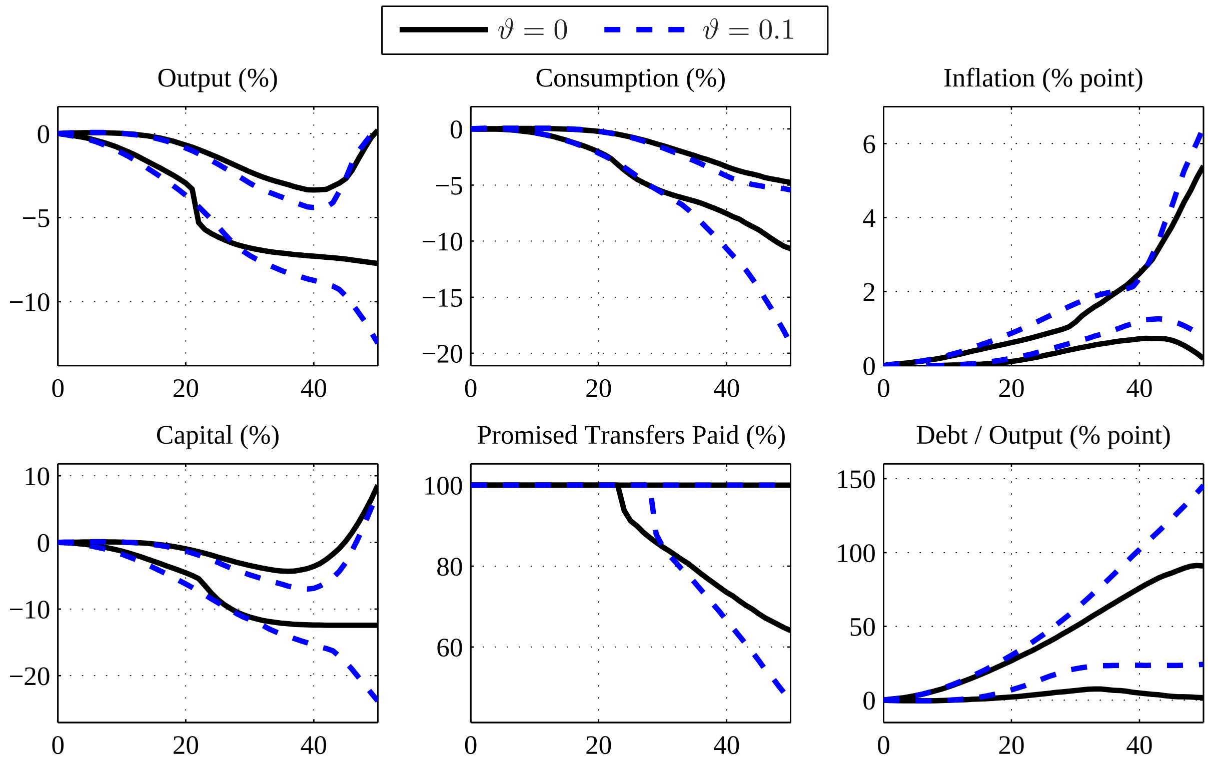


Figure 7: Inner 80th percentile range of time paths from 20,000 Monte Carlo simulations of the model. All values represent deviations from the corresponding simulation's stochastic steady state.

gardless of the probability of death, output falls and the monetary authority loses control of inflation for over four decades, even though it is aggressively targeted. Finite planning horizons lead to further reductions in output and make it more difficult for the monetary authority to meet its inflation target. When agents make decisions based on a ten year planning horizon ($\vartheta = 0.1$), the total loss in output exceeds 8 percent and inflation rises by over 2 percent. Only during the mid 1970s and early 1980s did the U.S. experience prolonged periods of inflation and simultaneous reductions in output. Moreover, in the post-World War II era, declines in output of this magnitude are unprecedented. Even during the Great Recession (2007-2009), output fell by just over 5 percent.

Figure 6 makes clear expectational effects of the fiscal limit, but it is based upon a specific sequence of policy regimes and does not capture alternative policy scenarios. To capture the range of possible outcomes, I conduct 20,000 Monte Carlo simulations of the model by drawing sequences of regimes and shocks to transfers, starting from the initial policy mix ($S_P = 1, S_Z = 1$).

Figure 7 plots the 10th and 90th percentile bands of time paths for each variable under a infinite and ten year planning horizon to highlight the extreme outcomes that are possible.[20] For roughly the first decade, the deviation from the stationary distribution is small regardless of the planning horizon. Given the initially low probability of hitting the fiscal limit, agents expect policy changes to occur far into the future and heavily discount these outcomes. Eventually, an increasing probability of hitting the fiscal limit implies a broad range of outcomes that could include any outcome

[20]The large jumps in real variables are caused by the tax rate jumping to its exogenously specified value, τ^{FL}, when the fiscal limit is hit. An alternative approach is to specify τ^{FL} endogenously so that it equals the prevailing tax rate, τ_{t-1}, when the fiscal limit is hit. Making τ^{FL} endogenous alleviates these unnatural features, but as the online appendix shows, the qualitative results are similar across these two specifications of τ^{FL}.

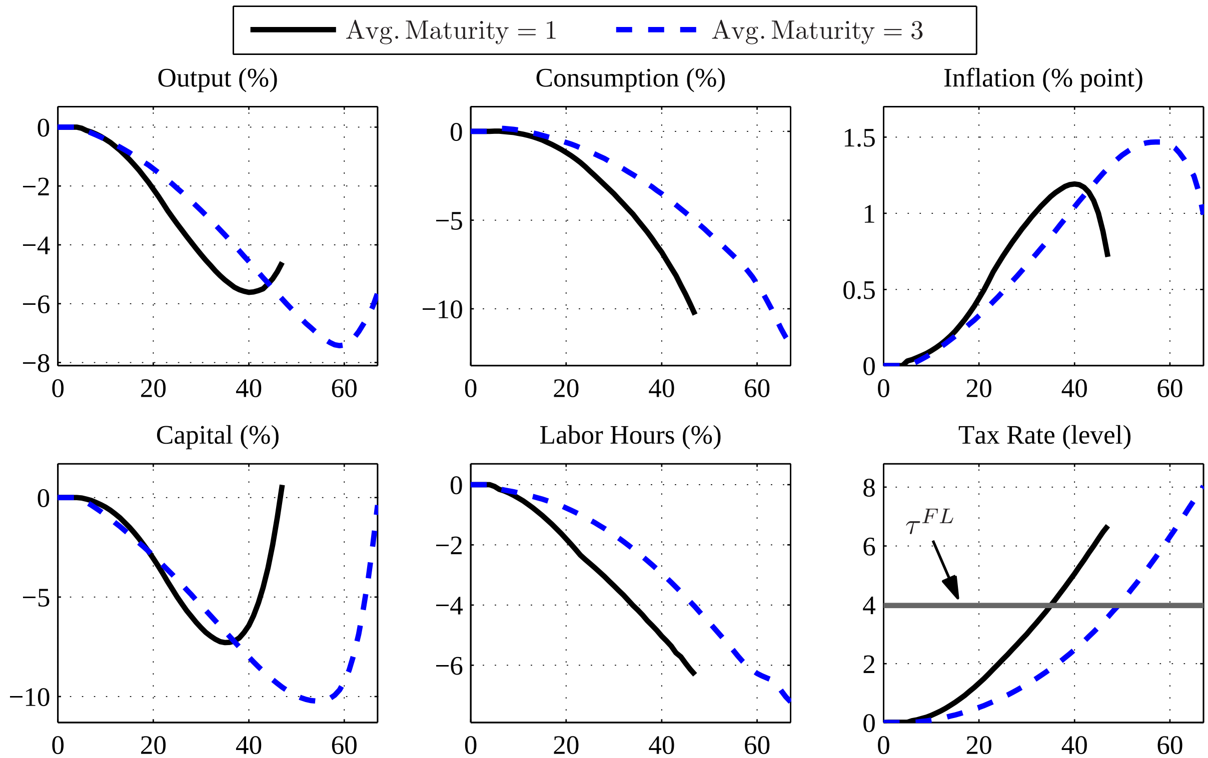


Figure 8: Responses to government transfers switching to a non-stationary path ($S_Z = 2$) in period 5, conditional on active monetary/passive tax/active transfers policy remaining in place after the fiscal limit is hit. The probability of death, ϑ, is set to zero. All values represent deviations from the corresponding simulation's stochastic steady state.

from a very severe contractionary period with high growth rates of debt and inflation to a very modest contractionary period with low debt and little inflation. These outcomes reflect that the fiscal limit can be hit and transfers can become non-stationary at any point, or not at all.

Due to the feedback effects between real variables and inflation, a higher probability of death increases the likelihood of a deep contractionary period, reneging, and rapidly rising debt and inflation. Nevertheless, when agents condition on policy adjustments that ensure a stable debt/output ratio, it never climbs to the extreme levels the CBO projects. Although the degree of reneging is dependent on probability distributions of the model, these simulations indicate that there is a strong probability large modifications in entitlement benefits will be required to stabilize debt.

Aside from passing reform, there is little the policy authorities can do to prevent stagflation. If the fiscal authority raises taxes more aggressively with debt (a higher γ), it causes deeper and more persistent stagflation for two reasons. First, it decreases incentives to work and invest, which leads to sharper reductions in output and consumption. Second, it increases the probability of hitting the fiscal limit, which increases the likelihood of debt revaluation and drives up the growth rate of inflation. If the monetary authority responds more aggressively to inflation (a higher ϕ), it has no impact on the trajectory of government debt. Thus, tax rates rise at the same speed, and the expectational effects of the fiscal limit continue to exert stagflationary pressures.

6.2 LONGER-TERM GOVERNMENT DEBT Figure 8 shows how the transition paths in figure 6 change when longer-term debt is added to the baseline model and the monetary authority no longer pegs the nominal interest rate after the fiscal limit. A longer average maturity of debt stretches the

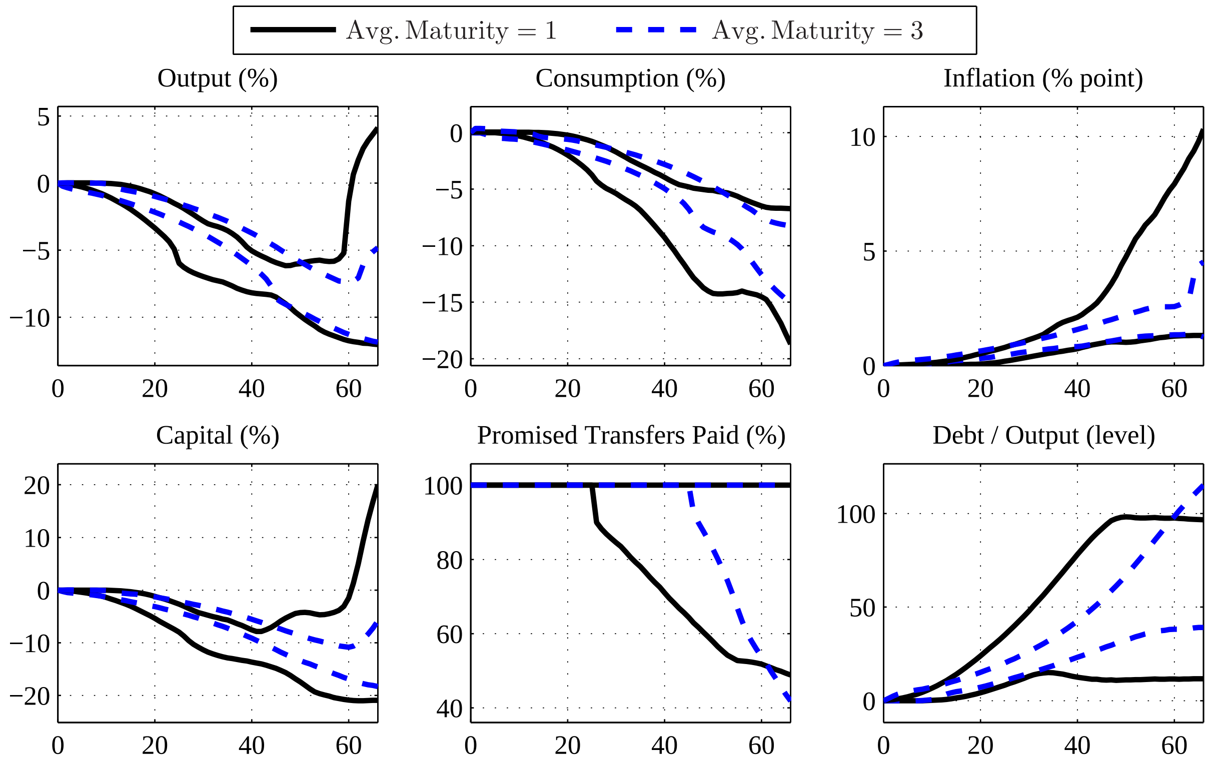


Figure 9: Inner 80th percentile range of time paths from 20,000 Monte Carlo simulations of the model. The probability of death is 6 percent. All values represent deviations from the corresponding simulation's stochastic steady state.

financing of government liabilities over several years. Since taxes are pushed into the future, agents react to the higher after-tax return on capital by increasing investment. Although this effect is partially offset by falling bond prices and an initially lower probability of reneging, the path of capital is initially higher when the average maturity of debt is three years. Labor supply unambiguously increases due to a higher after-tax real wage rate and lower real wealth.[21]

Longer-term debt also pushes the expectational effects of the fiscal limit further into the future, as inflation peaks roughly two decades later. Although a growing prospect of debt revaluation imposes steadily rising inflation, a longer average maturity of debt weakens this effect, since changes to the yield curve serve as a shock absorber. Growing transfers are now met with a steadily declining price of the maturity, which increases the slope of the yield curve and pushes debt and inflation into the future. Agents discount the fiscal limit more heavily in the short-runs and expect taxes to finance transfers for a longer duration. Incentives to work and invest steadily erode and cause larger reductions in the capital stock and labor supply. This produces sharp increases in marginal costs, which eventually translate into larger increases in inflation. Thus, longer-term debt reduces the short-run effects of the fiscal limit but still leads to severe consequences in the long-run.

To assess the quantitative features of lengthening the average maturity of debt, I return the

[21] The bond payment parameter, ρ, is set so the average maturity of debt is three years. This changes the deterministic steady state. To remain consistent with the baseline calibration, $\bar{\tau} = 0.22925$ is set to ensure a constant debt/output ratio across maturity lengths and $\tau^{FL} = 0.27$ remains four percentage points above steady state. Monetary and fiscal policy coefficients are held constant across maturity lengths. To ensure stability, γ, is increased to 0.20. To allow for movements in the bond price, $\phi = 0.2$ so that the nominal interest rate weakly responds to inflation. Finally, to isolate the differences in the equilibrium paths across maturity lengths, the probability of death is temporarily set to zero.

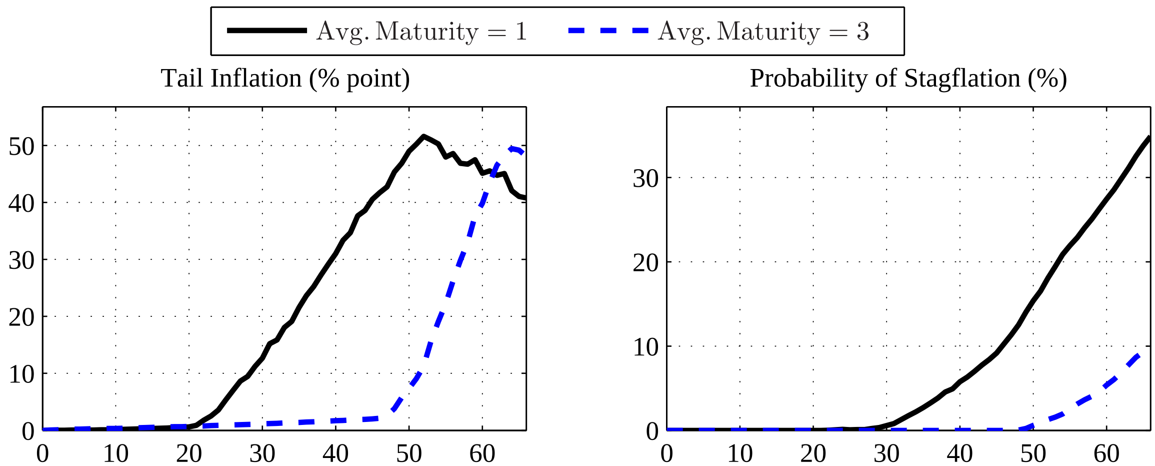


Figure 10: Left panel: Average of the upper 0.005 percentile of inflation. Values represent deviations from the corresponding simulation's stochastic steady state. Right panel: Probability of stagflation, defined as the probability that inflation is above 4 percent and the annual percent change in output in less than 1 percent. The probability of death is 6 percent. Reported values are based on 20,000 simulations.

probability of death parameter to its baseline value ($\vartheta = 0.06$) and conduct 20,000 Monte Carlo simulations. Figure 9 plots the 10th and 90th percentile bands of the time paths for the models with a one and three year average maturity of debt. With one-period debt, the 90th percentile shows the fiscal limit is consistently hit 45 years into the future. Although transfers continue to grow at 1 percent, this flattens the trajectory of debt, since both post-fiscal limit regimes stabilize debt. With a 50 percent chance of debt revaluation, the 90th percentile of inflation quickly rises to levels not seen since the 1970s. However, sharper increases in inflation—and many of the dire scenarios the CBO and others project [Kotlikoff and Burns (2005)]—are prevented by reneging on transfers, which induce precautionary savings. When agents try to offset the negative wealth effect from reneging by increasing savings on capital, real marginal costs fall, which prevents further inflation.

Once again, longer-term debt delays the consequences of the fiscal limit. Although rising tax rates immediately produce contractionary outcomes, stronger reductions in real variables do not take effect until 15 years after the model with only one-period debt. Thus, the short-run impact on nominal variables is reduced—over the next fifty years, the 90th percentile of inflation never exceeds 3 percent and real debt remains below World War II levels. Moreover, the likelihood of significant reneging is reduced in the short-run. With 90 percent confidence, the fiscal authority meets at least 80 percent of its transfers commitments fifty years into the future.[22]

The probability of the fiscal limit remains low for several decades, since longer-term debt delays the financing of government liabilities. This keeps the initial policy mix ($S_P = 1$) open longer, but pushes the distribution of debt higher than when only one-period debt is issued. As debt grows, the probability of hitting the fiscal limit rises and inflation mounts, but the 90th percentile of the distributions for inflation and output never reach the levels seen with one-period debt.

To obtain a better sense for the tail risk of inflation across maturity lengths, I follow Davig et al. (2011) and compute the average upper 0.005 percentile of inflation. To compute this statistic, order the $\pi_t^{(n)}$, $n = 1, 2, \ldots, N$ realizations of inflation from N simulations and average the $N \cdot \mathcal{T}$

[22]Bohn (2011) and Cochrane (2011) also contend that lengthening the average maturity of debt can reduce the short-run effects of fiscal stress, but without solving a fully specified general equilibrium model.

outcomes, where $\mathcal{T}$ is the desired percentile. The conditional tail expectation is $E[\pi_t|\pi_t > \pi^{\mathcal{T}}] = \sum_{n=1}^{N} \pi_t^{(n)} \mathcal{I}_{[\mathcal{T},\infty)}/N \cdot \mathcal{T}$, where $\pi^{\mathcal{T}}$ is the value of inflation corresponding to the $\mathcal{T}^{\text{th}}$ percentile and $\mathcal{I}_{[\mathcal{T},\infty)}$ is an indicator that signifies a value of inflation greater than the $\mathcal{T}^{\text{th}}$ percentile.

The left panel of figure 10 makes clear that a longer average maturity of debt reduces the risk of growing inflation and virtually eliminates the prospect of hyperinflation for the next several decades. When only one-period debt is issued, tail outcomes of inflation start to increase in period 20 and surpass 50 percent by period 50. In sharp contrast, when the average maturity of debt is three years, inflation only poses a serious risk more than 50 years into the future. When taxes come due and the probability of the fiscal limit rises, tail inflation rises sharply, but *never* surpasses the levels seen when only one-period debt is issued. Eventually tail inflation peaks, as agents place a higher weight on the fiscal authority reneging on transfers, instead of debt revaluation.

These results confirm that hyperinflation is a tail event that agents discount more heavily as the average maturity of debt rises, but it also serves as a warning sign to policymakers—the short-run consequences of growing transfers may seem insignificant, but if agents' expectations of debt revaluation rise, the consequences of fiscal stress can be quite severe.

Reporting percentiles across all simulations instead of looking at the characteristics of each simulation can be misleading. Thus, figure 10 also plots the probability of stagflation across debt maturity lengths, defined as any outcome where inflation is above 4 percent and the annual percent change in output in less than 1 percent. Once again, a longer average maturity of debt reduces the short-run risk of stagflation. Whereas the probability of stagflation rises in period 30 and surpasses 30 percent by period 60 when only one-period bonds are issued, the probability of stagflation remains below 10 percent when the average maturity of debt increases to 3 years. This result shows that a longer debt maturity structure not only delays the risk of stagflation, but also prevents heightened long-run risk. Fifteen years after the probability of stagflation starts to rise, there is a 10 percent probability that stagflation occurs, regardless of the average maturity of debt.

6.3 Costs of Delaying Entitlement Reform

Much of the recent policy debate centers around how government spending cuts can be used to stave off the dire scenarios the CBO projects.[23] The bleak outlook facing entitlement programs (figure 1) makes major reform measures such as adopting a single-payer heath care system, privatizing Social Security, reducing Social Security benefits, and amending Medicare and Medicaid reimbursement rates realistic policy outcomes. This section assesses the economic consequences of delaying reform by extending the baseline model to allow transfers to switch from a non-stationary to a stationary process.

When transfers switch to a non-stationary process ($S_Z = 2$), the fiscal authority has the option to pass reform—legislation that places transfers on a stable path. To capture the increasing political pressure for reform associated with rising debt, the probability of reform is endogenously determined by

$$p_{R,t} = 1 - \frac{\exp(\eta_0^R - \eta_1^R(b_{t-1}^M - b^*))}{1 + \exp(\eta_0^R - \eta_1^R(b_{t-1}^M - b^*))}, \tag{36}$$

where η_0^R and $\eta_1^R > 0$ are the intercept and slope of the logistic function.[24] Entitlement reform places transfers back on a stable path, regardless of whether it occurs before or after the fiscal limit

[23] For additional discussion on fiscal retrenchment, see Leeper (2011), Bi et al. (2011), and Corsetti et al. (2010).

[24] The logistic function parameters, η_0^R and η_1^R are calibrated so that there is a 4 percent chance of reform in the stationary equilibrium and a 20 percent chance of reform when the fiscal limit is hit.

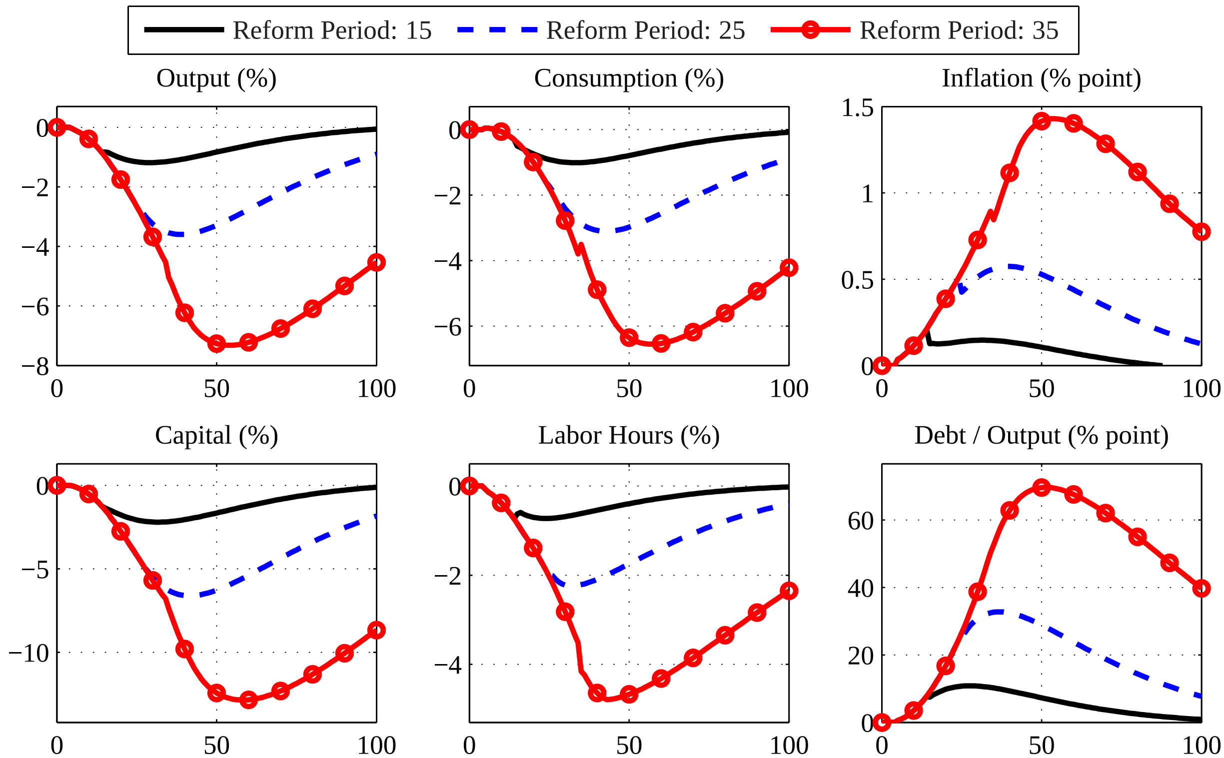


Figure 11: Impact of passing entitlement reform 10, 20, and 30 years after government transfers switch to a non-stationary process (period 5), conditional on active monetary/passive tax/active transfers policy remaining in place after the fiscal limit is hit. The probability of death is 6 percent. All values represent deviations from the corresponding simulation's stochastic steady state.

is hit. However, given the economic consequences of the fiscal limit, the fiscal authority is in a race to pass reform before the fiscal limit. When the fiscal limit is hit, either monetary or fiscal policy must adjust as described in section 2, but there is still a possibility of reform that rises with debt.

Figure 11 shows the consequences of delaying entitlement reform by 10, 20, and 30 years after transfers become non-stationary, conditional on the initial policy mix ($S_P = 1$) holding even after the fiscal limit. Once transfers switch to an explosive path in period 5, stagflation occurs, and each year the fiscal authority fails to pass reform, the economic consequences mount.

Regardless of when the fiscal authority passes reform, accumulated debt service obligations and a persistently high probability of hitting the fiscal limit continue to drive up debt and inflation even after the date of reform. As taxes respond, incentives to work and invest deteriorate. Eventually, transfers decay to a level sufficient for current tax policy to reduce debt and propel output and inflation back to their stationary levels. However, these results serve as another warning sign to policymakers—the number of years it takes the economy to rebound from a period of growing transfers increases exponentially with the number of years it takes to pass reform.

7 CONCLUSION

The U.S. is entering a period of heightened fiscal uncertainty. With little or no indication from policymakers about how future policy will adjust, this paper explores alternative scenarios for the evolution of policy while taking seriously the reality that there exists a limit to the revenues that taxes can generate. The possibility of hitting the fiscal limit always exists, but given the resistance to higher taxes and explosive entitlement projections, this outcome is increasingly relevant.

Recent work has been aimed at understanding the macroeconomic implications of this uncertainty but within the strict confines of a representative agent model, which is unable to account for key intergenerational redistributions of wealth. This paper introduces a fiscal limit into a Perpetual Youth model to assess the impact of intergenerational transfers of wealth on equilibrium outcomes. Another critical component commonly left out of most policy analysis is a debt maturity structure. This paper examines how the presence of longer-term debt impacts the expectational effects of the fiscal limit. Finally, this paper investigates the impact of delaying entitlement reform—legislation that places government transfers back on a stable path. Four key findings emerge:[25]

1. When government liabilities are seen by agents as net wealth, the expectational effects of policy uncertainty are substantially stronger. As a consequence, growing government transfers impose a deeper and more persistent contractionary period, which produces heightened inflation risk and further hinders the central bank's inflation targeting policy. Although current levels of inflation remain low, the extreme tails of the distribution show that higher levels of inflation can quickly strike as agents' expectations adjust to rising government debt. These results serve as a warning sign for policymakers—without reform that ensures the sustainability of government entitlement programs, the central bank's ability to combat inflation becomes increasingly difficult, the risk of a painful and protracted recession rises, and substantial reductions in entitlement benefits become increasingly likely.

2. The presence of longer-term government debt reduces the short/medium-run impacts of policy uncertainty. For the next fifty years, inflation only poses mild risk, even in the upper-tail of its distribution. Moreover, contractionary outcomes are less likely and much less severe. These results suggest that the fiscal authority can temporarily reduce the aggregate effects of fiscal stress by increasing the average maturity of debt. Such a policy buys policymakers time to resolve the looming fiscal crisis, but must be approached with caution. Without reform, the underlying problem persists and the long-run risk of stagflation steadily mounts.

3. Explosive government transfers bring economies toward the fiscal limit and force agents to condition on a broad set of possible outcomes. When only one-period nominal debt is issued, fiscal uncertainty produces *immediate* and steadily rising inflation. This, however, is inconsistent with current inflation expectations, which remain stable and low. Many economists contend that large fiscal imbalances and growing debt imply looming inflation [Feldstein (2009); Ferguson (2009)]. The presence of longer-term government debt delays the expectational effects of the fiscal limit and reconciles these points.

4. If entitlement reform is passed well before the fiscal limit is hit, policymakers can drastically reduce the severity and duration of the stagflationary period caused by exponentially rising government transfers obligations. If, however, reform is delayed, the economic consequences of the fiscal limit are stark, as the monetary authority loses control of inflation and contractionary outcomes persist for several decades after reform passes. Thus, economic outcomes may steadily improve after reform passes, but the consequences of delaying reform may hinder economic performance well into the future.

[25] A natural extension is to compute the welfare implications of alternative policy sequences. Such as extension is complicated by the heterogeneity imposed by finitely-lived agents and is an important topic for future research.

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Online Appendix: Not for Publication

APPENDIX A DETAILS ABOUT FIGURE 1

Figure 1a plots the actual and projected trust fund ratio, defined as assets as a percentage of annual expenditures, from 1970-2040 [Social Security Administration (2011)]. SSA projections paint a bleak outlook for the short-run solvency of government entitlement programs. When the trust fund ratio falls below 100 percent, projected costs exceed income, but entitlement programs would still pay out full benefits until the trust fund ratio falls to zero. The disability insurance (DI) trust fund ratio falls below 100 percent in 2013 and assets are completely exhausted in 2018. The outlook for the Hospital Insurance (HI, Medicare Part A) trust fund is also bleak. The trust fund ratio falls below 100 percent in 2012 and assets are fully depleted by 2024. The Old Age Survivors Insurance (OASI) trust fund is in better shape, since the trust fund ratio remains above 100 percent until 2035 and assets are not exhausted until 2039.

The CBO's projections, documented in its annual Long-Term Budget Outlook, are based on two scenarios—the Alternative Fiscal Financing (AF) and Extended-Baseline scenario (EB)—that reflect different assumptions about future federal government revenues and spending. The EB projection (dashed line) assumes current law will remain in effect. This means that in this scenario, the Bush Tax cuts of 2001 and 2003, which were recently extended in 2010, will sunset, the alternative minimum tax (AMT) base will continue to expand, and the tax provisions of the recent health care act (HR 3590) will take effect. Each of these policies projects higher revenues, which offset much of the growth in entitlement spending and keep the growth rate of debt relatively low. The AF projection (dash-dotted line) assumes that routine adjustments to current law will continue to be enacted in the future. Some of the adjustments include: (1) All tax provisions currently set to expire will be extended through 2021, including provisions related to the AMT; (2) Medicare's reimbursement rates for physicians will continue to grow at the same rate as the Medicare Economic Index; (3) Smaller decreases in discretionary spending. These assumptions contribute to a much bleaker budgetary outlook and portend an unsustainable path for the growth rate of government debt and entitlement spending [Congressional Budget Office (2011)]. Under the EB scenario, figure 1b shows how the effects of aging and "excess" cost growth contribute to the projected growth in entitlement spending as a percentage of GDP. Since 1975, Medicare costs have grown at an average of 2.3 percentage points faster than per capita GDP. The CBO defines this difference as *excess* cost growth. Over the next 25 years, the CBO projects the effect of aging will account for 64 percent of the growth in entitlement expenditures. By 2085, the effect of cost growth becomes the dominant factor, explaining 71 percent of the spending growth.

APPENDIX B DERIVATIONS

B.1 INDIVIDUAL LAW OF MOTION FOR CONSUMPTION

To derive the individual law of motion for consumption, note that the first order conditions are given by

$$\frac{m_{s,t}}{P_t} = \kappa \frac{R_t}{R_t - 1} c_{s,t}, \tag{A1}$$

$$w_{s,t} = \frac{\chi}{1-\tau_{s,t}} \frac{c_{s,t}}{1-n_{s,t}}, \tag{A2}$$

$$1 = E_t \left\{ q_{t,t+1}(s) \frac{P_t}{P_{t+1}} R_t \right\}, \tag{A3}$$

$$1 = E_t \left\{ q_{t,t+1}(s) \left[(1-\tau_{s,t+1}) R^k_{t+1} + 1 - \delta \right] \right\}, \tag{A4}$$

$$1 = E_t \left\{ q_{t,t+1}(s) \frac{1+\rho P^M_{t+1}}{P^M_t} \frac{P_t}{P_{t+1}} \right\}. \tag{A5}$$

We can use (A3)-(A5) to obtain the following identity:

$$\frac{P^S_t b^S_{s,t}}{P_t} + \frac{P^M_t b^M_{s,t}}{P_t} + k_{s,t} = E_t \left\{ q_{t,t+1}(s) \left[\frac{P_t}{P_{t+1}} R_t k_{s,t} + \frac{b^S_{s,t}}{P_{t+1}} + \frac{(1+\rho P^M_{t+1}) b^M_{s,t}}{P_{t+1}} \right] \right\}.$$

Given (A1), further manipulations then imply

$$\begin{aligned}
&\frac{P^S_t b^S_{s,t}}{P_t} + \frac{P^M_t b^M_{s,t}}{P_t} + \frac{m_{s,t}}{P_t} + k_{s,t} \\
&= E_t \left\{ q_{t,t+1}(s) \left[\frac{P_t}{P_{t+1}} R_t k_{s,t} + \frac{m_{s,t} + b^S_{s,t}}{P_{t+1}} + \frac{(1+\rho P^M_{t+1}) b^M_{s,t}}{P_{t+1}} \right] \right\} + \frac{R_t - 1}{R_t} \frac{m_{s,t}}{P_t} \\
&= E_t \left\{ q_{t,t+1}(s) \left[\left((1-\tau_{s,t+1}) R^k_{t+1} + 1 - \delta \right) k_{s,t} + \frac{m_{s,t} + b^S_{s,t}}{P_{t+1}} + \frac{(1+\rho P^M_{t+1}) b^M_{s,t}}{P_{t+1}} \right] \right\} + \frac{R_t - 1}{R_t} \frac{m_{s,t}}{P_t} \\
&= E_t \left\{ q_{t,t+1}(s) a_{s,t+1} \right\} + \frac{R_t - 1}{R_t} \frac{m_{s,t}}{P_t}.
\end{aligned}$$

Thus, the budget constraint can be rewritten as

$$c_{s,t} + E_t \left\{ q_{t,t+1}(s) a_{s,t+1} \right\} + \frac{R_t - 1}{R_t} \frac{m_{s,t}}{P_t} = \omega_{s,t} + (1-\vartheta)^{-1} a_{s,t}.$$

Note that (A1) implies

$$c_{s,t} + \frac{R_t - 1}{R_t} \frac{m_{s,t}}{P_t} = (1+\kappa) c_{s,t}. \tag{A6}$$

Plugging (A6) into the budget constraint then yields

$$a_{s,t} = (1-\vartheta) E_t \left\{ q_{t,t+1}(s) a_{s,t+1} \right\} + (1-\vartheta)(1+\kappa) c_{s,t} - (1-\vartheta) \omega_{s,t},$$

which can be solved forward to obtain

$$a_{s,t} = (1-\vartheta)^{T-t} E_t \left\{ q_{t,T}(s) a_{s,T} \right\} + (1-\vartheta) \sum_{k=0}^{T-t-1} (1-\vartheta)^k E_t \left\{ q_{t,T}(s) \left[(1+\kappa) c_{s,T} - \omega_{s,T} \right] \right\}.$$

Applying limits, imposing the transversality condition, (5), and re-indexing then implies

$$a_{s,t} = (1-\vartheta) \sum_{T=t}^{\infty} (1-\vartheta)^{T-t} E_t \left\{ q_{t,T}(s) \left[(1+\kappa) c_{s,T} - \omega_{s,T} \right] \right\}. \tag{A7}$$

Using the fact that $\beta^{T-t} c_{s,t} = q_{t,T}(s) c_{s,T}$, (A7) reduces to

$$c_{s,t} = \frac{1-\beta(1-\vartheta)}{1+\kappa} \left[\frac{a_{s,t}}{1-\vartheta} + \sum_{T=t}^{\infty} (1-\vartheta)^{T-t} E_t \left\{ q_{t,T}(s) \omega_{s,T} \right\} \right], \tag{A8}$$

which is identical to (6) in the main text.

B.2 AGGREGATE LAW OF MOTION FOR CONSUMPTION Equation (6) in the main text implies

$$C_t = \xi \left[A_t + \sum_{T=t}^{\infty} (1-\vartheta)^{T-t} E_t \left\{ Q_{t,T} \Omega_T \right\} \right]. \tag{A9}$$

Advancing (A9) one period and multiplying by $(1-\vartheta)Q_{t,t+1}$ gives

$$(1-\vartheta)E_t\{Q_{t,t+1}C_{t+1}\} = \xi \left[(1-\vartheta)E_t\{Q_{t,t+1}A_{t+1}\} + E_t \sum_{T=t+1}^{\infty} (1-\vartheta)^{T-t} \{Q_{t,T}\Omega_T\} \right]. \tag{A10}$$

Following a procedure similar to the individual case, there is a unique aggregate SDF that yields the following intertemporal relationship for a portfolio with random return A_{t+1} at time $t+1$:

$$\frac{P_t^S B_t^S}{P_t} + \frac{P_t^M B_t^M}{P_t} + \frac{M_t}{P_t} + K_t = E_t[Q_{t,t+1}A_{t+1}] + \frac{R_t - 1}{R_t}\frac{M_t}{P_t}.$$

Thus, the aggregate budget constraint can be written as

$$C_t + E_t\{Q_{t,t+1}A_{t+1}\} + \frac{R_t - 1}{R_t}\frac{M_t}{P_t} = \Omega_t + A_t. \tag{A11}$$

Imposing the aggregate counterpart of (A1), (A11) is given by

$$(1+\kappa)C_t + E_t\{Q_{t,t+1}A_{t+1}\} = \Omega_t + A_t,$$

which can be substituted into (A9) to obtain

$$C_t = \xi \left[(1+\kappa)C_t + E_t\{Q_{t,t+1}A_{t+1}\} + \sum_{T=t+1}^{\infty} (1-\vartheta)^{T-t} E_t\{Q_{t,T}\Omega_T\} \right]. \tag{A12}$$

Combining (A10) and (A12) implies

$$\begin{aligned} C_t &= \xi[(1+\kappa)C_t + E_t\{Q_{t,t+1}A_{t+1}\}] + (1-\vartheta)E_t\{Q_{t,t+1}C_{t+1}\} - \xi(1-\vartheta)E_t\{Q_{t,t+1}A_{t+1}\} \\ &= \xi[(1+\kappa)C_t + \vartheta E_t\{Q_{t,t+1}A_{t+1}\}] + (1-\vartheta)E_t\{Q_{t,t+1}C_{t+1}\}. \end{aligned}$$

Solving for aggregate consumption then yields (10) in the main text.

APPENDIX C ANALYTICAL EXAMPLE: FISCAL LIMIT

When fiscal shocks are persistent, the peak of the Laffer curve imposes an *economic* fiscal limit, but it is possible the *political* fiscal limit will bind at a lower tax rate. Using the model in section 3, this section shows how a fiscal limit impacts the equilibrium price level by imposing an exogenous tax rate, τ^{FL}, that binds after date T. Government transfers follow (30) for all periods. At the fiscal limit, the monetary authority switches from active to passive policy to stabilize debt.

To solve for the equilibrium market value of debt, first rewrite (33) as a difference equation using the pre-fiscal limit tax rule, (29). Then solve for the current market value of debt, iterate forward, and use (33) to substitute for the expected market value of debt at time $T-1$ to obtain

$$\hat{P}_t^M + \hat{b}_t^M = \begin{cases} -\left[\left(\frac{1}{1-\gamma\tilde{\beta}\tilde{\tau}} \right)^{T-t-1} \frac{(\tilde{\beta}\rho_Z^S)^{T-t}}{1-\tilde{\beta}\rho_Z^S} + \sum_{k=1}^{T-t-1} \left(\frac{\tilde{\beta}\rho_Z^S}{1-\gamma\tilde{\beta}\tilde{\tau}} \right)^k \right] \tilde{Z}\hat{Z}_t, & \text{for } t < T, \\ -\frac{\tilde{\beta}\rho_Z^S}{1-\tilde{\beta}\rho_Z^S}\tilde{Z}\hat{Z}_t, & \text{for } t \geq T. \end{cases} \tag{A13}$$

Regardless of whether agents are finitely lived, the presence of a fiscal limit prevents the fiscal authority from fully meeting its tax obligations, which makes agents feel wealthier, distorts decision rules, and breaks down Ricardian equivalence. This occurs even though the pre-fiscal limit policy mix exhibits Ricardian equivalence when agents are infinitely lived (section 3.1).

Two other results carry over from the representative agent model. First, higher transfers reduce the market value of debt. This result follows from the intertemporal equilibrium condition, (33), which shows that any increase in transfers reduces the discounted present value of primary surpluses, and therefore equilibrium debt. Second, the strength of the fiscal response to changes in debt, γ, impacts equilibrium real debt even if the probability of death is zero. This follows from the break-down of Ricardian equivalence, but is surprising since the timing of taxes is irrelevant when active monetary/passive fiscal policies are permanent and agents are infinitely lived.

When agents face shorter planning horizons (a higher probability of death), wealth effects from changes in government debt are magnified and the market value of debt is more sensitive to government transfers shocks. Monetary policy targets also affect the market value of debt, since both the interest rate and inflation targets impact the value of real government liabilities.

To determine the unique price level, rearrange the government budget constraint, (27), to obtain

$$\hat{P}_t = \hat{B}^M_{t-1} + \rho P^S \hat{P}^M_t + Q[\hat{P}^M_t + \hat{b}^M_t + \tilde{\tau}\hat{\tau}_t - \tilde{Z}\hat{Z}_t]. \tag{A14}$$

In general, the sequences of equilibrium prices cannot be solved for analytically, since the long-bond price is dependent on the entire path of future nominal interest rates. However, in the special case where only one-period government debt is issued, the complete trajectory of prices, real debt, and inflation prior to the fiscal limit can be solved for recursively, given $R_{-1}, B^M_{-1} > 0$. After the fiscal limit, the economy evolves according to the fixed regime considered in section 3.2.

It is useful to simulate the equilibrium paths of real debt and inflation to obtain a clearer picture of how the presence of a fiscal limit and intergenerational transfers of wealth affect equilibrium dynamics. Figure 12 isolates the effect of a fiscal limit by comparing the model with permanent passive monetary/active fiscal policy (section 3.2) to the model where active monetary/passive fiscal policy holds until a fiscal limit is hit with certainty at date $T = 50$ and policy permanently switches to passive monetary/active fiscal policy.[26]

Prior to the fiscal limit equilibrium debt and inflation are more volatile when a fiscal limit looms, since agents base their expectations on long-run policies. In a permanent active monetary/passive fiscal regime, the monetary authority aggressively targets inflation and the fiscal authority adjusts current and future taxes to stabilize debt. When a fiscal limit is present, the influence of the post-fiscal limit regime prevents the fiscal authority from fully meeting its obligations. Thus, debt deviates widely from target, and since the price level is determined by fluctuations in real debt, inflation also deviates from target. As the fiscal limit approaches, the discrepancy between the two models slowly dissipates, and from time $T = 50$ onward the equilibrium paths are identical, since forward-looking agents have completely accounted for the anticipated policy adjustment.

Figure 12 also plots expected inflation. Prior to the fiscal limit, expected inflation is given by

$$E_t\hat{\pi}_{t+1} = \phi\hat{\pi}_t - \mu\hat{b}_t. \tag{A15}$$

[26] The baseline calibration is as follows: The structural parameters are set to $\beta = 0.9615$ (4 percent real interest rate) and $\vartheta = 0.06$ [Leith and Wren-Lewis (2000)]. Prior to the fiscal limit $\phi = 1.5$ and $\gamma = 0.15$. After the fiscal limit is hit, $\phi = \gamma = 0$. Steady state values are set to $\bar{\tau} = 0.19$, $\bar{Z} = 0.17$, $\bar{\pi} = 1.02$, and $\bar{b}/\bar{Y} = 0.5$, which implies $\mu = 0.0032$. The parameters of the transfers process are set to $\rho^S_Z = 0.9$ and $\sigma_Z = 0.002$.

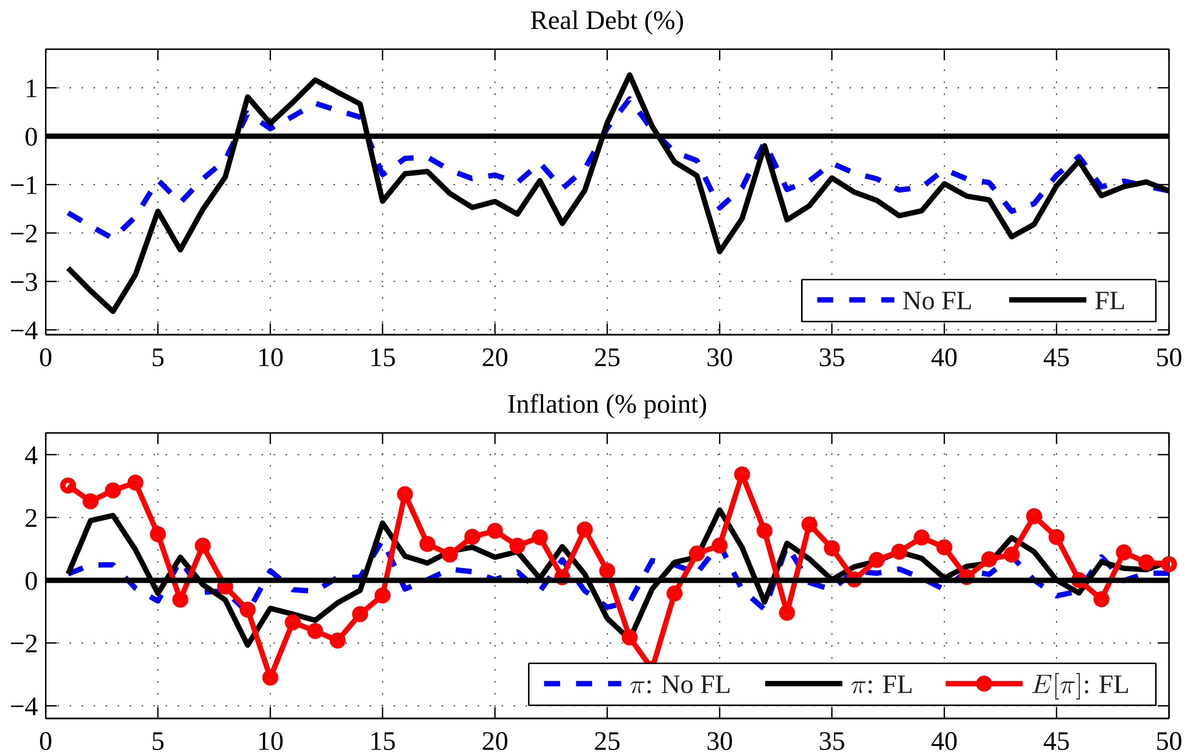

Figure 12: Equilibrium real debt and inflation across two models: one with permanent passive monetary/active fiscal policy (solid lines) and another where active monetary/passive fiscal policy holds until a fiscal limit is hit with certainty at date $T = 50$ and policy permanently switches to passive monetary/active fiscal policy (dashed lines). Reported values are based on a particular realization of transfers and are in deviations from the deterministic steady state.

Expected inflation also fluctuates with government debt and is more volatile than realized inflation. When the monetary authority adjusts the nominal interest rate more than one-for-one with inflation ($\phi > 1$), any deviation of realized inflation from target amplifies the deviation of expected inflation from target. Demand-side effects from changes in real debt cause agents to be systematically incorrect in their inflation forecasts, even though agents are constantly revising their expectations and reacting to changes in realized inflation. Shorter planning horizons dampen the fluctuations in expected inflation, since agents demand higher interest rates to hold additional debt, but this effect is dominated by fluctuations in realized inflation. At the fiscal limit, the monetary authority stabilizes debt by pegging the nominal interest rate. At this point, fluctuations in expected inflation are no longer amplified by realized inflation, but still fluctuate (negatively) with real debt.

In a fixed active monetary/passive fiscal regime, a fiscal authority that more aggressively adjusts taxes with changes in real debt (higher γ), reduces the volatility of real debt and inflation from transfers shocks. In contrast, when the fiscal authority faces a fiscal limit, (A13) shows that a higher γ increases the volatility of real debt, which leads to more volatile realized and expected inflation. The effectiveness of monetary policy is also compromised by the presence of a fiscal limit. In a fixed active monetary/passive fiscal regime, a monetary authority that more aggressively targets inflation (higher ϕ), helps to stabilize prices more quickly. However, when a fiscal limit looms, more aggressive monetary policy has no effect on real debt or realized inflation and increases the volatility of expected inflation before the fiscal limit. Both of these results are due to the fact that agents' expectations are guided by passive monetary/active fiscal policy. In this regime, prices

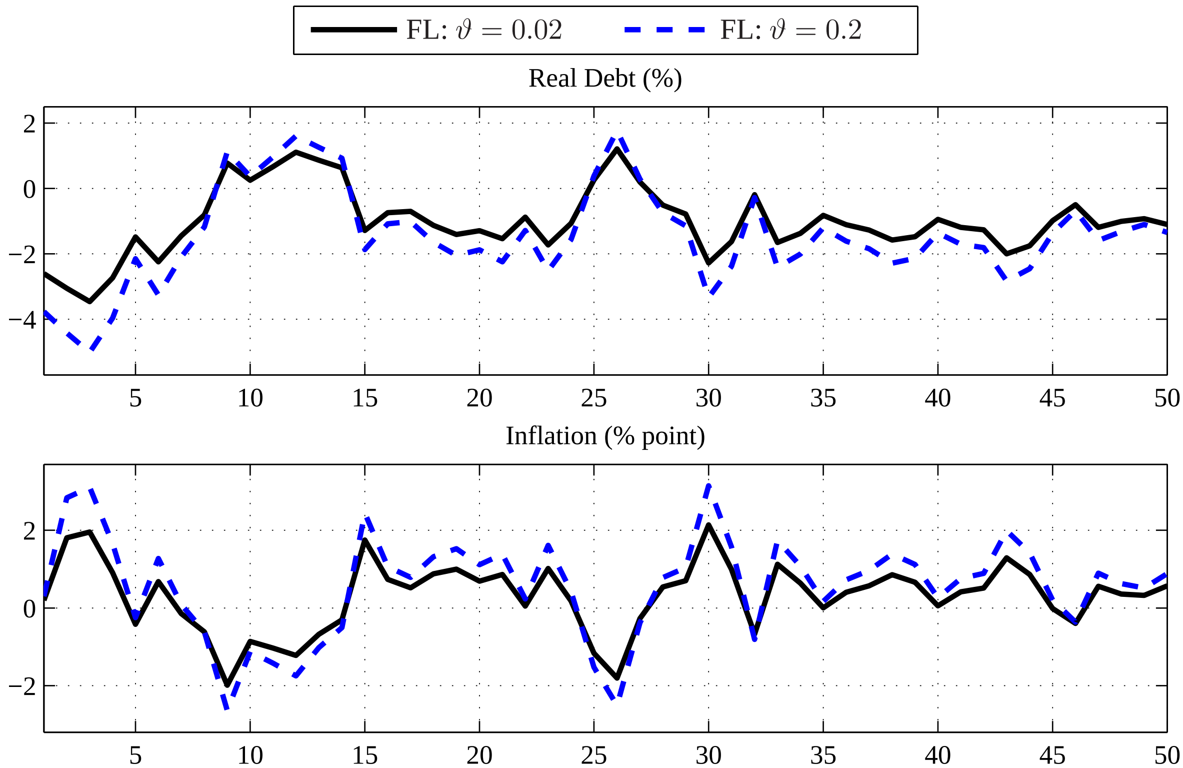

Figure 13: Equilibrium real debt and inflation across two probabilities of death: $\vartheta = 0.02$ (50 year planning horizon) and $\vartheta = 0.2$ (5 year planning horizon). All other parameters are identical to the baseline model. Equilibrium paths correspond to the model where the fiscal limit binds at $T = 50$. Reported values are based on a particular realization of transfers and are in deviations from the deterministic steady state.

are pinned down by the fiscal authority instead of the monetary authority. Thus, when the fiscal authority pursues a more passive policy before the fiscal limit, neither authority stabilizes prices, since monetary policy (aside from its targets) has no influence on the value of debt and inflation.

The probability of death, ϑ, pins down agents' planning horizons. Figure 13 illustrates the effect of reducing the planning horizon from fifty ($\vartheta = 0.02$) to five years ($\vartheta = 0.2$). Although this change is extreme, it shows how intergenerational transfers of wealth impact the volatility of real debt and inflation. When agents' planning horizons are shortened, fluctuations from target are stronger and the monetary authority's ability to control current and future inflation is weakened regardless of the presence of a fiscal limit. Greater volatility stems from the wealth effects created by transfers shocks. When agents restrict their planning horizons, government liabilities are seen as (net) wealth, and agents require higher real interest rates to induce them to hold additional debt. Thus, any increase in transfers increases the volatility of debt and inflation. Moreover, these results are magnified when accounting for higher order terms.

APPENDIX D NUMERICAL ALGORITHM

Policy function iteration is implemented with the following algorithm:

1. Perform the following initializations:
    - Define the parameters of the model according to their calibrated values (table 1) and specify a convergence criterion for the policy functions (a value no greater than $1 \times$

10^{-6}). Set the variance of the transfers shock, σ_Z^2, to 4×10^{-6}.

- Calculate the deterministic steady state of the model, conditional on the initial policy mix ($S_P = 1, S_Z = 1$).
- Discretize the state space in a manner that ensures adequate coverage over the simulation horizon. The minimum state is given by $\{m_{t-1}, b_{t-1}^M, K_{t-1}, Z_t, S_{P,t}, S_{Z,t}\}$.

2. Obtain initial conjectures for the policy functions, given by $\Theta_t = \{N_t, \pi_t, K_t, P_t^M, Q_{t,t+1}\}$. One approach is to first solve the linear model under both the initial (AM/PF/AT) and debt revaluation (PM/AT/AT) regimes using Sims (2002) `gensys` algorithm. Then use these linear solutions as initial guesses for the corresponding fixed-regime non-linear models, assuming there is no probability of hitting the fiscal limit. Finally, use weighted averages of these non-linear solutions to obtain initial conjectures for each regime combination (3 policy states and 2 transfers states form 6 combinations) in the model described in section 2.

3. Given values for each node (points in the discretized state space), find the updated policy functions that satisfy the equilibrium conditions of the model. Using the original policy function guess or the solution from the previous iteration, first calculate updated (time $t+1$) values for each of the policy variables using piecewise linear interpolation/extrapolation. Then solve for the variables necessary to calculate expectations and apply numerical integration (figure 14 illustrates the range of outcomes that must to be considered) using the Trapezoid rule outlined in (Judd, 1998, chap. 7). Using Chris Sims' root finder, `csolve`, solve for the zeros of the equations with embedded expectations, subject to each of the remaining equilibrium conditions. The output of `csolve.m` on each node are policy values that satisfy the equilibrium system of equations to a specified tolerance level. This set of values characterizes the updated policy functions for the next iteration.

4. If the maximum improvement for all policies over all nodes in the discretized state space is less than the convergence criterion, then the policy functions have converged to their equilibrium values at all nodes. Otherwise, repeat step 3 using the updated policy functions as the initial policy functions until convergence is achieved. When the algorithm is running properly, the policy functions will monotonically converge to the specified tolerance level. To provide evidence that the solution is locally unique, perturb the converged policy functions in several dimensions and check that the algorithm converges back to the same solution.[27]

APPENDIX E DIFFERENTIATED CAPITAL AND LABOR TAX RATES

In the baseline model, identical tax rates are levied against capital and labor income. This section grants the fiscal authority the flexibility to differentiate between these rates.

Figure 15 describes how policy evolves. The economy begins in "normal times" when the monetary authority aggressively targets inflation (AM) and the fiscal authority passively adjusts capital (PKT) and labor (PNT) tax rates to stabilize debt and meet its (stationary) transfers commitments

[27] One concern is whether this solution method consistently satisfies the transversality conditions, since it only iterates on the policy functions and has no formal mechanism for imposing these restrictions. As a safeguard, however, I simulate the model for thousands of periods and check that its average asset levels (i.e. capital, money, and bonds) are convergent. Moreover, it is easy to show that simulated paths in models that explicitly violate the transversality condition will typically diverge even if the algorithm converges. Although these exercises do not provide proof, they do provide reasonable confidence that transversaility conditions are met.

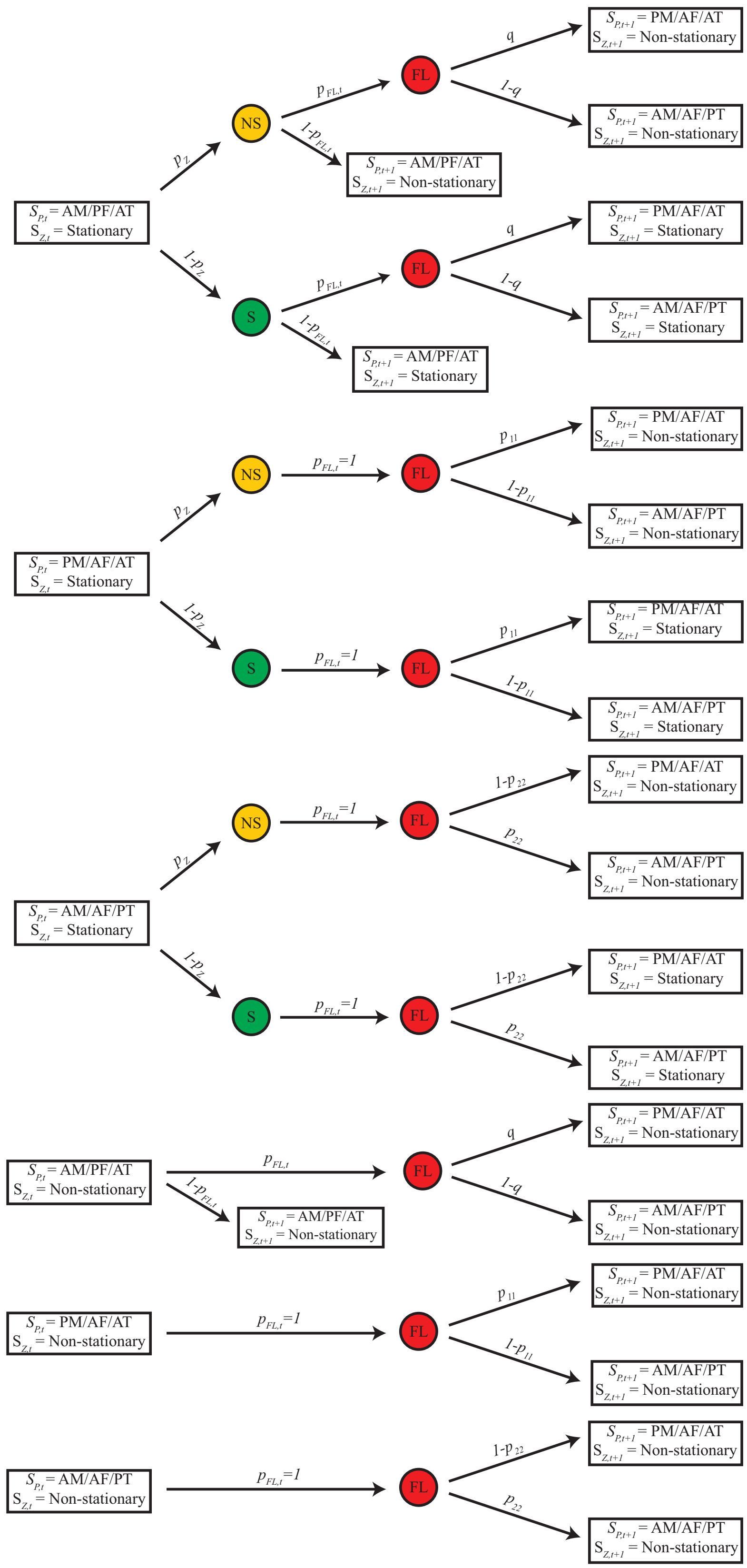

Figure 14: The range of outcomes accounted for during numerical integration (single tax rate).

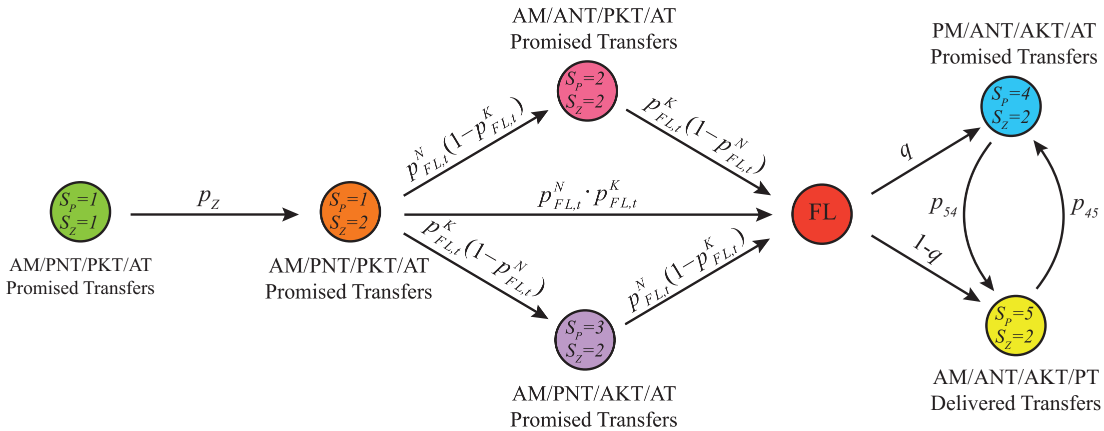

Figure 15: Possible evolution of monetary and fiscal policy regimes with differentiated tax rates. FL: fiscal limit, AM: active monetary policy, PM: passive monetary policy, ANT: active labor tax policy, AKT: active capital tax policy, PNT: passive labor tax policy, PKT: passive capital tax policy, AT: active transfers, PT: passive transfers.

(AT). Specifically, the monetary authority sets the short-term nominal interest rate according to

$$R_t = \begin{cases} \bar{R}(\pi_t/\pi^*)^{\phi}, & \text{for } S_{P,t} \in \{1,2,3,5\}, \\ \bar{R}, & \text{for } S_{P,t} = 4, \end{cases} \tag{A16}$$

and the fiscal authority sets capital and labor tax rates according to

$$\tau_t^N = \begin{cases} \bar{\tau}^N \left(b_{t-1}^M/(b^M)^*\right)^{\gamma_N}, & \text{for } S_{P,t} \in \{1,3\} \text{ (if the labor tax limit does \textit{not} bind)}, \\ \tau_N^{FL}, & \text{for } S_{P,t} \in \{2,4,5\} \text{ (if the labor tax limit binds)}, \end{cases} \tag{A17}$$

and

$$\tau_t^K = \begin{cases} \bar{\tau}^K \left(b_{t-1}^M/(b^M)^*\right)^{\gamma_K}, & \text{for } S_{P,t} \in \{1,2\} \text{ (if the capital tax limit does \textit{not} bind);} \\ \tau_K^{FL}, & \text{for } S_{P,t} \in \{3,4,5\} \text{ (if the capital tax limit binds)}, \end{cases} \tag{A18}$$

where $\bar{\tau}^K$ and $\bar{\tau}^N$ are the steady state capital and labor tax rates.[28] Government transfers continue to evolve according to (16). Once transfers begin to follow an explosive trajectory, capital and labor taxes steadily rise. As political resistance mounts, the probabilities of capital and labor tax rates hitting their respective fiscal limits rise according to

$$p_{FL,t}^N = 1 - \frac{\exp(\eta_0^N - \eta_1^N(\tau_{t-1}^N - \bar{\tau}^N))}{1+\exp(\eta_0^N - \eta_1^N(\tau_{t-1}^N - \bar{\tau}^N))} \tag{A19}$$

and

$$p_{FL,t}^K = 1 - \frac{\exp(\eta_0^K - \eta_1^K(\tau_{t-1}^K - \bar{\tau}^K))}{1+\exp(\eta_0^K - \eta_1^K(\tau_{t-1}^K - \bar{\tau}^K))}, \tag{A20}$$

[28]Following Leeper et al (2010), steady state capital and labor taxes are set to $\bar{\tau}^K = 0.184$ and $\bar{\tau}^N = 0.223$. When capital and labor taxes do not bind, the fiscal authority responds to government debt with reaction coefficients $\gamma_K = 0.20$ and $\gamma_N = 0.15$. The post-fiscal limit capital and labor tax rates are $\tau_K^{FL} = 0.225$ and $\tau_N^{FL} = 0.265$.

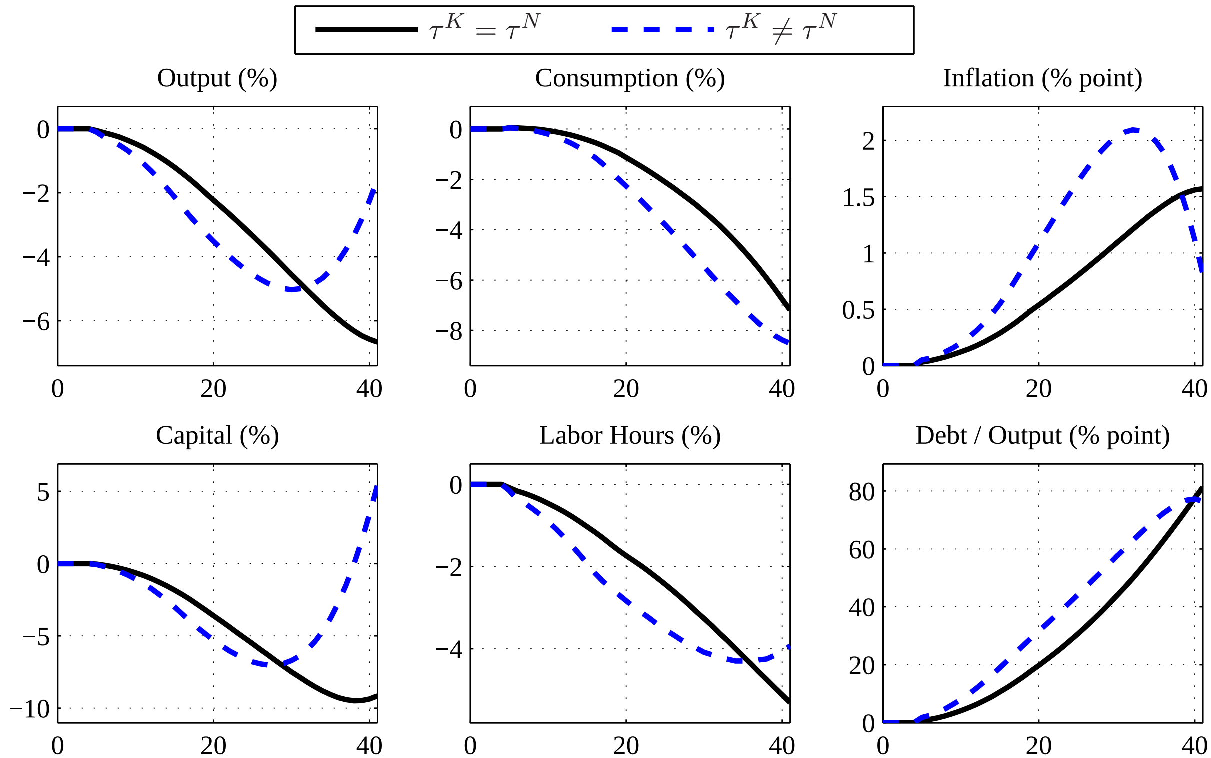

Figure 16: Responses to government transfers switching to a non-stationary path ($S_Z = 2$) in period 5, conditional on active monetary/passive capital tax/passive labor tax/active transfers policy remaining in place after the fiscal limit is hit. All values represent deviations from the corresponding simulation's stochastic steady state.

where η_0^i and $\eta_1^i > 0$, $i \in \{K, N\}$, are the intercept and slope of the logistic functions.[29] This setup adds a layer complexity to the evolution of fiscal policy, since capital and labor taxes can hit their respective fiscal limits at different dates. The capital [labor] tax rate hits its limit prior to the labor [capital] tax rate with probability $p^K_{FL,t}(1 - p^N_{FL,t})$ $[p^N_{FL,t}(1 - p^K_{FL,t})]$. In this event, the fiscal authority continues to passively adjust the labor [capital] tax rate with the size of government debt. As government debt continues to grow, opposition to this policy quickly mounts and eventually the labor [capital] tax rate hits its fiscal limit. Capital and labor tax rates reach their limits at the same time with probability $p^K_{FL,t} \cdot {}^N_{FL,t}$. Regardless of the timing, both tax rates eventually hit their fiscal limits and either monetary or fiscal policy adjusts as described in section 2.[30]

Figure 16 shows how the transition paths in figure 6 change when capital and labor tax limits bind at different dates. The possibility that the fiscal authority only has capital or labor taxes available as a debt financing mechanism prior to the fiscal limit increases the growth rate of government debt. More rapidly rising debt increases tax rates, which further distorts capital and labor markets and increases the probability of reaching the fiscal limit—the point at which *both* capital and labor tax rates hit their limits. This has two primary implications. First, it creates a greater likelihood of debt revaluation, which increases inflation growth. Second, it increases the weight that agents place on the capital tax rate hitting its limit, which increases the expected after-tax return on capital.

[29]The logistic functions are calibrated so that there is a 2 percent probability of both tax rates hitting their limits (14 percent probability of either rate hitting its limit) in the deterministic steady state and a 5 percent probability when $\tau^i = \tau_i^{FL}$ (22 percent probability of either rate hitting its limit), which is consistent with the baseline calibration.

[30]The expected duration of the debt revaluation and reneging regimes remains the same ($p_{44} = 0.9$ and $p_{55} = 0.99$).

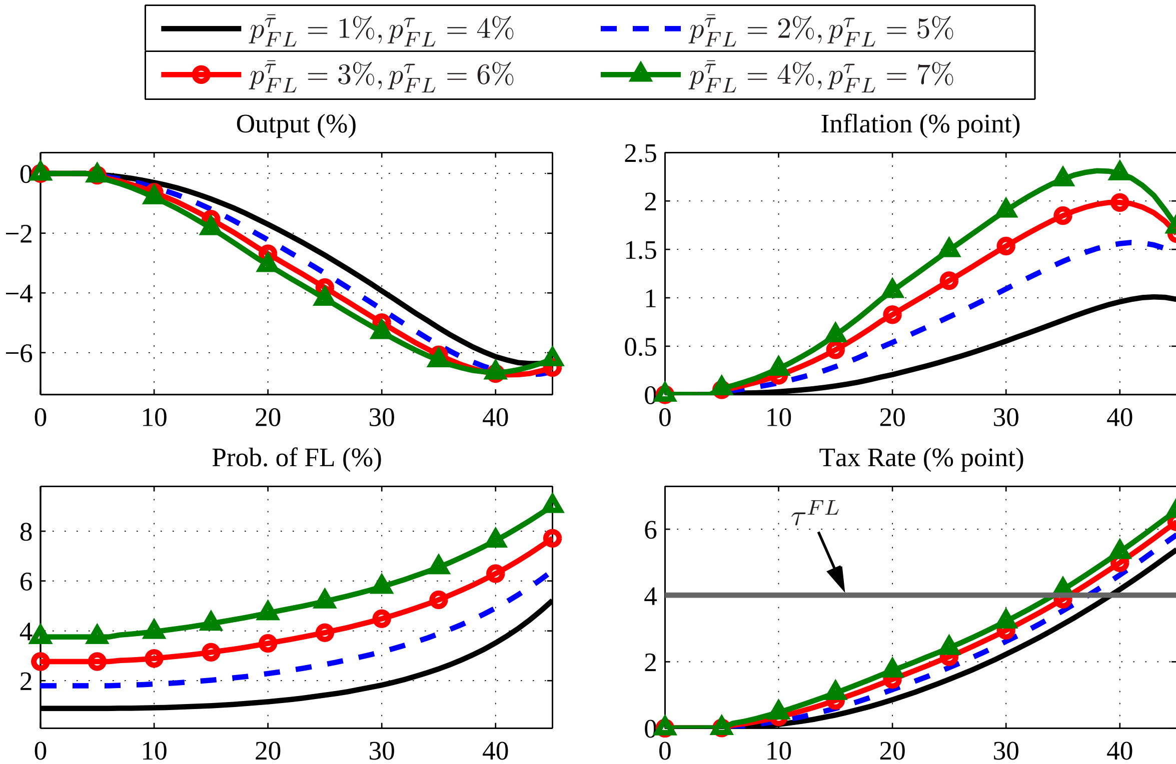

Figure 17: Responses to government transfers switching to a non-stationary path ($S_Z = 2$) in period 5, conditional on active monetary/passive capital tax/passive labor tax/active transfers policy remaining in place after the fiscal limit is hit. Responses are distinguished by the probability of hitting the fiscal limit. There is a $\{1\%, 2\%, 3\%, 4\%\}$ probability of reaching the fiscal limit when $\tau = \bar{\tau}$ and a $\{4\%, 5\%, 6\%, 7\%\}$ probability when $\tau = \tau^{FL}$. The grey line is the post-fiscal limit tax rate. All values represent deviations from the corresponding simulation's stochastic steady state.

Once this effect dominates the effect of rising capital tax rates, investment steadily rises. Rising aggregate supply reduces marginal costs and propels inflation on a downward trajectory.

Overall, the expectational effects of the fiscal limit are magnified and brought closer to the present when capital and labor tax rates bind at different dates. Although proportional taxes distort capital and labor markets, these results make clear that any expectation that Congress is unwilling to use both taxes to finance debt increases the negative economic effects of looming fiscal stress.

APPENDIX F PROBABILITY OF THE FISCAL LIMIT

The probability of reaching the fiscal limit is governed by the logistic function specified in (19). Without being able to point to historical episodes to calibrate the intercept, η_0, or slope, η_1, of the logistic function, it is worthwhile to examine how these parameters affect the qualitative results. Under the baseline calibration, there is a 2% probability of reaching the fiscal limit when $\tau = \bar{\tau}$ and a 5% probability when $\tau = \tau^{FL}$. Figure 17 shows how equilibrium outcomes are affected when these probabilities change to $\{1\%, 4\%\}$, $\{3\%, 6\%\}$, and $\{4\%, 7\%\}$, respectively.

Higher probabilities of reaching the fiscal limit are associated with greater inflation due to a higher likelihood of moving to a regime where debt is revalued. This has two immediate effects. First, it forces nominal interest rates higher and drives up real debt, since the monetary authority aggressively targets inflation prior to the fiscal limit. Second, when agents are finitely lived, it causes a shift in real wealth from current to future generations. Both of these effects reduce

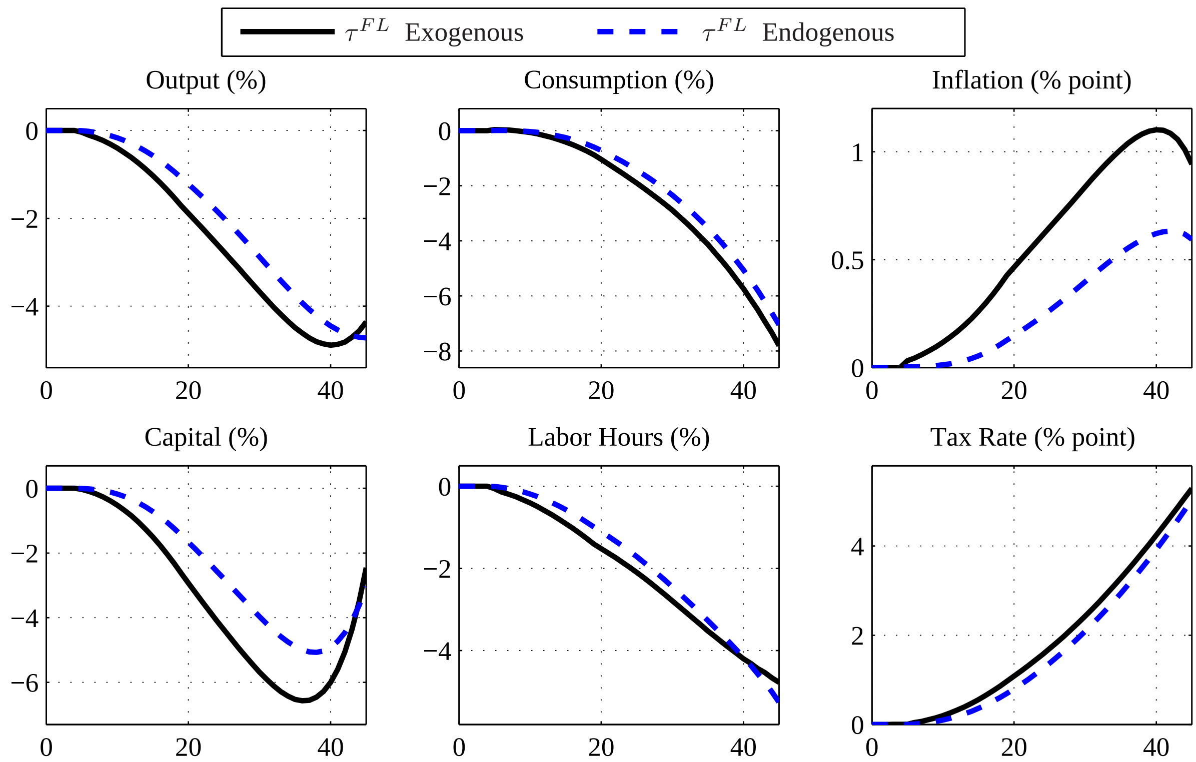

Figure 18: Responses to government transfers switching to a non-stationary path ($S_Z = 2$) in period 5, conditional on active monetary/passive tax/active transfers policy remaining in place after the fiscal limit is hit. The probability of death, ϑ, is set to zero. Responses are distinguished by the treatment of the post fiscal limit tax rate. All values represent deviations from the corresponding simulation's stochastic steady state.

investment and hours worked, which leads to more drastic reductions in output.

As discussed in the main text, the expectation of lower tax rates after the fiscal limit increases the after-tax return on capital, which reverses the trajectories of the capital stock, output, and inflation. With a greater prospect of reaching the fiscal limit, this expectational effect is much stronger and quicker to take effect. Overall, a higher probability of hitting the fiscal limit increases the volatility of aggregate outcomes—stagflation is more severe, but less persistent.

APPENDIX G ENDOGENOUS POST-FISCAL LIMIT TAX RATE

In the baseline model, agents have perfect foresight over the post fiscal limit tax rate, τ^{FL}. This simplifying assumption imposes the undesirable feature that taxes exogenously jump to τ^{FL} when the economy hits its fiscal limit. A more reasonable approach is to set τ^{FL} to the current tax rate when the fiscal limit is actually hit. Since agents face uncertainty over the timing of the fiscal limit, this approach forces agents to condition on a broad set of post-fiscal limit tax rates.

Figure 18, shows how the counterfactual in figure 6 changes when agents face uncertainty about τ^{FL}.[31] When τ^{FL} is endogenous, agents no longer place positive probability on taxes jumping to the post-fiscal limit tax rate. Instead, when government transfers switch to a non-stationary path, agents place positive probability on the fiscal limit being hit when the tax rate is relatively low. This lowers agents' expected future tax burden and increases incentives to invest. A relatively

[31] I temporarily set the probability of death to zero to isolate the effect of adding uncertainty over τ^{FL}.

higher capital stock increases output and keeps inflation initially lower.

Investment depends on the expected present values of capital tax rates. At each date t, this present value is a number that comes from weighting all future tax rates by their probability. These weighted tax rates are then discounted, with the heaviest discount placed on the more distant future periods. When the probability of the fiscal limit is small, only the discounting matters because agents are expecting to remain in the passive tax policy regime for the relevant horizon and switching to the fiscal limit occurs so far in the future that the post-fiscal limit tax rate is heavily discounted. As the probability of hitting the fiscal limit increases, agents believe it is more likely that the tax rate will be fixed at its current $(t-1)$ level and, as a consequence, much higher future rates get discounted by both the small probability of not hitting the fiscal limit and by the discount factor. Once agents beliefs about the fiscal limit dominate the effects of discounting, agents expect a lower tax burden and investment tilts upward. Steadily rising investment eventually dominates the falling labor supply, propelling output upward and reducing inflation. Thus, the qualitative expectational effects of the fiscal limit are identical to the case where τ^{FL} is exogenous.

Although the treatment of the post-fiscal limit tax rates quantitatively alters the equilibrium paths in the counterfactual, it has very little impact on the range of time paths that occur when simulating the model. Moreover, the degree of reneging and the tail risk of inflation are nearly identical. This is because the average date that the fiscal limit is hit, and therefore the average post-fiscal limit tax rate, is consistent with the exogenously specified post-fiscal limit tax rate. Considering its computational simplicity, these findings make the baseline specification very attractive.