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Fiscal Policy and Real Interest Rates

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Fiscal Policy and Real Interest Rates*

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Abstract

We employ a new class of general equilibrium models with partially unfunded debt, as proposed in Bianchi et al. (2023), to study the relation between real interest rates and fiscal policy. Unfunded fiscal shocks generate a decline in real interest rates, while funded fiscal shocks cause an increase. We use the model to assess the historical path of real interest rates in the United States, traditionally a key driver of international real interest rates. We find that the fiscal real interest rate, defined as the component of the real rate related to unfunded fiscal shocks, accounts for a large share of the low-frequency movements in real interest rates. This suggests that fiscal policy will play a key role in determining the future path of real interest rates.

JEL Codes: E50, E62, E30.

Keywords: Unfunded fiscal spending, persistent inflation, large public debt, inflation risk, shock-specific rule.

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1 Introduction

Monetary policy in the United States has been shown to have large effects on foreign economies and financial cycles (Rey, 2013). This analysis typically focuses on business cycle fluctuations. Bianchi et al. (2022) show that because of structural changes in the Fed's implicit inflation target and level of activism, US monetary policy can also account for decades-long movements in real interest rates and asset prices. However, Bianchi et al. (2022) leave the *reasons* for these shifts in the tolerable level of inflation unexplained. In this paper, we conjecture that, at least in part, these changes can be explained by the interaction between monetary and fiscal policy and study the implications of such interaction for low-frequency movements in real interest rates.

We employ a new class of general equilibrium models with partially unfunded debt, as proposed in Bianchi et al. (2023), to study the relation between real interest rates and fiscal shocks. Unfunded fiscal shocks are not backed by future fiscal adjustments and generate a decline in real interest rates, while funded fiscal shocks cause an increase in real interest rates. We use the model to assess the historical path of real interest rates in the United States, traditionally a key driver of international real interest rates. We find that unfunded fiscal shocks have historically played a significant role in explaining low-frequency changes in real interest rates.

To keep the paper self-contained, we first briefly review the distinction between funded and unfunded fiscal shocks. To isolate the key mechanism, we consider only shocks to transfers under the assumption of non-distortionary taxation. Funded fiscal shocks are assumed to be backed by future fiscal adjustments, while unfunded fiscal shocks are not. The central bank accommodates these shocks by responding less than one-to-one to the resulting movement in inflation. We study the propagation of these shocks in two production economies. In the first economy, prices are flexible. Funded fiscal shocks are irrelevant for inflation, while unfunded fiscal shocks cause an increase in inflation accommodated by the central bank. However, under flexible prices, real variables are not affected by inflation, and the real interest rate does not respond to an unfunded fiscal shock to transfers. Allowing the central bank to partially respond to fiscal inflation delivers a more persistent inflation response, while introducing a maturity structure tempers the size of the initial jump, but in both cases the real interest rate remains the same.

In the second economy, featuring nominal rigidities, the strict separation between the nominal and real side of the economy does not hold and unfunded fiscal shocks have real effects. Specifically, an unfunded fiscal shock to transfers generates a persistent increase in inflation, a persistent decline in real interest rates, and an increase in real activity. Given that the increase in inflation is front-loaded, a persistent unfunded fiscal shock generates a decline, as opposed to an increase, in the debt-to-GDP ratio. Instead, funded fiscal shocks are still neutral and they do not affect the real economy and real interest rates because of the assumption of non-distortionary taxation. As explained in detail below, this result changes once richer models featuring distortionary taxation or hand-to-mouth agents are considered.

We follow Bianchi et al. (2023) and embed funded and unfunded fiscal shocks to transfers into a quantitative Two-Agent New Keynesian (TANK) model. As before, the two shocks differ with respect to whether or not they are backed by future tax adjustments. The model also features hand-to-mouth agents. Thus, funded fiscal shocks also influence macroeconomic dynamics and real interest rates. Bianchi et al. (2023) show that unfunded fiscal shocks are important to understand persistent movements in inflation in the United States, including the post-pandemic surge in inflation. In this paper, we are mostly interested in their impact on real interest rates, especially with respect to other fiscal shocks. With this goal in mind, we extend the sample to 2024:Q2 and focus our analysis on the relation between real interest rates and unfunded fiscal shocks.

The key insight is that unfunded fiscal shocks generate an increase in inflation and a decline in real interest rates, while funded fiscal shocks generate a modest increase in inflation *and* real interest rates. This is because when the fiscal shock to transfers is funded, the presence of hand-to-mouth agents generates inflationary pressure that the central bank counteracts with a more than one-to-one increase in the policy rate. Unfunded shocks to transfers generate additional inflationary pressure because they are not backed by future tax adjustments. The central bank allows inflation to rise, causing real interest rates to fall instead of rise.

With this understanding of the heterogeneous consequences of funded and unfunded fiscal shocks, we turn to analyze their importance for historical changes in the real interest rate, focusing especially on the post-pandemic period. In what follows, we refer to the level of inflation and real interest rates implied by unfunded fiscal shocks as *fiscal inflation* and *fiscal real interest rates*, respectively. While unfunded fiscal shocks generate large movements in real interest rates, we find that the historical contribution of funded fiscal shocks to changes in the real interest rate has been modest, despite the presence of hand-to-mouth agents.

In the 1960s and 1970s, large unfunded shocks to spending caused a large and persistent decline in real interest rates of around 6%. These are the years during which expected spending in the United States increased significantly due to the introduction of the Great Society Initiatives. Thus, a large share of the record-low real interest rates of the 1960s and 1970s can be explained by unfunded fiscal shocks that were accommodated by the central bank. These dynamics started reverting in the mid-1970s, as no new large unfunded fiscal shocks occurred. The increase in fiscal real interest rates accelerated in the early 1980s, during the Volcker disinflation. Overall, between the mid-1970s and 1982, fiscal real interest rates increased by around 6%, with a visible acceleration in the early 1980s. This is consistent with the Volcker disinflation being a monetary *and* fiscal phenomenon, as explained in more detail in Bianchi and Ilut (2017) and Bianchi et al. (2023). After this large increase, fiscal real interest rates remained fairly constant until the post-Millennial period, when they declined by around 1%. The zero lower bound period was characterized by a further decline, but with higher volatility. During the pandemic, fiscal real interest rates fell to a historic low, as the Federal Reserve partially accommodated the inflationary pressure coming from two extremely large fiscal stimuli. Finally, as 2024, fiscal real interest rates are back to levels similar to the pre-pandemic period. This is consistent with the fact that no additional large fiscal shocks occurred after the ARPA fiscal stimulus.

Based on these results, we conclude that unfunded spending has played an important role in accounting for changes in the real interest rate, both historically and in the post-pandemic period. Thus, the outlook for future real interest rates depends in large part on the interaction between monetary and fiscal policy. Real rates will be larger if future spending shocks are perceived as backed by future fiscal adjustments. However, if a conflict between the goal of inflation stability and large spending programs were to arise, fiscal real interest rates could drop quickly. Of course, other factors will also play a role. In the pre-pandemic period, external forces, such as the increasing level of integration of the global economy, contributed to keeping inflation and real interest rates low. If these forces were to disappear, the high levels of fiscal inflation observed in the post-Millennial period could become a problem. This might cause a sudden shift in real interest rates, similar to the early 1980s. However, unlike in the 1980s, the debt-to-GDP ratio is now at a historic high. This creates a risk of fiscal stagflation, if the monetary and fiscal authorities fail to coordinate (Bianchi and Melosi, 2019, 2023).

This paper is part of a well-established literature on monetary and fiscal policy interaction. Key contributions are Sargent and Wallace (1981), Leeper (1991), Sims (1994), Woodford (1994, 1995, 2001), Cochrane (1998, 2001), Schmitt-Grohe and Uribe (2000), Bassetto (2002), Benhabib et al. (2002), and Bassetto and Sargent (2020). Hall and Sargent (2011) consider an historical decomposition of movements in the US debt-to-GDP ratio. They find that debt stabilization has been achieved through a combination of growth, revaluation effects, and low real interest rates, while fiscal adjustments play a relatively minor role. Bianchi and Ilut (2017) build and estimate a model with regime changes in the monetary/fiscal policy mix. They show that the high inflation of the 1960s and 1970s can be explained by large spending shocks combined with a Fiscally-led regime that was in place at that time. Bianchi and Melosi (2017, 2022) argue that the possibility of a return to such a regime can explain the lack of deflation in the aftermath of the Great Recession and the large spur in inflation in the post-pandemic period. Barro and Bianchi (2023) consider a large panel of OECD countries to show that the cross-sectional variation in post-pandemic inflation can largely be explained by differences in the increase in spending, rescaled by the amount and duration of outstanding debt.

2 Fiscal shocks and real interest rates

To keep the paper self-contained, we explain in detail the distinction between funded and unfunded fiscal shocks introduced in Bianchi et al. (2023). Bianchi et al. (2023) develop a new class of models in which a monetary-led and a fiscally-led policy mix coexist at the same time. In these models, shocks propagate differently based on the shock-specific policy response. We first explain how the two types of shock can coexist using a simple Fisherian model. We then employ a production economy to highlight that under nominal rigidities unfunded fiscal shocks can generate movements in real interest rates in a representative agent economy with non-distortionary taxation. We closely follow Bianchi et al. (2023). More details can be found in that paper and its various appendices.

2.1 Funded and unfunded fiscal shocks

Fisherian model Consider an endowment economy in which a representative infinitely lived household aims to maximize utility, while the government can provide a subsidy or collect taxes in each period. The representative household has concave and twice continuously differentiable preferences over non-storable consumption goods and in each period receives a constant endowment Y of these goods. The government issues one-period debt B_t that can be used by households to smooth consumption over time. The representative household chooses consumption and government bonds so as to maximize:

$$\max \ \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U\left(C_t\right),$$

subject to the flow budget constraint $P_tC_t + Q_tB_t + P_tT_t = P_tY + B_{t-1}$, where $\beta < 1$ is the households' discount factor, P_t denotes the price of consumption goods, T_t denotes real lump-sum net taxes, and $Q_t = 1/R_{n,t}$ is the price of the one-period government bond B_t, equal to the inverse of the gross nominal interest rate $R_{n,t}$.

The government budget constraint is $Q_tB_t + P_tT_t = B_{t-1}$. Given that the government only provides a subsidy or collects lump-sum taxes, T_t also coincides with the real primary surplus. The fiscal authority follows the fiscal rule:

$$\tau_t/\tau = (s_{b,t-1}/s_b)^{\gamma}\, e^{\zeta_t},$$

where $\tau_t = T_t/Y$ denotes the surplus-to-output ratio, $s_{b,t} = Q_t B_t/(P_t Y)$ denotes the debt-to-output ratio, τ and s_b denote their respective steady-state values, ζ_t is a shock to lump-sum taxes that follows an autoregressive process with one lag, and the parameter γ controls how strongly the fiscal authority adjusts primary surpluses to fluctuations in debt.

The central bank follows a monetary rule:

$$R_{n,t}/R_n = (\Pi_t/\Pi)^{\phi},$$

where $\Pi_t = P_t/P_{t-1}$ is the gross inflation rate at time t, R_n and Π denote steady-state values for the nominal interest rate and inflation, respectively, and the parameter ϕ captures how strongly the central bank reacts to movements of inflation from its target.

The market clearing condition in the goods market implies $C_t = Y$ in every period. Combining this condition with the household's first order condition returns the well-known Fisher equation connecting nominal interest rates to expected inflation $R_{n,t} = \beta^{-1}\mathbb{E}_t\left(\Pi_{t+1}\right)$.

We can then linearize the model equations around the deterministic steady state and use hatted variables to denote log-deviations from the steady state:

$$\hat{r}_{n,t} = \mathbb{E}_t\left(\hat{\pi}_{t+1}\right), \tag{1}$$

$$\hat{s}_{b,t} = \beta^{-1}[\hat{s}_{b,t-1} + \hat{r}_{n,t-1} - \hat{\pi}_t - (1-\beta)\hat{\tau}_t], \tag{2}$$

$$\hat{r}_{n,t} = \phi\hat{\pi}_t, \tag{3}$$

$$\hat{\tau}_t = \gamma\hat{s}_{b,t-1} + \zeta_t. \tag{4}$$

Plugging the monetary rule (3) into the Fisher equation (1) leads to the *monetary block*:

$$\mathbb{E}_t\left(\hat{\pi}_{t+1}\right) = \phi\hat{\pi}_t. \tag{5}$$

Combining the law of motion for debt (2) with the fiscal rule (4) yields the *fiscal block*:

$$\hat{s}_{b,t} = \beta^{-1}[1-(1-\beta)\gamma]\hat{s}_{b,t-1} + \beta^{-1}\left[\hat{r}_{n,t-1} - \hat{\pi}_t - (1-\beta)\zeta_t\right]. \tag{6}$$

Existence and uniqueness of a solution In this class of models there are two regions of the parameter space that deliver existence and uniqueness of a stationary solution (Leeper, 1991). In the first region, monetary policy responds more than one-to-one to deviations of inflation from its target ($\phi > 1$) and the fiscal authority implements the necessary fiscal adjustments to keep debt on a stable path ($\gamma > 1$). In this case, fiscal policy is said to be passive because it passively accommodates the behavior of the active monetary authority. Following, Bianchi et al. (2023), we label this policy combination the *Monetary-led policy mix*. In the second region of the parameter space, it is the monetary authority that passively accommodates the behavior of the active fiscal authority. In terms of parameter restrictions, this implies that the response to inflation in the monetary policy rule is less than one-to-one ($\phi \leq 1$), and that changes in primary surpluses are not large enough to keep debt on a stable path ($\gamma \leq 1$).

The first two panels of Figure 1 illustrate the differences between these two parameter combinations by reporting impulse responses of inflation to a fiscal shock. Under the Monetary-led policy mix, the macroeconomy is completely insulated from the fiscal block, and a negative shock to primary surpluses does not affect inflation. Households simply increase their bond holdings, expecting that taxes will eventually go up in the future. In this case, fiscal imbalances are irrelevant for inflation determination in equilibrium (*Monetary and Fiscal Dichotomy*). On the contrary, under the Fiscally-led policy mix, the macroeconomy is not insulated from fiscal imbalances. Inflation jumps to lower the real market value of debt. This is possible because the central bank fully accommodates the increase in inflation ($\phi = 0$).

Shock-specific rules and partially unfunded debt In what follows, we introduce the idea of shock specific rules. This allows to consider models in which policymakers' behavior changes based on the shock hitting the economy. In this specific case, we are interested in a situation in which the Monetary-led and Fiscally-led policy mixes coexist. We use the superscript M and F to denote policy parameters that imply a behavior in line with a Monetary-led policy mix and a Fiscally-led policy mix, respectively.

The linearized fiscal rule reads:

$$\hat{\tau}_t = \gamma^M \left(\hat{s}_{b,t-1} - \hat{s}^F_{b,t-1}\right) + \gamma^F \hat{s}^F_{b,t-1} + \zeta^M_t + \zeta^F_t. \tag{7}$$

where ζ^M_t and ζ^F_t denote funded and unfunded fiscal shocks, respectively. The above rule implies that the amount of unfunded debt $\hat{s}^F_{b,t-1}$ accumulated as a result of the unfunded fiscal shocks is not backed by large enough fiscal adjustments: $\gamma^F \leq 1$. The fiscal authority is instead willing to adjust primary surpluses to cover the remaining amount of debt, the funded component accumulated as a result of the funded fiscal shocks: $\gamma^M > 1$. Thus, fiscal policy is passive with respect to the funded component of debt ($\hat{s}_{b,t-1} - \hat{s}^F_{b,t-1}$), while it is active with respect to the unfunded component of debt ($\hat{s}^F_{b,t-1}$).

The linearized monetary rule reads:

$$\hat{r}_{n,t} = \phi^M \left(\hat{\pi}_t - \hat{\pi}^F_t\right) + \phi^F \hat{\pi}^F_t. \tag{8}$$

where $\hat{\pi}^F_t$ denotes fiscal inflation, i.e., the amount of inflation that is necessary to keep debt on a stable path in response to the unfunded fiscal shocks. In terms of parameter values, this implies that monetary policy is passive in response to fiscal inflation ($\phi^F \leq 1$). The central bank is instead active in stabilizing inflation originating from funded fiscal shocks. This is equivalent to saying that monetary policy responds more than one-to-one to deviations of inflation from fiscal inflation: $\phi^M > 1$. If we assume that fiscal inflation is fully accommodated, $\phi^F = 0$, we obtain a monetary policy rule that is isomorphic to a rule with a time-varying target: $\hat{r}_{n,t} = \phi^M \left(\hat{\pi}_t - \hat{\pi}_t^F\right)$. However, the time-varying target $\hat{\pi}_t^F$ is not an unrestricted latent variable, but rather an endogenous variable that needs to obey the model cross-equation restrictions.

Substituting the monetary rule (8) into the Fisherian equation (1) yields the monetary block of the model with partially unfunded debt:

$$\mathbb{E}_t \hat{\pi}_{t+1} = \phi^M \left(\hat{\pi}_t - \hat{\pi}_t^F\right) + \phi^F \hat{\pi}_t^F. \tag{9}$$

Plugging the policy rules in the law of motion of debt (2) yields the fiscal block:

$$\hat{s}_{b,t} = \beta^{-1}[1 - (1-\beta)\gamma^M]\hat{s}_{b,t-1} + \beta^{-1}[(1-\beta)\hat{s}_{b,t-1}^F + \hat{r}_{n,t-1} - \hat{\pi}_t - (1-\beta)(\zeta_t^M + \zeta_t^F)], \tag{10}$$

where we have assumed that the fiscal authority completely disregard the amount of unfunded debt: $\gamma^F = 0$.

Bianchi et al. (2023) explain that the model can be solved by constructing a shadow economy that keeps track of the amount of unfunded debt. In this shadow economy, only unfunded shocks occur. The resulting inflation and debt dynamics enter the full model as time-varying targets to which policymakers react to. In other words, the shadow economy keeps track of the share of debt that is unfunded and expected to be covered by inflation, while the remaining share, which is funded, is expected to be covered via fiscal adjustments. The monetary and fiscal blocks for the shadow economy are:

$$\mathbb{E}_t \hat{\pi}_{t+1}^F = \phi^F \hat{\pi}_t^F, \tag{11}$$

$$\hat{s}_{b,t}^F = \beta^{-1}\hat{s}_{b,t-1}^F + \beta^{-1}(\hat{r}_{n,t-1}^F - \hat{\pi}_t^F) - \beta^{-1}(1-\beta)\zeta_t^F. \tag{12}$$

The full model with partially unfunded debt is then given by equations (9), (10), (11), and (12). Since the model features two non-predetermined variables, $\hat{\pi}_t$ and $\hat{\pi}_t^F$, and two eigenvalues outside the unit circle associated, the model satisfies the Blanchard and Khan conditions for uniqueness of a solution.

The impulse responses for the model with partially unfunded debt are reported in the third panel of Figure 1. In response to a funded spending shock (solid blue line), the impulse responses coincide with what reported in the first panel, when the Monetary-led policy mix is assumed always in place. On the contrary, in response to a Fiscally-led policy mix, the inflation response coincides with what reported in the second panel, where policymakers always follow the Fiscally-led policy mix. However, in the model with partially unfunded debt the two responses coexist. Given that policy responses are shock specific, the propagation of shocks change completely between funded and unfunded fiscal shocks. Thus, in a model with partially unfunded debt, debt stability is achieved with a mix of fiscal stabilization and

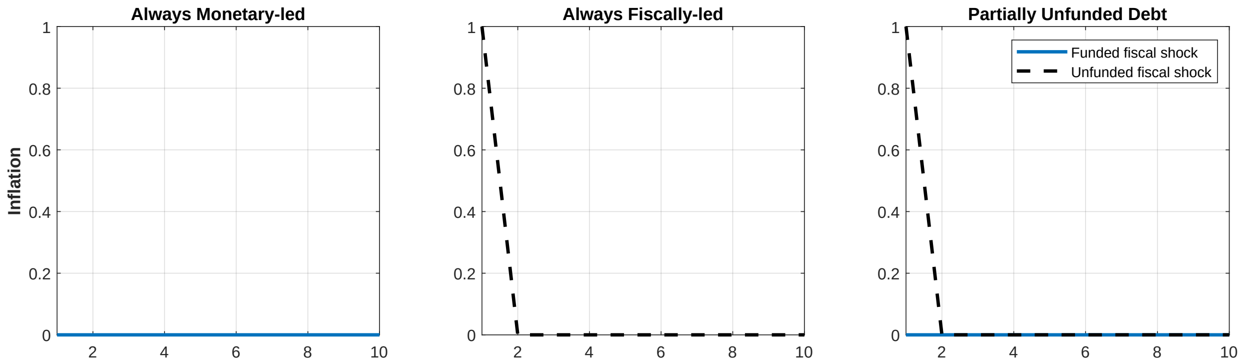

Figure 1: **Impulse response of inflation to a fiscal shock**. The figure reports impulse responses to a fiscal shock. The first and second panels refer to the Fisherian model under a Monetary-led and a Fiscally-led policy mix, respectively. The third panel refers to the model with partially unfunded debt. The parameters are chosen as follows: $\beta = 0.99$ and $s_b = 1$. In the model with partially unfunded debt, the monetary policy parameters are $\phi^M = 2$ and $\phi^F = 0$ and the fiscal policy parameters are $\gamma^M = 20$ and $\gamma^F = 0$. The Always Monetary-led model is parameterized as follows: $\phi = \phi^M$ and $\gamma = \gamma^M$. The Always Fiscally-led model is parameterized as follows: $\phi = \phi^F$ and $\gamma = \gamma^F$. Fiscal shocks have an autocorrelation coefficient of 0.5, and their variance is scaled to produce a unit response of inflation on impact of an unfunded shock.

inflation.

2.2 Unfunded fiscal shocks and nominal rigidities

The Fisherian model has the advantage of being extremely tractable. However, it does not present any connection to the real side of the economy, as output is fixed over time. In this section, we introduce a production economy and discuss why nominal rigidities are important to understand the connection between fiscal policy, inflation, and real interest rates.

We assume the period utility function $U(C_t, N_t) = \ln C_t + \phi \ln(1 - N_t)$, where N_t represents hours worked. Households receive real wage income $W_t N_t$ in exchange for supplying labor services to the firms, and the production function is $Y_t = N_t^{1-\alpha}$. All other assumptions are the same as described in the previous section, including the specification of the fiscal and monetary rules. In the case of flexible prices, which provides the benchmark for a classical economy, we assume perfect competition in both goods and labor markets. We calibrate this stylized model consistently with the parameters of the quantitative model of Section 4.

Figure 2 reports impulse responses to funded and unfunded fiscal shocks (the blue solid and black dashed lines, respectively) in the case of flexible prices. As in the simple Fisherian model, fiscal shocks lead to an increase in inflation only if they are unfunded; that is, only if they are not backed by future fiscal adjustments. Furthermore, as in the Fisherian model, inflation jumps on impact and immediately returns to zero after one period. Finally, despite the richer model, the real economy is fully insulated from the fiscal shock. This is consistent with the well-known fact that the real economy can be solved with no regard to inflation when prices are flexible.

The second row of Figure 2 shows that introducing a positive response to deviations of

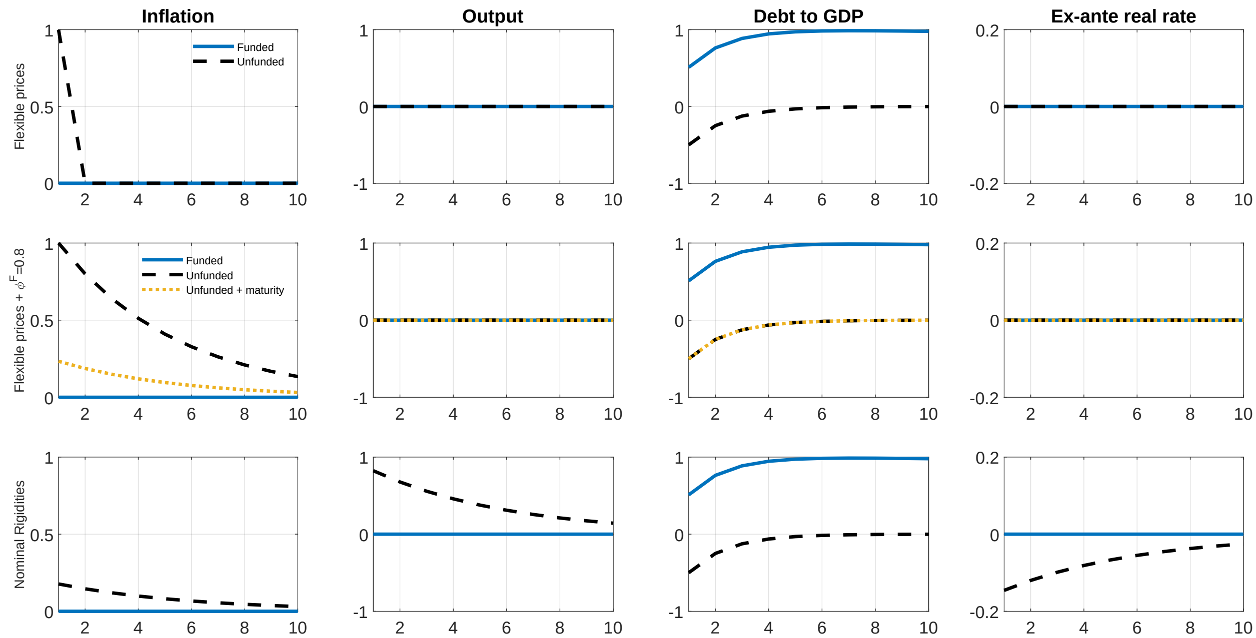

Figure 2: **Funded and unfunded fiscal shocks**. The figure reports impulse responses of inflation, output, the debt-to-GDP ratio, and the ex-ante real interest rate to funded (blue solid line) and unfunded shocks (black dashed line) to primary surpluses. The first row reports the propagation in a model with perfectly flexible prices and $\phi^F = 0$. The second row reports impulse responses in a model with perfectly flexible prices and $\phi^F = 0.8$. For unfunded shocks, we also consider the case with a maturity structure (dotted orange line). The last row reports the propagation of the same shocks under nominal rigidities.

inflation from fiscal inflation, ($\phi^F > 0$), or introducing a maturity structure (magenta line) does not change the fact that output and the real interest rate are insulated with respect to fiscal shocks. In these cases, the persistence of inflation coincides with $\phi^F > 0$ because of the Fisherian relation between nominal rates and inflation. A persistent inflation response, a positive response of interest rates, and maturity structure revaluation effects that lower the initial jump in inflation. But across all cases, inflation stabilization needs to be reached with movements in inflation and real interest rates are not affected by fiscal shocks.

The third row of Figure 2 reports impulse responses to the same shocks once imposing nominal rigidities. In this case, the model is similar to the prototypical textbook models presented in Galí (2008) and Woodford (2003). To isolate the effects of nominal rigidities, we assume $\phi^F = 0$ case and no maturity structure. Thus, the persistent response of inflation in response to an unfunded fiscal shock is exclusively driven by the presence of sticky prices. Note that the response of inflation is now largely reduced despite the absence of revaluation effects. This is because an increase in real activity and a persistent drop in the real interest rate contribute to debt stabilization. The other noticeable fact is that debt-to-GDP initially declines, as output and inflation jump.

Summarizing, transfer shocks can have large effects on real interest rates even in a parsimonious economy with non-distortionary taxation if the shocks are not backed by future fiscal adjustments. Noticeably, funded fiscal shocks do not have any impact on nominal and real variables across all cases considered above. This extreme outcome is weakened once introducing hand-to-mouth agents or shocks to government purchases, like in the quantitative model considered below.

3 A Quantitative Model

In this section, we describe a state-of-the-art Two Agents New Keynesian (TANK) model with a rich fiscal block and partially unfunded debt (Bianchi, Faccini, and Melosi, 2023). The model features traditional business cycle shocks with respect to which a Monetary-led policy mix applies. However, the model also features unfunded fiscal shocks. These shocks to transfers are not backed by future fiscal adjustments, implying that a share of the overall government debt is unfunded. In what follows, we outline the model in detail.

3.1 The economy

The economy is populated by a unit measure of households, of which a fraction μ are hand-to-mouth consumers. The remaining fraction of households, $1-\mu$, are savers, and we indicate them with an S superscript. Hand-to-mouth households, combined with distortionary taxes, disrupt Ricardian equivalence. As a result, funded transfers become relevant for part of the population, even under a monetary-led policy framework.

Savers. A household of optimizing saving agents, indexed by j, derives utility from the consumption of a composite good, $C_t^{*S}(j)$, which comprises private consumption $C_t^S(j)$ and government consumption G_t such that $C_t^{*S}(j) = C_t^S(j) + \alpha_G G_t$. The parameter α_G determines the relationship between private and government consumption. If α_G is negative, the two types of consumption are complements; if positive, they are substitutes. External consumption habits mean that utility depends on consumption relative to the previous period's aggregate savers' consumption of the composite good, represented by θC_{t-1}^{*S}, where $\theta \in [0,1]$ is the habit parameter. Saver households also derive disutility from the supply of differentiated labor services from all its members, indexed by l, $L_t^S(j) = \int_0^1 L_t^S(j,l)\,dl$. The period utility function is given by $U_t^S(j) = u_t^b \left(\ln\left(C_t^{*S}(j) - \theta C_{t-1}^{*S}\right) - L_t^S(j)^{1+\xi}/(1+\xi)\right)$, where u_t^b is a discount factor shock and ξ is the Frisch elasticity of labor supply.

Households build wealth by accumulating physical capital, denoted as $\bar{K}_t^S$. Capital depreciates at a rate δ and grows through investment I_t^S, adjusted for associated costs. The law of motion for physical capital is: $\bar{K}_t^S(j) = (1-\delta)\bar{K}_{t-1}^S(j) + u_t^i\left[1 - s\left(I_t^S(j)/I_{t-1}^S(j)\right)\right] I_t^S(j)$, where u_t^i is a shock to the marginal efficiency of investment and s denotes an investment adjustment cost function that satisfies the properties $s(e^{\varkappa}) = s'(e^{\varkappa}) = 0$ and $s''(e^{\varkappa}) \equiv s > 0$, where $\varkappa$ is a drift parameter capturing the logarithm of the gross rate of technology growth in steady state.

Households earn income by renting out effective capital, $K_t^S(j)$, to intermediate firms. Effective capital is linked to physical capital through the relationship $K_t^S(j) = \nu_t(j)\bar{K}_{t-1}^S(j)$, where $\nu_t(j)$ is the rate of capital utilization. The cost of utilizing one unit of physical capital is given by the function $\Psi(\nu_t(j))$. Given the steady-state utilization rate $\nu(j) = 1$, the function Ψ satisfies the following properties: $\Psi(1) = 0$, and $\frac{\Psi''(1)}{\Psi'(1)} = \frac{\psi}{1-\psi}$, where $\psi \in [0, 1)$. We denote the gross rental rate of capital as $R_{K,t}$ and the tax rate on capital rental income as $\tau_{K,t}$.

Households can save by buying one-period government bonds, which have zero net supply, or a broader portfolio of long-term government bonds, which have non-zero net supply. One-period bonds promise a nominal payoff of B_t at time $t+1$ and can be purchased at their present discounted value, $R_{n,t}^{-1}B_t$. Here, $R_{n,t}$ is the gross nominal interest rate chosen by the central bank. The long-term bond B_t^m mimics a portfolio of bonds with average maturity m and duration $(1-\beta\rho)^{-1}$, where $\rho \in [0, 1]$ is a constant rate of decay. This bond has price P_t^m, which is determined by the arbitrage condition $R_{n,t} = \mathbb{E}_t[(1 + P_{t+1}^m)/P_t^m]e^{-u_t^{rp}}$, where the wedge u_t^{rp} can be interpreted as a risk premium shock.

Each period, the household earns after-tax nominal income from labor, after-tax earnings from renting capital to firms, lump-sum transfers from the government (Z_t^S), and dividends from firms (D_t). These funds can be used for consumption, investment in physical capital, and purchasing bonds. To simplify notation, omitting the index j, the nominal budget constraint for the saver household is expressed as:

$$\begin{aligned} & P_t\left(1+\tau_{C,t}\right)C_t^S + P_t I_t^S + P_t^m B_t^m + R_{n,t}^{-1}B_t \\ = \quad & \left(1+\rho P_t^m\right)B_{t-1}^m + B_{t-1} + \left(1-\tau_{L,t}\right)\int_0^1 W_t(l)\, L_t^S dl \\ & + \left(1-\tau_{K,t}\right)R_{K,t}\nu_t \bar{K}_{t-1}^S - \Psi(\nu_t)\,\bar{K}_{t-1}^S + P_t Z_t^S + D_t, \end{aligned} \tag{13}$$

where $W_t(l)$ represents the wage rate applicable to all household members, while $\tau_{C,t}$ and $\tau_{L,t}$ are the tax rates on consumption and labor income, respectively. The household seeks to maximize its discounted utility, $\sum_{t=0}^{\infty}\beta^t U_t^S$, while adhering to the sequence of budget constraints given in equation (13).

Hand-to-Mouth Households. Each period, hand-to-mouth households spend their entire disposable, after-tax income on consumption. This income consists of earnings from labor and government transfers. These households provide differentiated labor services and set their wages equal to the average wage optimally chosen by saver households, as outlined later. Both savers and hand-to-mouth households are subject to the same tax rates on consumption and labor income. Denoting hand-to-mouth households with the superscript

N, their budget constraint can be expressed as:

$$\left(1+\tau_{C,t}\right) P_t C_t^N = \left(1-\tau_{L,t}\right) \int_0^1 W_t\left(l\right) L_t^N\left(l\right) dl + P_t Z_t^N.$$

Final Good Producers. A perfectly competitive sector of final goods firms produces a single homogeneous product, Y_t, at time t by combining a variety of intermediate inputs. The production process follows the technology $Y_t = \left(\int_0^1 Y_t\left(i\right)^{\frac{1}{1+\eta_t^p+u_t^{NKPC}}} di\right)^{1+\eta_t^p+u_t^{NKPC}}$, where η_t^p represents exogenous, independent, and identically distributed (i.i.d.) changes in the elasticity of substitution among different varieties of goods. In the linearized model, these changes affect the New Keynesian Phillips curve (NKPC) and are referred to as cost-push shocks. The variable u_t^{NKPC} also represents a cost-push shock but is assumed to follow a near-unit-root process, capturing persistent external influences, such as international trade, that drive low-frequency inflation trends. Profit maximization leads to the demand function for intermediate goods $Y_t\left(i\right) = Y_t\left(P_t\left(i\right)/P_t\right)^{-\left(1+\eta_t^p+u_t^{NKPC}\right)/\left(\eta_t^p+u_t^{NKPC}\right)}$, where $P_t\left(i\right)$ is the price of the differentiated good i and where P_t is the price of the final good.

Intermediate Good Producers. Intermediate firms produce output using the technology $Y_t\left(i\right) = K_t\left(i\right)^{\alpha}\left(A_t L_t\left(i\right)\right)^{1-\alpha} - A_t\Omega$, where Ω represents a fixed production cost that grows at the same rate as labor-augmenting technological progress (A_t), and $\alpha \in [0,1]$ is a production parameter. The technological progress, A_t, evolves according to an exogenous process with a stationary growth rate, expressed as $u_t^a = \left(1-\rho_a\right)\varkappa + \rho_a u_{t-1}^a + \varepsilon_t^a$, where $u_t^a = \ln(A_t/A_{t-1})$. Intermediate firms rent capital and labor in perfectly competitive factor markets. Labor, L_t, is a composite input derived from all differentiated labor services in the economy, aggregated into a homogeneous form by a labor agency, as described later. Cost minimization ensures that all firms face the same nominal marginal cost $MC_t = \left(1-\alpha\right)^{\alpha-1}\alpha^{-\alpha}\left(R_{K,t}\right)^{\alpha} W_t^{1-\alpha} A_t^{-1+\alpha}$.

Intermediate producers face price-setting Calvo-style frictions. At any given time t, a firm i has a probability ω_p of optimally resetting its price. If it cannot reset the price, it adjusts it partially based on the previous period's inflation rate, following the rule $P_t\left(i\right) = \left(\Pi_{t-1}\right)^{\chi_p}\left(\Pi\right)^{1-\chi_p} P_{t-1}\left(i\right)$, where $\chi_p \in [0,1]$ is a parameter, $\Pi_{t-1} = \frac{P_{t-1}}{P_{t-2}}$ is the inflation rate from the previous period, and Π represents the steady-state aggregate inflation rate.

Intermediate producers who can reset their prices aim to maximize the expected discounted value of their future nominal profits:

$$\max \mathbb{E}_t \sum_{s=0}^{\infty} \left(\beta\omega_p\right)^s \frac{\Lambda_{t+s}^S}{\Lambda_t^S}\left[\left(\prod_{k=1}^{s} \Pi_{t+k-1}^{\chi^p}\Pi^{1-\chi^p}\right) P_t\left(i\right) Y_{t+s}\left(i\right) - MC_{t+s} Y_{t+s}\left(i\right)\right],$$

subject to the demand function of the final good sector, with Λ^S denoting the marginal utility of the savers.

Wages We assume that both savers and hand-to-mouth households provide a unit of differentiated labor service, indexed by l. Each period, a saver household has a probability ω_w of being able to optimally adjust the wage rate for all its workers, $W_t(l)$. If the wage cannot be adjusted, it is updated based on the geometric average of the steady-state inflation rate Π and the previous period's inflation rate Π_{t-1}, following the rule: $W_t(l) = W_{t-1}(l)\left(\Pi_{t-1}e^{\varkappa}\right)^{\chi_w}\left(\Pi e^{\varkappa}\right)^{1-\chi_w}$, where $\chi_w \in [0,1]$ captures the degree of nominal wage indexation. All households, whether savers or non-savers, provide their labor services to a representative competitive agency. This agency combines the individual labor inputs into an aggregate labor input using the technology $L_t = \left(\int_0^1 L_t(l)^{\frac{1}{1+\eta_t^w}}\, dl\right)^{1+\eta_t^w}$, where η_t^w is an i.i.d. exogenous wage mark-up shock. The agency rents labor type $L_t(l)$ at price $W_t(l)$ and sells a homogeneous labor input to the intermediate producers at price W_t. The static profit maximization problem yields the demand function $L_t(l) = L_t\left(W_t(l)/W_t\right)^{-(1+\eta_t^w)/\eta_t^w}$.

Monetary and Fiscal Policy. Assuming one-period government bonds have zero net supply and all households, whether hand-to-mouth or savers, receive the same transfer amounts, the government's nominal budget constraint can be expressed as:

$$P_t^m B_t^m + \tau_{K,t}R_{K,t}K_t + \tau_{L,t}W_tL_t + \tau_{C,t}P_tC_t = \left(1+\rho P_t^m\right)B_{t-1}^m + P_tG_t + P_tZ_t, \quad (14)$$

where $C_t = \mu C_t^N + (1-\mu)C_t^S$ and $Z_t = \int_0^1 Z_t(j)\,dj$ denote aggregate consumption and total transfers, respectively. The budget constraint (14) indicates that the fiscal authority funds government spending, transfers, and the renewal of maturing long-term debt through a combination of taxes on consumption, labor, and capital, as well as by issuing new long-term debt.

We rescale the variables entering the fiscal rules as $g_t = G_t/A_t$ and $z_t = Z_t/A_t$. For each variable x_t, $\widehat{x}_t$ denotes the percentage deviation from its own steady state. Let $s_{b,t} = \frac{P_t^m B_t^m}{P_t Y_t}$ be the debt-to-GDP ratio. Similar to the models in Section 2, the deviation of the debt-to-GDP ratio from its steady state, $\hat{s}_{b,t}$, consists of two components: funded debt ($\hat{s}_{b,t}^M$) and unfunded debt ($\hat{s}_{b,t}^F$). As before, superscripts M and F indicate that the Monetary-led policy mix applies to funded debt, while the Fiscally-led policy mix applies to unfunded debt. For transfer shocks, we use the superscripts only to distinguish between the two types, assuming that all other shocks impact only the funded portion of the debt.

The fiscal authority adjusts government spending $\hat{g}_t$, transfers $\hat{z}_t$, and tax rates on capital income, labor income, and consumption $\hat{\tau}_J$, $J \in \{K, L, C\}$ as follows:

$$\hat{g}_t = \rho_G \hat{g}_{t-1} - (1-\rho_G)\ \gamma_G(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F) + \zeta_{g,t}, \quad (15)$$

$$\hat{z}_t^b = \rho_Z \hat{z}_{t-1}^b - (1-\rho_Z)\left[\ \gamma_Z(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F) + \phi_{zy}\hat{y}_t\right] + \zeta_{z,t}, \quad (16)$$

$$\hat{\tau}_{J,t} = \rho_J \hat{\tau}_{J,t-1} + (1-\rho_J)\ \gamma_J(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F), \quad (17)$$

where $\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F$ represents the portion of the debt-to-GDP ratio that the fiscal authority is responsible for stabilizing through fiscal adjustments. This stabilization is ensured by setting the reaction parameters γ_G, γ_Z, and $\gamma_J > 0$ to sufficiently high values, ensuring that this portion of debt stays on a stable trajectory. The fiscal authority does not adjust fiscal policy to address the remaining portion of the debt, which is unfunded and represented by $\hat{s}^F_{b,t-1}$. The total amount of transfers is expressed as $\hat{z}_t \equiv \hat{z}^b_t + \zeta^M_t + \zeta^F_t$. The shocks ζ^M_t and ζ^F_t affect the funded and unfunded portions of total transfers, respectively, and are modeled as persistent AR(1) processes to reflect the historical patterns of transfers in the United States. The term $\hat{z}^b_t$ represents temporary changes in funded transfers and any adjustments made in response to debt levels or the business cycle. Additionally, the fiscal shocks $\zeta_{g,t}$ and $\zeta_{z,t}$ are also assumed to follow AR(1) processes.

The central bank adjusts the short-term interest rate, $\hat{R}_{n,t}$, in response to inflation fluctuations caused by typical business cycle shocks and funded fiscal shocks, while accommodating the inflation changes needed to stabilize the unfunded portion of debt. As discussed in Section 2, this shock-specific monetary policy is represented by a standard Taylor rule, where the central bank reacts to deviations of inflation from the level required to stabilize the unfunded debt. This inflation level, referred to as fiscal inflation, is denoted by $\hat{\pi}^F_t$. Consequently, the linearized monetary policy rule, incorporating an effective lower bound (ELB) constraint, can be expressed as:

$$\hat{r}_{n,t} = \max\left[-\ln \underline{R_n}, \rho_r \hat{r}_{n,t-1} + (1-\rho_r)\left[\phi_\pi\left(\hat{\pi}_t - \hat{\pi}^F_t\right) + \phi_y \hat{y}_t\right] + u^m_t\right], \tag{18}$$

where u^m_t is a monetary policy shock.

The parameter $\phi_\pi > 1$ ensures that the Taylor principle is met, making monetary policy active in responding to deviations of inflation, $\hat{\pi}_t$, from fiscal inflation, $\hat{\pi}^F_t$. The variable $\hat{\pi}^F_t$ represents the rise in inflation, relative to the central bank's long-term target (and steady-state rate), that the central bank tolerates to stabilize the unfunded debt, $\hat{s}^F_{b,t-1}$. The policy mix defined by equations (15)-(18) implies that monetary policy actively responds to deviations of inflation from fiscal inflation but remains passive (non-responsive) to the inflation required to stabilize the unfunded debt's deviation from its long-term target. Concurrently, fiscal policy is passive with respect to its commitment in stabilizing the share of funded government debt $\hat{s}_{b,t-1} - \hat{s}^F_{b,t-1}$, and active (no response) with respect to the unfunded share of debt. Thus, a monetary-led policy mix addresses typical business cycle shocks, while a fiscally-led policy mix manages unfunded fiscal shocks.

Fiscal inflation $\hat{\pi}^F_t$ is incorporated into the Taylor rule in a manner similar to a time-varying inflation target or an inflation drift often included in medium-scale Dynamic Stochastic General Equilibrium (DSGE) models to account for persistent inflation observed in the data (e.g., Smets and Wouters 2007). In other models, the inflation drift typically follows an exogenous, near-random-walk process. In contrast, fiscal inflation in our model is endogenous, adjusting based on the requirements to stabilize the proportion of unfunded debt. Fiscal inflation $\hat{\pi}_t^F$ arises from the coordination between monetary and fiscal authorities in managing the stabilization of the existing public debt.

3.2 Solving the Model

To solve the model, we begin by detrending the non-stationary variables to address the unit root in labor-augmenting technology A_t. Next, we log-linearize the equations around the deterministic steady-state equilibrium. The log-linearized equations are provided in Appendix A.

As described in Section 2, we construct a shadow economy to track the unfunded portion of debt and its impact on endogenous variables. The shadow economy differs from the actual economy by considering only unfunded fiscal shocks, with policymakers adhering to a Fiscally-led policy mix. Apart from this distinction, all other model equations remain the same in both economies. The model is solved using standard techniques for linear rational expectations models.

4 Inference

The model is estimated using Bayesian methods. The posterior distribution is derived by combining the prior distributions of the model parameters with the likelihood function. The likelihood is computed using the Kalman filter.

4.1 Data

We extend the dataset used in Bianchi et al. (2023) from 2022:Q4 to 2024:Q2. We do not re-estimate the model, but rather filter the series for the extended sample based on the posterior mode parameters obtained in Bianchi et al. (2023). Below, we describe how priors are chosen in that paper, and discuss the posterior to keep the paper self-contained.

The dataset includes: real per-capita GDP growth; real per-capita consumption growth; real per-capita investment growth; a measure of the hours gap; the effective federal funds rate; the growth of average weekly earnings; price inflation based on the GDP deflator; the growth of real government transfers; the growth of government consumption and investment; the government debt-to-GDP ratio; 5-year break-even inflation.

The 5-year breakeven inflation is treated as a noisy measure of inflation expectations over the next five years and include an observation error that captures variations in premia. To account for the federal funds rate being stuck at the effective lower bound for most of the

2008:Q1-2024:Q2 period, we estimate the model over two subsamples: from 1960:Q1 through 2007:Q4 and then from 2008:Q1 through 2024:Q2. When estimating the model on the latter subsample, we add to the data set the expectations for the federal funds rate one- through ten-quarters ahead, based on overnight index swaps. Following Campbell et al. (2012), we use data on market-based future federal funds rates to estimate the model after 2008:Q4 taking into account agents' expectations about future interest rates.

4.2 Priors

To determine the prior distributions for the model parameters, we adopt the approach outlined by Del Negro and Schorfheide (2008). Certain parameters are fixed during the estimation process or determined by steady-state constraints. Specifically, the discount factor β is set to 0.99, ensuring the steady-state real interest rate aligns with its sample average. The quarterly capital depreciation rate δ is calibrated to achieve an investment rate of 2.5%.

Parameters for steady-state markups on wages and prices are not separately identifiable in the estimation, so they are fixed at 0.14, as in Leeper et al. (2017). The elasticity of output with respect to capital in the production function, α, is assigned the standard value of 0.33. Lastly, the parameter s_{gc}, representing the government expenditure-to-GDP ratio, is set to 0.11, following Leeper et al. (2017). The steady-state tax rates on labor, capital, and consumption, represented by the parameters τ_L, τ_K, and τ_C, are assigned values of 0.186, 0.218, and 0.023, respectively, following Leeper et al. (2017). The consumption tax rate, τ_C, is assumed to remain constant, which leads to setting the parameters γ_C and ρ_C to zero.

Average maturity measures based on the number of bonds outstanding or their value are fairly stable in the United States, fluctuating around 5.5 and 4.5 years, respectively. However, over the past 10 years, the means of the average maturities have increased to 6 and 5.8 years. Given that we are particularly interested in recent movements in real interest rates, we set the decay rate of the maturity of long-term bonds, ρ, to 0.9593, a value that implies a 6-year average maturity. This is also in line with Congressional Budget Office (2020) estimates. Our results are robust to choosing a range of alternative values for the average maturity.

The right panels of Tables 1 and 2 present the priors for the structural parameters and exogenous processes, respectively. The priors for macroeconomic and fiscal variables are generally broad. The prior for the share of hand-to-mouth households, μ, is centered at 0.11, reflecting the share of poor hand-to-mouth consumers as in Kaplan et al. (2014).

The autocorrelation coefficients for shocks to funded and unfunded transfers are tightly centered around a highly persistent mean, consistent with the belief that changes in these transfers are very persistent. This aligns with observed data, where transfers exhibit fluc-

Prior and Posterior Distributions for the Structural Parameters								
		Posterior Distribution				Prior Distribution		
Param	Description	Mode	Median	5%	95%	Type	Mean	Std
s_b	Debt to GDP (not annualized)	2.4582	2.4512	2.3736	2.5298	N	2.40	0.10
$100\varkappa$	Steady state growth rate	0.3979	0.3910	0.3329	0.4625	N	0.50	0.05
$100\ln\Pi$	Steady state inflation	0.5296	0.5333	0.4643	0.6000	N	0.50	0.05
ξ	Inverse Frisch elasticity	1.7974	1.7440	1.6095	1.8708	N	2.00	0.25
μ	Share of hand-to-mouth	0.0771	0.0787	0.0682	0.0906	N	0.11	0.01
ω_w	Wage Calvo param	0.8151	0.8167	0.7980	0.8335	B	0.50	0.10
ω_p	Price Calvo param	0.8673	0.8651	0.8436	0.8833	B	0.50	0.10
ψ	Capital utilization cost	0.6564	0.6739	0.5897	0.7520	B	0.50	0.10
s	Investment adjust. cost	5.5475	6.2053	5.4031	6.5048	N	6.00	0.50
χ_w	Wage infl. indexation	0.0375	0.0497	0.0126	0.0824	B	0.50	0.20
χ_p	Price infl. indexation	0.2356	0.2354	0.1908	0.3295	B	0.50	0.20
θ	Habits in consumption	0.9134	0.9103	0.9023	0.9174	B	0.50	0.20
α_G	Subs. private/gov. cons.	-0.0514	-0.0760	-0.1692	0.0060	N	0.00	0.10
ϕ_y	Interest response to GDP	0.0014	0.0012	0.0001	0.0034	N	0.25	0.10
ϕ_π	Interest response to infl.	2.0580	2.0826	1.9430	2.1966	N	2.00	0.10
ϕ_{zy}	Transfers response to GDP	0.0823	0.0546	0.0316	0.0804	G	0.10	0.05
γ_G	Gov. cons. response to debt	0.3443	0.3364	0.2874	0.3858	N	0.25	0.10
γ_K	Capital tax response to debt	0.0037	0.0020	0.0003	0.0057	N	0.25	0.10
γ_L	Labor tax response to debt	0.0027	0.0019	0.0002	0.0051	N	0.25	0.10
γ_Z	Transfers response to debt	0.0891	0.0867	0.0359	0.1399	N	0.25	0.10
ρ_r	AR coeff. monetary rule	0.7264	0.7284	0.6803	0.7722	B	0.50	0.10
ρ_G	AR coeff. gov. cons. rule	0.4080	0.4139	0.3150	0.4979	B	0.50	0.10
ρ_Z	AR coeff. transfers rule	0.5394	0.4525	0.3895	0.5843	B	0.50	0.10

Table 1: Posterior modes, medians, 90% posterior credible sets, and prior moments for the structural parameters. The letters in the column with the heading "Prior Type" indicate the prior density function: N, G, and B stand for Normal, Gamma, and Beta, respectively. Source: Bianchi et al. (2023).

tuations around a long-term trend. In contrast, cyclical increases in government transfers are assumed to be offset by higher tax revenues and reduced spending during subsequent economic recoveries.

The prior for the autocorrelation coefficient of the persistent cost-push shock ($\rho_{\mu^{NKPC}}$) is chosen to give the model an alternative mechanism for explaining persistent inflation. This setup permits, but does not mandate, persistent inflation to arise from unfunded fiscal shocks. The autocorrelation coefficients for the tax rules (ρ_K, ρ_L) are set to 0.5, as they are only weakly identified in the estimation process. Additionally, the prior for the standard deviation of the shocks is the same across all shock types.

Priors and Posteriors for the Exogenous Processes									
		Posterior Distribution				Prior Distribution		
Param	Description	Mode	Median	5%	95%	Type	Mean	Std
ρ_{eG}	AR coeff. gov. cons.	0.9361	0.9372	0.9096	0.9609	B	0.500	0.100
ρ_{eZ}^{M}	AR coeff. funded trans.	0.9954	0.9953	0.9936	0.9967	B	0.995	0.001
ρ_{eZ}^{F}	AR coeff. unfunded trans.	0.9954	0.9953	0.9936	0.9967	B	0.995	0.001
ρ_z	AR coeff. short-term trans.	0.4916	0.3314	0.2669	0.4590	B	0.500	0.100
ρ_a	AR coeff. technology	0.3107	0.2995	0.2156	0.3604	B	0.500	0.100
ρ_b	AR coeff. preference	0.7946	0.8033	0.7642	0.8369	B	0.500	0.100
ρ_m	AR coeff. mon. policy	0.2417	0.2613	0.2068	0.3296	B	0.500	0.100
ρ_i	AR coeff. investment	0.9218	0.9141	0.8982	0.9308	B	0.500	0.100
ρ_{rp}	AR coeff. risk premium	0.9035	0.9000	0.8844	0.9139	B	0.500	0.100
$\rho_{\mu^{NKPC}}$	AR coeff. pers. cost push	0.9966	0.9965	0.9953	0.9975	B	0.995	0.001
σ_G	St.dev. gov. cons.	2.0042	2.0463	1.8965	2.1828	IG	0.500	0.200
σ_Z^M	St.dev. funded transfers	2.9525	2.9530	2.7788	3.2491	IG	0.500	0.200
σ_Z^F	St.dev. unfunded transfers	0.5960	0.5628	0.4639	0.6674	IG	0.500	0.200
σ_z	St.dev. short-term trans.	0.3897	0.3739	0.3165	0.4661	IG	0.500	0.200
σ_a	St.dev. technology	1.2159	1.2243	1.1252	1.3274	IG	0.500	0.200
σ_b	St.dev. preference	4.9930	4.9951	4.9870	4.9994	IG	0.500	0.200
σ_m	St.dev. mon. policy	0.2420	0.2446	0.2228	0.2691	IG	0.500	0.200
σ_i	St.dev. investment	0.4976	0.5007	0.4467	0.5607	IG	0.500	0.200
σ_w	St.dev. wage markup	0.3453	0.3504	0.3217	0.3864	IG	0.500	0.200
σ_p	St.dev. transitory cost push	0.1694	0.1714	0.1534	0.1920	IG	0.500	0.200
σ_{rp}	St.dev. risk premium	0.3824	0.3994	0.3483	0.4509	IG	0.500	0.200
$\sigma_{\mu^{NKPC}}$	St.dev. persistent cost push	1.3257	1.3196	1.1878	1.6059	IG	0.500	0.200
σ_{GDP}^m	Measur. error GDP	0.4338	0.4343	0.4001	0.4710	IG	0.500	0.200
σ_{by}^m	Measur. error Debt/GDP	0.3245	0.3659	0.3123	0.5153	IG	0.500	0.200

Table 2: Posterior modes, medians, 90% posterior credible sets, and prior moments for the structural parameters. The letters in the column with the heading "Prior Type" indicate the prior density function: N, G, and B stand for Normal, Gamma, and Beta, respectively. Source: Bianchi et al. (2023).

4.3 Posterior Distributions

The left panels of Tables I and II present the posterior distributions for the structural parameters and exogenous processes, respectively, based on data from the sample period 1960:Q1 to 2007:Q4. The parameters governing the responsiveness of tax instruments to debt (γ_L and γ_K) are positive but relatively small in magnitude. As a result, the stabilization of funded debt largely relies on the higher estimates for γ_G and γ_Z, indicating that adjustments in government spending play a more significant role than tax changes in stabilizing debt.

Our estimates for price and wage rigidities are on the lower end compared to the existing literature, while the habit parameter is closer to the upper range of reported estimates but remains below the values found by Leeper et al. (2017). The output coefficient in the Taylor rule is nearly zero and lower than what is typically found in similar model estimations. This suggests that the central bank's interest rate adjustments are largely driven by changes in

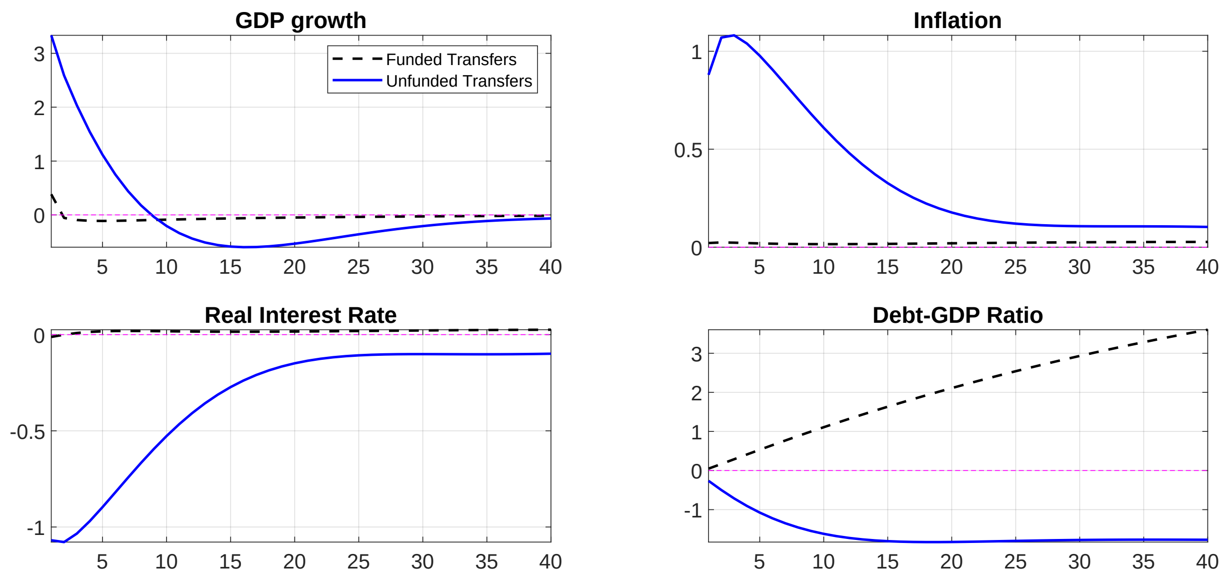

Figure 3: **Impulse responses to fiscal shocks.** Impulse responses of annualized GDP growth, inflation, the real interest rate, and the debt-to-GDP ratio to a shock to funded transfers (black dashed line), unfunded transfers (blue solid line), and government purchases (red dotted-dashed line). Units: percentage deviations from steady-state values. The magnitude of the initial shocks is set to be equal to one-standard deviation as estimated in the second sample (2008:Q1-2022:Q4).

fiscal inflation rather than fluctuations in output.

5 Results

In this section, we analyze the role of unfunded fiscal shocks in driving fluctuations in real interest rates using the estimated TANK model. We begin by evaluating impulse response functions and then explore the historical context.

5.1 Impulse responses

In this subsection, we use impulse responses to highlight the differences between funded and unfunded shocks to transfers. This analysis is also useful to understand how the two shocks are identified in the structural estimation of the model. Figure 3 reports the responses of annualized GDP growth, inflation, the real interest rate, and the debt-to-GDP ratio.

A funded fiscal shock generates only a modest increase in real activity and inflation, despite the presence of hand-to-mouth agents. The increase in growth immediately reverts, as the central bank responds by increasing rates more than one-to-one and real interest rates increase. The debt-to-GDP ratio starts trending up, as the shock to spending is persistent and taxation is slow to react to the increase in spending. An unfunded fiscal shock has very different effects. Growth jumps and remains elevated for a while. Inflation also experiences a large increase that is accommodated by the central bank. As a result, real interest rates

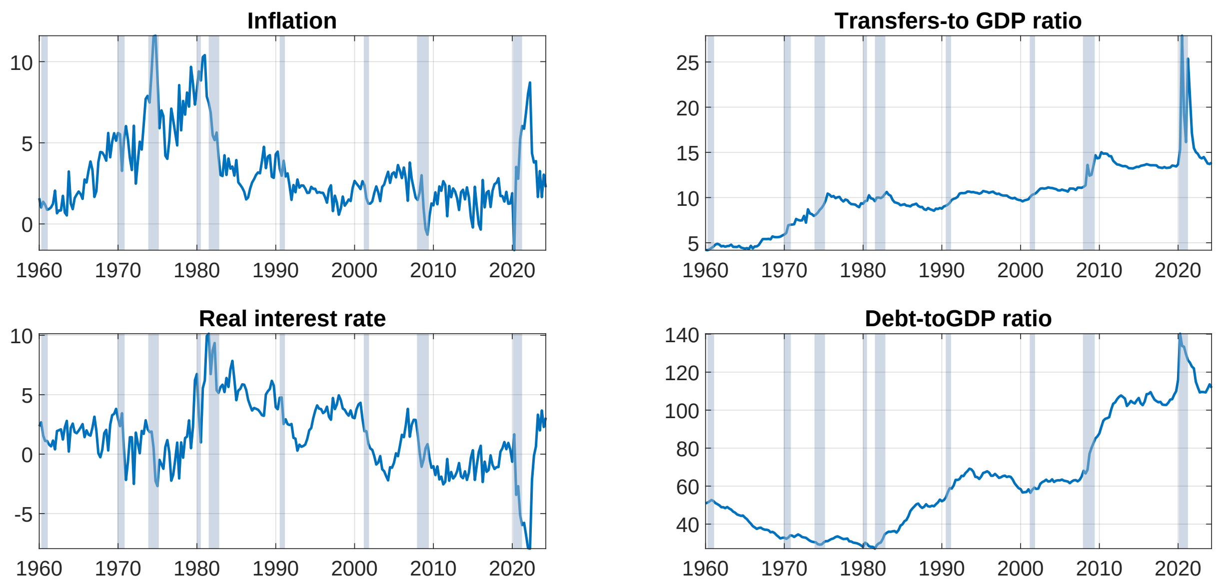

Figure 4: **Selected macro series.** The figure reports the series for inflation, real interest rates, transfers-to-GDP ratio, and debt-to-GDP ratio over the sample 2008:Q1-2024:Q2.

instead of increasing, experience a large decline. After the initial spur, inflation remains elevated for a long time. Importantly, the jump in real activity and the drop in real interest rates lead to a decline in the debt-to-GDP ratio. This is because the increase in spending is spread over time, while the increase in fiscal inflation and output and the drop in real interest rates are front-loaded.

Summarizing, funded and unfunded fiscal shocks imply very different commovement between macroeconomic and fiscal variables. Real interest rates experience a modest increase following funded fiscal shocks, while they decline by a large amount in response to an unfunded fiscal shock.

5.2 Real interest rates and fiscal shocks

Before analyzing the historical patterns of funded and unfunded transfers and their relation to movements in real interest rates, it is essential to understand how total federal transfers have changed over time and how these changes relate to movements in other key variables of our analysis. Figure 4 reports inflation, the ex-post real interest rate, the transfers-to-GDP ratio, and the debt-to-GDP ratio over the sample 2008:Q1-2024:Q2. The ex-post real interest rate is measured as FFR minus realized inflation.

From 1960 to 2024, the U.S. government's transfers-to-GDP have followed distinct phases:

1. Sharp increase in the 1960s and 1970s: During this period, there was a notable rise in government transfers. This growth reflects initiatives from President Johnson's "Great

Society" program aimed at reducing poverty, racial injustice, and crime. The increase continued under President Nixon (1969-1974) as many welfare programs initiated in the 1960s became long-term components of federal spending. During these years inflation keeps increasing, while the debt-to-GDP ratio and real interest rates decline.

2. Stagnation from the late 1970s to the 1990s: Following this surge, the growth of transfers slowed down and remained stable until around 1990. In the late 1970s and early 1980s, we also observe a quick reversal of real interest rates, triggering a persistent increase in the debt-to-GDP ratio and a relatively quick drop in inflation.

3. Growth in post-Millennial period: After the 1990s, transfers grew at a steady, though slower, pace. This period saw consistent, moderate increases in government spending, largely reflecting economic conditions and policy changes. We observe a significant jump in the aftermath of the Great Recession, with large accumulation of debt.

4. Pandemic Surge: During the pandemic recession in 2020-2024, there was an unprecedented jump in transfers, exceeding previous trends. Even as the pandemic subsided. Shortly after inflation experiences a large jump, washing out a large share of the debt accumulated during the recession. Ex-post real interest rates drop drammatically as the Fed initially accomodates the inflation surge.

As explained at length in Bianchi et al. (2023), the composition of spending between funded and unfunded changes significantly over time. These changes in the composition of spending are central to understanding the relation between spending and real interest rates, the role of monetary policy, and the consequences for inflation and the debt-to-GDP ratio. Figure 5 reports smoothed changes in unfunded (left panel) and funded (right panel) transfers together with the real interest rates. Unfunded transfers occur when policymakers rely on fiscal measures without adequate funding, leading to inflation and shifts in interest rates. When unfunded transfers increase, real interest rates tend to decrease. This generates a strong negative correlation between changes in unfunded spending and real interest rates: -0.59. This inverse relationship highlights the coordination between monetary and fiscal policy to manage the fiscal burden resulting from changes in spending. Instead, the relation between funded transfers and real interest rates is weak in the data, with a correlation of -0.08.

It is then useful to summarize the dynamics of unfunded transfers across the four periods identified above:

1. 1960s-1970s: The rapid growth of unfunded transfers played a significant role in driving inflation during this time, with increases reflecting rising welfare spending. This

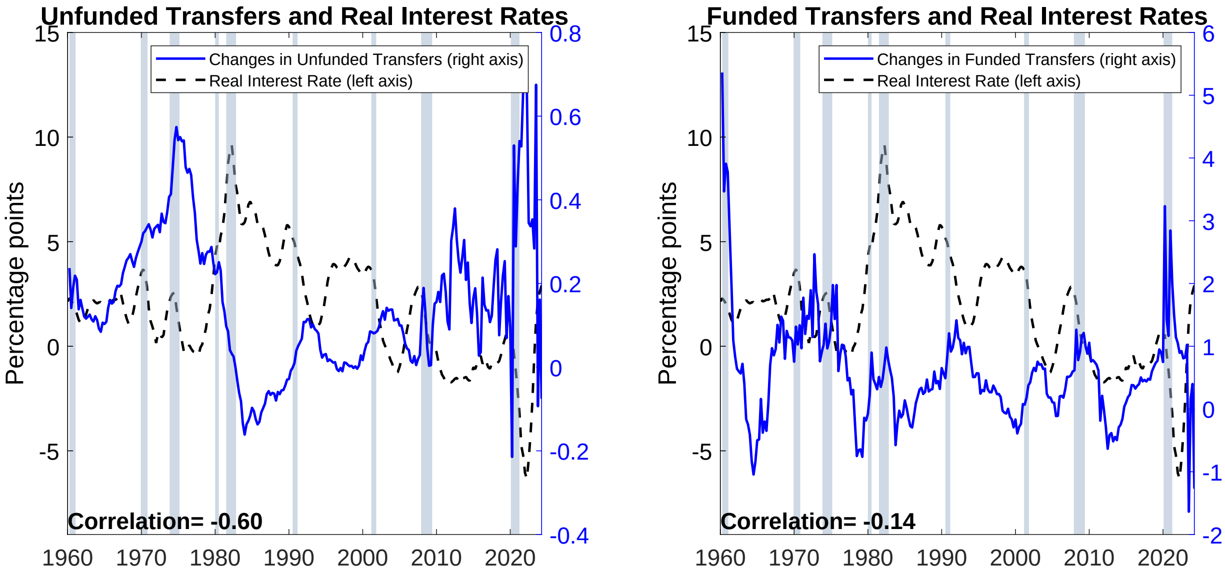

Figure 5: **Federal transfers and real interest rate.** The two panels report changes in the amount of unfunded transfers (blue line in the left panel) and funded transfers (blue line in the right panel) together with the ex-ante real interest rate (black line). The changes in transfers are computed by taking the one-year moving average of the quarter-over-quarter percentage changes in the amount of unfunded transfers predicted by the model (smoothed estimates). The real interest rate is computed by taking the three-year moving average of the annualized ex-ante real rate of interest predicted by the model (smoothed estimates). The sample period is 1960:Q1-2024:Q2.

increase in unfunded spending coincided with low real interest rates and higher real activity that kept the debt-to-GDP ratio low despite the acceleration in spending.

2. Late 1970s-1980s: The growth in unfunded transfers slowed, peaking in the late 1970s and then declining in the early 1980s. This period coincided with efforts by the Federal Reserve, under Chairman Paul Volcker, to control inflation through higher interest rates. In the 1980s, President Reagan arguably played an important role by running on an anti-inflation presidential campaign, advocating for a reduction in spending, and, later in his presidency, increasing the tax base. This policy shift is consistent with a reduction in unfunded spending. During the early 1980s. the United States ran primary deficits, but this was mostly the result of the sharp increase in the cost of borrowing and the recession that came with them. Higher real interest rates and lower real activity led to an increase in the debt-to-GDP ratio. Notice that this is consistent with a shift from unfunded to funded spending, as illustrated in the impulse responses in Section 3.

3. Post-1990: The growth in transfers continued, though at a slower pace. However, the amount of unfunded transfers remained under control. In the 2010s, the share of unfunded transfers increased more rapidly due to accommodating monetary policies that allowed for low or negative real interest rates.

4. Pandemic response: In response to the economic fallout from the COVID-19 pandemic, the federal government sharply increased transfers in 2020 and 2021. Initially, unfunded transfers remained stable, but by the third quarter of 2020, they began to rise, reflecting new monetary frameworks that allowed for inflation to exceed targets. This shift, combined with fiscal stimulus measures like the ARPA (American Rescue Plan Act), contributed to the post-pandemic inflation surge.

We now examine in more detail the relationship between unfunded transfers and the historical dynamics of inflation and real interest rates. Figure 7 presents a historical shock decomposition of inflation and the real interest rate. In each panel, the black dashed line corresponds to the data. In the lower panel, the model-implied ex-ante real interest rate is computed as the FFR minus the one-step-ahead expected inflation. Notice that this measure is slightly different from the real interest reported in Figure 4, where we use current inflation as a proxy for one-step-ahead expected inflation. However, the two series commove quite closely. The blue solid line corresponds to movements in inflation (top panel) and the real interest rate (lower panel) that can be explained by changes in unfunded fiscal shocks to transfers, while the red-dashed line also includes funded fiscal shocks.

The main finding from Figure 7 is that fiscal real interest rates—caused by unfunded transfers—account for a large share of the low-frequency movements in real interest rates. The persistent rise in inflation from the mid-1960s to the mid-1970s is largely explained by the inflationary effects of increased unfunded transfers during that period. This translates to a persistent decline in the fiscal real interest rate of around 6%. This is a large change that accounts for most of the low-frequency change in the overall real interest rate. The rise in fiscal inflation, accommodated by the central bank, helped support growth in the 1970s, counteracting the productivity slowdown of those years. Low real interest rates and high real activity lower the debt-to-GDP ratio.

The inflationary effects of this rise in transfers began to diminish in the late 1970s, while non-policy shocks were pushing up inflation. Although the share of unfunded transfers rose in the second half of the 1970s, the pace was not fast enough to sustain the high level of fiscal inflation caused by the large expansion in unfunded transfers in the first half of the 1970s. Consequently, fiscal real interest rates steadily increased in the second half of the 1970s, though they remained relatively low at the end of the decade.

The increase in fiscal real interest rates accelerated in the early 1980s, and coincided with the fall in inflation and the reversal of the debt-to-GDP dynamics described above. In the first five years of the 1980s, fiscal real interest rates increased by around 3%. The sharp increase in the real interest rate due to the aggressive monetary tightening by the Federal Reserve under Chairman Volcker coincided with a significant fall in fiscal inflation and output

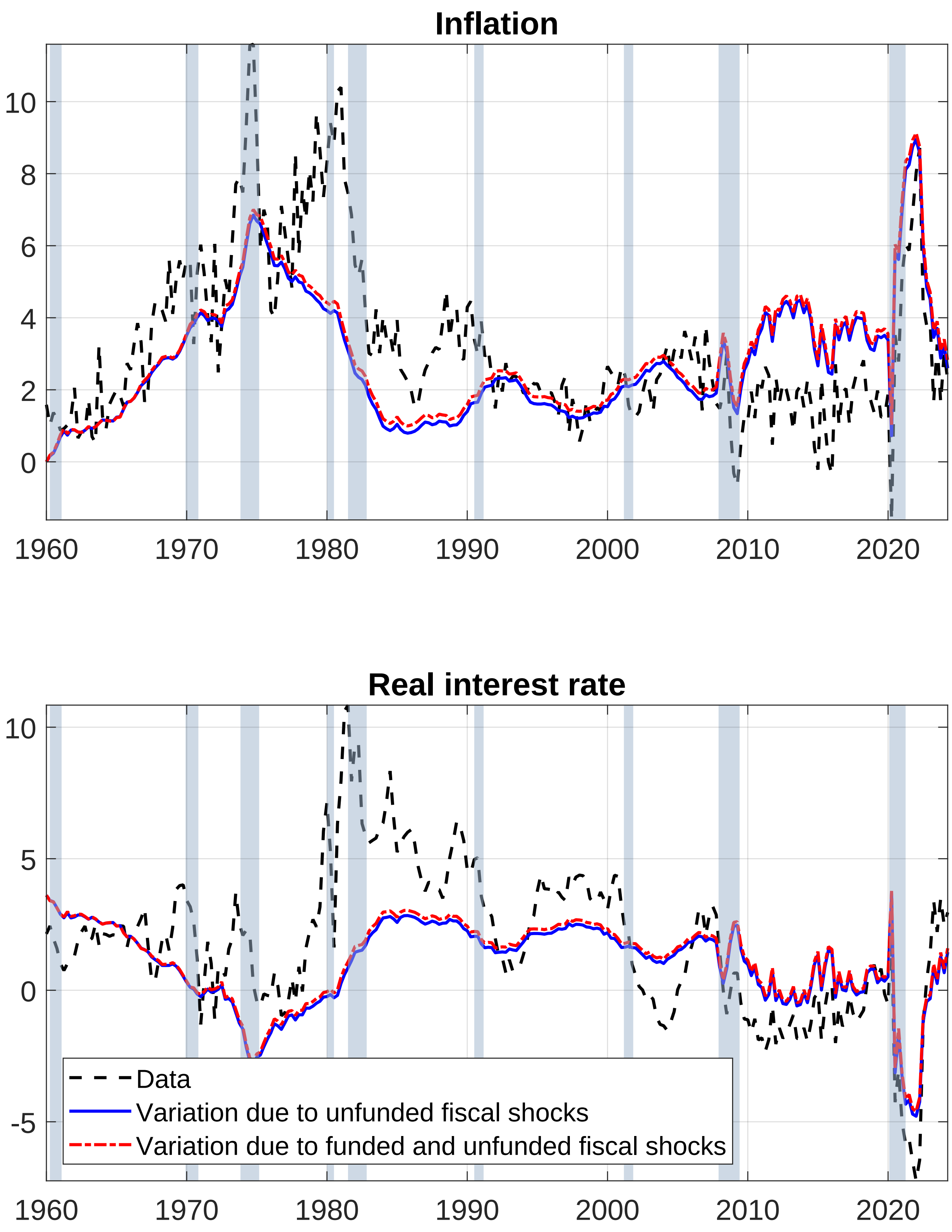

Figure 6: **Real interest rate and fiscal shocks**. The figure reports the contribution of funded and unfunded fiscal shocks to changes in inflation (top panel) the real interest rate (lower panel). The black dashed line reports the model-implied real interest, computed as FFR minus one-step-ahead expected inflation. The blue solid line is the value of the real interest rate if only unfunded fiscal shocks had occurred. The red dotted-dashed line represents the value of the real interest rate if only unfunded and funded fiscal shocks had occurred. The shaded areas correspond to the NBER recessions. Shocks and their contributions are constructed by using the Kalman smoother with the model parameters set at their posterior mode.

growth in the early 1980s. Thus, a policy change occurred before the appointment of Federal Reserve Chairman Volcker in August 1979. However, the early 1980s saw an acceleration in the policy environment change, propelled by President Reagan's election, which arguably provided political backing to the Federal Reserve's resolute disinflation policy (Samuelson 2008, Bianchi and Ilut 2017, Bianchi, Faccini, and Melosi, 2023). Thus, the rapid decline in inflation, the slowdown in real activity, and the increase in real rates of the early 1980s are interpreted as a joint monetary-fiscal policy phenomenon.

Fiscal real interest rates remained fairly stable until the post-Millennial period. This stability can be explained by the absence of major recessions and fiscal events. After the 2008 financial crisis, fiscal real rates remain very low, but above actual real rates. This is consistent with the fact that from the early 2000s, fiscal inflation persistently helped avert deflation. In the post-Great Recession period, fiscal inflation offset a deflationary bias caused by non-policy shocks—primarily a mix of favorable investment shocks and long-run cost-push shocks. Notably, these non-policy forces' deflationary effects are persistent and keep dragging inflation down for a long time. The counterpart of elevated fiscal inflation is a persistent decline in fiscal real rates.

Finally, the pandemic determines a large and unprecedented drop in real rates. This large drop is mostly explained by a large unfunded fiscal shock that was accommodated by the central bank. As explained in more detail in Bianchi et al. (2023), inflation was already on an upward trajectory following the CARES Act, but it accelerated significantly after the ARPA fiscal stimulus, which was implemented when the economy was already on a recovery path. Interestingly, the first change in the amount of unfunded transfers and the associated contribution to the economic rebound did not coincide with the increase in fiscal transfers associated with the CARES Act, but rather with the announcement of the Federal Reserve's policy strategy change. Thus, our model suggests that coordination between monetary and fiscal authorities triggered the large economic rebound and spur in inflation. The increase in funded transfers alone has limited efficacy because it also generates an expectation of large future tax increases. This result holds despite allowing for hand-to-mouth consumers who immediately spend the transfers they receive. Instead, an increase in unfunded transfers leads to a reflation of the economy, a decline in real interest rates, and an increase in real activity.

In this respect, the post-pandemic dynamics align with historical experience. Throughout the sample, fiscal inflation increases and fiscal real rates drop after recessions, consistent with findings documented in Hall and Sargent (2011, 2022). This pattern is particularly visible after the 1973-1975, 1990-1991, 2001, 2007-2009, and pandemic recessions. The only noticeable exception is the early 1980s recession, which is inherently different because the decline in inflation, the jump in real interest rates, and the contraction in real activity were largely caused by a decline in the share of unfunded spending associated with the policy shift. As discussed above, the model interprets the Volcker disinflation and the associated recession as a joint monetary and fiscal phenomenon.

The historical decomposition presented above allows us to further explain how to interpret the policy rules used in the paper. The coordination of monetary and fiscal policies may originate from the need to finance expensive social programs, long wars, or large fiscal stimuli. These are scenarios where the fiscal authority might not realistically be able to raise primary surpluses, leading to inflationary pressure. An example is the launch of the Great Society initiatives, which triggered an upward shift in transfers for several years after President Johnson's 1964 announcement. Financing these expensive, long-lasting social programs with only fiscal instruments could have been perceived as politically unfeasible. This generated inflationary pressure met by dovish monetary policy. In the early 1980s, Fed Chairman Volcker signaled that inflationary pressure would no longer be accommodated. The Reagan administration, unlike previous administrations, refrained from interfering and advocated for a small government, making this policy change credible.

5.3 Current outlook for real interest rates

Our analysis has demonstrated that the interaction between monetary and fiscal policies plays a pivotal role in explaining a significant portion of low-frequency movements in real interest rates. An unfunded fiscal shock precipitates a substantial increase in inflation, which is accommodated by the central bank, leading to a consequent decline in real interest rates. Although the initial surge in inflation is relatively short-lived, its inflationary effects persist for decades, thereby exerting long-term downward pressure on real interest rates.

In examining the post-pandemic period, it is therefore interesting to assess market expectations regarding future real interest rates. We utilize 5-year breakeven inflation and 10-quarter-ahead overnight index swaps as market-based measures of expectations for inflation and short-term interest rates, respectively. While these measures are inherently imperfect, they nonetheless provide valuable insights.

The left panel of Figure 7 reveals several noteworthy patterns. Firstly, 5-year breakeven was for many years slightly below the Fed's 2% target. It then experienced a visible but relatively modest increase during the pandemic, consistent with the view that the inflation spike was perceived as a temporary response to a significant fiscal shock, rather than a permanent alteration of the inflation target. Secondly, such an increase followed the rapid decline in expected interest rates that occurred in 2020:Q3, after the Fed completed the review of its monetary policy strategy and claimed that it was ready to let inflation overshoot

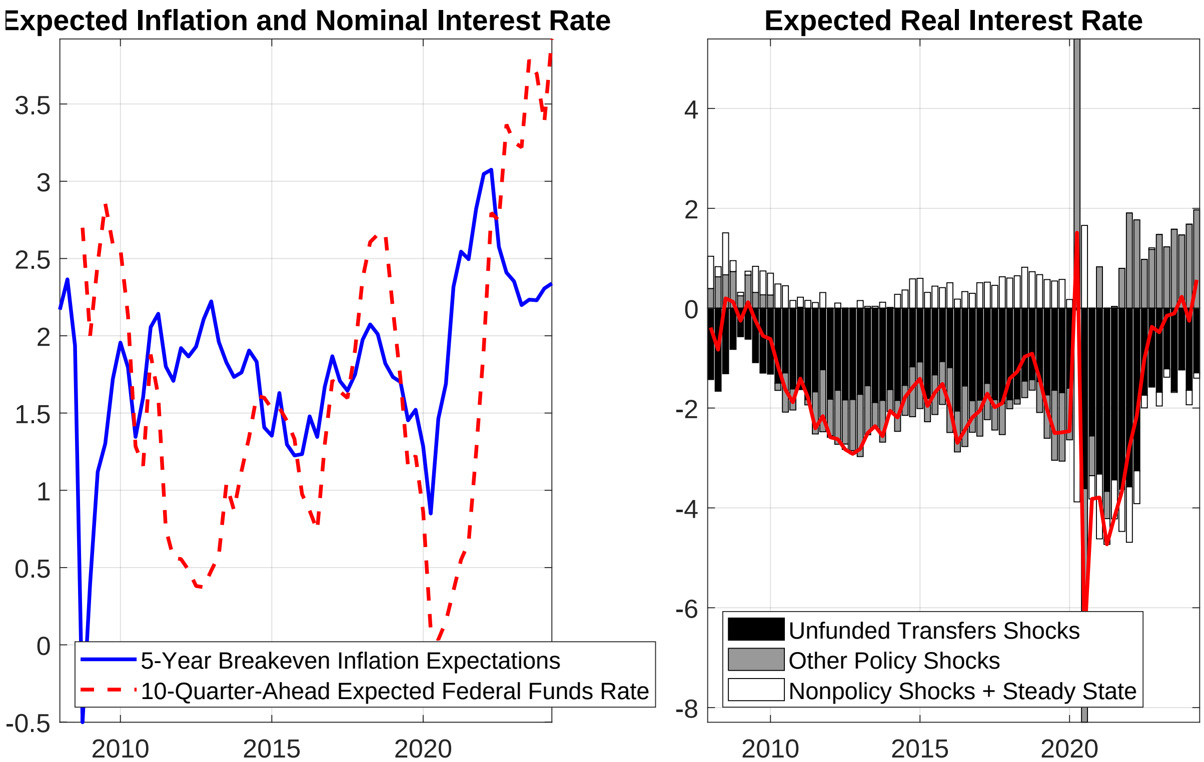

Figure 7: **Expected real interest rates**. In the left panel, the solid blue line and red dashed line correspond to the 5-year breakeven inflation and 10-quarter-ahead overnight index swaps, respectively. In the right panel, the red solid line corresponds to the model-implied 10-quarter-ahead short term real interest rate. The bars represent the cumulative contributions of unfunded transfers shocks (black bars), other policy shocks (gray bars), and non-policy shocks (white bars) on the two variables. The white bars also include the steady state and the initial conditions for the two variables. Other policy shocks include shocks to funded transfers, shocks to government purchases, and unanticipated and anticipated monetary policy shocks. Shocks are estimated using the Kalman smoother with the model parameters set at their posterior mode.

the target. Finally, after a decline in 2023, 5-year breakeven inflation began to rise again in 2024, potentially reflecting growing market concerns about the future fiscal outlook.

Equipped with this information, we ask how the model interprets the current outlook for future real interest rates. The right panel of Figure 7 presents a decomposition of the model-implied 10-quarter-ahead short-term real interest rate. The black, gray, and white bars represent changes attributable to unfunded transfer shocks, other policy shocks, and non-policy shocks, respectively. Expected real interest rates have reverted to pre-pandemic levels due to two primary factors: the dissipation of the short-term effects of unfunded pandemic shocks and the upward pressure exerted by other policy shocks, such as monetary policy adjustments. However, the decomposition also indicates that unfunded fiscal shocks continue to exert significant downward pressure on real interest rates.

6 Conclusions

In this paper, we extended the analysis of Bianchi et al. (2023) to study the role of fiscal shocks in driving fluctuations in the real interest rate. When embedded in a state-of-the-art TANK model, funded fiscal shocks cause modest *increases* in real interest rates, while unfunded fiscal shocks determine a large *drop* in real interest rates. This is because unfunded fiscal shocks generate additional inflationary pressure that is accommodated by the central bank.

We find that unfunded fiscal shocks play a key role in explaining slow-moving changes in real interest rates. Fiscal real rates decline in the 1960s and 1970s, while they increase quickly in the early 1980s. They remain roughly stable until the 1990s, while they drop again during the post-Millennial period. Unlike during the Great Inflation period, such low fiscal rates do not cause high inflation because they mostly counteract deflationary forces. Finally, the pandemic period is characterized by a sudden and large increase in unfunded spending, resulting in a spur of inflation accommodated by the central bank, with a consequent drop in real interest rates.

These results indicate that fiscal policy will play an important role in the evolution of real interest rates going forward. Spending is still elevated and the debt-to-GDP ratio is at an historic high. Furthermore, unlike other times in history, such large debt accumulation is not exclusively the result of a major catastrophic event. Surely, the pandemic presents analogies with major events of the past, such as the two world wars (Barro and Bianchi, 2024). However, debt and spending had been climbing before that. In fact, current debt would be significantly higher if not for the large post-pandemic increase in inflation. Given the current fiscal outlook, the extremely low real interest rates of the pre-pandemic period might not be compatible with low inflation, unless world economies resume their path toward increasing integration.

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A The Log-Linearized Model

This model features a trend in the state of labor-augmenting technological progress. In order to make the model stationary, we define the following variables: $y_t = \frac{Y_t}{A_t}$, $c_t^{*S} = \frac{C_t^{*S}}{A_t}$, $c_t^S = \frac{C_t^S}{A_t}$, $c_t^N = \frac{C_t^N}{A_t}$, $k_t = \frac{K_t}{A_t}$, $g_t = \frac{G_t}{A_t}$, $z_t = \frac{Z_t}{A_t}$, $b_t = \frac{P_t^m B_t^m}{P_t A_t}$, $s_{b,t} = \frac{P_t^m B_t^m}{P_t Y_t}$, $w_t = \frac{W_t}{P_t A_t}$, and $\lambda_t^S = \Lambda_t^S A_t$. We list below the equations of the log-linear model, starting with those that characterize the actual-economy block.

Production function:

$$\hat{y}_t = \frac{y + \Omega}{y} \left[\alpha \hat{k}_t + (1 - \alpha) \hat{L}_t \right]. \tag{19}$$

Capital-labor ratio:

$$\hat{r}_{K,t} - \hat{w}_t = \hat{L}_t - \hat{k}_t. \tag{20}$$

Marginal cost:

$$\widehat{mc_t} = \alpha \hat{r}_{K,t} + (1 - \alpha) \hat{w}_t. \tag{21}$$

Phillips curve:

$$\hat{\pi}_t = \frac{\beta}{1 + \chi_p \beta} \mathbb{E}_t \hat{\pi}_{t+1} + \frac{\chi_p}{1 + \chi_p \beta} \hat{\pi}_{t-1} + \kappa_p \widehat{mc_t} + \kappa_p \hat{\eta}_t^p + \kappa_p \hat{u}_t^{NKPC}, \tag{22}$$

where $\kappa_p = \left[(1 - \beta \omega_p)(1 - \omega_p) \right] / \left[\omega_p (1 + \beta \chi_p) \right]$.

Saver household's FOC for consumption:

$$\hat{\lambda}_t^S = \hat{u}_t^b - \frac{\theta}{e^{\varkappa} - \theta} \hat{u}_t^a - \frac{e^{\varkappa}}{e^{\varkappa} - \theta} c_t^{*S} + \frac{\theta}{e^{\varkappa} - \theta} c_{t-1}^{*S} - \frac{\tau^C}{1 + \tau^C} \hat{\tau}_{C,t}, \tag{23}$$

where $\hat{u}_t^a = u_t^a - \varkappa$.

Public/private consumption in utility:

$$\hat{c}_t^* = \frac{c^S}{c^S + \alpha_G g} \hat{c}_t^S + \frac{\alpha_G g}{c^S + \alpha_G g} \hat{g}_t. \tag{24}$$

Euler equation:

$$\hat{\lambda}_t^S = \hat{r}_{n,t} + \mathbb{E}_t \hat{\lambda}_{t+1}^S - \mathbb{E}_t \hat{\pi}_{t+1} - \mathbb{E}_t \hat{u}_{t+1}^a + \hat{u}_t^{rp}. \tag{25}$$

Maturity structure of debt:

$$\hat{r}_{n,t} + \hat{P}_t^m = \frac{\rho}{R} \mathbb{E}_t \hat{P}_{t+1}^m - \hat{u}_t^{rp}. \tag{26}$$

Saver household's FOC for capacity utilization:

$$\hat{r}_{K,t} - \frac{\tau_K}{1 - \tau_K} \hat{\tau}_{K,t} = \frac{\psi}{1 - \psi} \hat{\nu}_t. \tag{27}$$

Saver household's FOC for capital:

$$\hat{q}_t = \mathbb{E}_t \hat{\pi}_{t+1} - \hat{r}_{n,t} + \beta e^{-\varkappa} (1 - \tau_K) r_K \mathbb{E}_t \hat{r}_{K,t+1} - \beta e^{-\varkappa} \tau_K r_K \mathbb{E}_t \hat{\tau}_{K,t+1} + \beta e^{-\varkappa} (1 - \delta) \mathbb{E}_t \hat{q}_{t+1} - \hat{u}_t^{rp}. \tag{28}$$

Saver household's FOC for investment:

$$\hat{\imath}_t + \frac{1}{1+\beta}\hat{u}_t^a - \frac{1}{(1+\beta)\, se^{2\varkappa}}\hat{q}_t - \hat{u}_t^i - \frac{\beta}{1+\beta}\mathbb{E}_t\hat{\imath}_{t+1} - \frac{\beta}{1+\beta}\mathbb{E}_t\hat{u}_{t+1}^a = \frac{1}{1+\beta}\hat{\imath}_{t-1}. \tag{29}$$

Effective capital:

$$\hat{k}_t = \hat{\nu}_t + \hat{\bar{k}}_{t-1} - \hat{u}_t^a. \tag{30}$$

Law of motion for capital:

$$\widehat{\bar{k}}_t = (1-\delta)\, e^{-\varkappa}\left(\widehat{\bar{k}}_{t-1} - \hat{u}_t^a\right) + \left[1-(1-\delta)\, e^{-\varkappa}\right]\left[(1+\beta)\, se^{2\varkappa} + \hat{\imath}_t\right]. \tag{31}$$

Hand-to-mouth household's budget constraint:

$$\tau_C c^N \hat{\tau}_{C,t} + (1+\tau_C)\, c^N \hat{c}_t^N = (1-\tau_L)\, wL\left(\hat{w}_t + \hat{L}_t\right) - \tau_L wL\hat{\tau}_{L,t} + z\hat{z}_t. \tag{32}$$

Wage equation:

$$\begin{aligned}\hat{w}_t \;=\;& \frac{1}{1+\beta}\hat{w}_{t-1} + \frac{\beta}{1+\beta}\mathbb{E}_t\hat{w}_{t+1} - \kappa_w\left[\hat{w}_t - \xi\hat{L}_t + \hat{\lambda}_t^S - \frac{\tau_L}{1-\tau_L}\hat{\tau}_{L,t}\right] + \frac{\chi_w}{1+\beta}\hat{\pi}_{t-1}\\ &- \frac{1+\beta\chi_w}{1+\beta}\hat{\pi}_t + \frac{\beta}{1+\beta}\mathbb{E}_t\hat{\pi}_{t+1} + \frac{\chi}{1+\beta}\hat{u}_{t-1}^a - \frac{1+\beta\chi_w-\rho_a\beta}{1+\beta}\hat{u}_t^a + \kappa_w\hat{\eta}_t^w,\end{aligned} \tag{33}$$

where $\kappa_w \equiv \left[(1-\beta\omega_w)(1-\omega_w)\right] / \left[\omega_w (1+\beta)\left(1+\frac{(1+\eta^w)\xi}{\eta^w}\right)\right]$.

Aggregate households' consumption

$$c\hat{c}_t = c^S (1-\mu)\, \hat{c}_t^S + c^N \mu\hat{c}_t^N. \tag{34}$$

Aggregate resource constraint:

$$y\hat{y}_t = c\hat{c}_t + i\hat{\imath}_t + g\hat{g}_t + \psi'(1)\, k\hat{\nu}_t. \tag{35}$$

Government budget constraint:

$$\begin{aligned}&\frac{b}{y}\hat{b}_t + \tau_K r_K\frac{k}{y}\left[\hat{\tau}_{K,t} + \hat{r}_{K,t} + \hat{k}_t\right] + \tau_L w\frac{L}{y}\left[\hat{\tau}_{L,t} + \hat{w}_t + \hat{L}_t\right] + \tau_C\frac{c}{y}\left(\hat{\tau}_{C,t} + \hat{c}_t\right)\\ =\;& \frac{1}{\beta}\frac{b}{y}\left[\hat{b}_{t-1} - \hat{\pi}_t - \hat{P}_{t-1}^m - \hat{u}_t^a\right] + \frac{b}{y}\frac{\rho}{e^{\varkappa}}\hat{P}_t^m + \frac{g}{y}\hat{g}_t + \frac{z}{y}\hat{z}_t.\end{aligned} \tag{36}$$

Fiscal Rules:

$$\hat{g}_t = \rho_G\hat{g}_{t-1} - (1-\rho_G)\,\gamma_G(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F) + \zeta_{g,t}, \tag{37}$$

$$\hat{z}_t^b = \rho_Z\hat{z}_{t-1}^b - (1-\rho_Z)\left[\gamma_Z(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F) + \phi_{zy}\hat{y}_t\right] + \zeta_{z,t}, \tag{38}$$

$$\hat{z}_t = \hat{z}_t^b + \zeta_t^M + \zeta_t^F, \tag{39}$$

$$\hat{\tau}_{L,t} = \rho_L\hat{\tau}_{L,t-1} + (1-\rho_L)\,\gamma_L(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F), \tag{40}$$

$$\hat{\tau}_{K,t} = \rho_K\hat{\tau}_{K,t-1} + (1-\rho_K)\,\gamma_K(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F). \tag{41}$$

Monetary Rule:

$$\hat{r}_{n,t} = \max\left(-\ln\underline{R}, \rho_r\hat{r}_{n,t-1} + (1-\rho_r)\left[\phi_\pi(\hat{\pi}_t - \hat{\pi}_t^F) + \phi_y\hat{y}_t\right] + u_t^m\right). \tag{42}$$

The variables with the superscript F in equations (37) to (42) above belong to the shadow economy. In turn, the block of equations that characterize the shadow economy consists in an additional set of equations (19) to (36), where any variable that refers to the actual economy x_t is replaced by the same variable in the shadow economy x_t^F, plus the rule for the monetary authority

$$\hat{r}_{n,t}^F = \max\left(-\ln \underline{R}, \rho_r \hat{r}_{n,t-1}^F + (1-\rho_r)\left[\phi_\pi \hat{\pi}_t^F + \phi_y \hat{y}_t^F\right] + u_t^m\right) \tag{43}$$

and the rules for the fiscal authority,

$$\hat{g}_t^F = \rho_G \hat{g}_{t-1}^F - (1-\rho_G)\gamma_G \hat{s}_{b,t-1}^F + \zeta_{g,t}, \tag{44}$$

$$\hat{z}_t^{b,F} = \phi_{zy}\hat{y}_t^F + \rho_Z \hat{z}_{t-1}^{b,F} - (1-\rho_Z)\gamma_Z \hat{s}_{b,t-1}^F + \zeta_{z,t}, \tag{45}$$

$$\hat{z}_t = \hat{z}_t^{b,F} + \zeta_t^F, \tag{46}$$

$$\hat{\tau}_{L,t}^F = \rho_L \hat{\tau}_{L,t-1}^F + (1-\rho_L)\gamma_L \hat{s}_{b,t-1}^F, \tag{47}$$

$$\hat{\tau}_{K,t}^F = \rho_K \hat{\tau}_{K,t-1}^F + (1-\rho_K)\gamma_K \hat{s}_{b,t-1}^F. \tag{48}$$

B The Data Set

Real GDP growth is computed as the growth rate of nominal GDP (GDP), divided by the GDP deflator (JGDP). Real consumption growth is the growth rate of the sum of personal consumption expenditures in non durable goods (PCND) and services (PCESV), divided by their price indexes (DNDGRG3M086SBEA and DSERRG3M086SBEA, respectively). Real investment growth is the growth rate of the sum of gross private domestic investment (GPDICTPI) and personal consumption expenditures in durable goods (PCDG), divided by the respective price deflators (GPDICTPI and DDURRG3M086SBEA), and scaled by the 16+ US civilian population (CNP16OV). We construct a measure of hours per capita by dividing total hours worked (PRS85006023) by population (CNP16OV). We then construct a measure of the hours gap by taking the difference of hours per capita from its trend, which is computed as a fourth degree polynomial. We compute a measure of hourly wages dividing wage compensation (A576RC1) by average weekly hours in the nonfarm business sector (PRS85006023). Based on this series, we create a nominal wage index, which we divide by an index of the GDP deflator (based on JGDP) and take growth rates. The debt to GDP ratio is constructed dividing the nominal market value of gross federal debt (MVGFD027MNFRBDAL) by nominal GDP (GDP). The growth of government consumption and investment expenditures is computed as follows. We add nominal federal government consumption expenditures (A957RC1Q027SBEA) to nominal gross government investment (A787RC1Q027SBEA), divide by the implicit price deflator (A822RD3Q086SBEA) and by an index of the U.S. population, with base 2012Q3 (CNP16OV) and finally take growth rates. The growth of real government transfers is computed as follows. We add government social benefits (B087RC1Q027SBEA) to other current transfer payments, which include grants-in-aid to state and local governments (FGSL), create an index with base 2012Q3, divide by an index of the U.S. population (CNP16OV) and an index of the GDP deflator (GDPDEF) with the same base year and finally take growth rates. Inflation is computed as the rate of growth of the GDP deflator (JGDP) and the interest rate is given the Effective Federal Funds Rate (FEDFUNDS). Finally, we also employ the 5-year breakeven inflation rate as a noisy measure of inflation expectations (T5YIE).

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