NBER WORKING PAPER SERIES

A FISCAL THEORY OF PERSISTENT INFLATION

Francesco Bianchi
Renato Faccini
Leonardo Melosi

Working Paper 30727
http://www.nber.org/papers/w30727

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
December 2022, Revised March 2023

We are grateful to Russell Miles for excellent research assistance. We wish to thank Robert Barro, Marco Bassetto, Larry Christiano, Jonas Fisher, Mark Gertler, Spence Krane, and Federico Ravenna for their very helpful comments and all seminar participants at the 2021 NBER Summer Institute, Columbia University, Johns Hopkins University, Bilkent University, Brandeis University, Bank of Israel, Danmarks Nationalbank, Rutgers University, UT Austin, 2020 ESCB cluster 2 conference, European Stability Mechanism, and the conference on New Developments in Business Cycle Analysis. The views in this paper are solely those of the authors and should not be interpreted as reflecting the views of the Federal Reserve Bank of Chicago, Danmarks Nationalbank, or any person associated with the Federal Reserve System the European System of Central Banks, or the National Bureau of Economic Research.

A Fiscal Theory of Persistent Inflation
Francesco Bianchi, Renato Faccini, and Leonardo Melosi
NBER Working Paper No. 30727
December 2022, Revised March 2023
JEL No. E30,E50,E62

ABSTRACT

We develop a new class of general equilibrium models with partially unfunded debt to propose a fiscal theory of persistent inflation. In response to business cycle shocks, the monetary authority controls inflation, and the fiscal authority stabilizes debt. However, the central bank accommodates unfunded fiscal shocks, causing persistent movements in inflation, output, and real interest rates. In an estimated quantitative model, fiscal inflation accounts for the bulk of inflation dynamics. In the aftermath of the pandemic, unfunded fiscal shocks sustain the recovery, but also cause a persistent increase in inflation. The model is able to predict the inflationary effects of the ARPA fiscal stimulus out of sample and using real time data.

Francesco Bianchi
Johns Hopkins University
Department of Economics
3400 N. Charles Street
544E Wyman Bldg.
Baltimore, Maryland 21218
and CEPR
and also NBER
francesco.bianchi@jhu.edu

Renato Faccini
Danmarks Nationalbank
Research department
Langelinie AllÃ© 47
2100 Copenhagen
Denmark
and Queen Mary University of London and Centre for Macroeconomics
rmmf@nationalbanken.dk

Leonardo Melosi
Federal Reserve Bank of Chicago
230 S. LaSalle street
Chicago, IL 60604
and the European University Institute and CEPR
leonardo.melosi@chi.frb.org

Persistent high inflation is always and everywhere a fiscal phenomenon.
Thomas J. Sargent (2013)

1 Introduction

We build a novel class of general equilibrium models with partially unfunded debt to propose a fiscal theory of persistent inflation. In response to business cycle shocks and funded fiscal shocks, the monetary authority controls inflation, and the fiscal authority stabilizes debt. However, the central bank accommodates unfunded fiscal shocks, causing persistent movements in inflation and real interest rates.

We first illustrate the distinction between funded and unfunded fiscal shocks in the context of a Fisherian model. Funded and unfunded shocks coexist in the model. The difference between the two types of shocks is that funded fiscal shocks are backed by future fiscal adjustments, while unfunded fiscal shocks are not. As a result, funded fiscal shocks are irrelevant for inflation, while unfunded fiscal shocks lead to an increase in inflation accommodated by the central bank. We then move to consider the effects of unfunded fiscal shocks in production economies. Absent nominal rigidities, unfunded fiscal shocks cause large and temporary jumps in inflation and do not have real effects, as in the Fisherian model. 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. However, these extensions leave real activity and real interest rates unaffected and create a counterfactually tight link between inflation persistence and the monetary policy rule. Instead, with nominal rigidities, unfunded fiscal shocks have real effects and cause persistent movements in inflation and real interests rates, leading to a fiscal theory of persistent inflation.

We then augment a quantitative New Keynesian (NK) model with unfunded fiscal shocks to assess their importance for US inflation dynamics. The model features all the ingredients that have been proven successful in matching US business cycle dynamics, including a large set of business cycle shocks. With respect to these shocks, monetary policy satisfies the Taylor principle and the fiscal authority is in control of debt stabilization. Thus, in this respect, the model behaves as its counterparts extensively studied in the literature. However, the model also features unfunded fiscal shocks. We model these as shocks to transfers that are not backed by future fiscal adjustments, implying that a share of the overall government debt is unfunded. The central bank accommodates the increase in inflation necessary to stabilize the unfunded amount of debt. As in the textbook version of the new Keynesian model described above, these shocks trigger persistent movements in inflation, output, and real interest rates.

The model is endowed with a rich set of shocks, including a persistent shifter to the New Keynesian Phillips Curve (NKPC) that is meant to capture autonomous factors, such as globalization and demographic changes, that can affect inflation in the long run. The model also features hand-to-mouth agents to allow for the possibility that funded fiscal shocks can influence macroeconomic dynamics. Thus, it is an empirical question whether unfunded fiscal shocks play an important role in explaining the data. We show that they do.

A persistent and partially unfunded increase in transfers in the mid-1960s, related to the introduction of the Great Society initiatives, accounts for the persistent rise in inflation during the Great Inflation. Symmetrically, the end of the Great Inflation is explained by a sharp revision in the amount of inflation that the Federal Reserve was going to tolerate to stabilize the portion of unfunded debt. In this respect, the aggressive increase in interest rates implemented by the Federal Reserve Chairman Paul Volcker can be interpreted as a strong signal of this policy change. After that, fiscal inflation does not completely disappear. The amount of unfunded spending increases sluggishly starting from the 1990s, and then accelerates in the aftermath of the Great Recession. However, during these years fiscal inflation is to some extent beneficial because it counteracts a deflationary bias due to non-policy shocks, arguably related to demographics and international trade.

Unfunded spending experiences a new acceleration during the pandemic. Large part of the economic rebound at the end of 2020 is attributed to the $2.2 trillion fiscal package introduced in March of the same year to combat the consequences of the pandemic crisis and that we find to be partially unfunded. Absent these unfunded shocks, the economy would have experienced deflation. Interestingly, a shift in the portion of unfunded spending is observed in the third and fourth quarters of 2020, after the Federal Reserve announced its new operating framework which contemplates the possibility of letting inflation overshoot its 2% target after the Pandemic recession.[1] This new monetary policy strategy is reflected in the market expected path of the federal funds rate, which we observe in the estimation. Finally, with the economy already on a recovery path, the 2021 $1.9 trillion American Rescue Plan Act (ARPA) fiscal stimulus determines a further increase in the amount of unfunded spending, exacerbating the post-pandemic inflation increase.

As an important validation, we then show that the model correctly predicts the inflationary effects of the ARPA even *out-of-sample* and when using real-time-data as available in 2021:Q2. We proceed in two steps. First, we produce a projection for inflation using only estimates and data up to the end of 2020. This projection reflects the effects of the

[1] On August 27, 2020, Federal Reserve Chairman Jerome Powell announced the new framework for the first time at the Jackson Hole Economic Symposium as follows: "Following periods when inflation has been running below 2 percent, appropriate monetary policy will likely aim to achieve inflation moderately above 2 percent for some time."

the Coronavirus Aid, Relief, and Economic Security (CARES) act. Under this scenario, the model predicts a modest inflation overshoot for the next four years, with a peak of 3.7%, and then a gradual return to the 2% target. We then consider the effects of the American Rescue Plan Act (ARPA). We assign part of the increase in spending in the first quarter of 2021 to unfunded transfers based on the historical evidence. We then construct a conditional forecast and show that the model can replicate very closely the inflation figures for 2021. The model now predicts a substantially more robust overshoot of inflation, with a peak of 6.3% instead of 3.7%, and a very slow return to the 2% target.

Based on these results, we conclude that unfunded spending has played an important role in accounting for inflation dynamics, both historically and in the post-pandemic period. From this point of view, the post-pandemic situation is not necessarily different from the historical experience of the United States. However, two qualifications have to be made. First, in the post-Millennial period fiscal inflation has been counteracting a deflationary bias. The risk of persistent high inflation depends in part on whether this deflationary bias will persist or not. If it were to disappear, perhaps because of a change in the degree of integration of the world economy, the post-Millennial high level of fiscal inflation could become a problem. Second, as of 2023, spending is at an historical maximum. This implies that even small changes in the share of unfunded debt can lead to large swings in inflation.

In the last part of the paper, we conduct a counterfactual simulation to highlight the key mechanisms that make unfunded fiscal shocks quantitatively important. We trim down the quantitative baseline model to only retain nominal rigidities as in a textbook NK model. We show that when this bare bone NK model is fed with the same unfunded fiscal shocks identified in the data, it delivers a very similar path for inflation, suggesting that the additional features of our baseline model do not drive the results with respect to the empirical relevance of fiscal inflation. These additional features are included to preserve the propagation mechanism of the other shocks and to avoid ruling out *a priori* other explanations for movements in inflation.

From the methodological standpoint, this paper develops a new class of models in which policymakers are allowed to react differently to different shocks. The focus of this paper is on the effects of unfunded fiscal shocks. However, this new class of models can be used to study other forms of heterogeneity in policy responses. The paper builds on Bianchi and Melosi (2019) who introduced the concept of shock-specific rules as a way to resolve a conflict between the monetary and fiscal authorities in the presence of a high fiscal burden that the fiscal authority is reluctant or unable to stabilize. In that paper, we apply a shock specific rule to study the macroeconomic effects of introducing an emergency budget to mitigate a large recession. In this paper, we extend the notion of shock-specific rules to solve general equilibrium models in which monetary and fiscal authorities adopt state-dependent targets. This delivers a fiscal theory of persistent inflation that is always at work, not only in response to exceptional events.

This paper is connected to the vast literature on monetary-fiscal policy interaction (Sargent and Wallace 1981; Leeper 1991; Sims 1994; Woodford 1994, 1995, 2001; Cochrane 1998, 2001; Schmitt-Grohe and Uribe 2000, 2002; Bassetto 2002; Reis 2016; Bassetto and Sargent 2021, among many others). Barro (1974) shows that an alternative way to generate non-Ricardian effects is if agents erroneously regard bonds as net-wealth. Aiyagari and Gertler (1985) study the implications of fiscal backing of government bonds for the propagation of shocks. They find that for debt to be irrelevant, the model needs to feature a considerable degree of accommodation with respect to the monetary authority. Leeper and Zhou (2013) find that inflation plays an important role in the optimal marginal financing of fiscal needs in models similar to the one used in our empirical analysis. Hall and Sargent (2011) show that historically most of US debt stabilization has been achieved through a combination of growth, revaluation effects, and low real interest rates. Bianchi and Ilut (2017) estimate a model with regime changes in the monetary/fiscal policy mix and link the high inflation of the 1960s-1970s to a Fiscally-led regime. Bianchi and Melosi (2017, 2022) argue that the possibility of a return to such regime can explain the lack of deflation in the aftermath of the Great Recession and the post-pandemic inflation. In a recent opinion piece, Barro (2022) reaches a conclusion similar to the one proposed in this paper with respect to the post-pandemic inflation: a realignment in prices necessary to stabilize the large pandemic increase in the fiscal burden.

With respect to models with regime changes in the monetary/fiscal policy mix, we move in a new and different direction. Monetary-led and Fiscally-led rules coexist in our model and the policy coordination is shock specific. Shocks to unfunded transfers are dealt with fiscally-led policies. With respect to all other shocks, the monetary authority controls inflation and the fiscal authority is responsible for debt stabilization. As a result, this new modeling approach delivers low-frequency movements in inflation linked to unfunded fiscal shocks, while at the same time preserving the typical propagation of the business cycle shocks employed in NK models. In this respect, our work is related to Cochrane (2022) that considers a class of NK models in which pre-existing debt is backed by future surpluses, but in response to unexpected movements in inflation, policymakers are not committed to make fiscal adjustments. The key difference is that Cochrane (2022) assumes that the policy mix is always fiscally-led, while in our setting a Monetary-led and a Fiscally-led policy mix coexist at the same time. The two papers share the goal of integrating elements of the fiscal theory of price level in a NK framework.

2 Persistent Fiscal Inflation

In this section, we introduce a new class of models in which a Monetary-led and a Fiscally-led policy mix coexist at the same time. The propagation of shocks changes depending on the shock specific policy response. This allows us to introduce unfunded fiscal shocks in an otherwise standard model. We illustrate the logic of this new class of models with shock specific rules in the context of a simple Fisherian model (Leeper 1991 and Sims 1994, 2016). Our focus is on fiscal inflation, but the method can be applied in other settings in which a researcher is interested in modeling shock specific policy responses. We then move to a production economy and discuss the consequences of introducing nominal rigidities. We show that in a model with nominal rigidities, unfunded fiscal shocks lead to persistent movements in inflation and real effects.

2.1 Funded and unfunded fiscal shocks

Stylized model The economy is populated by a continuum of infinitely many households and a government. The representative household has concave and twice continuously differentiable preferences over non-storable consumption goods and is endowed in each period with a constant quantity Y of these goods. The government issues one-period debt B_t to households who can trade them for consumption goods. The representative household chooses consumption and government bonds so as to maximize:

$$\max \sum_{t=0}^{\infty} \beta^t U(C_t),$$

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 reads $Q_tB_t + P_tT_t = B_{t-1}$, where net taxes, T_t, coincide 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 $\tau = T_t/Y$ denotes the surplus-to-output ratio, $s_{b,t} = Q_tB_t/(P_tY)$ denotes the real market value of debt as a share of output, τ and s_b are their respective steady-state values, ζ_t is a shock to lump-sum taxes that follows an AR(1) process, and the parameter γ determines how strongly the fiscal authority adjusts primary surpluses to fluctuations in debt.

The central bank behaves according to the following 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, variables without the time subscript denote the corresponding steady states, and the parameter ϕ controls the strength with which the central bank reacts to movements of inflation from its target.

Combining the households' Euler equation with the market clearing condition $C_t = Y$ in every period leads to the Fisher equation: $Q_t = \beta \left(\mathbb{E}_t \Pi_{t+1}\right)^{-1}$.

Linearized system of equations We linearize the model equations around the deterministic steady state. Henceforth, hatted variables denote variables in log-deviation from their steady-state values. We obtain the following system of equations:

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

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

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

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

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

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

Combining the law of motion for real 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 As shown by Leeper (1991), in this class of models there are two regions of the parameter space that deliver existence and uniqueness of a stationary solution. In the first region, monetary policy is active and responds more than one-to-one to deviations of inflation from its target ($\phi > 1$). The fiscal authority implements the necessary fiscal adjustments to keep debt on a stable path ($\gamma > 1$). Fiscal policy is defined as passive because it passively accommodates the behavior of the monetary authority. We label this policy combination the Monetary-led policy mix. The distinctive feature of the Monetary-led policy mix is that the macroeconomy is completely insulated from the fiscal block and fiscal imbalances are irrelevant for inflation determination in equilibrium (*Monetary and Fiscal Dichotomy*). This is because debt stability is achieved with fiscal adjustments.[2] The first panel of Figure 1 illustrates this point by showing that inflation does not move in response to a negative shock to primary surpluses.

In the second region of the parameter space, labelled Fiscally-led policy mix, the fiscal authority is not committed to implementing the necessary fiscal adjustments. Monetary policy is now passive ($\phi \leq 1$) because it passively accommodates the behavior of the ac-

[2] In richer models with distortionary taxation and government purchases, fiscal variables affect the macroeconomy, but through a different channel with respect to the one analyzed here.

tive fiscal authority ($\gamma \leq 1$). Under the Fiscally-led policy mix, the macroeconomy is not insulated with respect to fiscal imbalances. In fact, inflation is determined by the need of stabilizing government debt. Consequently, fiscal imbalances affect inflation. The second panel of Figure 1 illustrates this point. Now a negative shock to primary surpluses leads to an increase in inflation. This increase in inflation is fully accommodated by the central bank ($\phi = 0$) and debt stability is preserved.

Shock specific rules and partially unfunded debt We now extend the model to allow the Monetary-led and Fiscally-led policy mixes to coexist. In this new class of models, the dynamics typical of a Monetary-led policy mix coexist with the dynamics typical of a Fiscally-led policy mix. We focus on fiscal shocks, but the logic outlined below applies to all types of shocks that move the fiscal burden of the economy, as illustrated in the richer model considered in our empirical analysis. In what follows, 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.

We consider the following fiscal rule:

$$\tau_t/\tau = \left(s_{b,t-1}/s^F_{b,t-1}\right)^{\gamma^M} \left(s^F_{b,t-1}/s\right)^{\gamma^F} e^{\zeta^M_t + \zeta^F_t}, \tag{7}$$

where ζ^M_t and ζ^F_t denote funded and unfunded fiscal shocks, respectively. With respect to the amount of unfunded debt $s^F_{b,t}$ accumulated as a result of the unfunded fiscal shocks, the fiscal authority is not committed to implementing a large enough fiscal adjustment: $\gamma^F \leq 1$. Instead, the fiscal authority is willing to fully stabilize deviations of debt from its unfunded component: $\gamma^M > 1$. Thus, fiscal policy is passive with respect to the funded component of debt $(s_{b,t-1}/s^F_{b,t-1})$), while it is active with respect to the unfunded component of debt $(s^F_{b,t-1})$.

The new monetary rule is:

$$R_{n,t}/R_n = (\Pi_t/\Pi^F_t)^{\phi^M} (\Pi^F_t/\Pi)^{\phi^F}. \tag{8}$$

where Π^F_t denotes fiscal inflation, i.e., the amount of inflation that is tolerated by the central bank due to unfunded fiscal shocks. With respect to fiscal inflation, monetary policy is passive: the central bank reacts less than one-to-one, $\phi^F \leq 1$. Instead, the central bank is active in stabilizing inflation in deviations from fiscal inflation: $\phi^M > 1$.

Linearizing the fiscal rule in equation (7), we obtain:

$$\hat{\tau}_t = \gamma^M \left(\hat{s}_{b,t-1} - \hat{s}^F_{b,t-1}\right) + \gamma^F \hat{s}^F_{b,t-1} + \zeta^M_t + \zeta^F_t. \tag{9}$$

Given that $\gamma^F \leq 1$, the expression above makes clear that the fiscal adjustments are not large enough to cover the entirety of the fiscal burden.

Linearizing the monetary rule, we obtain:

$$\hat{r}_{n,t} = \phi^M \left(\hat{\pi}_t - \hat{\pi}_t^F\right) + \phi^F \hat{\pi}_t^F. \tag{10}$$

If we further assume $\phi^F = 0$, we obtain a Taylor rule that is isomorphic to a rule with a time-varying target: $\hat{r}_{n,t} = \phi^M \left(\hat{\pi}_t - \hat{\pi}_t^F\right)$. Crucially, the time-varying target $\hat{\pi}_t^F$ is not an additional shock, but it is instead tightly related to the amount of inflation tolerated by the central bank to stabilize a portion of the overall fiscal burden, leading to a fiscal theory of persistent inflation.

Appendix A exploits the linearity of the model to prove that the components of debt and inflation in deviations from their corresponding targets, $\hat{s}_{b,t}^M = \hat{s}_{b,t} - \hat{s}_{b,t}^F$ and $\hat{\pi}_t^M = \hat{\pi}_t - \hat{\pi}_t^F$, are *exactly* the amounts of debt and inflation that would arise if the Monetary-led policy mix were always in place and only funded shocks occurred. We can then interpret $\hat{s}_{b,t}^M$ as the amount of funded debt that the fiscal authority is committed to stabilize through fiscal adjustments. Analogously, $\hat{\pi}_t^M$ corresponds to movements in inflation originating from shocks that the central bank does not accommodate and that are instead responsibility of the fiscal authority. We use the superscript M to emphasize that the Monetary-led policy mix applies with respect to these variables.

Using the fact that in the linearized model the total amount of debt is the sum of two components, funded and unfunded debt, $\hat{s}_{b,t} = \hat{s}_{b,t}^M + \hat{s}_{b,t}^F$, we can rewrite the fiscal rule as:

$$\hat{\tau}_t = \gamma^M \hat{s}_{b,t-1}^M + \gamma^F \hat{s}_{b,t-1}^F + \zeta_t^M + \zeta_t^F.$$

Similarly, exploiting the fact that in the linearized model $\hat{\pi}_t = \hat{\pi}_t^M + \hat{\pi}_t^F$, the monetary rule can be re-written as:

$$\hat{r}_{n,t} = \phi^M \hat{\pi}_t^M + \phi^F \hat{\pi}_t^F.$$

Thus, the linearized model allows two equivalent ways to interpret the policy rules. First, the policy rules can be interpreted as describing a situation in which policymakers react to time-varying targets that are driven by the need of stabilizing the amount of unfunded debt. Alternatively, the policy rules can be interpreted as shock specific rules in which policymakers react differently to the different components of the endogenous target variables depending on the shocks that generate the fluctuations.

Substituting the monetary rule (10) into the Fisherian equation (1) yields the monetary block of the model with partially unfunded debt:

$$\mathbb{E}_t \hat{\pi}_{t+1} = \phi^M \left(\hat{\pi}_t - \hat{\pi}_t^F\right) + \phi^F \hat{\pi}_t^F. \tag{11}$$

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

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

where to simplify the exposition, and without loss of generality, we have assumed that the

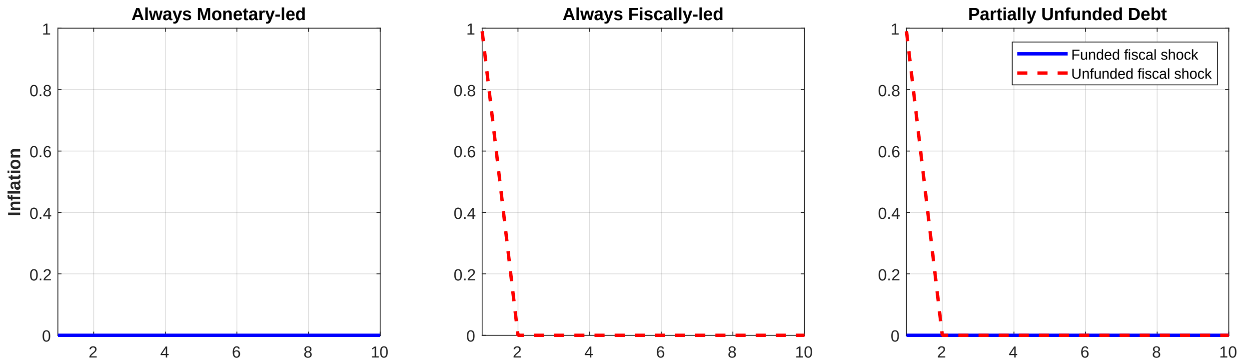


Figure 1: **Impulse response of inflation to a fiscal shock**. The discount factor β is set to 0.99 and the steady-state value of debt-to-GDP s_b to 1. In the model with partially unfunded debt, the monetary policy parameters are $\phi^M = 2$ and $\phi^F = 0$ and the fiscal policy parameters are $\gamma^M = 20$ 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 autocorrelation coefficient of 0.5 and their variance is scaled to produce a unit response of inflation on impact of an unfunded shock.

fiscal authority completely disregards the amount of unfunded debt: $\gamma^F = 0$.

To close the model, we need to characterize the dynamics of fiscal inflation, $\hat{\pi}_t^F$, and of the associated amount of unfunded debt, $\hat{s}_{b,t}^F$. To do so, we construct a shadow economy in which the Fiscally-led policy mix is always in place and only the shocks to unfunded spending ζ_t^F occur. The shadow economy keeps track of fiscal inflation and the amount of unfunded debt. The monetary and fiscal blocks for the shadow economy are then:

$$\mathbb{E}_t \hat{\pi}_{t+1}^F = \phi^F \hat{\pi}_t^F, \tag{13}$$

$$\hat{s}_{b,t}^F = \beta^{-1} \hat{s}_{b,t-1}^F + \beta^{-1}(\hat{r}_{n,t-1}^F - \hat{\pi}_t^F) - \beta^{-1}(1-\beta)\zeta_t^F. \tag{14}$$

Note that the monetary and fiscal blocks for the shadow economy are isomorphic to those in equations (5) and (6) once the parameter restrictions for the Fiscally-led policy mix are imposed and only unfunded shocks are allowed.

The set of equations (11), (12), (13), and (14) describe the model with partially unfunded debt. Since there are two non-predetermined variables ($\hat{\pi}_t$ and $\hat{\pi}_t^F$) and two eigenvalues outside the unit circle associated with equations (11) and (14), the model satisfies the Blanchard and Khan conditions and is thereby determinate—there exists a unique stable Rational Expectations equilibrium.

The third panel of Figure 1 presents the impulse responses in the model with partially unfunded debt. As before, we assume that the monetary authority fully accommodates the increase in fiscal inflation: $\phi^F = 0$. In response to a funded spending shock (solid blue line), the economy with partially unfunded debt behaves exactly as in the left panel, where policymakers always follow the Monetary-led policy mix, and inflation is unaffected by the shock. In response to an unfunded spending shock, inflation increases. The economy with partially unfunded debt behaves exactly as in the middle panel, where policymakers always follow the Fiscally-led policy mix. The policy rules in the model with partially unfunded debt are shock-specific and policymakers respond differently depending on the nature of the fiscal shocks. Thus, the properties of the Monetary-led and Fiscally-led policy mix coexist in the model with partially unfunded debt.

At a more intuitive level, our modeling formalism connects to a central idea of the fiscal theory of price level, namely that debt stability can be achieved with a mix of fiscal adjustments and movements in inflation that are accommodated by the central bank. With respect to this idea, the shadow economy serves the purpose of measuring the evolution of the share of debt that is not expected to be covered with fiscal adjustments, while the remaining, funded share is expected to be covered via movements in inflation. In this sense, the partition between funded and unfunded spending is akin to an accounting exercise, under the typical assumption of perfect and symmetric information of both agents and policymakers.

Finally, it is worth mentioning that we could also have solved the model by constructing a different (Monetary-led) shadow economy in which all public debt is funded, the central bank always follows the Taylor principle, but only the funded fiscal shocks occur. This duality in solving models with shock specific rules stems from the linearity of the model. Linearity implies that the two shadow economies are indeed additive sub-economies of the actual economy. This means that the sum of the inflation rates and the sum of debts in the two parallel economies equal their counterparts in the actual economy (see Appendix A).

2.2 Unfunded fiscal shocks and nominal rigidities

We now introduce a production side to the model presented in the previous section. We will use this model to investigate the role of price rigidity in the propagation of funded and unfunded fiscal shocks to inflation, output, debt, and the real interest rate.

We modify the setup presented above by assuming 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 rules in eq.(7). 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 that we estimate in Section 4. The linearized equations and the calibrated parameter values are reported in Appendix B.

The graphs in the first row of Figure 2 illustrate the impulse responses to funded and unfunded fiscal shocks (the blue and red lines, respectively) in the case of flexible prices.

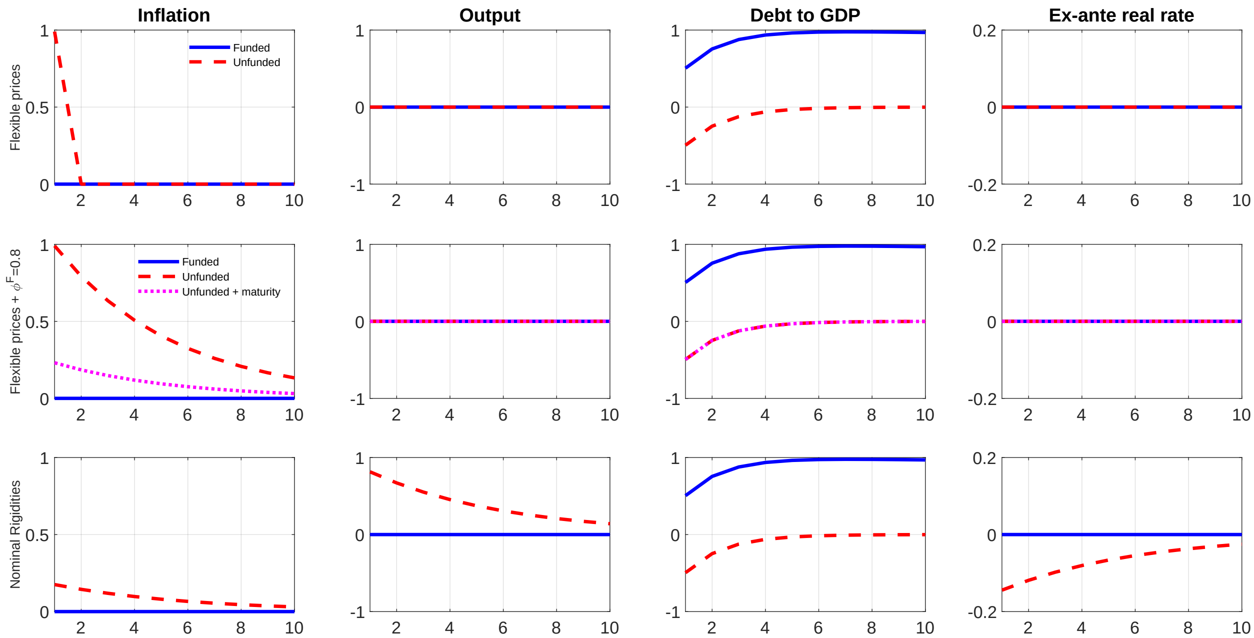


Figure 2: **Funded and unfunded fiscal shocks in production economies**. Impulse responses of inflation, real output, debt-to-GDP, and the real interest rate to funded (blue solid line) and unfunded shocks (red dashed line) to primary surpluses. The first row shows the propagation in a model with perfectly flexible prices and $\phi^F = 0$. The second row shows the propagation in a model with perfectly flexible prices and $\phi^F = .8$. For unfunded shocks, we also consider the case with a maturity structure (dotted magenta line). The last row reports the propagation in a prototypical New Keynesian model.

Two points emerge from these graphs. First, expansionary 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. Second, regardless of whether an expansionary fiscal shock is funded or unfunded, the real economy is perfectly insulated from fiscal shocks. Like the typical model with flexible prices, the real economy is not affected by movements in inflation. Also note that the debt-to-output ratio falls in the aftermath of an unfunded fiscal shock because the increase in inflation raises nominal output (but not real output). Thus, introducing a production economy with flexible prices does not change the behavior of inflation with respect to the Fisherian model. This should not come as a surprise, as in this class of models, real activity and real interest rates are exogenous with respect to inflation.

In the second row of Figure 2, we consider two extensions of the model with flexible prices. First, we allow for the central bank response to fiscal inflation to be positive, ($\phi^F > 0$), but still less than one-to-one ($\phi^F < 1$). Without loss of generality, we choose $\phi^F = .8$. Introducing a response to fiscal inflation larger than zero does not affect the response to funded shocks, but it determines a persistent response of inflation to unfunded fiscal shocks. To understand why, rewrite the monetary block (13) as:

$$\hat{\pi}^F_{t+1} = \phi^F \hat{\pi}^F_t + \eta^{\pi^F}_{t+1}. \tag{15}$$

where $\eta_{t+1}^{\pi^F} \equiv \hat{\pi}_{t+1}^F - \mathbb{E}_t \hat{\pi}_{t+1}^F$ is the inflation surprise in response to the unfunded fiscal shock.

The expression above elucidates that the persistence of fiscal inflation is controlled by the Taylor rule coefficient ϕ^F. The central bank, by moving the nominal interest rate, sets expected inflation. If, in turn, the central bank moves the nominal interest rate in response to current inflation, the central bank induces a persistent movement in inflation. The change in expected inflation does not have a role in determining the size of the initial jump in inflation $\eta_{t+1}^{\pi^F}$. This is because anticipated inflation cannot be used to devalue one-period bonds that have not been issued yet. The Online Appendix C provides additional details and shows that the initial jump only depends on the change in the present discounted value of future real surpluses.

We now make a second change and add a maturity structure for government debt, while keeping $\phi^F = .8$. We choose an average maturity of six years. The magenta line in the second row of Figure 2 shows how the maturity structure changes the propagation of an unfunded fiscal shock. The persistence of inflation is still controlled by the parameter ϕ^F. However, the presence of a maturity structure reduces the initial jump in inflation. This is because with a persistent movement in inflation and a maturity structure, the resulting increase in long term interest rates devalues the outstanding long-term bonds. The Online Appendix shows analytically that the initial response declines if ϕ^F increases or if the maturity increases.

To sum up, for a given maturity, a larger ϕ^F determines a larger increase in long-term interest rates for given inflation path, devaluing outstanding long-term bonds. For a given $\phi^F > 0$, a longer maturity implies a larger devaluation of outstanding debt. If $\phi^F = 0$ or debt is only composed of one-period bonds, the initial response collapses to what obtained with no maturity structure. If bonds have a long maturity, but $\phi^F = 0$, inflation and short-term rates have no persistence and they cannot devalue currently outstanding long-term bonds. If $\phi^F > 0$, but debt is only short-term, there are no outstanding long-term bonds to be devalued in the first place.

Across all the cases considered so far, ex-ante real interest rates and output are unaffected by the unfunded fiscal shocks. This implies that all debt stabilization needs to be achieved via a surprise in inflation (present or future). We now make a different change to the model by introducing monopolistically competitive firms facing price rigidities. These changes make the linearized model similar to the types of stylized New Keynesian models studied in the textbooks of Galí (2008) and Woodford (2003). The linearized equations for this model are reported in Appendix B. To isolate the effects of nominal rigidities, we revert to the $\phi^F = 0$ case and no maturity structure.

In the third row of Figure 2, we show the propagation of funded (blue solid lines) and unfunded shocks (red dashed line) for the model with nominal rigidities. Comparing these responses to the ones shown in the first row highlights the effects of nominal rigidities on the propagation of these two fiscal shocks. Noticeably, introducing nominal rigidities does not affect the response to funded shocks. These shocks are still irrelevant for output and inflation. However, nominal rigidities deeply affect the response to unfunded fiscal shocks. Unlike the model with fully flexible prices, in the aftermath of an unfunded fiscal shock, the change in inflation is spread over time, even if the model does not feature a maturity structure. Furthermore, now unfunded fiscal shocks affect the path of real interest rates and hence output. As a result, the increase in inflation is substantially more contained because debt stabilization is in part achieved with larger output and a prolonged decline in the cost of financing debt.

Summarizing, persistent movement in inflation can be obtained in a frictionless environment by allowing a positive response of interest rates to fiscal inflation. Furthermore, a maturity structure can greatly reduce the initial impact of an unfunded fiscal shock. However, movements in real interest rates and output only arise when introducing nominal rigidities. The lower cost of financing debt and the higher level of real activity contribute to stabilize debt and mitigate the size of the initial jump in inflation.

In our quantitative evaluation, we opt for a model with nominal rigidities for a series of reasons. First, real interest rates and output present significant low frequency variation in the data and play an important role in the evolution of debt-to-GDP ratio. A model with flexible prices cannot account for these facts. Second, the lower panels of Figure 2 reveal some key empirical cross-correlations, which will be crucial to identify unfunded fiscal shocks in the large-scale model that we estimate in Section 4. Namely, unfunded shocks increase inflation while decreasing both the real interest rate and the debt-to-GDP ratio. Finally, a model with flexible prices can generate persistence in fiscal inflation only if the central bank partially reacts to fiscal inflation ($\phi^F > 0$). This creates a very tight link between nominal interest rates and expected inflation that seems at odds with the data. For example, in the post-pandemic period, inflation increased persistently even if nominal interest rates did not initially react to inflation ($\phi^F = 0$). A model with nominal rigidities in which the central bank accommodates the jump in fiscal inflation seems more appealing to account for this stylized fact.

3 A Quantitative Model

In this section, we build and estimate a state-of-the-art Two Agents New Keynesian (TANK) model with a rich fiscal block and partially unfunded debt. The model features all the ingredients that have been proven successful in matching US business cycle dynamics, including a large set of business cycle shocks. With respect to these shocks, monetary policy satisfies the Taylor principle and the fiscal authority is in control of debt stabilization. Thus, in this respect, the model behaves as its counterparts extensively studied in the literature (see among many others, Christiano et al. (2005) and Leeper et al. (2017)). 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.[3] 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, $1-\mu$, are savers and we indicate them with an S superscript. The presence of hand-to-mouth households, together with distortionary taxation, breaks Ricardian equivalence and makes funded transfers relevant for a fraction of the population even under a Monetary-led policy mix.

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 governs the substitutability between private and government consumption. When negative, the goods are complements; when positive, they are substitutes. External habits in consumption imply that utility is derived relative to the previous period value of aggregate savers' consumption of the composite good 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 accumulate wealth in the form of physical capital $\bar{K}_t^S$. The stock of capital depreciates at rate δ and accrues with investment I_t^S, net of adjustment 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.

[3] We focus on shocks to transfers because historically government purchases ("G") have been constantly declining as a fraction of GDP since WWII. Thus, government purchases do not seem to represent a problem for fiscal sustainability, while transfers have been increasing over the same period. Our results are robust to allowing both types of spending to be partially unfunded.

Households derive income from renting effective capital $K_t^S(j)$ to the intermediate firms. Effective capital is related to physical capital according to $K_t^S(j) = \nu_t(j)\bar{K}_{t-1}^S(j)$, where $\nu_t(j)$ is the capital utilization rate. 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 $\tau_{K,t}$.

The household can also save by purchasing one-period government bonds in zero net supply and a more general portfolio of long-term government bonds in non-zero net supply. The one-period bonds promising a nominal payoff B_t at time $t+1$ can be purchased at the present discounted value $R_{n,t}^{-1}B_t$, where the gross nominal interest rate $R_{n,t}$ is set 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 can be purchased at 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 receives after-tax nominal labor income, after-tax revenues from renting capital to the firms, lump-sum transfers from the government Z_t^S and dividends from the firms D_t. These resources can be spent to consume and to invest in physical capital and bonds. Omitting the index j for notation simplicity, the nominal budget constraint for the saver household can be written as:

$$\begin{aligned} & P_t\left(1-\tau_{C,t}\right)C_t^S + P_t I_t^S + P_t^m B_t^m + R_{n,t}^{-1}B_t \qquad (16) \\ = \; & \left(1+\rho P_t^m\right)B_{t-1}^m + B_{t-1} + \left(1-\tau_{L,t}\right)\int_0^1 W_t(l)\,L_t^S dl \\ & + \left(1-\tau_{K,t}\right)R_{K,t}\nu_t\bar{K}_{t-1}^S - \psi(\nu_t)\bar{K}_{t-1}^S + P_t Z_t^S + D_t, \end{aligned}$$

where $W_t(l)$ denotes the wage rate faced by all household members, and $\tau_{C,t}$ and $\tau_{L,t}$ denote the tax rates on consumption and labor income, respectively. The household maximizes discounted utility $\sum_{t=0}^{\infty}\beta^t U_t^S$ subject to the sequence of budget constraints in equation (16).

Hand-to-mouth households Every period, hand-to-mouth households consume all of their disposable, after-tax income, which comprises revenues from labor supply and government transfers. The hand-to-mouth households supply differentiated labor services, and set their wage to be equal to the average wage that is optimally chosen by the savers, as described below. Both savers and non-savers face the same tax rates on consumption and labor income. Using the superscript N to indicate the non-saving, hand-to-mouth households, their budget constraint can be written as follows:

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

Final good producers A perfectly competitive sector of final good firms produces the homogeneous good Y_t at time t by combining a unit measure of intermediate differentiated inputs using 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 denotes exogenous i.i.d. changes in the elasticity of substitution among good varieties. In the linearized version of the model, these shocks shift the New Keynesian Phillips curve (NKPC) and are often dubbed cost-push shocks. The variable u_t^{NKPC} is also a cost-push shock but it is assumed to follow a near-unit-root process. This highly persistent cost-push shock is meant to capture other external forces, such as international trade, that can generate low-frequency movements of inflation. Profit maximization yields 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 P_t is the price of the final good.

Intermediate good producers Intermediate firms produce 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 is a fixed cost of production that grows with the rate of labor-augmenting technological progress A_t and $\alpha \in [0,1]$ a parameter. The technological progress A_t follows an exogenous process that is stationary in the growth rate. Specifically, we assume that $u_t^a = \left(1-\rho_a\right)\varkappa + \rho_a u_{t-1}^a + \varepsilon_t^a$, where $u_t^a = \ln(A_t/A_{t-1})$. Intermediate firms rent capital and labor in perfectly competitive factor markets. L_t is a bundle of all the differentiated labor services supplied in the economy, which are aggregated into a homogeneous input by a labor agency, as described below. Cost minimization implies that all firms incur the same nominal marginal cost $MC_t = \left(1-\alpha\right)^{\alpha-1}\alpha^{-\alpha}\left(R_{K,t}\right)^{\alpha} W_t^{1-\alpha} A_t^{-1+\alpha}$.

When setting prices, intermediate producers face frictions *à la* Calvo, i.e., at time t a firm i can optimally reset its price with probability ω_p. Otherwise it adjusts the price with partial indexation to the previous period inflation rate according to 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, $\Pi_{t-1} = \frac{P_{t-1}}{P_{t-2}}$ and Π denotes the aggregate rate of inflation at steady state.

Intermediate producers that are allowed to reset their price maximize the expected discounted stream of 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, where Λ^S denotes the marginal utility of the savers.

Wages We assume that both savers and hand-to-mouth households supply a unit measure of differentiated labor service, indexed by l. Each period, a saver household gets an opportunity to optimally readjust the wage rate that applies to all of its workers, $W_t\left(l\right)$, with probability ω_w. If the wage cannot be reoptimized, it will be increased at the geometric average of the steady-state rate of inflation Π and of last period inflation Π_{t-1}, according to the rule $W_t(l) = W_{t-1}(l)(\Pi_{t-1}e^{\varkappa})^{\chi_w}(\Pi e^{\varkappa})^{1-\chi_w}$, where $\chi_w \in [0,1]$ captures the degree of nominal wage indexation. All households, including both savers and non-savers, sell their labor service to a representative, competitive agency that transforms it into an aggregate labor input, according to 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 $L_t(l) = L_t(W_t(l)/W_t)^{-(1+\eta_t^w)/\eta_t^w}$.

Monetary and Fiscal Policy Assuming that one-period government bonds are in zero net supply and that households receive the same amount of transfers regardless of whether it is hand-to-mouth or saver, the government nominal budget constraint can be written as:

$$P_t^m B_t^m + \tau_{K,t} R_{K,t} K_t + \tau_{L,t} W_t L_t + \tau_{C,t} P_t C_t = (1+\rho P_t^m) B_{t-1}^m + P_t G_t + P_t Z_t, \tag{17}$$

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 (17) implies that the fiscal authority finances government expenditures, transfers, and the rollover of expiring long-term debt by raising taxes on consumption, labor and capital, and by issuing new long-term debt obligations.

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. As in the models presented in Section 2, the debt-to-GDP ratio in deviations from the steady state, $\hat{s}_{b,t}$, is the sum of two components, funded $\hat{s}_{b,t}^M$ and unfunded $\hat{s}_{b,t}^F$ debt. As before, we use superscripts M and F to emphasize that the Monetary-led policy mix applies to funded debt, while the Fiscally-led policy mix applies to unfunded debt. For the shocks, we use the superscripts only to label the two types of transfers shocks, while we assume that all other shocks only affect the funded portion of 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:

$$\hat{g}_t = \rho_G \hat{g}_{t-1} - (1-\rho_G)\ \gamma_G(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F) + \zeta_{g,t}, \tag{18}$$

$$\hat{z}_t^b = \rho_Z \hat{z}_{t-1}^b - (1-\rho_Z)\left[\ \gamma_Z(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F) + \phi_{zy}\hat{y}_t\right] + \zeta_{z,t}, \tag{19}$$

$$\hat{\tau}_{J,t} = \rho_J \hat{\tau}_{J,t-1} + (1-\rho_J)\ \gamma_J(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F) \tag{20}$$

where $\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F$ denotes the portion of the debt-to-GDP ratio that the fiscal authority is committed to stabilize with fiscal adjustments. This commitment is captured by the values for the reaction parameters γ_G, γ_Z, and $\gamma_J > 0$ that are large enough to guarantee that this portion of debt remains on a stable path. The fiscal authority does not make fiscal adjustments in response to the remaining, unfunded, portion of debt $\hat{s}_{b,t-1}^F$. The total amount of transfers is given by $\hat{z}_t \equiv \hat{z}_t^b + \zeta_t^M + \zeta_t^F$. The shocks ζ_t^M and ζ_t^F influence the funded and unfunded share of total transfers and are assumed to follow persistent AR(1) processes to capture the historical evolution of transfers in the United States. The term $\hat{z}_t^b$ captures transitory movements in funded transfers and possible adjustments in response to debt and the business cycle. The fiscal shocks $\zeta_{g,t}$ and $\zeta_{z,t}$ follow AR(1) processes.

The central bank moves the short-term interest rate $\hat{R}_{n,t}$ in response to fluctuations of inflation originating from the typical business cycle shocks and the funded fiscal shocks, while it fully accommodates the movements in inflation necessary to stabilize the unfunded portion of debt. As explained in Section 2, this shock specific monetary policy rule can be captured by a standard Taylor rule in which the central bank reacts to deviations of inflation from the level of inflation needed to stabilize the unfunded share of debt. We call this level of inflation tolerated by the central bank, fiscal inflation, $\hat{\pi}_t^F$. It follows that the linearized monetary policy rule with an effective lower bound constraint (ELB) can be written as:

$$\hat{r}_{n,t} = \max\left[-\ln \underline{R_n}, \rho_r \hat{r}_{n,t-1} + (1-\rho_r)\left[\phi_\pi\left(\hat{\pi}_t - \hat{\pi}_t^F\right) + \phi_y \hat{y}_t\right] + u_t^m\right], \tag{21}$$

where u_t^m is a monetary policy shock.

The parameter $\phi_\pi > 1$ implies that the Taylor principle is satisfied and monetary policy is active when responding to deviations of inflation, $\hat{\pi}_t$, from fiscal inflation, $\hat{\pi}_t^F$. The variable $\hat{\pi}_t^F$ measures the increase in inflation, relative to the central bank long-term target (and steady-state rate), that the central bank accommodates so as to stabilize the amount of unfunded debt $\hat{s}_{b,t-1}^F$. The policy mix characterized by equations (18) - (21) therefore implies that monetary policy is active in response to deviations of inflation from fiscal inflation and passive (no response) with respect to the inflation needed to stabilize the share of unfunded debt in deviations from its long-term target. Concurrently, fiscal policy is passive with respect to its commitment in stabilizing the share of funded government debt $\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F$, and active (no response) with respect to the unfunded share of debt. Thus, a monetary-led policy mix with respect to the typical business cycle shocks coexists with a fiscally-led policy mix with respect to the unfunded fiscal shocks.

The way fiscal inflation $\hat{\pi}_t^F$ enters the Taylor rule is similar to a time-varying target or an inflation drift that are typically added to estimated medium-scale DSGE models to explain persistent inflation in the data (e.g., Smets and Wouters 2007). However, while the inflation drift in these other models evolves exogenously according to a close-to-random-walk process, fiscal inflation in our model varies in response to the need to stabilize the share of unfunded debt, which is endogenous. Changes in fiscal inflation $\hat{\pi}_t^F$ result from the coordination between monetary and fiscal authorities regarding the stabilization of the existing public debt.

3.2 Solving the Model

To solve the model, we first detrend the non-stationary variables to account for the unit root in the labor-augmenting technology A_t. We then log-linearize the model equations around the deterministic steady state equilibrium. The list of the log-linearized equations of the model is reported in Appendix D.

As in Section 2, we construct a shadow economy that keeps track of the unfunded portion of debt and the associated evolution of the endogenous variables. The shadow economy differs from the actual economy insofar there are only unfunded fiscal shocks and policymakers follow a Fiscally-led policy mix. All other model equations are identical across the actual and shadow economies. The model can be solved with standard techniques that apply to linear rational expectations models.

4 Inference

The model is estimated using Bayesian techniques. The posterior distribution is obtained combining the priors for the model parameters with the model's likelihood function. The likelihood is evaluated with the Kalman filter.

4.1 Data

The data set that we use for estimation comprises eleven variables for the U.S. economy observed at quarterly frequency over the period 1960:Q1 to 2022:Q3: 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 breakeven inflation. Appendix E shows how these series are constructed.

We treat 5-year breakeven inflation 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 period 2008:Q1-2022:Q3 period, we estimate the model over two subsamples: from 1960:Q1 to 2007:Q4 and then from 2008:Q1 to 2022:Q3. When estimating the model on the latter subsample, we add to the dataset the expectations for the federal funds rate one-through ten-quarters ahead, based on overnight index swaps.[4] Formally modeling the lower

[4] We construct series of the market-expected federal funds rate in the same way as Campbell et al. (2017). See Appendix E for further details.

bound for the interest rate would raise substantially the computational challenge of our empirical exercise because it would introduce a non-linearity in the model, which requires using non-linear Monte Carlo filters to evaluate the likelihood (Fernandez-Villaverde and Rubio-Ramirez, 2007). We adopt a simpler approach, following Campbell et al. (2012), who use data on market-based future federal funds rates to estimate the model after 2008:Q4. Agents' expectations about future interest rates are informed by the market forecasts, which enforce the effective lower bound in the model.

4.2 Priors

To elicit the prior distributions for the model parameters, we follow the approach proposed by Del Negro and Schorfheide (2008). Some parameter values are fixed in the estimation or implied by steady-state restrictions. We fix the discount factor β to the value of 0.99, so that the steady-state real interest rate is broadly consistent with its sample average. The quarterly rate of capital depreciation, δ, is set to target an investment rate of 2.5%. The parameters governing the steady-state markups on wages and prices cannot be separately identified in estimation, so we set them to 0.14, following Leeper et al. (2017). The elasticity of output to capital in the production function α is set to the standard value of 0.33. The parameter s_{gc}, capturing the ratio of government expenditures to GDP, is set to 0.11 following Leeper et al. (2017). Finally, the steady-state tax rates on labor, capital and consumption, denoted by the parameters τ_L, τ_K, and τ_C, are set to the values of 0.186, 0.218 and 0.023, respectively, also based on Leeper et al. (2017). The consumption tax rate τ_C is assumed to be constant, so the parameters γ_C and ρ_C are set to zero.

Figure 3 reports the number of outstanding government bonds of different maturities (in years). Darker areas imply that a larger number of securities of the corresponding maturity is outstanding. The green dashed line corresponds to the average maturity based on the number of bonds outstanding, while the red solid line reports the value weighted average maturity. The first noticeable fact is that both measures of average maturity 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 our interest in the post-pandemic increase in inflation and given that the Congressional Budget Office (2020) estimates an average maturity of six years, 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. However, our results are robust to choosing a range of alternative values for the average maturity.

The right panels in Tables 1 and 2 report the priors for the structural parameters and for the exogenous processes, respectively. The priors for both macroeconomic and fiscal variables

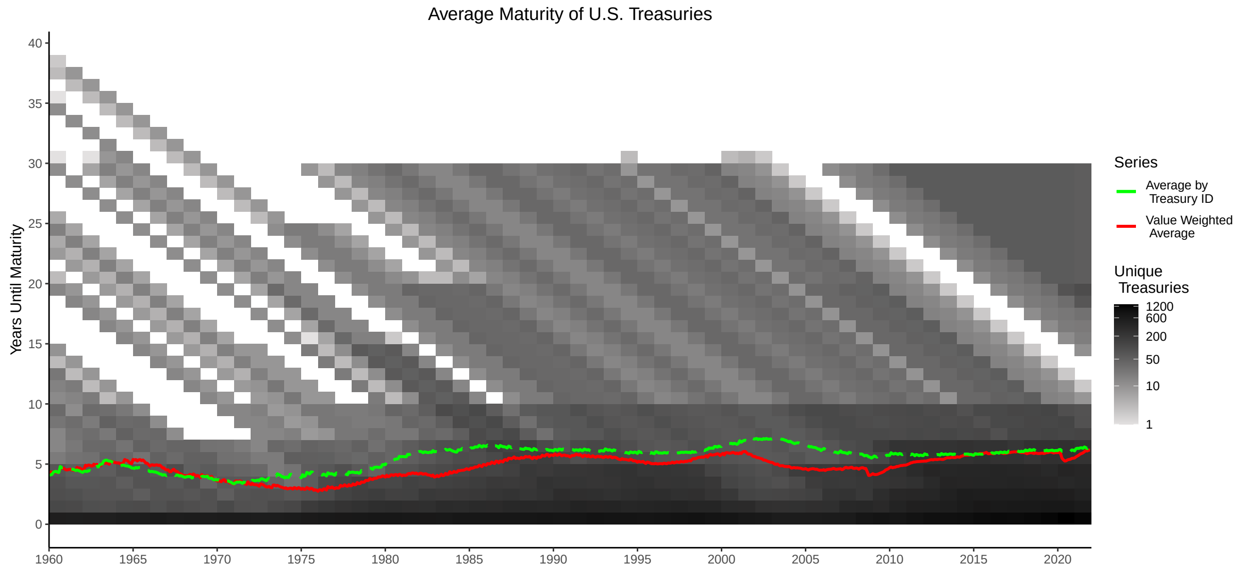


Figure 3: **Maturity of US government debt.** The figure reports the number of outstanding government bonds of different maturities (in years) over the sample 1960-2021. Darker areas imply that a larger number of securities of the corresponding maturity is outstanding. The green dashed line corresponds to the average maturity based on the number of bonds outstanding, while the red solid line reports the value weighted average maturity.

are generally quite diffuse. We center the prior for the share of hand-to-mouth households μ to 0.11, to match the share of poor hand-to-mouth consumers, following Kaplan et al. (2014). The priors for the autocorrelation coefficients of both the funded and unfunded transfers shocks are tightly centered around a very persistent mean to reflect the econometrician's beliefs that changes in funded and unfunded transfers are very persistent and to capture the fact that in the data transfers present fluctuations around a persistent trend. Conversely, cyclical increases in government transfers are expected to be backed by the increase in tax revenues and the decline in spending ensuing the next economic recovery.

We also set the prior on the autocorrelation coefficient of the persistent cost-push shock ($\rho_{\mu^{NKPC}}$) so as to provide the model with a competing mechanism to explain persistent inflation. Thus, the model allows, but does not require, persistent inflation to be generated by unfunded fiscal shocks. The autocorrelation coefficients of the tax rules (ρ_K, ρ_L) are set to 0.5 because they are only weakly identified in the estimation. The prior for the standard deviation of the shocks is the same across the different shocks.

4.3 Posterior Distributions

The left panels of Tables 1 and 2 report the posterior distributions for the structural parameters and the exogenous processes, respectively, obtained over the sample period 1960:Q1 to 2007:Q4. The estimates obtained over the second subsample, 2008:Q1 to 2022:Q3, are reported in Appendix F. We note that the parameters governing the response of the tax

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 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.

instruments to debt, (i.e., γ_L and γ_K) are positive but quantitatively small. The stabilization of the share of funded debt is therefore ensured by the relatively higher estimate of the parameter γ_G and γ_Z, implying that debt stabilization is mostly achieved by changing government spending rather than taxes. Our estimated price and wage rigidities are on the lower side relative to the literature, while the habit parameter lies towards the upper end of the multitude of estimates reported in the literature, but are smaller than those obtained by Leeper et al. (2017). The output coefficient in the Taylor rule is close to zero, and smaller than typically obtained in the estimation of similar models, suggesting that fluctuations in amount of fiscal inflation accommodated by the central bank dominate the interest rate response to output.

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.

5 Results

In this section, we use the estimated TANK model to assess the empirical relevance of unfunded fiscal shocks in explaining fluctuations in inflation and GDP growth. We first take an historical perspective and then focus on the pandemic period.

5.1 Identification of Unfunded Transfers Shocks

In this subsection, we study how unfunded transfers shocks, ζ_t^F, funded transfers shocks, ζ_t^M, and shocks to long-run cost-push shocks, u_t^{NKPC}, propagate through the economy. This analysis sheds light on how the three shocks are identified in the estimation. Figure 4 shows that the three shocks give rise to very different impulse responses for key macroeconomic variables, i.e. the inflation rate, the real interest rate, and the debt-to-GDP ratio.

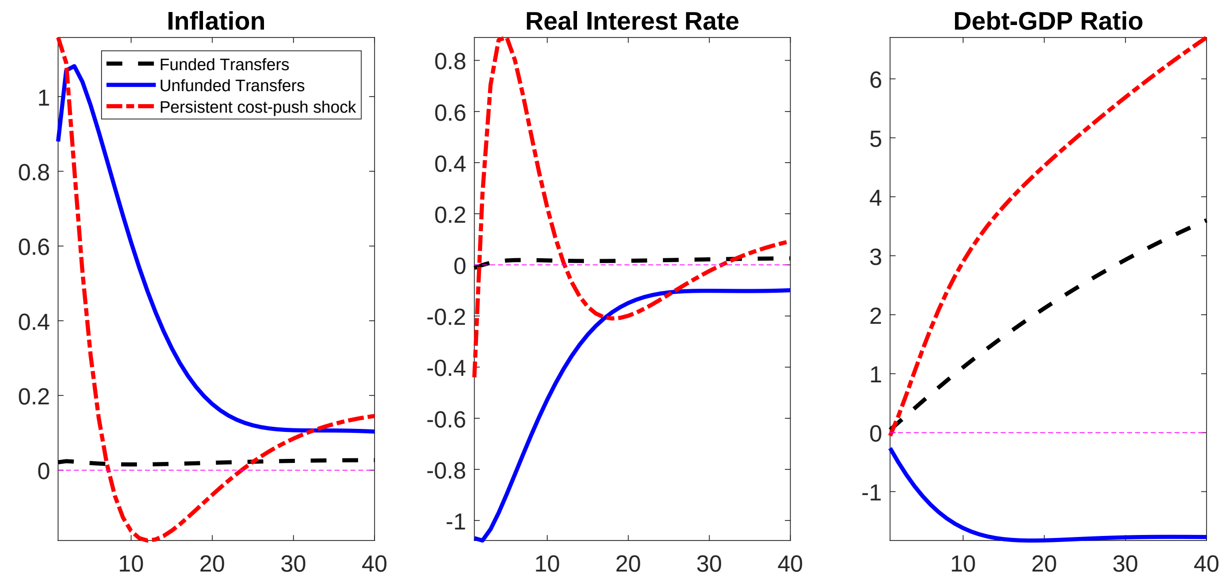


Figure 4: **Impulse Responses for quantitative model.** Impulse responses for inflation, real interest rate, and debt-to-GDP ratio to a shock to funded transfers (black dashed line), to unfunded transfers (blue solid line), and to the persistent cost-push shock (red dotted-dashed line). Units: percentage 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).

Despite the presence of hand-to-mouth households, a funded transfers shock (dashed black line) produces only a modest impact on the macroeconomy, as the expansionary impulse of current transfers is offset by the expectations of higher taxes and/or a decrease in government spending in the future; qualitatively, inflation rises, following the positive stimulus to aggregate demand and real marginal costs. Concurrently, the debt-to-GDP ratio increases to fund the rise in transfers. The increase in the debt-to-GDP ratio is very persistent because tax revenues and government purchases react very sluggishly to the increase in debt. However, debt is still on a sustainable path because the fiscal adjustments are eventually going to occur. In fact, the debt-to-GDP ratio increases exactly because it is backed by the expectation of future fiscal adjustments.

Unfunded transfers shocks, conversely, have a quantitatively strong expansionary effect on the macroeconomy (solid blue line). In sharp contrast with the propagation of funded transfers shocks, unfunded transfers lead to a fall in the real interest rate, as the monetary authority allows inflation to rise to stabilize the increase in transfers. This coordinated policy increases both inflation and inflation expectations. Note that 5 years after the shock, inflation remains above its long-run value. The lower real interest rate also stimulates aggregate production. Lower financing costs and higher GDP determine a fall in the debt-to-GDP ratio, despite the increase in spending. The opposite responses of the debt-to-GDP ratio produced by funded vs. unfunded transfers, together with the large effects on the macroeconomy of unfunded shocks that are absent in response to funded shocks, allow us to separately identify

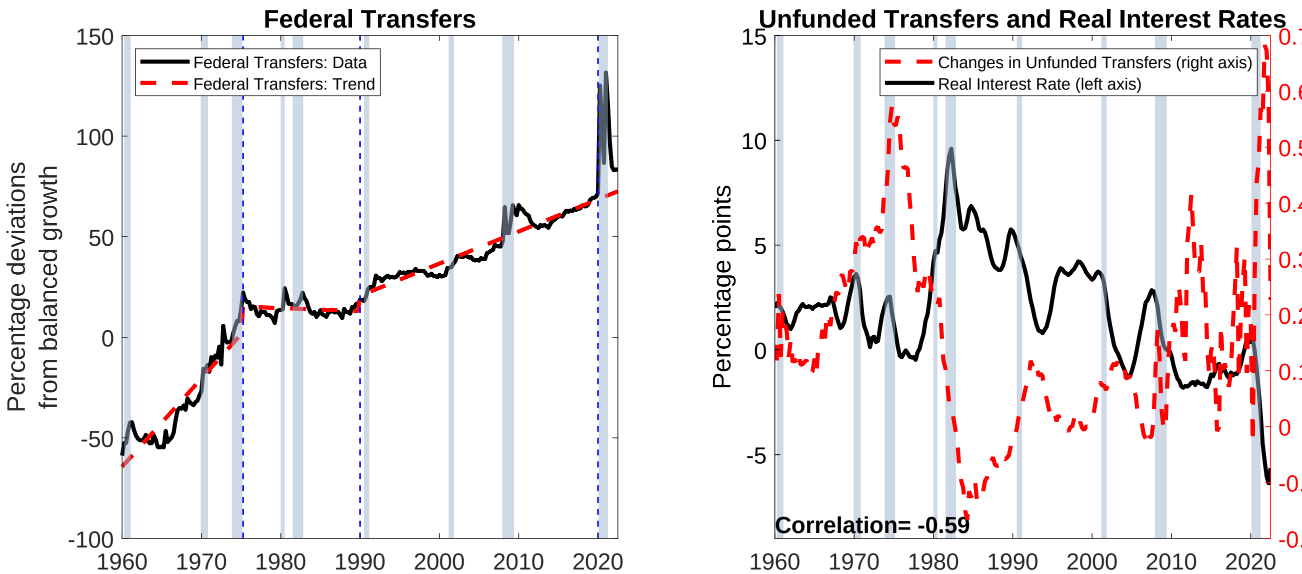


Figure 5: **Federal transfers and real interest rate.** Left panel: Federal transfers in percentage deviations from balanced growth (black solid line) and their linear trend fitted on each of the first three sub-sample periods (1960:Q1-1974:Q4; 1975:Q1-1989:Q4; 1990:Q1-2019:Q4) – marked by the vertical blue lines. The trend computed over the third period is projected onto the last subsample, 2020:Q1-2022:Q3. Right panel: Changes in the amount of unfunded transfers (red dashed line) and ex-ante real interest rate (black solid line). The former is 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 latter 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:Q1-2022:Q3.

these two transfers shocks in the estimation.

A shock to firms' long-run cost-push shocks (dot-dashed red line) produces a temporary but short-lived rise in inflation. The real interest rate falls, but only on impact, and then rises persistently as the central bank reacts to the inflationary pressure. The rise in real rates and the associated contraction in aggregate production lead to an increase in the debt-to-GDP ratio. The opposite responses of the real interest rate and of the debt-to-GDP ratio following a shock to unfunded transfers shocks and a long-run cost-push shock, provide identification for the two shocks. The response of the debt-to-GDP ratio to all the three shocks is very persistent. This is consistent with the fact that the debt-to-GDP ratio is very persistent in the data. In the model, the persistence depends on the inverse of agents' discount factor (β^{-1}) and the sluggish adjustment of taxes and spending in response funded debt.[5]

[5]It takes roughly 600 quarters for the debt-to-GDP ratio to converge to steady state after an unfunded transfers shocks and roughly twice as long to converge following a shock to the funded transfers shocks and to the long-run cost-push shocks. However, debt is always on a stable path in virtue of the adjustments of the other variables that can move faster.

5.2 Funded and Unfunded Transfers

Before using the model to infer the historical behavior of the share of funded and unfunded transfers, it is useful to examine how total federal transfers have evolved over time. The left panel of Figure 5 plots the evolution of real U.S. government transfers from 1960:Q1 to 2022:Q3 (black line), in deviations from the steady state. The red dashed line in the figure corresponds to a linear trend fitted on three time periods of interest, which are marked by the vertical blue lines in the figure. The trend computed over the third period is also projected onto the pandemic subsample, 2020:Q1-2022:Q3. The first period, spanning the 1960s and going up to the mid 1970s, is characterized by a sharp increase in transfers. This increase reflects policy initiatives, initiated by President Johnson, aimed at reducing poverty levels. These initiatives were part of the Great Society program, which aspired to reduce racial injustice and crime and to improve the environment.

After President Johnson ended his second term in 1969, the level of transfers continued to increase during the Nixon administration (1969-1974). This is consistent with the fact that many of the welfare programs introduced in the 1960s shifted the long-term path of spending. But in the subsequent period, which starts from the mid 1970s and ends around 1990, the growth in transfers came to a halt, and their level remained broadly unchanged. Next, after 1990, the level of transfers started to increase again; the rate of growth has been rather stable throughout this third period, although smaller than the one observed between the mid-1960s and the mid-1970s. Finally, the very last period, which captures the pandemic recession, has witnessed a large jump in the level of transfers, whose magnitude exceeds by far any increase observed over the estimation sample. After this large spike, the level of transfers remains well above the pre-pandemic trend even at the end of the sample (around 11% above).

What portion of these changes can be attributed to funded and unfunded transfers? The right plot of Figure 5 shows the change in the amount of unfunded transfers based on the model estimates and its relation with the real interest rate. This plot illustrates how the structural estimation is able to attribute the observed changes in total transfers to the two components, funded and unfunded. The unfunded component of transfers is defined as the amount of transfers in the shadow economy where policymakers follow fiscally-led policies and the only shocks hitting the economy are the unfunded transfers shocks.

The figure highlights that the real interest rate declines when the amount of unfunded transfers increases, and vice versa. The correlation between the two series is -0.59. This result is consistent with the impulse response functions shown in Figure 4, where the real interest rate responds negatively to increases in the share of unfunded transfers. Changes in the share of unfunded transfers require monetary and fiscal coordination. Specifically, monetary policy accommodates the movements in inflation resulting from changes in unfunded transfers, leading to fluctuations in the real interest rate.

The left panel of Figure 6 reports the historical evolution of unfunded transfers in percentage deviations from the balanced growth path. The display in the north-east corner of the panel zooms on the pandemic period. The four panels on the right hand side of Figure 6 show the contribution of changes in unfunded and funded transfers to the overall increase in transfers over the sample. These four panels refer to the same four periods discussed above and highlighted in Figure 5. The red line in these panels corresponds to total transfers.

Changes in the amount of unfunded transfers capture revisions in expectations about the monetary and fiscal commitment to use fiscal instruments to repay the persistent flow of total transfers. For instance, total transfers may fall while the share of unfunded transfers rises (e.g., in 2020Q4). In the estimation, the changes in the share of unfunded transfers are chiefly informed by the joint dynamics of inflation, real interest rate, and debt-to-GDP ratio, as shown in the previous section (Figure 4). Historical events like an exceptionally large recession, the creation of large welfare programs, the appointment of a new Chairman can be linked to the estimated movements in the share of unfunded transfers.

The increase in transfers that occurred between the mid 1960s and the mid 1970s was partially funded, and partially unfunded (Panel B). Specifically, the rise in the amount of unfunded transfers over this period is substantial. While the overall amount of transfers remain fairly stable between the mid 1970s and 1990, the amount of unfunded transfers exhibits a strong hump-shaped pattern (Panel C). The amount of unfunded transfers keeps increasing in the second half of the 1970s, but at a lower rate with respect to the previous period. It then starts declining rapidly in the early 1980s and, by the end of this subsample, it reaches levels seen in the mid 1970s.

As we will discuss in more detail below, the initial acceleration in the late 1960s,the subsequent slowdown in the second half of the 1970s, and the drop in the early 1980s play an important role in accounting for the rise and fall in inflation. The sharp rise in the real interest rate in the first half of the 1980s – primarily due to Volcker's aggressive monetary tightening – and the concomitantly sharp rise in the debt-to-GDP ratio explain why a smaller fraction of transfers are interpreted as unfunded. As we will see, this change in the composition of spending implies a sharp reduction in the inflation rate that the central bank is expected to tolerate ($\hat{\pi}_t^F$). Concurrently, the overall level of transfers (red line) exhibits quite an erratic behavior, which mainly affects the funded share of transfers (the white bars). These movements are mostly due to a quite volatile economy, with two large recessions in the late 1970s and early 1980s.

Panel (D) illustrates that the steady rise in transfers observed after 1990 was partially un-

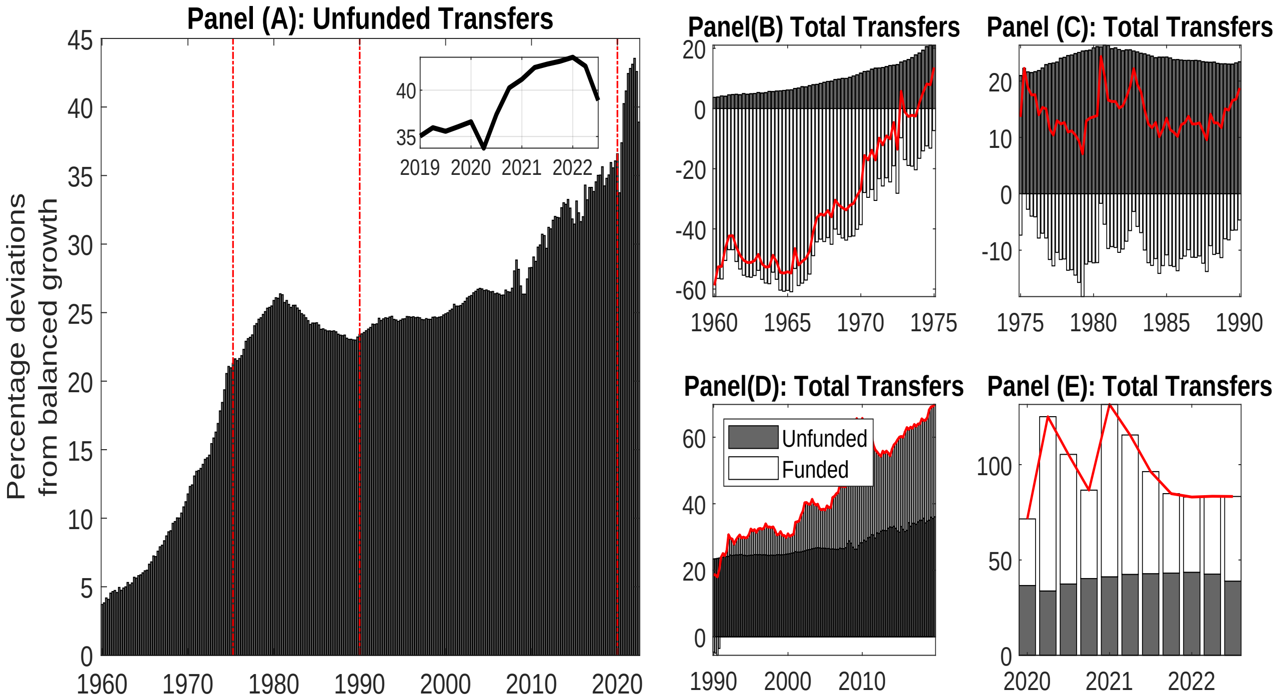


Figure 6: **Estimated decomposition of total federal transfers into funded and unfunded components**. In Panel A, we show the historical evolution of unfunded transfers in percentage deviations from the balanced growth path. The display in the north-east corner of the panel zooms into the pandemic period. In Panel B, C, D, and E, we show the contribution of changes in unfunded and funded transfers to the overall increase in transfers over the sample in each of the four sub-sample periods (1960:Q1-1974:Q4; 1975:Q1-1989:Q4; 1990:Q1-2019:Q4; 2020:Q1-2022:Q3). The red line in these panels corresponds to total transfers. The unfunded component is the amount of transfers in the shadow economy – i.e., a counterfactual economy in which the monetary and fiscal authorities follow the fiscally-led policy mix and the unfunded transfers shocks (ζ_t^F) are the only exogenous disturbances. Parameters are set at their posterior mode and shocks are estimated using the Kalman smoother. Units: percentage deviations from balanced growth. The sample is 1960:Q1-2022:Q3.

funded; the black bars rise steadily, albeit sluggishly, over this period. In the post-Millennial period, the model recovers a more rapid increase in the share of unfunded debt observed in the 2010s in light of a very accommodating monetary policy that engendered a decade-long negative real interest rate (Bianchi et al. 2021). As shown in the right panel of Figure 5, this pattern corresponds to a decline in the real interest rate, which is interpreted by the model as a sign that the central bank is willing to tolerate a higher amount of inflation.

Panel (E) of Figure 6 shows that the federal government increased total transfers sharply in the second quarter of 2020, in an attempt to combat the severe consequences of the pandemic crisis, and then again in the first quarter of 2021. The amount of unfunded transfers slightly fell in the second quarter of 2020 and only increased in the third and fourth quarter of 2020. Interestingly, the increase in the expected share of unfunded transfers happened concomitantly with the introduction of the new monetary framework in the last days of the third quarter of 2020 (August 27). The new framework contemplates the possibility for the Federal Reserve to let inflation overshoot its two-percent target after the Pandemic recession. This new monetary policy strategy is reflected in the change of the expected path of the future federal funds rate, which we observe in the estimation using overnight index swaps. Finally, the ARPA fiscal stimulus determined a further increase in the share of unfunded transfers. As we will see in the next subsections, this last policy intervention played a key role in driving the post-pandemic surge in inflation.

5.3 Drivers of Inflation and GDP growth

We now turn our attention to the relation between unfunded transfers and the the historical dynamics of inflation and GDP growth. Figure 7 provides a historical shock decomposition of inflation and GDP growth. The black bars in the figure illustrate the evolution of inflation and GDP growth originating from unfunded transfer shocks. The gray and white bars highlight the role of the other policy shocks and the non-policy shocks, respectively.[6]

The key result that emerges from Figure 7 is that fiscal inflation, the amount of inflation due to unfunded transfers, accounts for the bulk of inflation dynamics. The persistent rise in inflation between the mid-1960s and the mid-1970s is largely explained by the inflationary effects of the rise in unfunded transfers that took place in that period, as illustrated in Figure 6. This increase in fiscal inflation, accommodated by the central bank, contributes to supporting growth in the 1970s, counteracting the productivity slowdown of those years.

The inflationary effects of this rise in the level of transfers started to wither away during the late 1970s, while non-policy shocks were pushing up on the rate of inflation. Even though the share of unfunded transfers rose in the second half of the 1970s (Panel (C) of Figure 6), the pace of this increase was not fast enough to sustain the high level of fiscal inflation caused by the large expansion in unfunded transfers of the first half of the 1970s (Panel (B) of Figure 6). As a result, fiscal inflation fell steadily in the second half of the 1970s, even if it remained elevated at the end of the 1970s, when unfunded transfers still explain about half of observed inflation. The decline in fiscal inflation contributes to the decline in growth of the late 1970s.

The fall in inflation and GDP growth accelerated in the first half of the 1980s – mostly driven by a fall in fiscal inflation. In the first five years of the 1980s, fiscal inflation declined by 3%, moving from 3.8% to 0.8% in deviations from the steady state. The sharp increase in the real interest rate due to the aggressive monetary tightening conducted by the Federal Reserve Chairman Volcker coincides with a large fall in fiscal inflation and output growth, in the first five years of the 1980s. Thus, as in Sims and Zha (2006), we document that a policy change occurred before the appointment of Fed Chairman Volcker in August 1979. However,

[6] Other policy shocks include the monetary policy shock, funded transfers shocks, and the other fiscal shocks. A detailed historical decomposition of the role played by each one of these policy shocks is shown in Figure 12 Appendix G. Non-policy shocks include all other shocks.

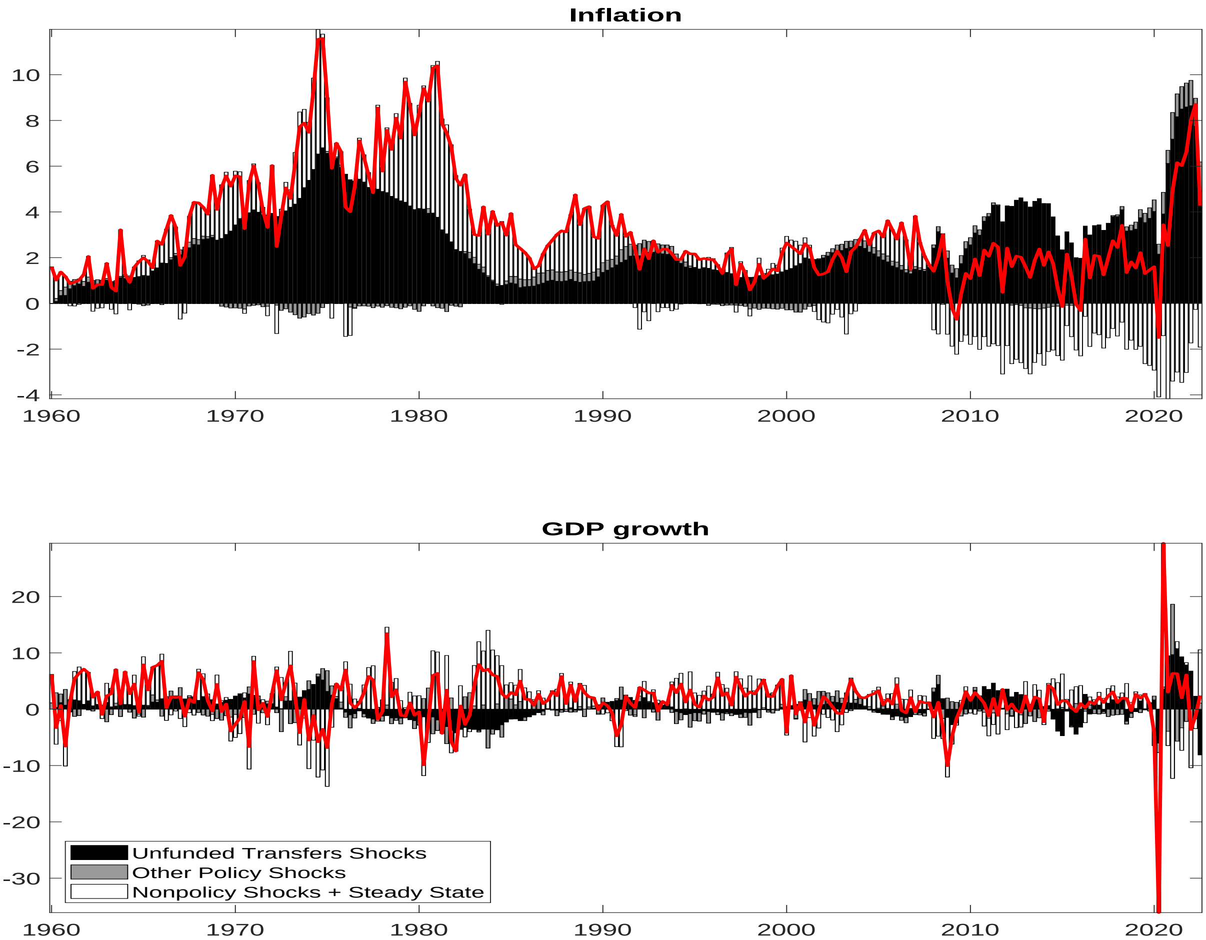


Figure 7: **Drivers of Inflation and GDP growth**. The red solid lines correspond to annualized quarterly inflation (top panel) and annualized GDP growth (lower panel). The bars represent the cumulative contributions of unfunded transfers shocks (black bars), other policy shocks (gray bars), and nonpolicy shocks (white bars) on the two variables. The white bars also include the steady state and the initial conditions for the two variables and, for GDP growth, the measurement error. 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 and setting the model parameters at their posterior mode.

the early 1980s led to an acceleration in the change of the policy environment, propelled by the election of President Reagan who arguably provided the political backing to the resolute disinflation policy of the Federal Reserve (Samielson, 2008, Bianchi and Ilut, 2017). 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.[7] These results are also consistent with the evidence provided by Hazell et al. (2020). They argue that the Phillips curve has always been flat in the US and that the primary force behind the Volcker disinflation was a change in long-term inflation expectations triggered by the policy change,

[7] Our results suggest an interesting interpretation for the finding of the seminal paper by Clarida et al. (2000) that the systematic response of the Federal Reserve to inflation was weaker in the 1970s than in the following decade, a result confirmed by subsequent work by Lubik and Schorfheide (2004), Fernandez-Villaverde and Rubio-Ramirez (2007b), and Bianchi (2013) in estimated DSGE models. In light of our results, the estimated coefficient of a standard Taylor rule could be interpreted as a weighted average of two different coefficients whose weights change depending on the type of shocks that determine movements in inflation.

rather than high unemployment working through a steep Phillips curve.

From about 1990 until the most recent years, fiscal inflation contributes persistently to averting deflation. In the post-Great Recession period, fiscal inflation offsets a deflationary bias set off by non-policy shocks – primarily a mix of favorable investment shocks and long-run cost-push shocks. Notably, the deflationary effects of these non-policy forces are persistent and keep dragging inflation down for a long period of time.

Fiscal inflation increases significantly in the aftermath of the pandemic recession. This helps in sustaining the recovery, but at the cost of a very large persistent increase in inflation. As we will see in more detail in the next two subsections, inflation is already on an upward trajectory following the CARES act, but it accelerates significantly following the ARPA fiscal stimulus that was implemented with the economy already on a path to recovery. Interestingly, the first change in the amount of unfunded transfers and the associated contribution to the rebound of the economy do not coincide with the increase in fiscal transfers associated with the CARES act, but rather with the announcement of the change of the policy strategy followed by the Federal Reserve. Thus, our model suggests that it is the coordination between monetary and fiscal authorities that triggers the large rebound of the economy. The increase in funded transfers alone has limited efficacy because it also generates an expectation of large tax increases in the future. This result holds despite the fact that we allow for hand-to-mouth consumers that immediately spend the transfers that 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 are in line with the historical experience. Throughout the sample, fiscal inflation increases in the aftermath of recessions, a finding consistent with what documented in Hall and Sargent (2011, 2022). The pattern is particularly visible after the 1974, 1991, 2001, 2009, and pandemic recessions. The only noticeable exception is the recession of the early 1980s. This recession is inherently different precisely because the decline in inflation and the contraction in real activity were largely caused by a *decline* in the share of unfunded spending. 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 employed in the paper. Agents and policymakers understand that spending can be covered by future fiscal adjustments or movements in inflation. At each point in time, the shadow economy serves the purpose of summarizing symmetric beliefs about the share of debt that is unfunded, making sure that movements in inflation are consistent with the cross equations restrictions of the model. However, the underlying information flow can go either way. Agents can observe the actions of the Federal Reserve and decide how much of the stabilization will occur with inflation, or they can observe the actions of the fiscal authority and conclude that inflation *must* increase to keep debt on a stable path. In the background, there can also be a political economy game between the two authorities with respect to the amount of unfunded spending. In this case, our rules would capture the final outcome of the game.

Agents and policymakers are assumed to be perfectly informed and rational, a pervasive assumption in macroeconomics that we maintain for tractability. Because of this standard –albeit admittedly strong– assumption, the monetary and fiscal authority as well as the private sector know precisely the share of spending that will be stabilized by fiscal inflation. As modelers, we resort to a shadow economy to conduct an accounting exercise and track the share of unfunded spending. The assumption that policymakers respond to persistent macro variables defined in a shadow economy has a long-standing tradition in theoretical and empirical macroeconomics. A prominent example is the assumption positing that the central bank responds to the output gap, which requires the modeler to construct a counterfactual economy with flexible prices and no inefficient shocks. Even in that case, the shadow economy captures a policy relevant economic concept identified using the structure of the model.

The coordination of monetary and fiscal policy may originate from the need of financing expensive social programs, long wars, or large fiscal stimuli. These are scenarios in which the fiscal authority might not be realistically able to raise primary surpluses, leading to inflationary pressure. An example of this situation is the launch of the Great Society initiatives, which triggered an upward shift in transfers for several years after the announcement by President Johnson in 1964. Arguably, financing these expensive long-lasting social programs with only fiscal instruments would have been politically unfeasible. This generated inflationary pressure that was met by dovish monetary policy. In the early 1980s, Fed Chairman Volcker signalled that inflationary pressure was not going to be accommodated anymore. The Reagan administration, unlike previous administrations, refrained from interfering and advocated for a small government instead, making this policy change credible.

For a given fiscal burden, there can be situations in which the monetary authority communicates its willingness to tolerate a temporary increase in inflation that reduces the needs of fiscal stabilization. Agents in the model find this increase in inflation not only credible, but also necessary because they do not see any concrete action on the side of the fiscal authority to stabilize debt. This increase in inflation erodes a fraction of debt, requiring a smaller fiscal adjustment. An example of this willingness to accept a temporary increase in inflation is the revision of the Fed's framework announced on August 2020. This announcement occurred in the aftermath of the CARES act and can be seen as a way to trigger a rebound of the economy at a moment in which monetary policy was constrained by the zero lower bound.

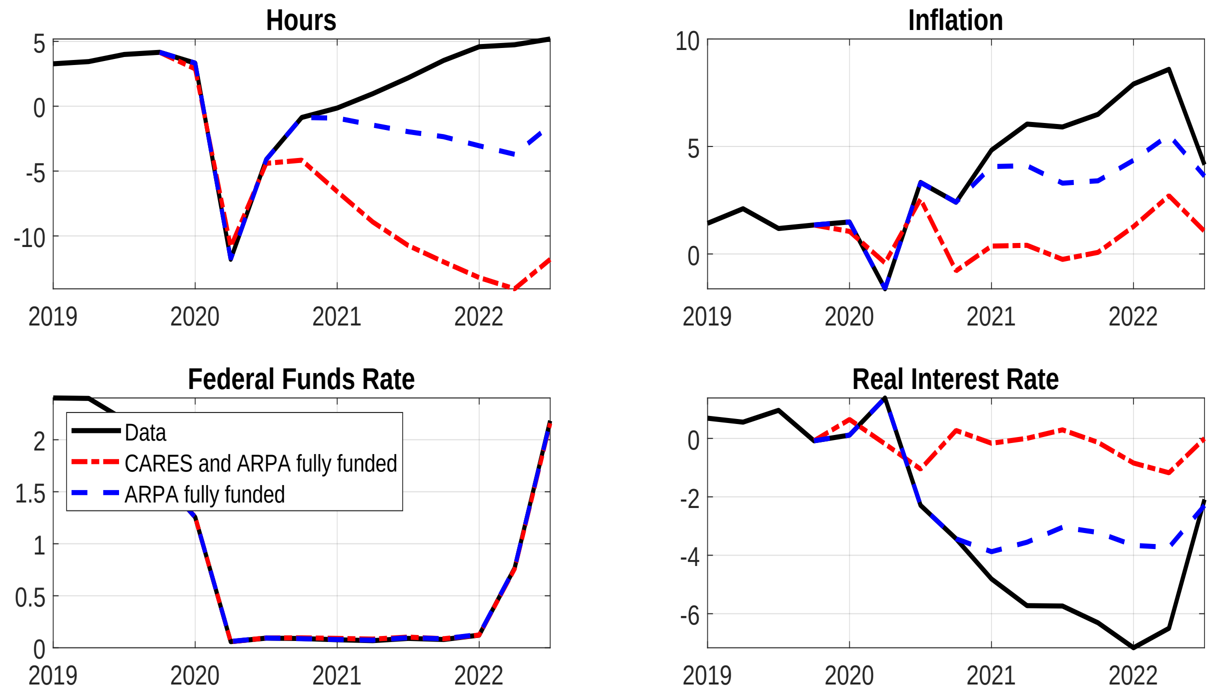


Figure 8: **Unfunded fiscal shocks and the post-pandemic rise in inflation**. The figure compares the data (black solid line) for hours, inflation, the Federal Funds rate, and the real interest rate, with two counterfactual scenarios. In the first counterfactual simulation, all transfers shocks estimated starting from the Pandemic Recession (i.e., 2020:Q1) are assumed to be funded (red dashed-dotted line). In the second counterfactual simulation, only all transfers shocks estimated starting from 2021:Q1 are assumed to be funded (blue dashed line). All other shocks are left unchanged. Shocks are estimated using the Kalman smoother. Model parameters are set at their posterior mode. Estimation sample is 1960:Q1-2022:Q3.

Against this backdrop, the ARPA generated additional inflationary pressure as the economy was already along the recovery path.

5.4 Unfunded Fiscal Shocks during the Pandemic

We now analyze in more detail the importance of monetary and fiscal policy coordination in the context of the pandemic recession. We isolate the role played by the share of unfunded fiscal transfers in boosting the real economic activity and generating the post-pandemic increase in inflation. Figure 8 compares the realized outcomes (black solid line), with two counterfactual simulations. In the first counterfactual scenario, all transfers shocks estimated starting from 2021:Q1 are assumed to be funded (blue dashed line). In the second one, all transfers shocks estimated starting from the Pandemic Recession (i.e., 2020:Q1) are assumed to be funded (red dashed-dotted line). Thus, in the first simulation, both the CARES act and the ARPA are assumed to be fully funded, while in the second simulation only the ARPA shock is assumed to be fully funded. These two counterfactual simulations allow us to understand the relative contribution of unfunded spending associated with the two fiscal stimuli in determining the post-pandemic recovery and surge in inflation.

A first key takeaway from the figure, is that unfunded fiscal shocks played a central role in boosting real activity and fueling the rise in inflation. As noted earlier, this overshoot of inflation over the central bank's 2% target allows the central bank to regain space for future monetary policy in an environment of elevated ELB risk. If all transfers shocks that occurred starting from 2020 had been funded (red dotted-dashed line), the rate of inflation would have fallen in negative territory, persistently undershooting the long-run target of 2%. This deflationary bias is the consequence of the long-run drag on inflation played by a number of persistent non-policy shocks at the end of the sample. The highly persistent effect of these shocks on inflation is denoted by the white bars in Figure 7.

Furthermore, in this alternative scenario, policymakers largely fail to rescue the economy. This can be seen by noticing that hours, which can be thought as a proxy for the output gap, fall considerably in 2021. This prediction of our model should not come as a surprise given that in this alternative scenario, nominal interest rates are mired at the ELB and agents expect that the large fiscal stimuli of the pandemic period will be financed by substantial fiscal adjustments in the future. This counterfactual policy scenario compounds, instead of counteracting, the effects of adverse non-policy shocks (see Figure 7).

The difference between this first counterfactual (red dashed-dotted line) and the second one (blue dashed line) captures the effects of the increase in the share of unfunded transfers associated with the CARES act in the fourth quarter of 2020. This fiscal intervention gives rise to inflationary pressure that counteracts the long-lasting deflationary forces allowing the central bank to overshoot its long-term 2% target and avoid deflation (blue dashed line). Under this scenario, inflation is found to peak at 5.5% in 2022. The fall in real interest rates generated by the rise in inflation provides persistent stimulus to the economy, boosting total hours by as much as 18.8%. Furthermore, since part of the transfers paid by the government to help the economy weather the pandemic recession are expected to be unfunded, agents anticipate that future fiscal adjustments will be lighter, also contributing to the economic recovery that follows the pandemic recession.

The increase in inflation following the CARES stimulus is relatively modest and tolerated by the central bank, that does not anticipate the lift-off of the FFR. This behavior of the nominal interest rate reflects the coordinated action of the monetary and fiscal authorities, aimed at stabilizing a fraction of the 2020 fiscal stimulus with inflation. From this point of view, the interaction of monetary and fiscal policies plays a key role in implementing the asymmetric policy strategy outlined by the Federal Reserve following its 2020 policy review (Bianchi et al. 2019, Clarida 2020). The increase in the share of unfunded transfers makes the asymmetric strategy not only credible, but also necessary.[8]

[8]This finding echoes the remarks by Sims (2016) at the 2016 Jackson Hole symposium: "[...] interest rate

The difference between the realized outcomes (black line) and the second counterfactual simulation (blue dashed line) is due to the unfunded fiscal shocks that occurred starting from 2021Q1, the quarter in which the ARPA fiscal stimulus unfolded. The ARPA fiscal stimulus helps in bringing hours back to pre-pandemic level, counteracting contractionary non-policy shocks (See Figure 7). However, this large fiscal stimulus also exacerbates the pre-existing inflationary pressure, arguably because implemented with the economy already along a recovery path. The unfunded shocks associated with the ARPA fiscal stimulus increase the peak of inflation by 3.1%, from 5.5% to 8.6%. It is worth emphasizing that this acceleration in inflation is only due to the share of unfunded spending, as the counterfactual simulations do not remove the fiscal stimuli, but only assume that all spending was funded. If the ARPA had been fully funded, its inflationary effects would have been modest, despite the presence of hand-to-mouth households. This result is consistent with Parker et al. (2022), who find that the *direct* impact of the fiscal stimulus was modest.

So far we have conducted an in-sample analysis. We show in the next subsection that our model with partially unfunded debt would have been able to predict the inflationary effects of the ARPA even out of sample. In other words, according to our model, the inflationary effects of the large fiscal stimulus were largely predictable based on where the economy was at the end of 2020 and the fact that historically fiscal expansions are partially unfunded.

5.5 Real time predictions of the effects of the ARPA

The results of the previous subsection show that inflation started increasing in response to the fiscal stimulus introduced by the Trump administration, but it accelerated significantly following the subsequent stimulus of the Biden administration. This additional $1.9 trillion stimulus had led influential commentators and scholars to express concern about price stability even before its implementation (e.g., Blanchard, 2021, and Summers, 2021). In this subsection, we show that our model could have predicted *in real time* the largely inflationary effects of the ARPA fiscal stimulus.[9] The ability of the model to predict the post-pandemic inflation is an important validation of the analysis presented in this paper.

We re-estimate the model over the sample 1960:Q1-2020:Q4, only using data that were available *in real time* in 2021:Q2. We then consider model-projections based on real-time estimates and two alternative scenarios: With and without the ARPA fiscal shock. Figure 9 reports the results. The first forecast (blue dashed line) is obtained by projecting into the future the data as of 2020:Q4. This forecast takes into account the fiscal stimulus introduced by the Trump administration, but it excludes the ARPA stimulus enacted in 2021:Q1. The

policy, tax policy, and expenditure policy, [...] jointly determine the price level."

[9] In fact, the results discussed here were presented at the 2021 NBER Summer Institute.

second forecast (red dotted-dashed line) revises this initial projection to account for the transfers observed in 2021:Q1, which reflect the ARPA stimulus. The dataset used to produce this revised forecast differs from the dataset used to produce the first forecast only to the extent that it adds information on the transfers implemented in 2021Q1. In other words, we do not include observations for the other series of the model. The ARPA stimulus mostly rested on providing additional transfers to households, which received a new stimulus check in their mailbox the last weeks of March 2021. Hence the difference between the two projections isolates the contribution of the ARPA stimulus predicted by our model, everything else being equal. Importantly, the increase in transfers observed in 2021:Q1 is attributed by the filter to funded and unfunded shocks according to their historical pattern, using parameters estimates obtained using real time data up to 2020:Q4.[10]

Figure 9 shows that the ARPA stimulus produces a further increase in inflation, up from 3.7% to 6.3% at its peak. This conditional forecast can replicate very well the inflation data for 2021 (black solid line), data points that are not used in the filtering exercise. After completing a larger overshoot, inflation retrenches to the central bank target in 2025. Because of the larger increase in inflation, the real interest rate falls further, providing an even bigger boost to the economy in 2021 and over the following years, as shown by the forecasts of hours (upper left panel). This is despite a modest anticipated lift-off of the nominal interest rate starting from 2021:Q1, relative to the baseline case. This anticipated lift-off occurs because part of the increase in transfers due to the fiscal stimulus is fiscally funded and the central bank does not accommodate the (small) increase in inflation attributed to funded fiscal shocks.

The objective of this exercise is to conduct a true out-of-sample forecast using real-time data. Therefore, we control for market expectations about future monetary policy as of 2020:Q4. This is why the more aggressive lift-off in this conditional forecast only occurs in 2023, while in the data occurs in 2022. In Figure 8, instead, we also control for the realized path of the FFR and the other shocks occurring in 2021. The fact that inflation is largely predictable out-of-sample indicates that these other shocks largely affect the realized paths of GDP growth and the FFR, but have a relatively modest impact on realized inflation. This in consistent with the historical decomposition presented in Figure 7.

This out-of-sample exercise shows that even from an ex-ante perspective the model could

[10]The decomposition of the transfers in 2021:Q1 into the funded and unfunded components is shown in Figure 13 in Appendix H. The amount of total transfers observed in the data as of 2021:Q2 (the real-time dataset that we use in the out-of-sample forecast) is $5.950 trillions, for a change of $2.300 trillions between 2020:Q4 and 2021:Q1. The parameters of the model estimated over the shorter sample are similar to the ones estimated over the baseline sample period, shown in Table 4 of Appendix F. The table is available upon request.

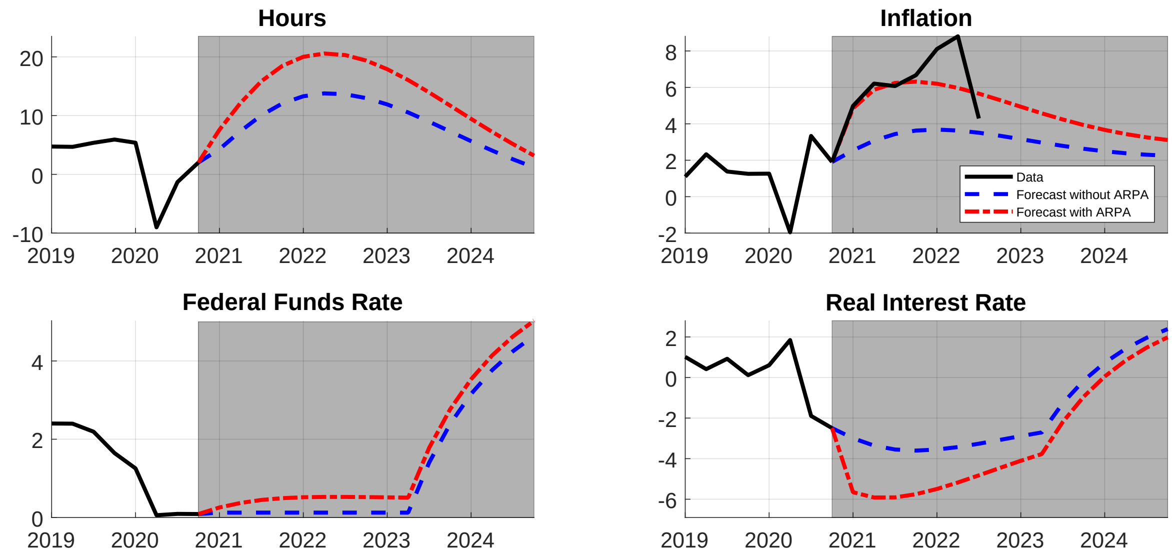


Figure 9: **Real-time out-of-sample projections: The Macroeconomic Effects of the ARPA Stimulus.** Model forecast for hours worked, inflation, the Federal Funds rate, and the real interest rate, conditional on using estimates over the sample 1960:Q1-2020:Q4 and based on data as available in 2021:Q2. The blue dashed line provides a real time forecast based on filtered data up to 2020:Q4 and model parameters estimated using data up to 2020:Q4. The red-dotted dashed line provides a real time forecast conditional on filtered data up to 2020:Q4 and the federal transfers payment in the first quarter of 2021, which is when most of the ARPA stimulus checks were sent out. Shocks are estimated using the Kalman filter. Model parameters are set at their posterior mode.

foresee the rise in inflation associated with the ARPA. In other words, the model is not only able to rationalize ex-post what happened, but also to predict the inflationary effects of a large fiscal stimulus like the ARPA. In light of these results, we conclude that the post-pandemic macroeconomic outcomes are largely in line with the historical experience for the United States, where unfunded spending has played an important role in accounting for inflation dynamics. The initial pandemic fiscal interventions might have been necessary to help the recovery and move away from a low interest rate environment that limits the actions of the Federal Reserve. With benefit of hindsight, the ARPA fiscal stimulus might have been too large, given that the economy was already on a path to recovery, and caused the acceleration in inflation starting from 2021. Absent this shock, inflation would have only moderately overshot the 2% target. As of 2023, the debt-to-GDP is at an historical maximum and its service cost is on the rise. This implies that even small changes in the way debt will be stabilized can lead to large swings in inflation. An implication of these findings is that a clear path for both monetary and fiscal policy is necessary to manage inflation in a post-pandemic world.

6 Fiscal inflation in a textbook model

The reason for estimating the large-scale model of Section 3, rather than a bare-bone New Keynesian model, is that the former features multiple competing mechanisms that can explain persistent inflation. Whether our fiscal mechanism plays a dominant role is therefore an empirical question. Indeed, in Figure 7, we see that from the early 1990s, non-policy factors – primarily persistent cost-push shocks and favorable technology shocks – have persistently contributed to keeping inflation down. The model predicts, however, that fiscal inflation has played an important role in dampening these deflationary pressures due to non-policy factors. Estimating a simple New Keynesian model, such as the one presented in Section 2.2, would not be appropriate to address the quantitative importance of our mechanism, as it rules out by construction alternative ways to account for movements in inflation. Thus, the additional features of the baseline model mostly serve the purpose to render the propagation of familiar business-cycle shocks consistent with standard general-equilibrium models and with decades of empirical work based on VAR analysis and to avoid ruling out *a priori* other sources of inflation fluctuations.

However, a drawback of estimating large models, is that it is often hard to assess to what extent the results are driven by all the intricacies of the auxiliary assumptions. The purpose of this section is to show that the fiscal mechanism proposed in this paper is successful in explaining persistent inflation even when it is studied using a bare-bone New Keynesian model. To make this point, we take the stylized model with nominal rigidities of Section 2.2, and calibrate its parameters consistently with the estimated counterparts of the quantitative New Keynesian model. We then simulate the stylized model using only the shocks to unfunded transfers as estimated using the quantitative New Keynesian model. The simulated series of inflation for the simple model is shown in Figure 10 (black dashed line) along with the U.S. GDP deflator in the data (red dotted line). For comparison, we also report fiscal inflation based on the baseline model (the blue solid line). The important takeaway is that the inflation simulated from the stylized model explains persistent inflation quite successfully.

In addition, if we compare the black dashed line with the blue solid line, which corresponds to fiscal inflation implied by the estimated NK model, we observe that the textbook NK model endowed with the fiscal mechanism proposed in our paper generates a series of fiscal inflation that is remarkably similar to what the large New Keynesian model predicts. This is despite the fact that the shocks are not re-estimated to account for the differences between the two models. This indicates that what makes the quantitative model successful in accounting for the persistent movements in inflation is the presence of nominal rigidities, and not the ancillary frictions that are popular in the New Keynesian literature.

To sum up, we conclude that the many bells and whistles of the estimated New Keynesian

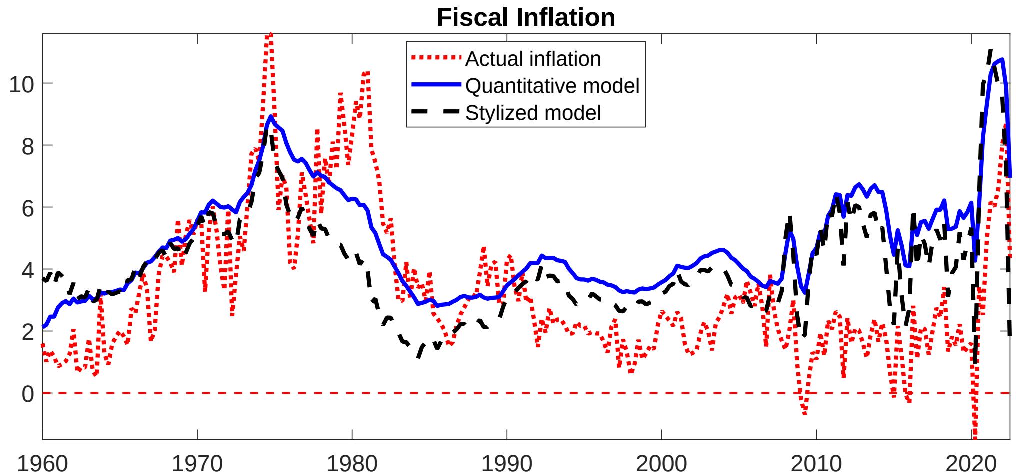


Figure 10: **Fiscal inflation in a textbook NK model.** The red dotted line shows the GDP deflator in the data. The blue solid line shows the inflation rate simulated from the quantitative New Keynesian DSGE model, introduced in Section 3, using unfunded transfers shocks. The dashed black line shows the inflation rate simulated from the stylized New Keynesian model using the same sequence of estimated unfunded transfers shocks. The sample is 1960:Q1-2022:Q3.

model do not play a key role in accounting for our results. Even when a bare-bone New Keynesian model is used in place of the large New Keynesian model, we obtain very similar results. The fiscal theory of persistent inflation arises because of the interaction between the fiscal mechanism and nominal rigidities, in line with what explained in Section 2.2.

7 Conclusions

In this paper, we developed a novel class of models in which unfunded fiscal shocks coexist with typical business cycle shocks to propose a fiscal theory of persistent inflation. We first discussed the role of unfunded shocks in a series of stylized models. We then incorporated unfunded fiscal shocks in a quantitative NK model. Our empirical results show that fiscal inflation plays a major role in explaining persistent movements in inflation. We then use the model to study the post-pandemic rise in inflation. Unfunded shocks sustained the recovery, counteracting deflationary forces. The ARPA occurred with an economy already on a recovery path and exacerbated the rise in inflation because partially unfunded. As external validation of the proposed mechanism, we show that the model is able to predict the effect of the ARPA out of sample, using real time data. Absent further unfunded fiscal shocks, inflation is expected to slowly revert to its long-term target, consistently with a fiscal theory of persistent inflation.

Bianchi and Melosi (2017, 2022) emphasize the role of agents' beliefs about future policymakers' behavior to explain inflation dynamics in the aftermath of the Great Recession and the COVID-19 pandemic, while in the current paper the post-pandemic rise in inflation is caused by an increase in unfunded spending. In both cases, the analysis moves away from the idea that debt is perceived as entirely backed by future taxation to make sense of the rapid increase in inflation following large fiscal expansions.

While the interpretation of the recent inflation surge provided in this paper is qualitatively consistent with these previous contributions, there are some important differences. With respect to regime changes, the current framework allows for a continuum of intermediate outcomes between the two canonical regimes and preserves the familiar propagation of shocks that do not affect the amount of unfunded debt. This captures the idea that central bankers might remain committed to long-term price stability but accommodate a temporary bout of inflation to help with fiscal sustainability. On the other hand, regime changes allow to model swings in beliefs for a given policymakers' behavior, whereas in this paper we assume that beliefs and policy actions are perfectly aligned. While this is the typical assumption employed in most of macro models, we believe that it could be relaxed in future research. In reality agents might have to learn the share of unfunded debt as policymakers could lack the ability to perfectly coordinate and communicate their policies (Melosi 2017). The speed of learning could be slow as in Bianchi and Melosi (2013), but also subject to sudden accelerations as in Bassetto and Miller (2022). Combining the two approaches would allow to retain the possibility of rapid swings in beliefs as in Bianchi and Melosi (2017, 2022), while at the same time preserving the desirable features of the current framework. The fact that in our estimates the share of unfunded debt typically moves sluggishly, but it is also subject to more rapid changes during important economic events such as the Volcker disinflation or the COVID pandemic, suggests that this is a promising direction for future research.

References

Aiyagari, S. R. and M. Gertler (1985). The backing of government bonds and monetarism. *Journal of Monetary Economics 16*(1), 19–44.

Barro, R. (2022). Understanding Recent US Inflation. Technical report, project syndicate.

Barro, R. J. (1974, Nov.-Dec.). Are Government Bonds Net Wealth? *Journal of Political Economy 82*(6), 1095–1117.

Bassetto, M. (2002). A game-theoretic view of the fiscal theory of the price level. *Econometrica 70*(6), 2167–2195.

Bassetto, M. and D. Miller (2022). A monetary-fiscal theory of sudden inflations. *Unpublished manuscript*.

Bassetto, M. and T. J. Sargent (2020). Shotgun wedding: Fiscal and monetary policy. *Annual Review of Economics 12*(1), 659–690.

Benhabib, J., S. Schmitt-Grohe, and M. Uribe (2002). Avoiding Liquidity Traps. *Journal of Political Economy 110*(3), 535–563.

Bianchi, F. (2013). Regime switches, agents' beliefs, and post-world war ii us macroeconomic dynamics. *The Review of Economic Studies*, rds032.

Bianchi, F. and C. Ilut (2017). Monetary/Fiscal Policy Mix and Agents' Beliefs. *Review of Economic Dynamics 26*, 113–139.

Bianchi, F. and L. Melosi (2013). Dormant Shocks and Fiscal Virtue. In *NBER Macroeconomics Annual 2013, Volume 28*, NBER Chapters, pp. 1–46. National Bureau of Economic Research, Inc.

Bianchi, F. and L. Melosi (2019). The dire effects of the lack of monetary and fiscal coordination. *Journal of Monetary Economics 104*, 1–22.

Bianchi, F. and L. Melosi (2022, 08). Inflation as a Fiscal Limit. Working paper series, Federal Reserve Bank of Chicago.

Bianchi, F., L. Melosi, and M. Rottner (2019). Hitting the Elusive Inflation Target. NBER working paper.

Blanchard, O. (2021). In defense of concerns over the $1.9 trillion relief plan. PIIE opinion, 18 February 2021.

Campbell, J. R., C. L. Evans, J. D. Fisher, and A. Justiniano (2012). Macroeconomic Effects of Federal Reserve Forward Guidance. *Brookings Papers on Economic Activity 43*(1 (Spring), 1–80.

Campbell, J. R., J. D. M. Fisher, A. Justiniano, and L. Melosi (2017). Forward guidance and macroeconomic outcomes since the financial crisis. *NBER Macroeconomics Annual 31*(1), 283–357.

Christiano, L. J., M. Eichenbaum, and C. L. Evans (2005). Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. *Journal of Political Economy 113*(1), 1–45.

Clarida, R., J. Galí, and M. Gertler (2000). Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory. *Quarterly Journal of Economics 115*, 147–180.

Clarida, R. H. (2020). The federal reserve's new monetary policy framework: A robust evolution. Technical report.

Cochrane, J. H. (1998). A Frictionless Model of U.S. Inflation. In B. S. Bernanke and J. J. Rotemberg (Eds.), *NBER Macroeconomics Annual 1998*, pp. 323–384. Cambridge, MA: MIT Press.

Cochrane, J. H. (2001). Long Term Debt and Optimal Policy in the Fiscal Theory of the Price Level. *Econometrica 69*, 69–116.

Cochrane, J. H. (2022). A fiscal theory of monetary policy with partially-repaid long-term debt. *Review of Economic Dynamics 45*, 1–21.

Congressional Budget Office (2020). Federal debt: a primer. (CBO Publication No. 56165). Washington, DC: Congressional Budget Office.

Del Negro, M. and F. Schorfheide (2008). Forming Priors for DSGE Models (And How it Affects the Assessment of Nominal Rigidities). *Journal of Monetary Economics 55*(7), 1191–1208.

Fernandez-Villaverde, J. and J. F. Rubio-Ramirez (2007a). Estimating Macroeconomic Models: A Likelihood Approach. *Review of Economic Studies 74*(4), 1059–1087.

Fernandez-Villaverde, J. and J. F. Rubio-Ramirez (2007b). How Structural are Structural Parameters? *2007 NBER Macroeconomics Annual*.

Galí, J. (2008). *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework*. Princeton University Press.

Hall, G. J. and T. J. Sargent (2011). Interest Rate Risk and Other Determinants of Post-WWII U.S. Government Debt/GDP Dynamics. *American Economic Journal: Macroeconomics 3*(3), 192–214.

Hall, G. J. and T. J. Sargent (2022). Three world wars: Fiscal–monetary consequences. *Proceedings of the National Academy of Sciences 119*(18), e2200349119.

Hazell, J., J. Herreno, E. Nakamura, and J. Steinsson (2020). The slope of the phillips curve: evidence from us states. Technical report, National Bureau of Economic Research.

Kaplan, G., G. Violante, and J. Weidner (2014). The Wealthy Hand-to-Mouth. *Brookings Papers on Economic Activity 44*(1), 77–138.

Leeper, E. M. (1991). Equilibria Under Active and Passive Monetary and Fiscal Policies. *Journal of Monetary Economics 27*, 129–147.

Leeper, E. M., N. Traum, and T. B. Walker (2017, August). Clearing Up the Fiscal Multiplier Morass. *American Economic Review 107*(8), 2409–2454.

Leeper, E. M. and X. Zhou (2013). Inflation's role in optimal monetary-fiscal policy. *NBER Working Paper*.

Lubik, T. and F. Schorfheide (2004). Testing for Indeterminacy: An Application to U.S. Monetary Policy. *American Economic Review 94*(1), 190–217.

Melosi, L. (2016, 09). Signalling Effects of Monetary Policy. *The Review of Economic Studies 84*(2), 853–884.

Parker, J. A., J. Schild, L. Erhard, and D. Johnson (2022). Household spending responses to the economic impact payments of 2020: Evidence from the consumer expenditure survey. Technical report, National Bureau of Economic Research.

Reis, R. (2016). QE in the future: the central bank's balance sheet in a financial crisis. Discussion Papers 1620, Centre for Macroeconomics (CFM).

Samuelson, R. J. (2008). *The Great Inflation and its Aftermath: The Past and Future of American Affluence*. Random House Digital, Inc.

Sargent, T. and N. Wallace (1981). Some Unpleasant Monetarist Arithmetic. *Federal Reserve Bank of Minneapolis Quarterly Review Fall*, 1–17.

Schmitt-Grohe, S. and M. Uribe (2000). Price level determinacy and monetary policy under a balanced-budget requirement. *Journal of Monetary Economics 45*(1), 211–246.

Sims, C. A. (1994). A Simple Model for Study of the Determination of the Price Level and the Interaction of Monetary and Fiscal Policy. *Economic Theory 4*, 381–399.

Sims, C. A. (2016). Fiscal policy, monetary policy and central bank independence. In *Kansas City Fed Jackson Hole Conference*.

Sims, C. A. and T. Zha (1998). Bayesian Methods for Dynamic Multivariate Models. *International Economic Review 39*(4), 949–968.

Sims, C. A. and T. Zha (2006). Were There Regime Switches in US Monetary Policy? *American Economic Review 91*(1), 54–81.

Smets, F. and R. Wouters (2007a). Shocks and frictions in us business cycles: A bayesian dsge approach. *The American Economic Review 97*(3), 586–606.

Smets, F. and R. Wouters (2007b). Shocks and Frictions in U.S. Business Cycles: A Bayesian DSGE Approach. *American Economic review 97*(3), 586–606.

Summers, L. H. (2021). Opinion: The inflation risk is real. Washington Post, 24 May 2021.

Woodford, M. (1994). Monetary Policy and Price Level Determinacy in a Cash-in-Advance Economy. *Economic Theory 4*, 345–389.

Woodford, M. (1995). Price Level Determinacy without Control of a Monetary Aggregate. *Carnegie-Rochester Series of Public Policy 43*, 1–46.

Woodford, M. (2001). Fiscal Requirements of Price Stability. *Journal of Money, Credit, and Banking 33*, 669–728.

Woodford, M. (2003). *Interest and prices: Foundations of a theory of monetary policy.* Princeton, New Jersey: Princeton University Press.

A Solving Economies with Partially Unfunded Debt

To prove that the system of equations (11), (12), (13), (14), are the correct policy functions of the model with partially unfunded debt, we have to show that the two following claims are true. First, the difference between the overall stock of debt and its unfunded share is funded, that is, $\hat{s}_{b,t} - \hat{s}^F_{b,t} = \hat{s}^M_{b,t}$. Second, the inflation rate the central bank strives to stabilize with active monetary policy in the actual economy is precisely the actual rate of inflation net of the inflation needed to stabilize the unfunded debt (i.e., $\hat{\pi}^M_t = \hat{\pi}_t - \hat{\pi}^F_t$).

Both claims can be proved by constructing yet another parallel economy to pin down (i) the share of inflation the monetary authority has to control with active monetary policy, $\hat{\pi}^M_t$, and (ii) the share of funded debt, $\hat{s}^M_{b,t}$, which is the share of debt the fiscal authority is responsible to repay by raising future surpluses. This parallel economy is as follows:

$$\begin{aligned} \mathbb{E}_t \hat{\pi}^M_{t+1} &= \hat{r}^M_{n,t}, && (22)\\ \hat{s}^M_{b,t} &= \beta^{-1}(\hat{s}^M_{b,t-1} - \hat{r}^M_{n,t-1} - \hat{\pi}^M_t - (1-\beta)\hat{\tau}^M_t), && (23)\\ \hat{r}^M_{n,t} &= \phi^M \hat{\pi}^M_t, && (24)\\ \hat{\tau}^M_t &= \gamma^M \hat{s}^M_{b,t} + \zeta^M_t. && (25) \end{aligned}$$

In this parallel economy, all fiscal shocks are funded, ζ^M_t, and the policy mix is monetary led ($\phi^M > 1$ and $\gamma^M > 1$). The monetary and fiscal blocks are obtained as done for the other economies we studied in the main text:

$$\begin{aligned} \mathbb{E}_t \hat{\pi}^M_{t+1} &= \phi^M \hat{\pi}^M_t, && (26)\\ \hat{s}^M_{b,t} &= \beta^{-1}\left[1-(1-\beta)\gamma^M\right]\hat{s}^M_{b,t-1} + \beta^{-1}[\hat{r}^M_{n,t-1} - \hat{\pi}^M_t - (1-\beta)\zeta^M_t]. && (27) \end{aligned}$$

To prove the first claim, we need to show that $\hat{\pi}^M_t = \hat{\pi}_t - \hat{\pi}^F_t$. This can be done by subtracting equations (26) and (13) from equation (12). This yields:

$$\mathbb{E}_t(\hat{\pi}_{t+1} - \hat{\pi}^F_{t+1} - \hat{\pi}^M_{t+1}) = \phi^M(\hat{\pi}_t - \hat{\pi}^F_t - \hat{\pi}^M_t). \quad (28)$$

Because $\phi^M > 0$, the above expression implies $\hat{\pi}_t - \hat{\pi}^F_t - \hat{\pi}^M_t = 0$, i.e., $\hat{\pi}^M_t = \hat{\pi}_t - \hat{\pi}^F_t$.

Let us now turn to the second claim. This claim requires us to show that $\hat{s}^M_{b,t} = \hat{s}_{b,t} - \hat{s}^F_{b,t}$. Substituting the fiscal rule in equation (9) (with $\gamma^F = 0$) and the monetary rule in equation (10) into the law of motion of debt in equation (2), we obtain:[11]

$$\begin{aligned} \beta\hat{s}_{b,t} = (1-(1-\beta)\gamma^M)\hat{s}_{b,t-1} + (1-\beta)\gamma^M\hat{s}^F_{b,t-1} + \phi^M(\hat{\pi}_{t-1} - \hat{\pi}^F_{t-1}) && (29)\\ +\phi^F\pi^F_{t-1} - \pi_t + (1-\beta)(\zeta^M_t + \zeta^F_t). && (30) \end{aligned}$$

Substituting (25) and (24) into (23) implies:

$$\beta\hat{s}^M_{b,t} = (1-(1-\beta)\gamma^M))\hat{s}^M_{b,t-1} + \phi^M\hat{\pi}_{t-1} - \hat{\pi}^M_t + (1-\beta)\zeta^M_t. \quad (31)$$

[11]The fiscal rule could be equivalently expressed as $\tau_t/\tau = \left(b_{t-1}/b^M_{t-1}\right)^{\gamma^F}\left(b^M_{t-1}/b\right)^{\gamma^M} e^{\zeta^M_t + \zeta^F_t}$.

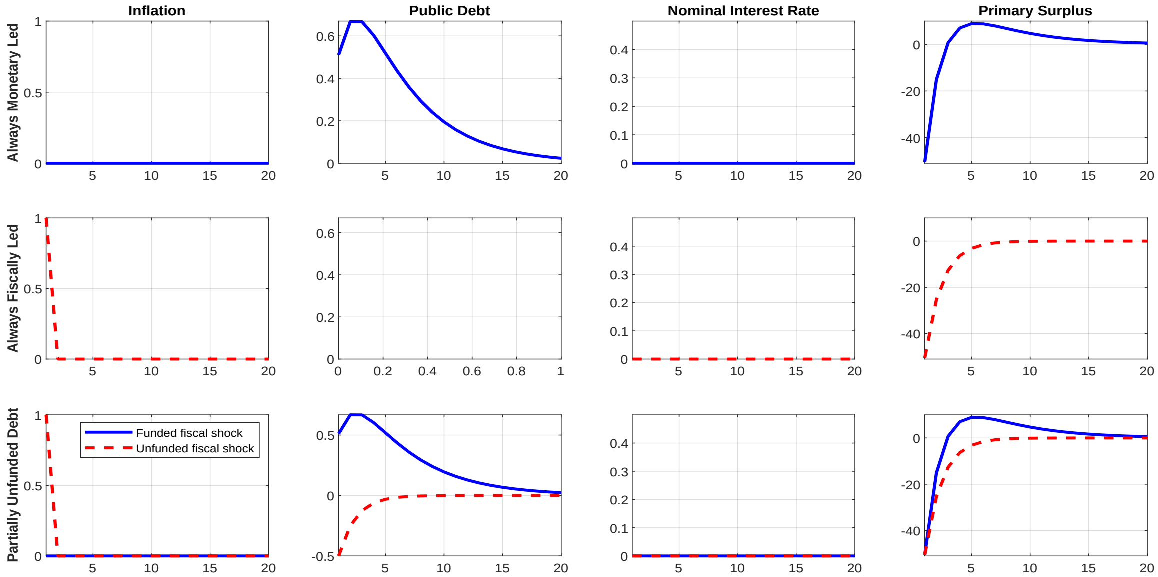


Figure 11: Response of Model Variables to a Fiscal Shock.

Repeating the same steps for the shadow economy with unfunded debt yields:

$$\beta \hat{s}^F_{b,t} = (1 - (1-\beta)\gamma^F))\hat{s}^F_{b,t-1} + \phi^F \hat{\pi}_{t-1} - \hat{\pi}^F_t + (1-\beta)\zeta^F_t. \tag{32}$$

Subtracting $\beta \hat{s}^M_{b,t}$ and $\beta \hat{s}^F_{b,t}$ from $\beta \hat{s}_{b,t}$ yields:

$$\beta(\hat{s}_{b,t} - \hat{s}^M_{b,t} - \hat{s}^F_{b,t}) = (1 - (1-\beta)\gamma^M)(\hat{s}_{b,t-1} - \hat{s}^M_{b,t-1} - \hat{s}^F_{b,t-1}) \tag{33}$$

$$+\phi^M(\hat{\pi}_{t-1} - \hat{\pi}^F_{t-1} - \hat{\pi}^M_{t-1}) - \hat{\pi}_t + \hat{\pi}^F_t + \hat{\pi}^M_t. \tag{34}$$

Using the first claim, $\hat{\pi}^M_t = \hat{\pi}_t - \hat{\pi}^F_t$, it follows that $\hat{s}^M_{b,t} = \hat{s}_{b,t} - \hat{s}^F_{b,t}$ for every period t.

Finally, Figure 11 shows the complete plot of the response of all the variables of the toy model to funded and unfunded fiscal shocks.

B Production Economies: Linearized Equations

B.1 Flexible-price model

Euler equation

$$\mathbb{E}_t \hat{y}_{t+1} = \hat{y}_t + \hat{r}_t \tag{35}$$

Labor supply

$$\frac{n}{1-n}\hat{n}_t = \hat{y}_t + \widehat{w}^r_t \tag{36}$$

Labor demand

$$\hat{w}^r_t = -\alpha \hat{n}_t \tag{37}$$

Production function

$$\hat{y}_t = (1-\alpha)\hat{n}_t \tag{38}$$

Equations (35) to (38) denote an autonomous system that solves for the real block of the economy, $\hat{y}_t$, $\hat{n}_t$, $\hat{w}_t^r$, $\hat{r}_t$. However, inflation is not determined. We introduce the behavior of the monetary and fiscal authorithies to pin down the path of inflation.

Real rate definition

$$\hat{r}_t = \hat{r}_{n,t} - \mathbb{E}_t\hat{\pi}_{t+1} \tag{39}$$

Taylor rule

$$\hat{r}_{n,t} = \phi_\pi^M(\hat{\pi}_t - \hat{\pi}_t^F) + \phi_\pi^F\hat{\pi}_t^F \tag{40}$$

Evolution of debt-to-GDP

$$\hat{s}_{b,t} = \beta^{-1}\left(\hat{y}_{t-1} - \hat{y}_t + \hat{r}_{n,t-1} - \hat{\pi}_t + \hat{s}_{b,t-1} - (1-\beta)\hat{\tau}_t\right) \tag{41}$$

Fiscal rule

$$\hat{\tau}_t = \gamma^M(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F) + \gamma^F\hat{s}_{b,t-1}^F + \zeta_t^F + \zeta_t^M \tag{42}$$

The system of equations above is supplemented with a block of equations that characterize the shadow economy. This block consists in an additional set of equations (35) to (42), where any variable that refers to the actual economy x_t is replaced by the same variable in the shadow economy x_t^F, funded shocks $\zeta_t^M$are shut down, and the central Bank only responds to deviations of inflation from its long-run target.

B.2 New Keynesian model

Euler equation

$$\mathbb{E}_t\hat{y}_{t+1} = \hat{y}_t + \hat{r}_t \tag{43}$$

Labor supply

$$\frac{n}{1-n}\hat{n}_t = \hat{y}_t + \widehat{w}_t^r \tag{44}$$

New Keynesian Phillips Curve

$$\hat{\pi}_t = \kappa\hat{w}_t^r + \beta\mathbb{E}_t\hat{\pi}_{t+1} \tag{45}$$

Production function

$$\hat{y}_t = (1-\alpha)\hat{n}_t \tag{46}$$

Real rate definition

$$\hat{r}_t = \hat{r}_{n,t} - \mathbb{E}_t\hat{\pi}_{t+1} \tag{47}$$

Taylor rule

$$\hat{r}_{n,t} = \phi_\pi^M(\hat{\pi}_t - \hat{\pi}_t^F) + \phi_\pi^F \hat{\pi}_t^F \tag{48}$$

Evolution of debt-to-GDP

$$\hat{s}_{b,t} = \beta^{-1}\left(\hat{y}_{t-1} - \hat{y}_t + \hat{r}_{n,t-1} - \hat{\pi}_t + \hat{s}_{b,t-1} - (1-\beta)\hat{\tau}_t\right) \tag{49}$$

Fiscal rule

$$\hat{\tau}_t = \gamma^M(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F) + \gamma^F \hat{s}_{b,t-1}^F + \zeta_t^F + \zeta_t^M \tag{50}$$

The block of equations that characterize the shadow economy consists in an additional set of equations (43) to (50), where any variable that refers to the actual economy x_t is replaced by the same variable in the shadow economy x_t^F, funded shocks $\zeta_t^M$are shut down, and the central Bank only responds to deviations of inflation from its long-run target.

Plugging eq.(47) into (43), and combining eq.(44) and (46) to substitute for $\hat{w}_t$ into eq.(45), it is possible to express the New-Keynesian block (eq.43) to (48)) as three equations:

$$\mathbb{E}_t\hat{y}_{t+1} = \hat{y}_t + \hat{r}_{n,t} - \mathbb{E}_t\hat{\pi}_{t+1}, \tag{51}$$

$$\hat{\pi}_t = \tilde{\kappa}\hat{y}_t + \beta\mathbb{E}_t\hat{\pi}_{t+1}, \tag{52}$$

where $\tilde{\kappa} = \left(\frac{\eta}{1-\alpha} - 1\right)\kappa$ and $\eta = \frac{n}{1-n}$, and

$$\hat{r}_{n,t} = \phi_\pi^M(\hat{\pi}_t - \hat{\pi}_t^F) + \phi_\pi^F(\hat{\pi}_t^F) + \phi_y\hat{y}_t. \tag{53}$$

B.3 Calibration

The parameter values of the model are calibrated to the estimated model and reported in Table 3. See the posterior mode of Table 1 and Table 2 in the paper.

C The Role of the Maturity Structure

This appendix derives the role of the maturity structure in determining the initial response to inflation in a flexible prices economy featuring non-distortionary taxation and a Taylor rule.

Parameter	Value	Description
Preferences, technology and price frictions		
β	0.99	Discount factor
α	0.33	Elasticity production fn
N	0.4	Average hours worked
Π	1	Gross steady-state inflation
s_b	2.45	debt to output ratio
κ	0.02	Slope Phillips curve
Monetary and fiscal authorities		
ϕ_π^M	2	Taylor rule response to regular inflation $(\pi - \pi^F)$
γ^M	1.5	Debt response with surplus $(s_b - s_b^F)$
ϕ_π^F	0	Taylor rule response to unfunded inflation (π^F)
γ^F	0	Debt response with surplus (s_b^F)
Shocks		
ρ_τ	0.5	Autocorrel. fiscal shocks
STD_τ	1	St. dev. fiscal shocks

Table 3: Calibrated parameter values in the simple model with price rigidities

C.1 A model with flexible prices and a maturity structure

This appendix describes the role of the central bank response to inflation and the maturity of outstanding debt in determining the response of inflation to a shock to primary surpluses in a model with flexible prices. To simplify the exposition, we assume that there are only unfunded shocks. As explained in the paper, under a Monetary-led policy mix fiscal shocks do not have any effect, so introducing a maturity structure does not affect the propagation of funded fiscal shocks in this simple flexible-prices model.

As in our quantitative model, we assume that there are two types of government bonds: One-period government bonds, B_t, in zero net supply with price $R_{n,t}^{-1}$ and a more general portfolio of government bonds, B_t^m, in non-zero net supply with price $P_t^{(m)}$. The latter debt instrument has payment structure $\rho^{T-(t+1)}$ for $T > t$ and $0 < \rho < 1$. The value of such an instrument issued in period t in any future period $t+j$ is $P_{t+j}^{m-j} = \rho^j P_{t+j}^m$. The asset can be interpreted as a portfolio of infinitely many bonds, with weights along the maturity structure given by $\rho^{T-(t+1)}$. Varying the parameter ρ varies the average maturity of debt. The rest of the model is standard and it is described in the body of the paper.

The linearized system of equations is described as follows. All variables are expressed in log-deviations from the steady state.

- Euler equation

$$\mathbb{E}_t\left[\hat{y}_{t+1}\right] - \hat{y}_t = \hat{r}_t \tag{54}$$

where $\hat{r}_t$ is the real interest rate and $\hat{y}_t$ is real output.

- Labor supply

$$\frac{n}{1-n}\hat{n}_t = \hat{y}_t + \widehat{w}_t^r \tag{55}$$

where $\hat{n}_t$ is hours and $\widehat{w}_t^r$ is the real wage.

- Labor demand

$$\hat{w}_t^r = -\alpha\hat{n}_t \tag{56}$$

- Production function

$$\hat{y}_t = (1-\alpha)\hat{n}_t \tag{57}$$

Equations (54) to (57) denote an autonomous system that solves for the real block of the economy, $\hat{y}_t$, $\hat{n}_t$, $\hat{w}_t^r$, $\hat{r}_t$. However, inflation is not determined. We introduce the behavior of the monetary and fiscal authorithies to pin down the path of inflation.

- Real rate definition

$$\hat{r}_t = \hat{r}_{n,t} - \mathbb{E}_t\left[\hat{\pi}_{t+1}\right] \tag{58}$$

where $\hat{r}_{n,t}$ is the nominal interest rate and $\hat{\pi}_t$ is inflation.

- Taylor rule

$$\hat{r}_{n,t} = \phi\hat{\pi}_t \tag{59}$$

- Fiscal rule

$$\hat{\tau}_t = \rho_\tau\widehat{\tau}_{t-1} + \varepsilon_\tau \tag{60}$$

- Return on the portfolio of bonds with long maturity

$$\widehat{r}^m_{n,t,t+1} = \varpi\widehat{p}^{(m)}_{t+1} - \widehat{p}^m_t$$

  where we have defined $\varpi \equiv \rho/R_n < 1$, with R_n the steady-state gross nominal interest rate and ρ the parameter controlling the average maturity of the portfolio of long term bonds.

- Non-arbitrage condition for the portfolio of bonds with long maturity

$$\widehat{r}^{(1)}_{n,t,t+1} \equiv \widehat{r}_{n,t} = \mathbb{E}_t\left[\widehat{r}^m_{n,t,t+1}\right].$$

  where $\widehat{r}^{(1)}_{n,t,t+1}$ is the nominal return between t and $t+1$ of a degenerate console with average maturity equal to 1. This is by definition equal to a one-period bond whose nominal return is known in advance and equal to the short-term interest rate $\widehat{r}_{n,t}$.

- Linearized government budget constraint:

$$\widehat{s}^m_{b,t} = \beta^{-1}\left(\widehat{s}^m_{b,t-1} + \widehat{r}^m_{n,t-1,t} - \widehat{\pi}_t - \Delta\widehat{y}_t\right) - \frac{\tau}{s_b}\widehat{\tau}_t \tag{61}$$

  where $\widehat{s}^m_{b,t}$ is the debt-to-GDP ratio, $\widehat{r}^m_{n,t-1,t}$ is the return between period t-1 and t of a console that mimics a portfolio of bonds with average maturity m, and $\widehat{\tau}_t$ is the primary surplus as a fraction of GDP. The parameters τ and s_b denote the steady states of the corresponding variables.

- Without maturity structure, the government budget constraint becomes:

$$\widehat{s}_{b,t} = \beta^{-1}\left(\widehat{s}_{b,t-1} + \widehat{r}_{n,t-1} - \widehat{\pi}_t - \Delta\widehat{y}_t\right) - \frac{\tau}{s_b}\widehat{\tau}_t \tag{62}$$

We follow Cochrane (2022) and derive two additional relations that will be used in our derivations below:[12]

$$\widehat{p}^m_t = -\sum_{j=1}^{\infty}\varpi^{j-1}\widehat{r}^m_{n,t,t+j}$$

$$\Delta\mathbb{E}_{t+1}\left[\widehat{r}^m_{n,t,t+1}\right] = -\sum_{j=1}^{\infty}\varpi^{j}\Delta\mathbb{E}_{t+1}\left[\widehat{r}^m_{n,t+j,t+1+j}\right]$$

[12] Cochrane (2022) has a typo in the appendix (page 568) with the exponent equal to to j instead of $j-1$ in the first expression. The results derived here and in the book are not affected by the typo.

The first expression above is obtained by solving (65) forward for $\widehat{p}_t^m$. To obtain the second expression, we shift the time index by one period and take innovations:

$$\begin{aligned}
\widehat{p}_{t+1}^m - \mathbb{E}_t\left[\widehat{p}_{t+1}^m\right] &= -\sum_{j=1}^{\infty} \varpi^{j-1} \Delta\mathbb{E}_{t+1} \widehat{r}_{n,t+j,t+j+1}^m \\
\varpi^{-1}\left(\widehat{r}_{n,t,t+1}^m + \widehat{p}_t^m - \mathbb{E}_t\left[\widehat{r}_{n,t,t+1}^{(m)} + \widehat{p}_t^m\right]\right) &= -\sum_{j=1}^{\infty} \varpi^{j-1} \Delta\mathbb{E}_{t+1} \widehat{r}_{n,t+j,t+j+1}^m \\
\Delta\mathbb{E}_{t+1} \widehat{r}_{n,t,t+1}^m &= -\sum_{j=1}^{\infty} \varpi^{j} \Delta\mathbb{E}_{t+1} \widehat{r}_{n,t+j,t+j+1}^m
\end{aligned}$$

We are interested in the response to fiscal shocks. The model also features a production block, but under the assumption of non-distortionary taxation and flexible prices, the determination of real activity and real interest rates is independent of monetary policy and fiscal policy. Thus, without loss of generality, we assume that there are no other shocks apart from fiscal shocks. This implies that the ex-ante real interest rate will be constant over time, $\widehat{r}_t = \widehat{r}_{n,t} - \mathbb{E}_t\left[\widehat{\pi}_{t+1}\right] = 0$, as there are not shocks that can move the (ex-ante) real interest rate.

C.1.1 Responses to a fiscal shock

We are interested in deriving impulse responses to a shock to primary surpluses. We consider two cases. In the first case debt is all one-period, while in the second case we allow for a maturity structure controlled by the parameter ρ that in turn controls $\varpi \equiv \rho/R_n$.

No maturity structure

We can shift the time index for the linearized budget constraint (62) by one period:

$$\widehat{s}_{b,t+1} = \beta^{-1}\left(\widehat{s}_{b,t} + \widehat{r}_{n,t} - \widehat{\pi}_{t+1} - \Delta\widehat{y}_{t+1}\right) - \frac{\tau}{s_b}\widehat{\tau}_{t+1}$$

Taking expectations and solving forward for $\widehat{s}_{b,t}$:

$$\begin{aligned}
\widehat{s}_{b,t} &= \beta\widehat{s}_{b,t+1} + \frac{\beta\tau}{s}\widehat{\tau}_{t+1} - \left(\widehat{r}_{n,t} - \widehat{\pi}_{t+1}\right) + \Delta\widehat{y}_{t+1} \\
\widehat{s}_{b,t} &= \mathbb{E}_t\left[\sum_{j=0}^{\infty} \beta^j \left(\frac{\beta\tau}{s}\right)\widehat{\tau}_{t+1+j}\right] - \mathbb{E}_t\left[\sum_{j=0}^{\infty} \beta^j \left(\widehat{r}_{n,t+j} - \widehat{\pi}_{t+1+j}\right)\right] + \mathbb{E}_t\left[\sum_{j=0}^{\infty} \beta^j \Delta\widehat{y}_{t+1+j}\right]
\end{aligned}$$

Following Cochrane (2022), we take the change in expectations between t and $t+1$:

$$0 = \Delta\mathbb{E}_{t+1}\left[\sum_{j=0}^{\infty} \beta^j \left(\frac{\beta\tau}{s}\right)\widehat{\tau}_{t+1+j}\right] - \Delta\mathbb{E}_{t+1}\left[\sum_{j=0}^{\infty} \beta^j \left(\widehat{r}_{n,t+j} - \widehat{\pi}_{t+1+j}\right)\right] + \Delta\mathbb{E}_{t+1}\left[\sum_{j=0}^{\infty} \beta^j \Delta\widehat{y}_{t+1+j}\right]$$

We can now use the fact that in this flexible prices model real interest rates and growth are exogenous with respect to fiscal innovations:

$$\widehat{\pi}_{t+1} - \mathbb{E}_t\left(\widehat{\pi}_{t+1}\right) = -\Delta\mathbb{E}_{t+1}\left[\sum_{j=0}^{\infty} \beta^j \left(\frac{\beta\tau}{s}\right)\widehat{\tau}_{t+1+j}\right]$$

where we have used the fact that $\mathbb{E}_t\left[\sum_{j=0}^{\infty} \beta^j \left(\widehat{r}_{n,t+j} - \widehat{\pi}_{t+1+j}\right)\right] = \widehat{r}_{n,t} - \mathbb{E}_t\left(\widehat{\pi}_{t+1}\right)$ and $\mathbb{E}_{t+1}\left[\sum_{j=0}^{\infty} \beta^j \left(\widehat{r}_{n,t+j} - \widehat{\pi}_{t+1+j}\right)\right] = \widehat{r}_{n,t} - \widehat{\pi}_{t+1}$. Thus, the inflation surprise $\eta_{t+1}^{\pi} \equiv \widehat{\pi}_{t+1} -$

$\mathbb{E}_t\left(\widehat{\pi}_{t+1}\right)=\Delta\mathbb{E}_{t+1}\left[\widehat{\pi}_{t+1}\right]$ is purely determined by the change in the present discounted value (PDV) of future primary surpluses. Given that primary surpluses follow and AR(1) process $\widehat{\tau}_{t+1}=\rho_\tau\widehat{\tau}_t+\varepsilon_{\tau,t+1}$, we get that the initial jump in inflation is:

$$\begin{aligned}\widehat{\pi}_{t+1}-\mathbb{E}_t\left(\widehat{\pi}_{t+1}\right) &= -\Delta\mathbb{E}_{t+1}\left[\sum\nolimits_{j=0}^{\infty}\beta^j\left(\frac{\beta\tau}{s_b}\right)\widehat{\tau}_{t+1+j}\right]\\ &= -\left[\sum\nolimits_{j=0}^{\infty}\left(\beta\rho_\tau\right)^j\left(\frac{\beta\tau}{s_b}\right)\varepsilon_{\tau,t+1}\right]\\ &= -\left(1-\beta\rho_\tau\right)^{-1}\left(\frac{\beta\tau}{s_b}\right)\varepsilon_{\tau,t+1}\end{aligned}$$

This gives us the initial response of inflation to a fiscal shock. What determines the subsequent propagation? This can be obtained combining the Taylor rule with the Fisherian equation:

$$\phi\widehat{\pi}_t=\mathbb{E}_t\left[\widehat{\pi}_{t+1}\right]$$

where we have used the fact that $\widehat{r}_t=0$. We have:

$$\widehat{\pi}_{t+1}=\phi\widehat{\pi}_t+\eta_{t+1}^{\pi}.$$

Thus, the persistence of inflation is controlled by the Taylor rule coefficient ϕ. The central bank, by moving the nominal interest rate, sets expected inflation. If, in turn, the central bank moves the nominal interest rate in response to current inflation, the central bank creates a persistent movement in inflation. Notice that this movement in expected inflation does not have a role in determining the size of the initial jump in inflation. This is because expected inflation cannot be used to devalue short-term bonds that have not been issued yet. As we will see in the next subsection, this result changes once we introduce a maturity structure. However, even in that case the persistence of inflation will be controlled by ϕ.

With maturity structure

We can shift the time index for the linearized budget constraint (61) by one period:

$$\widehat{s}_{b,t+1}^{m}=\beta^{-1}\left(\widehat{s}_{b,t}^{m}+\widehat{r}_{n,t,t+1}^{m}-\widehat{\pi}_{t+1}-\Delta\widehat{y}_{t+1}\right)-\frac{\tau}{s_b}\widehat{\tau}_{t+1}$$

Taking expectations and solving forward for $\widehat{s}_{b,t}$:

$$\begin{aligned}\widehat{s}_{b,t}^{m} &= \beta\widehat{s}_{b,t+1}^{(m)}+\frac{\beta\tau}{s}\widehat{\tau}_{t+1}-\left(\widehat{r}_{n,t,t+1}^{m}-\widehat{\pi}_{t+1}\right)+\Delta\widehat{y}_{t+1}\\ \widehat{s}_{b,t}^{m} &= \mathbb{E}_t\left[\sum\nolimits_{j=0}^{\infty}\beta^j\left(\frac{\beta\tau}{s}\right)\widehat{\tau}_{t+1+j}\right]-\mathbb{E}_t\left[\sum\nolimits_{j=0}^{\infty}\beta^j\left(\widehat{r}_{n,t+j,t+1+j}^{m}-\widehat{\pi}_{t+1+j}\right)\right]+\mathbb{E}_t\left[\sum\nolimits_{j=0}^{\infty}\beta^j\Delta\widehat{y}_{t+1+j}\right]\end{aligned}$$

Following Cochrane (2022), we take the change in expectations between t and $t+1$:

$$0=\Delta\mathbb{E}_{t+1}\left[\sum\nolimits_{j=0}^{\infty}\beta^j\left(\frac{\beta\tau}{s}\right)\widehat{\tau}_{t+1+j}\right]-\Delta\mathbb{E}_{t+1}\left[\sum\nolimits_{j=0}^{\infty}\beta^j\left(\widehat{r}_{n,t+j,t+1+j}^{m}-\widehat{\pi}_{t+1+j}\right)\right]+\Delta\mathbb{E}_{t+1}\left[\sum\nolimits_{j=0}^{\infty}\beta^j\Delta\widehat{y}_{t+1+j}\right]$$

We can now use the fact that real interest rates and growth are exogenous and constant with respect to fiscal innovations:

$$0=\Delta\mathbb{E}_{t+1}\left[\sum\nolimits_{j=0}^{\infty}\beta^{j}\left(\frac{\beta\tau}{s}\right)\widehat{\tau}_{t+1+j}\right]-\Delta\mathbb{E}_{t+1}\left[\widehat{r}_{n,t,t+1}^{m}-\widehat{\pi}_{t+1}\right]$$

We then use the fact that:

$$\begin{aligned}\Delta\mathbb{E}_{t+1}\left[\widehat{r}_{n,t,t+1}^{m}\right] &= -\sum\nolimits_{j=1}^{\infty}\varpi^{j}\Delta\mathbb{E}_{t+1}\left[\widehat{r}_{n,t+j,t+1+j}^{m}\right]\\ &= -\sum\nolimits_{j=1}^{\infty}\varpi^{j}\Delta\mathbb{E}_{t+1}\left[\left(\widehat{r}_{n,t+j,t+1+j}^{m}-\widehat{\pi}_{t+1+j}\right)+\widehat{\pi}_{t+1+j}\right]\\ &= -\sum\nolimits_{j=1}^{\infty}\varpi^{j}\Delta\mathbb{E}_{t+1}\left[\widehat{\pi}_{t+1+j}\right]\end{aligned}$$

and obtain:

$$\sum\nolimits_{j=0}^{\infty}\varpi^{j}\Delta\mathbb{E}_{t+1}\left[\widehat{\pi}_{t+1+j}\right]=-\Delta\mathbb{E}_{t+1}\left[\sum\nolimits_{j=0}^{\infty}\beta^{j}\left(\frac{\beta\tau}{s_b}\right)\widehat{\tau}_{t+1+j}\right] \tag{63}$$

Thus, the initial inflation surprise $\eta_{t+1}^{\pi}\equiv\widehat{\pi}_{t+1}-\mathbb{E}_t\left(\widehat{\pi}_{t+1}\right)=\Delta\mathbb{E}_{t+1}\left[\widehat{\pi}_{t+1}\right]$ now depends on both the revision in expected inflation and the change in the PDV of future primary surpluses. Thus, to find the initial response of inflation we also need to know what happens to inflation going forward. This is because part of the adjustment is driven by a revaluation effect that depends on how persistent inflation is and how the central bank reacts to it. As before, the persistence of inflation can be obtained combining the Taylor rule with the Fisherian equation:

$$\phi\widehat{\pi}_t=\mathbb{E}_t\left[\widehat{\pi}_{t+1}\right]$$

where we have used the fact that $\widehat{r}_t=0$. We have:

$$\widehat{\pi}_{t+1}=\phi\widehat{\pi}_t+\eta_{t+1}^{\pi}.$$

If follows, that:

$$\begin{aligned}\Delta\mathbb{E}_{t+1}\left[\widehat{\pi}_{t+1}\right] &= \eta_{t+1}^{\pi}\\ \Delta\mathbb{E}_{t+1}\left[\widehat{\pi}_{t+1+j}\right] &= \phi^{j}\eta_{t+1}^{\pi}\end{aligned}$$

We can plug this in (63) to obtain the initial response of inflation:

$$\eta_{t+1}^{\pi}=-\left(1-\phi\varpi\right)\Delta\mathbb{E}_{t+1}\left[\sum\nolimits_{j=0}^{\infty}\beta^{j}\left(\frac{\beta\tau}{s_b}\right)\widehat{\tau}_{t+1+j}\right] \tag{64}$$

Given that primary surpluses follow and AR(1) process $\widehat{\tau}_{t+1}=\rho_\tau\widehat{\tau}_t+\varepsilon_{\tau,t+1}$, we get that the initial jump in inflation is:

$$\begin{aligned}\widehat{\pi}_{t+1}-\mathbb{E}_t\left(\widehat{\pi}_{t+1}\right) &= -\left(1-\phi\varpi\right)\Delta\mathbb{E}_{t+1}\left[\sum\nolimits_{j=0}^{\infty}\beta^{j}\left(\frac{\beta\tau}{s_b}\right)\widehat{\tau}_{t+1+j}\right]\\ &= -\left(1-\phi\varpi\right)\left[\sum\nolimits_{j=0}^{\infty}\left(\beta\rho_\tau\right)^{j}\left(\frac{\beta\tau}{s_b}\right)\varepsilon_{\tau,t+1}\right]\\ &= -\left(1-\phi\varpi\right)\left(1-\beta\rho_\tau\right)^{-1}\left(\frac{\beta\tau}{s_b}\right)\varepsilon_{\tau,t+1}\end{aligned}$$

As before, the persistence of inflation is controlled by the Taylor rule coefficient ϕ. The central bank, by moving the nominal interest rate, sets expected inflation. If, in turn, the central bank moves the nominal interest rate in response to current inflation, the central bank creates a persistent movement in inflation. However, now this movement in expected inflation reduces the initial jump in inflation. This is because with a persistent movement in inflation and a maturity structure, the increase in long term interest rates devalues the current outstanding long-term bonds. The initial response declines if ϕ increases or if ϖ increases. For a given maturity ($\varpi > 0$), a larger ϕ determines a larger increase in long-term interest rates for given inflation path, devaluing outstanding long-term bonds. For a given $\phi > 0$, a longer maturity (larger ϖ) implies a stronger response of nominal interest rates and a larger depreciation of long-term bonds. Note that if any of these two parameters is equal to zero, then the initial response collapses to what obtained with no maturity structure. If $\varpi > 0$ but $\phi = 0$, expected inflation and long-term interes rates do not increase, so expected inflation cannot devalue currently outstanding long-term bonds. If $\phi > 0$ but $\varpi = 0$, there are no outstanding long-term bonds to be devalued in the first place.

C.1.2 Details on the maturity structure

In what follows, we provide additional details about the derivation of the linearized government budget constraint and the way in which we model the maturity structure.

We can rewrite the government budget constraint using its market value $P_t^m B_t^m$:

$$P_t^m B_t^m = B_{t-1}^m \left(1 + \rho P_t^m\right) - T_t$$

$$\left(P_t^m B_t^m\right) / \left(P_t Y_t\right) = \left[\left(B_{t-1}^m P_{t-1}^{(m)}\right) / \left(P_{t-1} Y_{t-1}\right)\right] \left(\Gamma_t \Pi_t\right)^{-1} \left[\left(1 + \rho P_t^m\right) / P_{t-1}^m\right] - T_t / \left(P_t Y_t\right)$$

$$s_{b,t}^m = s_{b,t-1}^m \left(\Pi_t Y_t / Y_{t-1}\right)^{-1} R_{n,t-1,t}^m - \tau_t$$

where $s_{b,t}^m = \left(P_t^m B_t^m\right) / \left(P_t Y_t\right)$ is the market value of government debt with respect to GDP, $\tau_t = T_t / \left(P_t Y_t\right)$ is the primary surplus to GDP ratio, and $R_{n,t-1,t}^m \equiv \left(1 + \rho P_t^m\right) / P_{t-1}^m$ is the gross nominal return of the maturity bonds in non-zero net supply.

The definition of return for the bonds in non-zero net supply deserves some explanation. If P_t^m is the price of a bond issued today that pays ρ^j for all future j periods, it must be the case that the same bond issued k periods ago has price $P_t^{m-k} = \rho^k P_t^m$ given that all payments are smaller by the amount ρ^k. Now consider the return of an asset that has been issued k periods ago:

$$R_{n,t-1,t}^{m-k} = \frac{\rho^{k-1} + \rho^k P_t^{(m)}}{\rho^{k-1} P_{t-1}^m} = \frac{1 + \rho P_t^m}{P_{t-1}^m} = R_{n,t-1,t}^{(m)}$$

This modeling choice is convenient given that it does not require to keep track of the issuing date. Consider a bond that was issued last period. Today it pays $\rho^0 = 1$. Then, we can convert the quantity of bonds with seniority 1 in bonds with seniority 0: $B_{t-1}^{m-1} = \rho B_{t-1}^m$. Then, we can use the price of new bonds for these assets, such that the total resources available at time t are $\left(1 + \rho P_t^m\right) B_{t-1}^m$. This is the relation used in the household budget constraint. Note that these relations are implicit in the payment structure and *definition* of the asset, but these considerations might help in making them more transparent.

We can use a non-arbitrage condition derived from the Euler equation to link $R_{n,t,t+1}^m$ and $R_{n,t}$:

$$\begin{aligned} R_{n,t,t+1}^m &= \frac{1 + \rho P_{t+1}^m}{P_t^m} \\ R_{n,t} &= \mathbb{E}_t \left[R_{n,t,t+1}^m \right] \end{aligned}$$

In steady state:

$$R_n = \frac{1 + \rho P^m}{P^m} = R_n^{(m)}$$

Loglinearizing:

$$\begin{aligned} R_n \widehat{r}_{n,t,t+1}^m &= \rho \mathbb{E}_t \left[\widehat{p}_{t+1}^m \right] - \frac{1 + \rho P^m}{P^m} \widehat{p}_t^m \\ &= \rho \mathbb{E}_t \left[\widehat{p}_{t+1}^m \right] - R_n \widehat{p}_t^m \end{aligned}$$

Therefore we have two equations describing the relation between short and long term bonds:

$$\widehat{r}_{n,t,t+1}^m = R_n^{-1} \rho \widehat{p}_{t+1}^m - \widehat{p}_t^m$$

$$\widehat{r}_{n,t,t+1}^{(1)} \equiv \widehat{r}_{n,t} = \mathbb{E}_t \left[\widehat{r}_{n,t,t+1}^m \right]$$

where the second relation implies that if the bonds have maturity equal to 1 ($\rho = 0$) their expected return is known and equal to the short term interest rate controlled by the central bank.

If we define $\varpi \equiv \rho / R_n < 1$, we obtain the type of maturity structure used in Cochrane (2022):

$$\widehat{r}_{n,t,t+1}^m = \varpi \widehat{p}_{t+1}^m - \widehat{p}_t^m \tag{65}$$

$$\widehat{r}_{n,t} = \mathbb{E}_t \left[\widehat{r}_{n,t,t+1}^{(m)} \right]$$

D 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:

$$\hat{y}_t = \frac{y+\Omega}{y}\left[\alpha\hat{k}_t + (1-\alpha)\hat{L}_t\right]. \tag{66}$$

Capital-labor ratio:

$$\hat{r}_{K,t} - \hat{w}_t = \hat{L}_t - \hat{k}_t. \tag{67}$$

Marginal cost:

$$\widehat{mc_t} = \alpha\hat{r}_{K,t} + (1-\alpha)\hat{w}_t. \tag{68}$$

Phillips curve:

$$\hat{\pi}_t = \frac{\beta}{1+\chi_p\beta}\mathbb{E}_t\hat{\pi}_{t+1} + \frac{\chi_p}{1+\chi_p\beta}\hat{\pi}_{t-1} + \kappa_p\widehat{mc_t} + \kappa_p\hat{\eta}_t^p + \kappa_p\hat{u}_t^{NKPC}, \tag{69}$$

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:

$$\hat{\lambda}_t^S = \hat{u}_t^b - \frac{\theta}{e^{\varkappa}-\theta}\hat{u}_t^a - \frac{e^{\varkappa}}{e^{\varkappa}-\theta}c_t^{*S} + \frac{\theta}{e^{\varkappa}-\theta}c_{t-1}^{*S} - \frac{\tau^C}{1+\tau^C}\hat{\tau}_{C,t}, \tag{70}$$

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

Public/private consumption in utility:

$$\hat{c}_t^* = \frac{c^S}{c^S+\alpha_G g}\hat{c}_t^S + \frac{\alpha_G g}{c^S+\alpha_G g}\hat{g}_t. \tag{71}$$

Euler equation:

$$\hat{\lambda}_t^S = \hat{r}_{n,t} + \mathbb{E}_t\hat{\lambda}_{t+1}^S - \mathbb{E}_t\hat{\pi}_{t+1} - \mathbb{E}_t\hat{u}_{t+1}^a + \hat{u}_t^{rp}. \tag{72}$$

Maturity structure of debt:

$$\hat{r}_{n,t} + \hat{P}_t^m = \frac{\rho}{R}\mathbb{E}_t\hat{P}_{t+1}^m - \hat{u}_t^{rp}. \tag{73}$$

Saver household's FOC for capacity utilization:

$$\hat{r}_{K,t} - \frac{\tau_K}{1-\tau_K}\hat{\tau}_{K,t} = \frac{\psi}{1-\psi}\hat{\nu}_t. \tag{74}$$

Saver household's FOC for capital:

$$\hat{q}_t = \mathbb{E}_t\hat{\pi}_{t+1} - \hat{r}_{n,t} + \beta e^{-\varkappa}(1-\tau_K)r_K\mathbb{E}_t\hat{r}_{K,t+1} - \beta e^{-\varkappa}\tau_K r_K\mathbb{E}_t\hat{\tau}_{K,t+1} + \beta e^{-\varkappa}(1-\delta)\mathbb{E}_t\hat{q}_{t+1} - \hat{u}_t^{rp}. \tag{75}$$

Saver household's FOC for investment:

$$\hat{\imath}_t + \frac{1}{1+\beta}\hat{u}_t^a - \frac{1}{(1+\beta)se^{2\varkappa}}\hat{q}_t - \hat{u}_t^i - \frac{\beta}{1+\beta}\mathbb{E}_t\hat{\imath}_{t+1} - \frac{\beta}{1+\beta}\mathbb{E}_t\hat{u}_{t+1}^a = \frac{1}{1+\beta}\hat{\imath}_{t-1}. \tag{76}$$

Effective capital:

$$\hat{k}_t = \hat{\nu}_t + \widehat{\bar{k}}_{t-1} - \hat{u}_t^a. \tag{77}$$

Law of motion for capital:

$$\hat{\hat{k}}_t = (1-\delta)\, e^{-\varkappa} \left(\hat{\hat{k}}_{t-1} - \hat{u}_t^a\right) + \left[1 - (1-\delta)\, e^{-\varkappa}\right] \left[(1+\beta)\, s e^{2\varkappa} + \hat{\imath}_t\right]. \tag{78}$$

Hand-to-mouth household's budget constraint:

$$\tau_C c^N \hat{\tau}_{C,t} + (1+\tau_C)\, c^N \hat{c}_t^N = (1-\tau_L)\, wL \left(\hat{w}_t + \hat{L}_t\right) - \tau_L wL \hat{\tau}_{L,t} + z\hat{z}_t. \tag{79}$$

Wage equation:

$$\begin{aligned} \hat{w}_t \;=\; & \frac{1}{1+\beta}\hat{w}_{t-1} + \frac{\beta}{1+\beta}\mathbb{E}_t \hat{w}_{t+1} - \kappa_w \left[\hat{w}_t - \xi \hat{L}_t + \hat{\lambda}_t^S - \frac{\tau_L}{1-\tau_L}\hat{\tau}_{L,t}\right] + \frac{\chi_w}{1+\beta}\hat{\pi}_{t-1} \\ & - \frac{1+\beta\chi_w}{1+\beta}\hat{\pi}_t + \frac{\beta}{1+\beta}\mathbb{E}_t\hat{\pi}_{t+1} + \frac{\chi}{1+\beta}\hat{u}_{t-1}^a - \frac{1+\beta\chi_w - \rho_a\beta}{1+\beta}\hat{u}_t^a + \kappa_w \hat{\eta}_t^w, \end{aligned} \tag{80}$$

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

$$c\hat{c}_t = c^S (1-\mu)\, \hat{c}_t^S + c^N \mu \hat{c}_t^N. \tag{81}$$

Aggregate resource constraint:

$$y\hat{y}_t = c\hat{c}_t + i\hat{\imath}_t + g\hat{g}_t + \psi'(1)\, k\hat{\nu}_t. \tag{82}$$

Government budget constraint:

$$\begin{aligned} & \frac{b}{y}\hat{b}_t + \tau_K r_K \frac{k}{y}\left[\hat{\tau}_{K,t} + \hat{r}_{K,t} + \hat{k}_t\right] + \tau_L w \frac{L}{y}\left[\hat{\tau}_{L,t} + \hat{w}_t + \hat{L}_t\right] + \tau_C \frac{c}{y}\left(\hat{\tau}_{C,t} + \hat{c}_t\right) \\ = \; & \frac{1}{\beta}\frac{b}{y}\left[\hat{b}_{t-1} - \hat{\pi}_t - \hat{P}_{t-1}^m - \hat{u}_t^a\right] + \frac{b}{y}\frac{\rho}{e^{\varkappa}}\hat{P}_t^m + \frac{g}{y}\hat{g}_t + \frac{z}{y}\hat{z}_t. \end{aligned} \tag{83}$$

Fiscal Rules:

$$\hat{g}_t = \rho_G \hat{g}_{t-1} - (1-\rho_G)\, \gamma_G(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F) + \zeta_{g,t}, \tag{84}$$

$$\hat{z}_t^b = \rho_Z \hat{z}_{t-1}^b - (1-\rho_Z)\left[\, \gamma_Z(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F) + \phi_{zy}\hat{y}_t\right] + \zeta_{z,t}, \tag{85}$$

$$\hat{z}_t = \hat{z}_t^b + \zeta_t^M + \zeta_t^F, \tag{86}$$

$$\hat{\tau}_{L,t} = \rho_L \hat{\tau}_{L,t-1} + (1-\rho_L)\, \gamma_L(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F), \tag{87}$$

$$\hat{\tau}_{K,t} = \rho_K \hat{\tau}_{K,t-1} + (1-\rho_K)\, \gamma_K(\hat{s}_{b,t-1} - \hat{s}_{b,t-1}^F). \tag{88}$$

Monetary Rule:

$$\hat{r}_{n,t} = \max\left(-\ln \underline{R}, \rho_r \hat{r}_{n,t-1} + (1-\rho_r)\left[\phi_\pi(\hat{\pi}_t - \hat{\pi}_t^F) + \phi_y \hat{y}_t\right] + u_t^m\right). \tag{89}$$

The variables with the superscript F in equations (84) to (89) above belong to the shadow economy. In turn, the block of equations that characterize the shadow economy consists in an additional set of equations (66) to (83), 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

$$\hat{r}^F_{n,t} = \max\left(-\ln \underline{R}, \rho_r \hat{r}^F_{n,t-1} + (1-\rho_r)\left[\phi_\pi \hat{\pi}^F_t + \phi_y \hat{y}^F_t\right] + u^m_t\right) \tag{90}$$

and the rules for the fiscal authority,

$$\hat{g}^F_t = \rho_G \hat{g}^F_{t-1} - (1-\rho_G)\gamma_G \hat{s}^F_{b,t-1} + \zeta_{g,t}, \tag{91}$$

$$\hat{z}^{b,F}_t = \phi_{zy}\hat{y}^F_t + \rho_Z \hat{z}^{b,F}_{t-1} - (1-\rho_Z)\gamma_Z \hat{s}^F_{b,t-1} + \zeta_{z,t}, \tag{92}$$

$$\hat{z}_t = \hat{z}^{b,F}_t + \zeta^F_t, \tag{93}$$

$$\hat{\tau}^F_{L,t} = \rho_L \hat{\tau}^F_{L,t-1} + (1-\rho_L)\gamma_L \hat{s}^F_{b,t-1}, \tag{94}$$

$$\hat{\tau}^F_{K,t} = \rho_K \hat{\tau}^F_{K,t-1} + (1-\rho_K)\gamma_K \hat{s}^F_{b,t-1}. \tag{95}$$

E The Dataset

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).

F Second Sample Estimates

Table 4 shows the prior and the posterior moments for the parameters estimated in the second sample. In the second sample estimation, we add the time series of the 5-year Breakeven inflation, which is observed up to a Gaussian mean-zero measurement error whose standard deviation is denoted by σ^m_{bei}. The prior for the parameters that are estimated in the first sample is centered at their posterior mode in the first sample. We report only the posterior mode of the parameters estimated in the second sample. The prior and posterior moments of the parameters of the factor model governing the contemporaneous correlation of forward guidance shocks follows closely Campbell et al. (2017) and is not shown here.

Priors and Posteriors for the Structural Parameters

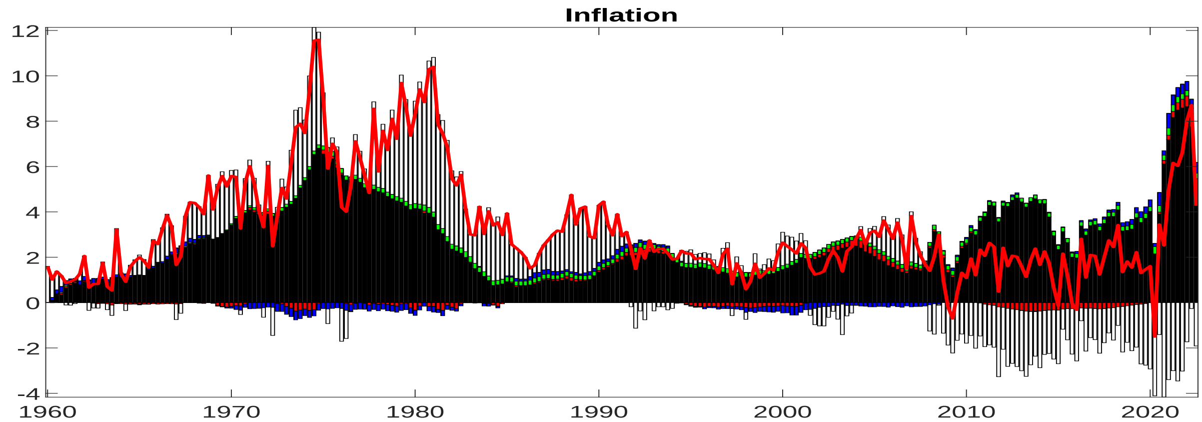
		Posterior Distribution	Prior Distribution		
Param	Description	Mode	Type	Mean	Std
σ_G	St.dev. gov. cons.	4.5701	IG	2.0042	0.500
σ_Z^M	St.dev. funded transfers	4.9934	IG	2.9525	0.500
σ_Z^F	St.dev. unfunded transfers	1.3908	IG	0.5960	0.500
σ_z	St.dev. short-term transfers	4.9934	IG	0.3897	0.500
σ_a	St.dev. technology	3.6794	IG	1.2159	0.500
σ_b	St.dev. preference	4.9979	IG	4.9930	0.500
σ_m	St.dev. mon. policy	0.1125	IG	0.2420	0.500
σ_i	St.dev. investment	2.6127	IG	0.4976	0.500
σ_w	St.dev. wage markup	0.6598	IG	0.3453	0.500
σ_p	St.dev. price markup	0.1387	IG	0.1694	0.500
σ_{rp}	St.dev. risk premium	3.1232	IG	0.3824	0.500
$\sigma_{\pi^{NKPC}}$	St.dev. infl. drift	4.9862	IG	1.3257	0.500
σ^m_{GDP}	Measur. error GDP	1.6964	IG	0.4338	0.200
σ^m_{by}	Measur. error Debt/GDP	4.9908	IG	0.3245	0.200
σ^m_{bei}	Measur. error 5y infl. expectations	0.2014	IG	0.5000	0.200

Table 4: Posterior modes, medians, 90% posterior credible sets, and prior moments for the structural parameters estimated in the second sample (2008:Q1-2022:Q3). 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.

G Historical Decomposition

Figure 12 shows the historical decomposition of inflation (upper panel) and GDP growth (lower panel). This decomposition is more detailed than the one shown in Figure 7 in the main text. In the figure in the appendix, we show the contribution of the monetary policy shocks, that of the unfunded transfers shocks, and that of the other fiscal shocks (the g shocks and the (funded) transitory shocks to transfers). The contributions of all these shocks are wrapped in the gray bar of the figure shown in the main text.

Figure 12 shows that funded shocks have sometimes visible effects, while monetary policy shocks have typically very small effects. However, as in the previous draft, the impact of funded shocks on inflation is much smaller than the impact of unfunded shocks. This result is consistent with the impulse responses of Figure 4 in the paper that show that funded and unfunded shocks have very different effects, both qualitatively and quantitatively. This is despite the fact that we allow for hand-to-mouth agents. Unfunded shocks generate large effects because the central bank accommodates the increase in inflation necessary to stabilize the increase in spending. With respect to the small estimated effect of funded shocks, we believe that our results are consistent with recent studies based on micro data. For example, Parker et al. (2022) shows that the direct impact of the post-pandemic fiscal stimulus is in fact quite small. With respect to the role of monetary policy shocks, it is quite common that monetary policy shocks explain a relatively small portion of macroeconomic volatility (both in VAR and in DSGE). See, for example, Smets and Wouters (2007b). In our model, monetary policy shocks are even less important because the model interprets some deviations from active inflation stabilization as accommodation of fiscal inflation, as opposed to a monetary policy shock. This of course does not mean that monetary policy is irrelevant, but only that the deviations from the rules explain a small amount of macro volatility. In fact, in our paper monetary policy plays an important role to the extent that it accommodates movements in fiscal inflation, determining persistent movements in inflation.



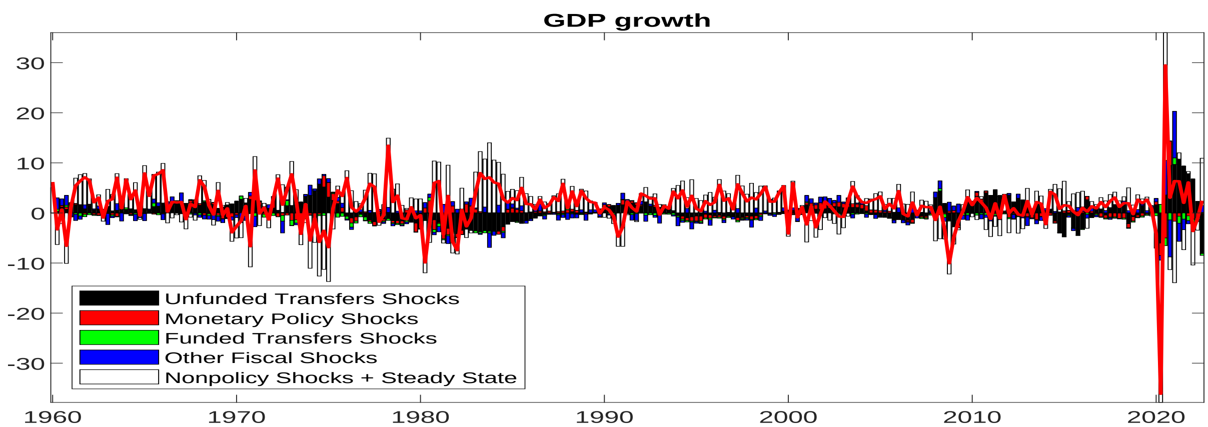


Figure 12: **Drivers of Inflation and GDP growth: Additional details**. The red solid lines correspond to annualized quarterly inflation (top panel) and annualized GDP growth (lower panel). The bars represent the cumulative contributions of unfunded transfers shocks (black bars), monetary policy shocks (red bars), unfunded transfers shocks (green bars), the other fiscal shocks (the g shocks, $\zeta_{g,t}$, and, the transitory funded shocks to transfers, $\zeta_{z,t}$) (blue bars), and nonpolicy shocks (white bars) on the two variables. The white bars also include the steady state and the initial conditions for the two variables and, for GDP growth, the measurement error. 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 and setting the model parameters at their posterior mode.

H ARPA Stimulus Decomposition: Funded vs. Unfunded Transfers

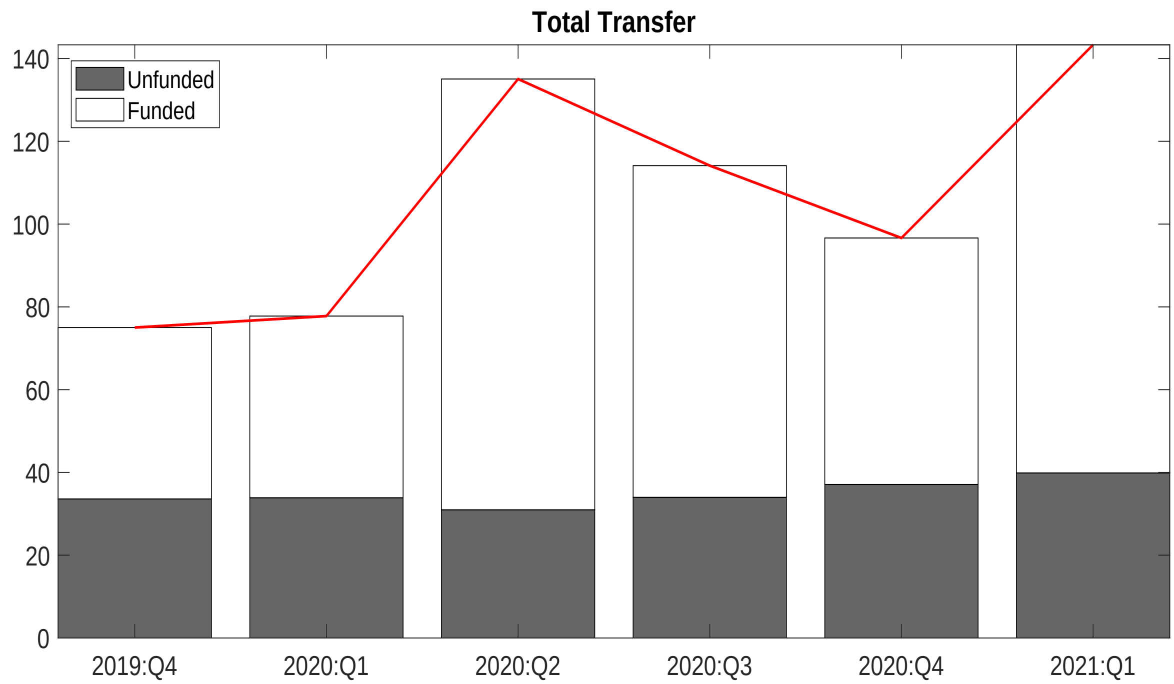


Figure 13: Estimated Decomposition of U.S. Government Transfers (red solid line) into their funded and unfunded components. These components isolate the cumulative effects of the historical realizations of funded or unfunded shocks on transfers in percentage points. These realizations are estimated using the smoother Kalman filter. Parameters are set at their posterior mode.

I Estimation of the Small-Scale Model

We estimate a version of the simple New Keynesian model presented in Section (3) and augmented to include shocks to the growth rate of TFP, preferences, markups, taxes, government spending, funded and unfunded shock to long-term transfers, a shock to short term transfers a monetary shock. We include the following observable variables in estimation: real GDP growth, inflation as measured by the GDP deflator, the Federal Funds rate, the debt-to-GDP ratio, government purchases, and the growth rate of taxes and transfers. All fiscal variables are expressed as a fraction of GDP. For the construction of these series and their sources we refer to Section (E). We follow the same two-sample approach to estimation explained in Section (4.1). Specifically, over the post-2008 period we add the data for the path of the Federal funds rates and a full array of forward guidance shocks.

The model is a stripped down version of the model in Bianchi and Melosi (2022), under the restrictions that there are no different regimes, no habits, and no long term bonds. We refer to that paper for further details. This model consists of a standard three-equation New Keynesian block and a fiscal block that allows for unfunded fiscal transfers shocks. The system of linearized equations is reported below, using the same notation of the medium-scale model in Section (D).

IS:

$$\hat{y}_t = -\left[\hat{r}_t - E_t\hat{\pi}_{t+1} - (1-\rho_b)\,\hat{u}_t^b\right] + \rho_a a_t + E_t\hat{y}_{t+1} + (1-\rho_g)\tilde{g}_t, \tag{96}$$

where $\ln(A_t/A_{t-1}) = \varkappa + a_t$, $a_t = \rho_a a_{t-1} + \varepsilon_{a,t}$.

Phillips curve:

$$\hat{\pi}_t = \kappa\left[\left(1+\frac{\alpha}{1-\alpha}\right)\hat{y}_t - \tilde{g}_t\right] + \beta E_t\hat{\pi}_{t+1} + \tilde{\eta}_t^p, \tag{97}$$

where we have used the rescaled markup $\tilde{\eta}_t^p = \kappa\left(\frac{v}{1-v}\right)\tilde{v}_t$ and v denotes the elasticity of substitution.

Taylor rule:

$$\hat{r}_{n,t} = \max\left\{-\ln \underline{R}, \rho_r\hat{r}_{n,t-1} + (1-\rho_r)\left[\phi_\pi(\hat{\pi}_t - \hat{\pi}_t^F) + \phi_y(\hat{y}_t - \hat{y}_t^*)\right] + u_t^m\right\}, \tag{98}$$

where the output target $\hat{y}_t^*$ is given by

$$\frac{\alpha}{1-\alpha}\hat{y}_t^* = \tilde{g}_t$$

Government budget constraint

$$\tilde{s}_{b,t} = \beta^{-1}\tilde{s}_{b,t-1} + s_b\beta^{-1}\left(\hat{r}_{n,t} - \hat{y}_t + \hat{y}_{t-1} - \hat{u}_t^a - \hat{\pi}_t\right) - \tilde{\tau}_t + \tilde{z}_t + g^{-1}\tilde{g}_t, \tag{99}$$

Government spending:

$$\tilde{g}_t = \rho_g\tilde{g}_{t-1} + \zeta_t^g \tag{100}$$

Tax rule:

$$\tilde{\tau}_t = \rho_\tau\tilde{\tau}_{t-1} + (1-\rho_\tau)\left[\gamma_\tau\tilde{s}_{b,t-1}^M + \gamma_{e^*}\left(\tilde{z}_t^* + g^{-1}\tilde{g}_t\right) + \gamma_{\tau,y}\left(\hat{y}_t - \hat{y}_t^*\right)\right] + \zeta_t^\tau \tag{101}$$

Transfers:

$$\tilde{z}_t - \tilde{z}_t^* = \rho_z\left(\tilde{z}_{t-1} - \tilde{z}_t^*\right) + (1-\rho_z)\,\gamma_{z,y}\left(\hat{y}_t - \hat{y}_t^*\right) + \zeta_{z,t}^M \tag{102}$$

Long-term component of transfers

$$\tilde{z}_t^* = \rho_z^*\tilde{z}_{t-1}^* + \zeta_{z,t}^{*M} + \zeta_{z,t}^{*F}. \tag{103}$$

The variables with superscripts M in equations (98) and (101) to (103) above belong to the shadow economy. In turn, the block of equations characterizing the shadow economy consists in an additional set of equations (96) to (102), where any variable that refers to the actual economy x_t is replaced by the same variable in the shadow economy x_t^M, plus the rule for the long component of transfers:

$$\tilde{z}_t^{*M} = \rho_z^*\tilde{z}_{t-1}^{*M} + \zeta_{z,t}^{*M}. \tag{104}$$

Prior and posterior distributions related to the estimation of this small-scale NK model are reported in Tables 5 and 6.

The main output of the estimation is reported in Figure 14, which shows the dynamics of inflation (black dashed line) together with the rate of inflation predicted by fiscally unfunded

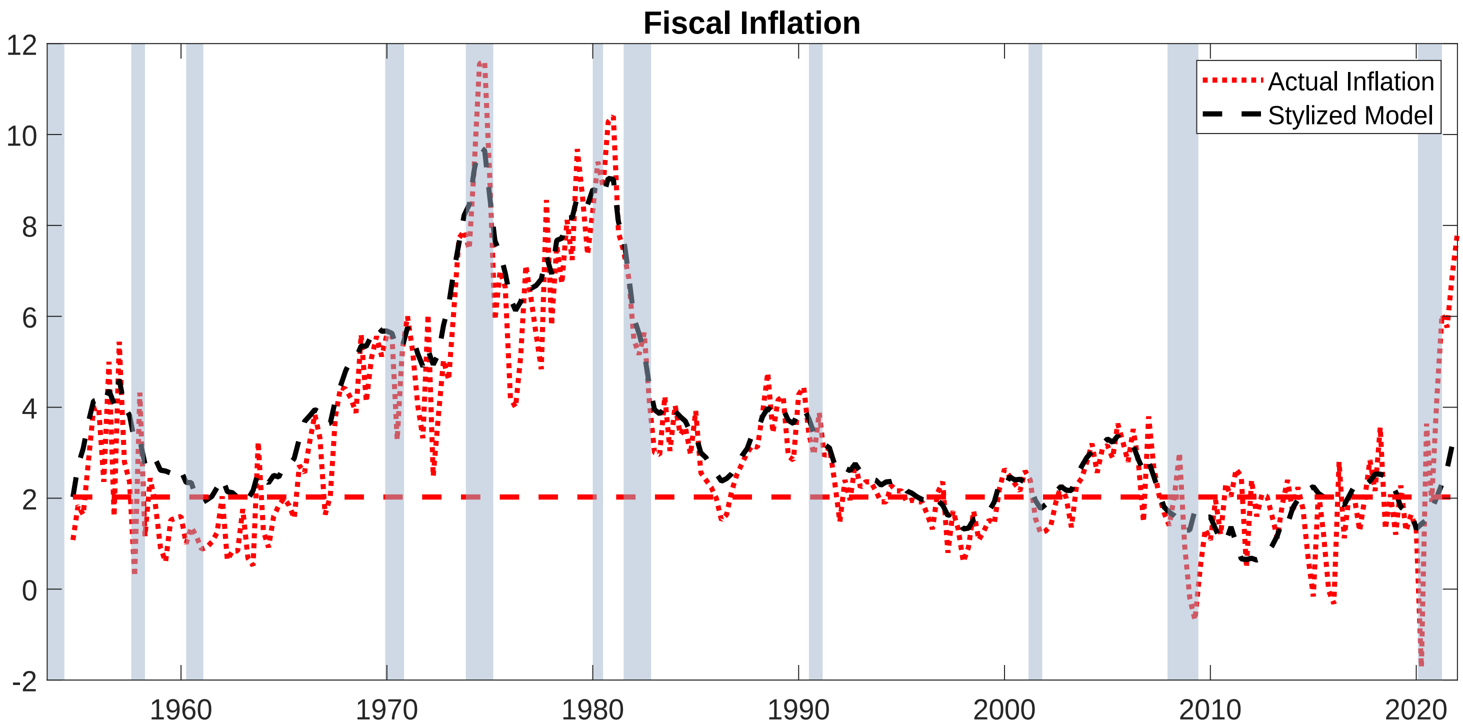


Figure 14: The black dashed line is the inflation rate in the data. The blue solid line is the predicted rate of inflation conditional on unfunded fiscal transfers shocks.

transfers shocks (solid blue line). The result illustrate that the unfunded shocks explain persistent inflation remarkably well. Hence, we conclude that the result that unfunded fiscal shocks explain persistent inflation is not due to the many auxiliary assumption that characterize the medium-scale model of Section (3).

Priors and Posteriors for the Structural Parameters					
		Posterior Distribution	Prior Distribution		
Param	Description	Mode	Type	Mean	Std
κ	Slope Phillips Curve	0.0113	G	0.300	0.15
100π	Steady state inflation	0.5066	N	0.500	0.05
$100\varkappa$	Steady state growth	0.4221	N	0.400	0.05
s_b	Steady state debt/GDP	2.1386	N	2.400	0.05
g	Steady state gov. spending	1.0922	N	1.080	0.05
τ	Steady state tax rate	0.1616	N	0.175	0.05
$\gamma_{z,y}$	Elasticity of transf. to output	−0.0197	N	−0.400	0.20
ϕ_y	Interest response to y	1.4128	N	0.400	0.20
ϕ_π	Interest response to π	1.8924	N	2.500	0.30
ρ_r	AR1 coeff Taylor rule	0.7963	B	0.500	0.20
γ_{e^*}	Spending elasticity of taxes	0.0043	B	0.500	0.20
$\gamma_{\tau,y}$	Debt elasticity of taxes	0.0163	G	0.070	0.02
ρ_Z	AR1 coeff short term transfers	0.5007	B	0.200	0.05
ρ_τ	AR1 coeff taxes	0.4977	B	0.500	0.20

Table 5: Posterior modes 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.

Priors and Posteriors for the Exogenous Processes					
		Posterior Distribution	Prior Distribution		
Param	Description	Mode	Type	Mean	Std
ρ_g	AR coeff. gov. cons	0.9787	B	0.500	0.100
ρ_Z^*	AR coeff. long transfers	0.9951	B	0.995	0.001
ρ_a	AR coeff. technology	0.5765	B	0.500	0.100
ρ_b	AR coeff. preference	0.8735	B	0.500	0.100
ρ_μ	AR coeff. markup	0.2082	B	0.500	0.200
σ_m	AR coeff. mon. policy	0.2052	IG	0.500	0.200
σ_g	St dev gov cons.	0.0064	IG	0.500	0.200
σ_a	St dev technology	0.4247	IG	0.100	0.050
σ_τ	St dev tax	0.0072	IG	0.500	0.200
σ_b	St dev preference	2.3997	IG	0.250	0.200
σ_z	St dev short transfers	0.0071	IG	0.500	0.200
σ_μ	St dev markup	0.1662	IG	0.500	0.200
σ_z^{*M}	St dev long funded trans.	0.0163	IG	0.500	0.200
σ_z^{*F}	St dev long unfunded trans.	0.0158	IG	0.100	0.050

Table 6: Posterior modes and prior moments for the exogenous processes. 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.

J Robustness checks

In this Appendix, we conduct a series of additional exercises. We first discuss how persistent fiscal inflation differs from an exogenous time-varying inflation target. We then provide external validation for our results based on a VAR.

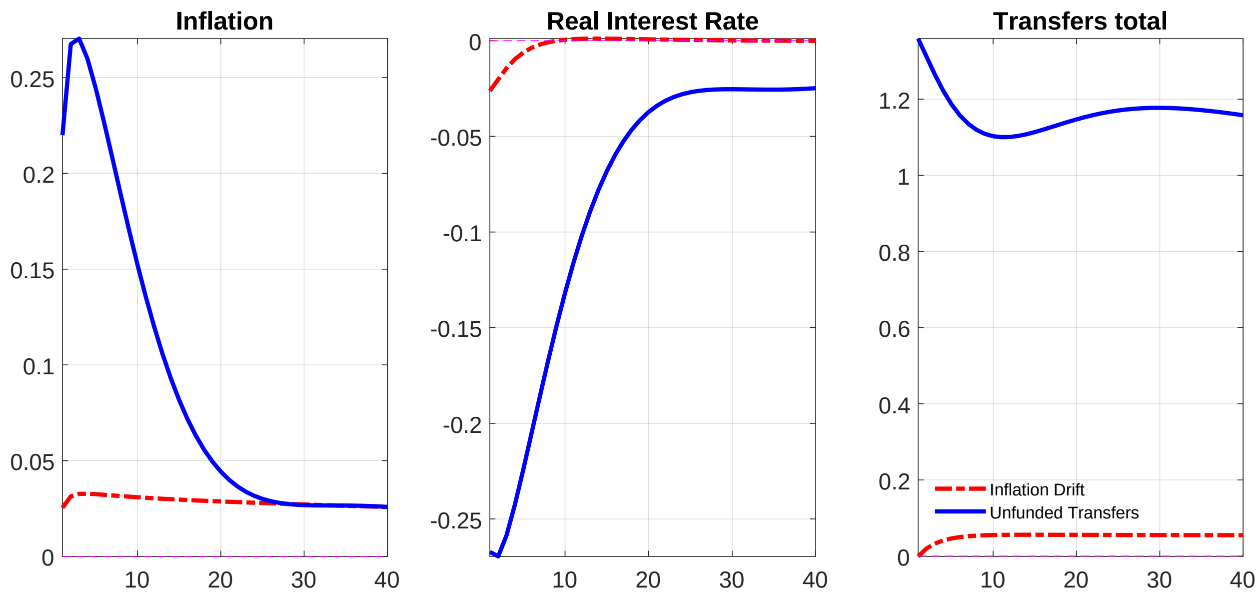


Figure 15: **Propagation of unfunded fiscal shocks vs. exogenous inflation target in the estimated model**. The impulse responses of a shock to the exogenous inflation target are obtained by calibrating the standard deviation to match the long-term impulse response of inflation to an estimated shock to unfunded transfers.

J.1 Time-varying exogenous target

In Section 2, we discussed that unfunded fiscal shocks generate low frequency movements in inflation that are accommodated by the central bank. When the response to these movements in inflation is restricted to zero, like in our baseline analysis, the central bank's Taylor rule can be rewritten in a way that is isomorphic to having a time-varying inflation target. However, while the Taylor rule appears as such, the movements in inflation have a fiscal origin and need to obey specific cross equation restrictions, leading to our fiscal theory of persistent inflation. In this subsection, we further elaborate on this point by showing that our estimated measure of fiscal inflation is *not* observationally equivalent to having an exogenous time-varying inflation target. This is because fiscal inflation and an exogenous inflation target generate different commovement of the variables of interest.

To illustrate this point, we compare the impulse responses to an unfunded fiscal shock to the impulse responses to a shock to the exogenous inflation target. In this second scenario, we modify our baseline model to have an exogenous target that evolves according to an AR(1) process. Specifically, ignoring the effective lower bound constraint, the the Taylor rule becomes:

$$\hat{r}_{n,t} = \rho_r \hat{r}_{n,t-1} + (1-\rho_r)\left[\phi_\pi\left(\hat{\pi}_t - \hat{\pi}_t^{ET}\right) + \phi_y \hat{y}_t\right] + u_t^m, \tag{105}$$

where the exogenous target follows the process:

$$\hat{\pi}_t^{ET} = \rho_{ET}\hat{\pi}_{t-1}^{ET} + \varepsilon_t^{ET}. \tag{106}$$

Figure 15 presents the results. We choose the size of the initial shock to the target to match the long-term response of inflation (10 years).

A clear trade-off arises when trying to replicate the dynamics of fiscal inflation with an exogenous inflation target shock. If the properties of the exogenous target shock are chosen to match the long-term response of inflation, then the real interest rate and transfers barely move and inflation does not feature the large increase at the time of the shock. This point is particularly important because it is what allows our model to account for the observed dynamics of inflation following the pandemic. Fiscal inflation can at the same time generate large and persistent movements in inflation, while the time-varying exogenous target necessarily fails in one of the two dimensions because it does not obey the cross-equation restrictions that identify the unfunded fiscal shocks.

Finally, it is important to underscore that the direction of causality is different. In the case of persistent fiscal inflation, the fiscal shock triggers inflationary pressure that the central bank accommodates. In the case of a shock to the exogenous inflation target, the central bank cuts rates to achieve a higher target. To make sense of the post-pandemic inflation, with interest rates already stuck at the zero lower bound, the first mechanism appears much more plausible. The ability of the model to account for the post-pandemic rise of inflation out of sample is an important validation for the mechanism proposed in this paper.

J.2 Model-free evidence of fiscal inflation

In this section, we estimate a VAR using the same variables used to estimate the empirical DSGE model (Section 4.1) plus the Michigan Survey 1-year-ahead inflation expectations over the sample period (1960:Q1 to 2007:Q4).[13] The objective of this section is to provide some "model-free" evidence to support the general mechanism studied in this paper.

Unfunded fiscal shocks are identified by imposing minimal parametric restrictions concerning the responses of the monetary and fiscal authorities to inflation and the debt-to-GDP ratio. Specifically, we assume that an unfunded fiscal shock raises real transfers growth for two years while the monetary authority refrains from responding by raising the FFR over the same period. The debt-to-GDP ratio is expected to fall for five years after the shock.[14] It should be noted that all business cycle shocks can also affect real government transfers.

[13]We do not estimate the model in the subsequent period to avoid issues with the federal funds rate being mired at zero for several years. Since the trend component of inflation is very volatile in the first sample period, our exercise is pertinent. We cannot use breakeven inflation expectations as we did in the second-sample estimation of the empirical model in Section 4 because this series is not available prior to the 2000s. Following Sims and Zha (1998), we adopt a unit root prior for the parameters of the VAR with a pre-sample of four quarters. The prior hyperparameters are chosen so as to maximize the marginal likelihood.

[14]In Appendix J.3, we show that results are virtually unchanged if we do not impose any restrictions on the response of the debt-to-GDP ratio over the first two years following the shock.

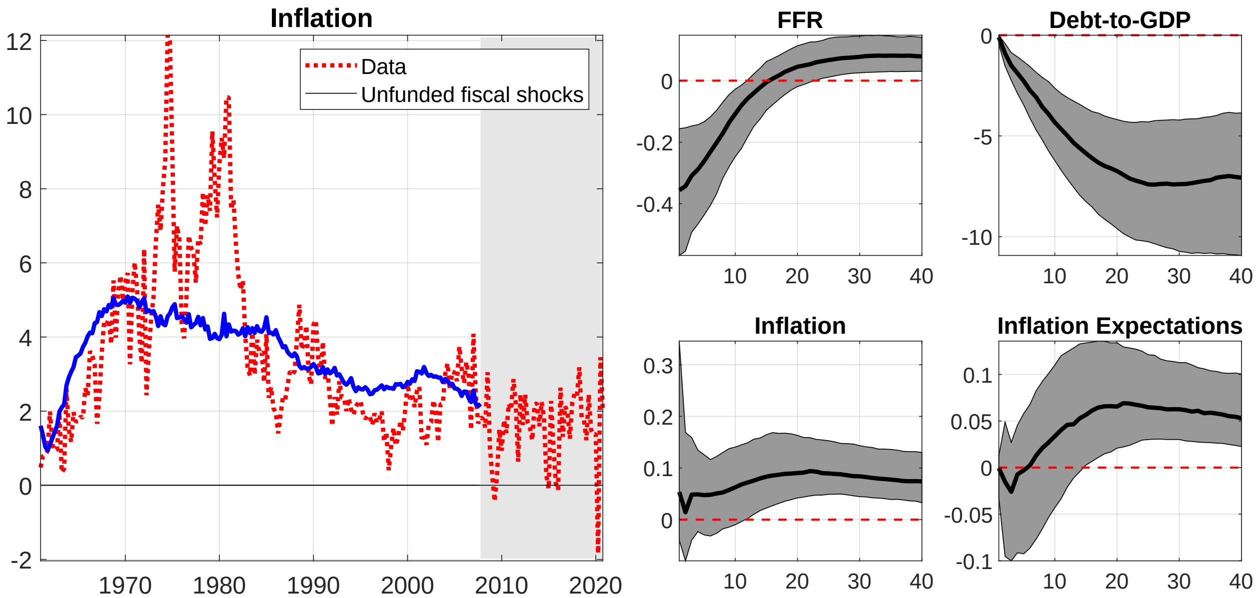


Figure 16: Propagation of unfunded fiscal shocks in a model-free setting. Unfunded fiscal shocks are identified by imposing that these shocks raise real transfers growth for two years while the monetary authority refrains from increasing the federal funds rate (FFR) in that period. The debt-to-GDP ratio is expected to fall for five years after the shock. The first figure on the left compares inflation in the data (red dotted line) with inflation explained by the identified unfunded fiscal shocks in the first sample 1960:Q1-2007:Q4 (the blue solid line). The figures on the right show the response of the FFR, debt-to-GDP ratio, inflation, and the Michigan Survey's one-year inflation expectations to the identified unfunded fiscal shock. The black lines denote the posterior median of these responses and the gray bands their 60 percent posterior interval. The x-axes report quarters following the shock. Inflation and inflation expectations, and the FFR are expressed in percentage points of annualized rates.

For instance, a recessionary shock is likely to raise transfers. However, such shock would also increase the debt-to-GDP ratio, which would violate one of our identifying restrictions. An exogenous change to the central bank's inflation target would lower the debt-to-GDP ratio and the FFR. However, as shown in Figure 15, this shock to the central bank's target would also lower transfers, which is at odd with our identifying restrictions. Finally, an expansionary shock to funded transfers would increase the debt-to-GDP ratio and, most likely, the federal funds rate. Both responses are ruled out by our identifying assumptions.[15]

The VAR is not subject to the theoretical cross-equation restrictions characterizing the micro-founded models considered so far. Thus, this exercise provides further corroborating evidence that our main findings are not driven by auxiliary assumptions embedded in the baseline model. The plot on the left of Figure 16 compares inflation in the data (red dotted line) with inflation explained by the unfunded fiscal shocks identified in the VAR model (blue

[15]One might be concerned about the consistency of the VAR with the estimated structural model since we do not explicitly model the shadow economy in the VAR model. However, the shadow economy is just an accounting exercise that is justified by the assumptions that (i) agents are rational and have full information and (ii) the monetary and fiscal authority always coordinate their policies consistently with fiscal inflation $\hat{\pi}_t^F$. We do not make these assumptions in the VAR model since we want to be agnostic as to whether agents are perfectly informed and how policymakers coordinate monetary and fiscal policies.

solid line). Consistently with the predictions of our estimated structural model shown in Subsection 5.3, the identified unfunded transfers shocks play an important role in explaining the run-up and the subsequent slow down in inflation in the first three decades of the sample. Since we use only minimal restrictions to identify the unfunded fiscal shocks, one should not expect that the historical contribution of this shock to inflation mimics exactly that of the unfunded fiscal shocks in the structural model. For instance, shocks to unfunded transfers may not increase total government transfers. This is the case when a larger funded transfers shock lowers total transfers. To the extent that funded and unfunded transfers shocks are orthogonal, this is not an issue for our sign-restriction identification strategy. However, in a short sample, the estimated shocks may violate the orthogonality condition and, when this is the case, our identification procedure may discard some genuine shocks to unfunded transfers. That said, it is reassuring that unfunded shocks identified with minimal theoretical restrictions play an important role in explaining persistent inflation analogously to the unfunded transfers shocks estimated in our microfounded model.

The four panels on the right side of the figure show the response of the FFR, debt-to-GDP ratio, inflation, and the Michigan Survey's one-year inflation expectations to the identified unfunded fiscal shock. Inflation and inflation expectations are unrestricted variables and their response is not significantly different from zero at first. Nevertheless, they then become positive and significant, and remain heightened for many years – consistently with our fiscal theory of persistent inflation.

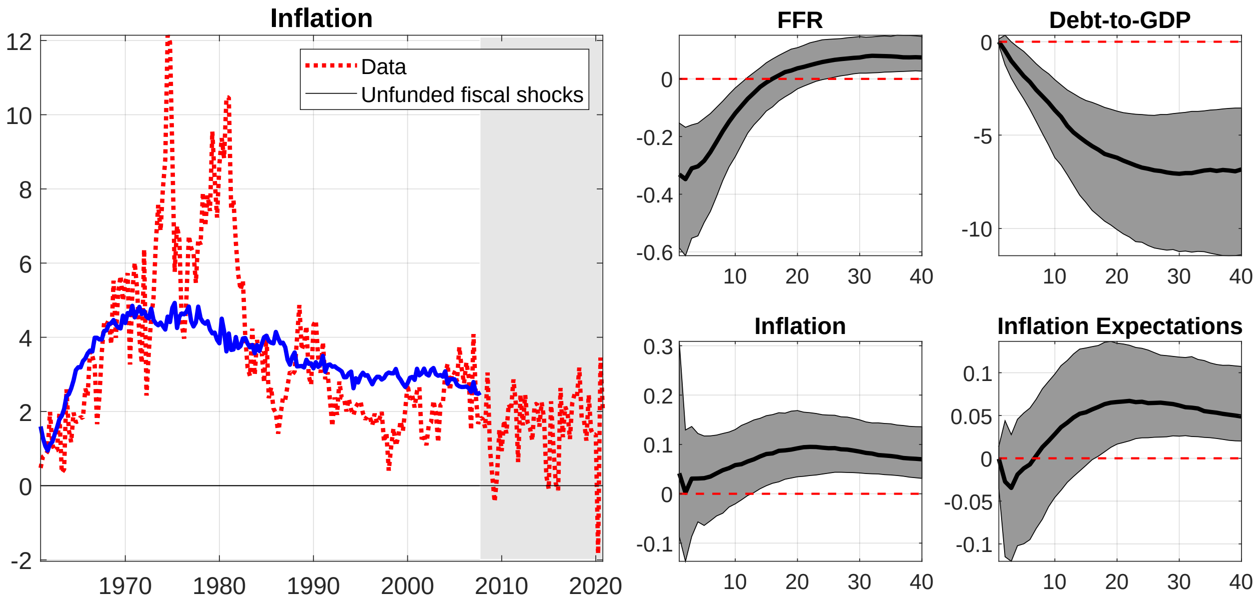


Figure 17: **Propagation of unfunded fiscal shocks when no restrictions are imposed on the response of debt-to-GDP ratio to unfunded transfers shocks over the first two years**. Unfunded fiscal shocks are identified by imposing that these shocks raise real transfers growth for two years while the monetary authority refrains from increasing the federal funds rate (FFR) in that period. The debt-to-GDP ratio is expected to fall two years after the shock and for the next three years. The first figure on the left compares inflation in the data (red dotted line) with inflation explained by the identified unfunded fiscal shocks in the first sample 1960:Q1-2007:Q4 (the blue solid line). The figures on the right show the response of the FFR, debt-to-GDP ratio, inflation, and the Michigan Survey's one-year inflation expectations to the identified unfunded fiscal shock. The black lines denote the posterior median of these responses and the gray bands their 60 percent posterior interval. The x-axes report quarters following the shock. Inflation and inflation expectations, and the FFR are expressed in percentage points of annualized rates.

J.3 VAR evidence: Unrestricted initial response for debt

When we identify unfunded transfers shocks in the VAR model in Section J.2, we impose restrictions on both the short-term and long-term response of debt-to-GDP ratio. One could argue that, outside our structural model, the response of debt-to-GDP is in the long-run negative, but short-run behavior might be more governed by other dynamics. To address this concern, in this appendix, we redo the analysis shown in Section 17 without imposing any restrictions on the response of debt-to-GDP ratio in the two years following the identified unfunded fiscal shocks. That is, an unfunded fiscal shock raises real transfers growth for two years while the monetary authority refrains from responding by raising the FFR over the same period. The debt-to-GDP ratio is expected to fall for five years after the shock. Figure 17 shows the results shown in Figure 16 of the text when we impose no restrictions on the response of debt-to-GDP ratio in the short run. The results shown in both figures are very similar, suggesting that imposing the short-term restrictions on the response of debt-to-GDP ratio to the identified unfunded fiscal shock does not significantly alter the results of our VAR analysis shown in Section J.2 of the paper.

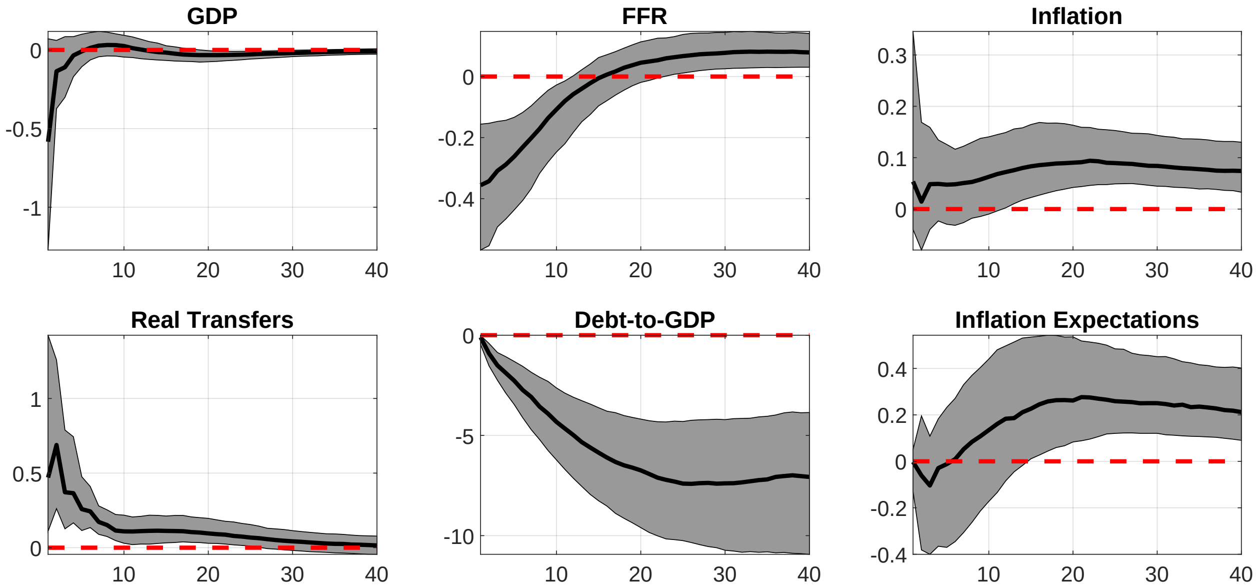


Figure 18: **Impulse response function of selected variables implied by the VAR model introduced in Section J.2.** The observable variables are the same as the ones used to estimate the empirical structural model in the first sample except for the addition of Michigan Survey's 12-month inflation expectations.

In Figure 18, we show the response of a selected number of variables to the unfunded transfers shocks identified in the estimated VAR model. This picture shows the responses in the case where we impose restrictions on the short-term response of debt-to-GDP ratio. The case of when such restrictions are not impose is extremely similar to the one shown in Figure 18.