The Dire Effects of the Lack of Monetary and Fiscal Coordination*

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Abstract

What happens if the private sector starts questioning the government's commitment to take corrective fiscal measures to stabilize a large stock of debt? If the central bank is committed to keep inflation low and stable, tightening monetary policy can actually bring about higher inflation and a deep recession because the effect of contractionary monetary policy on output creates additional inflationary pressure. A coordinated commitment to inflate away only the portion of debt resulting from a large recession leads to a better macroeconomic outcome. This strategy can be systematically used to rule out episodes in which the central bank becomes constrained by the lower bound for the nominal interest rate.

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"This is the United States government. First of all, you never have to default because you print the money, I hate to tell you, OK?"

(Donald Trump, May 10, 2016 at CNN)

"Moreover, uncertainty regarding fiscal and other economic policies has increased. [...] Participants noted that, in the circumstances of heightened uncertainty, it was especially important that the Committee continue to underscore in its communications that monetary policy would continue to be set to promote attainment of the Committee's statutory objectives of maximum employment and price stability."

(Minutes of the Federal Open Market Committee's meeting of December 13-14, 2016)

1 Introduction

One of the main legacies of the Great Recession is the severe fiscal imbalance that is characterizing many advanced economies. Some scholars have argued that fiscal imbalances can affect both inflation and real activity even in absence of plain default on government debt (Leeper 1991; Sims 1994; Woodford 1994). Recent contributions to this literature show that whether these effects materialize or not largely depends on how policymakers are expected to conduct their monetary and fiscal policies (Bianchi and Ilut 2017, Bianchi and Melosi 2013 and 2017). One possibility is that the government is expected to be able to take the adequate corrective fiscal measures to stabilize the dynamics of debt while the central bank is credibly committed to keep inflation low and stable.[1] In this case, the macroeconomic implications of fiscal imbalances have been shown to be quite tenuous. Alternatively, the private sector may find it implausible that the large debt can be stabilized by just future economic growth and fiscal adjustments. When this type of beliefs start materializing, inflation expectations tend to rise since the private sector expects that inflation will ultimately stabilize the fiscal imbalance. If the central bank is expected to accommodate this upsurge in inflation expectations, the real interest rate falls causing a temporary economic boom and a reduction in the fiscal burden.[2] As the first quotation illustrates, this interdependence between monetary and fiscal policies is well-understood by policymakers, even if not always so bluntly spelled out.

In both cases outlined above, the private sector believes that an agreement between the two authorities is at work to implement policies that are coordinated to attain an appropriate inflation rate. Nevertheless, a third scenario in which the private sector expects that policymakers will follow non-coordinated policies could also arise. Specifically, the fiscal authority keeps

[1] In Leeper's (1991) parlance, the private sector expects that an active monetary/passive fiscal policy mix will be carried out.

[2] Leeper (1991) dubbed this policy mix passive monetary/active fiscal.

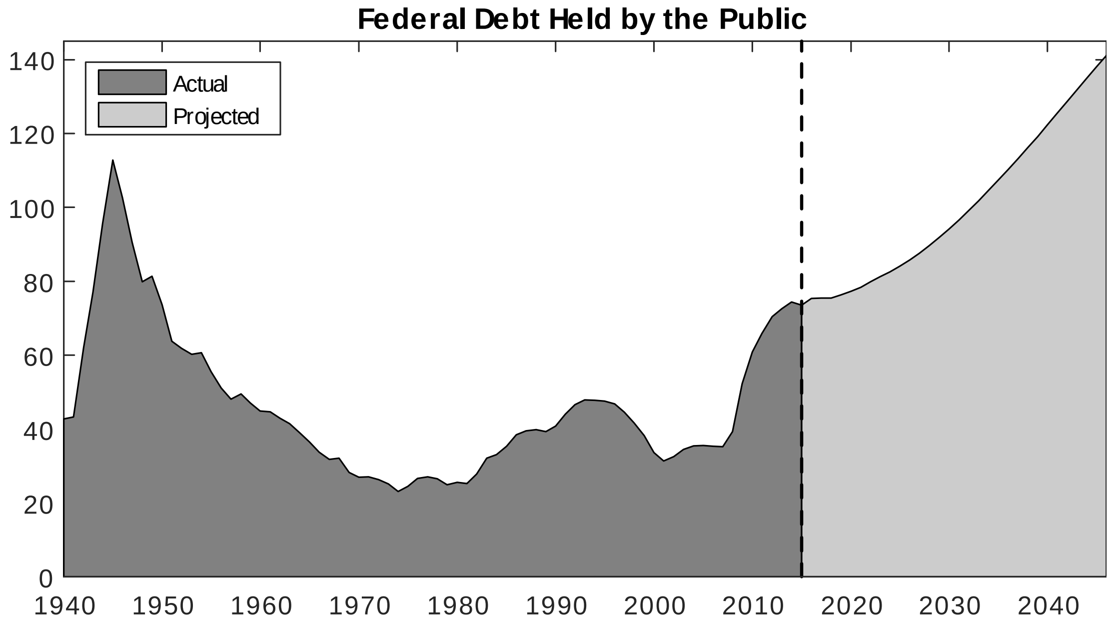

Figure 1: Debt is reported in percentage of GDP. Data from 2016 onward are projected. Vertical dashed line marks fiscal year 2015. Source: Congressional Budget Office (CBO 2016).

postponing indefinitely the necessary fiscal adjustments, while the monetary authority insists that inflation stability will be preserved, remaining credibly committed to raise interest rates to contrast inflation.[3] This policy mix is not coordinated, reflecting a disagreement between the two authorities on whether inflation should or should not be used to stabilize debt. This third scenario is still not fully understood. In this paper, we investigate the macroeconomic consequences of lack of coordination between the monetary and fiscal authorities in presence of large fiscal imbalances.

We believe that there are several reasons that make lack of monetary and fiscal coordination particularly relevant. Currently, the U.S. public debt is on an unstable path. Figure 1 shows the projected dynamics of the federal debt as a percentage share of GDP under current law by the Congressional Budget Office as of August 2016. This picture strongly suggests that fiscal sustainability is far from being accomplished. Population aging and lower expected potential growth contributes to this gloomy outlook. Furthermore, U.S. debt is at its highest level since the beginning of the Korean War in 1950, suggesting that economic growth alone is unlikely to be enough to guarantee its sustainability in absence of fiscal adjustments. As of now, no plan has been announced to reduce this severe fiscal imbalance. Given the explosive dynamics of U.S. debt, delaying the fiscal consolidation will call for more sizable corrective measures up to the point where markets could become skeptical that such massive adjustments can be realistically implemented. Similarly, uncertainty about the potential growth rate of the U.S.

[3]In Leeper's (1991) parlance, this situation occurs when both the monetary and the fiscal authorities engage in active policies.

economy after the Great Recession compounds the problem by making harder to precisely quantify how large the corrective measures have to be.[4] If the U.S. government overestimates the potential economic growth rate, the fiscal adjustment may be considered insufficient by the markets. On the other hand, as the second quotation at the beginning suggests, the Federal Reserve seems committed not to give up on inflation stabilization, especially in situations of high uncertainty about what the fiscal authority is expected to do.

We first introduce a simple frictionless Fisherian model to review the role of monetary and fiscal policy coordination in determining inflation and inflation expectations. When this coordination entails that the fiscal authority disregards the level of government debt and the monetary authority de-emphasizes inflation stabilization, inflation expectations adjust to make sure that real public debt is on a stable path. This simple model allows us to derive a closed-form analytical relation between fiscal imbalances and inflation expectations. Furthermore, this simple model proves to be useful in highlighting the key mechanisms at play when policymakers temporarily fail to coordinate. When the fiscal authority is not committed to stabilize debt, monetary policy is not only ineffective at controlling inflation, but also counterproductive. We show that if the fiscal authority withdraws its backing to the monetary authority by disregarding the level of public debt, every attempt at fighting inflation by the central bank ends up generating bigger fiscal imbalances, which, in turn, heighten the path of inflation.

We then build a more elaborate model by extending the basic new-Keynesian framework to include a fiscal rule, policy uncertainty, and the possibility of discrete negative demand shocks that occasionally trigger large recessions. We use this model to study the macroeconomic effects of monetary and fiscal policy coordination. We show that the lack of policy coordination can be highly detrimental. For instance, if the fiscal authority disregards the level of debt but the monetary authority insists that inflation will not be allowed to rise, the economy can enter a spiral of lower output, higher inflation, and higher debt. Under this scenario, agents expect that inflation will eventually increase because of the rising fiscal imbalances. The central bank raises the interest rate to keep inflation at bay. However, this action causes the fiscal burden to become larger, inducing agents to expect even higher inflation. In this case, hawkish monetary policy is not only unable to keep inflation low, but has also the perverse effect of significantly depressing economic activity.

We then use the model to evaluate a coordinated policy strategy according to which policymakers clearly announce that they will not try to stabilize the portion of debt resulting from the large recession. This strategy can be implemented when markets lose confidence about the government's ability/willingness to stabilize debt through fiscal adjustments. This strategy

[4]A recent article in the New York Times argues that President Donald Trump and the Federal Reserve have different view about the potential growth rate for the U.S. economy. See Appelbaum (2017). The Federal Reserve have continuously revised down its expectations for future growth since the end of the Great Recession (Leubsdorf 2016), highlighting the high uncertainty about the long-run growth of the U.S. economy.

commits the central bank to accept just enough inflation to stabilize the portion of debt resulting from the large recession. Our model predicts that this coordinated policy mix effectively mitigates the recession, while inflation rises by only a moderate amount. This is because of a general equilibrium effect. Since the recession is attenuated, public debt increases only moderately and so does inflation given that only a small fiscal imbalance needs to be stabilized. Furthermore, the policy clearly separates long-run fiscal sustainability from short-run fiscal interventions, with the result that the pre-existing stock of debt does not contribute to create inflationary pressure and macroeconomic instability. As a methodological contribution, we show how to model this type of coordinated strategies based on endogenous targets in dynamic general equilibrium models.

If followed systematically, this strategy is shown to be particularly useful when large deflationary shocks cause the nominal interest rate to hit its lower bound. By promising to inflate away the debt resulting from exceptionally large recessions, the proposed strategy works like an automatic stabilizer that raises inflation expectations exactly when monetary policy would otherwise become constrained by the zero lower bound. In this respect, our work is related to Woodford (2003) and Benhabib, Schmitt-Grohe and Uribe (2002) who show that liquidity traps can be made fiscally unsustainable. Furthermore, the coordinated strategy that we propose shares some features with the policy interventions that Chris Sims has advocated at the 2016 Jackson Hole meeting to replace ineffective monetary policy at the zero lower bound (Sims 2016.) Sims calls for central banks "to explain that fiscal, as well as monetary policy should be aimed at meeting inflation targets. This means, specifically, stating that inflation will intentionally be at least part of the means for financing current debt and deficits."

This paper belongs to a research agenda that aims to understand the role of fiscal policy in explaining changes in the reduced form properties of the macroeconomy. In their study of the Great Inflation, Bianchi and Ilut (2017) show that the absence of fiscal backing can explain the failed disinflationary attempts of the 1970s, providing support for the relevance of situations in which the authorities fail to coordinate. However, in their context, periods of conflict are found to be quite short-lasting and the fiscal burden was relatively low. In this paper, we study the consequences of prolonged periods during which the two authorities fail to coordinate on how to address the problem of a large and quickly growing stock of debt in the aftermath of a severe recession. Furthermore, in this paper we propose a possible coordinated resolution of the conflict between the two authorities. Bianchi and Melosi (2013) introduce the notion of *dormant shocks*, showing that a fiscal imbalance can lead to an increase in inflation many years after it occurred. Bianchi and Melosi (2016) show that policy uncertainty about the way debt will be stabilized empirically accounts for the lack of deflation in the United States during the Great Recession. This paper differs from the aforementioned contributions across several dimensions. First, we focus on the perils related to a lack of coordination between the monetary and fiscal authorities. We show that the *possibility* of such a conflict now or in the future represents a drag on the economy. Second, we argue that the inability of central banks to generate inflation during the recovery from the Great Recession can be understood in light of this possible conflict. Finally, we show how policymakers can spark an increase in inflation expectations and stimulate economic activity by using a coordinated policy strategy.

Our work is related to the vast literature that studies the interaction between monetary and fiscal policies in determining inflation dynamics (Sargent and Wallace 1981; Leeper 1991; Sims 1994; Woodford 1994, 1995, and 2001; Cochrane 1998 and 2001; Schmitt-Grohe and Uribe 2000; Bassetto 2002; Eggertsson, 2008; Reis 2016; among many others). Most of this literature is focused on the US economy, but Jarociński and Maćkowiak (2017) study the implications of different monetary and fiscal coordination schemes for achieving determinacy of a unique rational expectations equilibrium in the model that captures the salient features of the Euro Area. Our focus is on the US economy, but we believe that some of our results are also relevant for other countries. Del Negro and Sims (2015) argue that when the central bank's balance sheet is large and composed of long-duration nominal assets, fiscal support to the balance sheet would be appropriate to allow the monetary authority to control inflation. This sort of support is different from what we call fiscal backing in this paper, which is required for keeping inflation stable regardless of the level of the central bank's balance sheet. Davig et al. (2010) study how to resolve the "unfounded liabilities problem," which stems from the unsustainable exponential growth in the Social Security, Medicare, and Medicaid spending with no plan to finance it. They provide a coordinated resolution of this long-term fiscal imbalance, which requires specifying a probability distribution for monetary and fiscal behavior over a long time span. The emphasis in our paper is instead on the lack of coordination between the monetary and fiscal authorities and on how to reconcile the benefits of short-run stabilization policies with the need of long-run fiscal sustainability. While Fernandez-Villaverde et al. (2015) study the macroeconomic effects of fiscal volatility, we focus on the effects of uncertainty about the future policy mix.

2 A Simple Model of Inflation Determination

We construct a simple model to lay the groundwork for how monetary and fiscal policies jointly determine equilibrium dynamics for inflation. This model draws from previous studies by Leeper (1991); Leeper and Walker (2013); Sims (1994); Woodford (2001).

2.1 Deterministic economy

Let us first consider a deterministic economy populated by infinitely many households and a government. An infinitely lived representative household is endowed each period with a constant quantity of non-storable goods E and derive utility from consuming these goods C_t. The government issues one-period debt (liabilities) to households who can trade them for one unit of the goods at price P_t. Government liabilities have purchase price $q_t < 1$. The government raises real net surpluses τ_t (net to the returns paid on the debt outstanding) to repay its maturing liabilities. In symbols, the government budget constraint reads as follows:

$$P_t \tau_t + q_t B_t = B_{t-1}. \tag{1}$$

Market clearing requires $C_t = E$ in every period and the households' Euler equation implies the Fisherian equation; $q_t^{-1} = \beta^{-1} P_{t+1}/P_t$, where $\beta < 1$ is the households' discount factor.

The two-period case. Let us assume that the households live only two periods, implying that the government cannot sell new debt in the last period, $B_2 = 0$. For a given time sequence of net real surpluses $\{\tau_1, \tau_2\}$ and nominal debts (B_0, B_1), the government's budget constraint pins down the price level:[5]

$$P_1 = \frac{-q_1 B_1 + B_0}{\tau_1} \tag{2}$$

$$P_2 = \frac{B_1}{\tau_2}. \tag{3}$$

Thus, for a given sequence of primary surpluses/deficits, the larger the stock of debt at the end of the previous period, the higher the price level in a period. The last period's budget constraint is particularly illustrative. This equation says that for a given primary surplus the government is able to raise in the last period, the larger the stock of debt outstanding at the beginning of period 2, the higher the relative price of consumption goods (to government liabilities/bonds) in period 2, P_2. The government is issuing too much debt with respect to its ability of raising real resources to repay its debt. So the relative price of the less abundant consumption goods to the abundant government debt has to go up to clear the market.

The infinite-period case. Now we assume that households are infinitely lived. We can expand the government budget constraint forward to obtain

$$B_{t-1} = P_t \tau_t + \sum_{s=1}^{\infty} \left[\prod_{l=1}^{s} q_{t+l-1} \right] P_{t+s} \tau_{t+s} \tag{4}$$

Dividing both sides of this equation by the current price level P_t and using the Fisherian equation, we can write

$$\frac{B_{t-1}}{P_t} = \sum_{s=0}^{\infty} \beta^s \tau_{t+s} \tag{5}$$

[5]Note that q_1 is determined by the price level in the two periods because of the Fisherian equation.

This is the valuation equation for the government debt. The real value of debt (i.e., its value in terms of consumption goods) is given by the discounted stream of future primary real surpluses that the government is able to generate. Notice that this is just the intertemporal version of equation (3) that pins down the real value of government debt in the last period of the two-period model. Again, higher debt must be backed by future higher real surpluses. Otherwise, the relative price of the less abundant consumption goods to the more abundant government debt has to go up to clear the market where goods and government liabilities are traded. Notice that as long as the real returns to government debt is constant (or exogenous), the link between inflation and fiscal imbalances stems from the intertemporal budget constraint. The other model equations do not interfere with this mechanism.

2.2 A stochastic environment with monetary and fiscal policy

Let us assume that the discount factor is no longer fixed and, in fact, is allowed to vary according to an exogenous process. Specifically, let us denote $r_t = 1/\beta_t$ and assume that $\ln r_t = \ln r_* + \varepsilon_t^r$, where $E(\varepsilon_t^r) = 0$ and $r_* > 1$.

Furthermore, we introduce a monetary authority that controls the nominal interest rate on government bond $R_t = q_t^{-1}$ by using the rule

$$\frac{R_t}{R_*} = \left(\frac{\Pi_t}{\Pi_*}\right)^{\phi} \exp\left(\varepsilon_t^m\right) \tag{6}$$

where ε_t^m is a Gaussian i.i.d. process with zero mean and the starred variables denote the value of the variables at the deterministic steady state. This equation describes monetary policy and ties the changes in the nominal rate to inflation deviations from its steady-state value and to an exogenous shock. The Fisherian equation becomes

$$R_t = r_t E_t \Pi_{t+1}. \tag{7}$$

We refer to equations (6) and (7) as the monetary block of this simple economy.

The government budget constraint equation (1) can be equivalently re-written as

$$\tau_t + R_t^{-1} b_t = \frac{b_{t-1}}{\Pi_t} \tag{8}$$

where $b_t \equiv B_t/P_t$ denotes the real value of the government liabilities at time t.

The government's ability or willingness to raise primary real surpluses τ_t across periods is captured by the following fiscal rule (expressed in real terms):

$$\tau_t - \tau_* = \gamma\left(b_{t-1} - b_*\right) + \varepsilon_t^\tau \tag{9}$$

where ε_t^τ follows an i.i.d. zero-mean exogenous process: $E(\varepsilon_t^\tau) = 0$. Note that this simple fiscal rule responds to the last period's real stock of debt. We refer to equations (8) and (9) as the fiscal block of the economy.

We linearized the model equations around the steady-state equilibrium, which is derived in the Appendix. The monetary rule (6) and the Fisherian equation (7) can be expressed as follows:

$$\tilde{R}_t = \varepsilon_t^r + E_t\tilde{\pi}_{t+1}, \quad (10)$$

$$\tilde{R}_t = \phi\tilde{\pi}_t + \varepsilon_t^m. \quad (11)$$

The fiscal block can be written as follows:[6]

$$\hat{\tau}_t + \hat{b}_t = \beta^{-1}\hat{b}_{t-1} + b_*\tilde{R}_t - \beta^{-1}b_*\tilde{\pi}_t. \quad (12)$$

$$\hat{\tau}_t = \gamma\hat{b}_{t-1} + \varepsilon_t^\tau. \quad (13)$$

Equation (13) highlights the *two key links* between monetary and fiscal policy. The first link is captured by the interest rate appearing on the right-hand side of that equation: a monetary tightening brings about fiscal imbalances. Conversely, a rate cut reduces the fiscal burden. The second link is captured by the inflation term appearing on the right hand side of the fiscal-block equation: a fall (rise) in inflation raises (reduces) the real burden of government debt. These two links make monetary policy and fiscal policy interdependent. Notice that both inflation $\hat{\pi}_t$ and the nominal interest rate $\hat{\imath}_t$ are multiplied by the magnitude of the steady-state stock of real debt b_* in the fiscal-block equation (15). Therefore, the larger the long-run size of fiscal imbalances, the stronger the degree of interdependence between monetary and fiscal policy. As we shall see, how policymakers perceive these links matter a lot for determining whether there exists a unique stable rational expectations equilibrium (determinacy), or infinitely many of them (indeterminacy), or none of them in our simple model.

Plugging the monetary rule (11) into the Fisherian equation (10)

$$\phi\tilde{\pi}_t = \varepsilon_t^r + E_t\tilde{\pi}_{t+1} - \varepsilon_t^m, \quad (14)$$

which we will refer to as the monetary-block equation. Furthermore, combining equation (12) with the fiscal rule (13) and with the monetary rule (11) yields

$$\hat{b}_t = \left[\beta^{-1} - \gamma\right]\hat{b}_{t-1} + b_*\left(\phi - \beta^{-1}\right)\tilde{\pi}_t - \varepsilon_t^\tau + b_*\varepsilon_t^m. \quad (15)$$

[6] Note that we linearize the primary surplus τ_t and the real debt b_t around steady state as this variables can potentially be negative.

which we will refer to as the fiscal-block equation. Notice that contractionary monetary shocks ($\varepsilon_t^m > 0$) bring about fiscal imbalances. This channel is very important to understand how inflation respond to shocks as well as the interactions between monetary and fiscal policy in the model.

Defining the rational expectations errors $\eta_t \equiv \tilde{\pi}_t - E_{t-1}\tilde{\pi}_t$ and replacing $\tilde{\pi}_t$ with $E_{t-1}\tilde{\pi}_t + \eta_t$ in both equations (14)-(15) yield the following system of linear equations:

$$\begin{bmatrix} E_t\tilde{\pi}_{t+1} \\ \hat{b}_t \end{bmatrix} = \begin{bmatrix} \phi & 0 \\ b_*\left(\phi - \beta^{-1}\right) & \beta^{-1} - \gamma \end{bmatrix} \begin{bmatrix} E_{t-1}\tilde{\pi}_t \\ \hat{b}_{t-1} \end{bmatrix} + \begin{bmatrix} -1 & 0 & 1 \\ 0 & -1 & b_* \end{bmatrix} \begin{bmatrix} \varepsilon_t^r \\ \varepsilon_t^\tau \\ \varepsilon_t^m \end{bmatrix} + \begin{bmatrix} \phi \\ b_*\left(\phi - \beta^{-1}\right) \end{bmatrix} \eta_t. \tag{16}$$

This system has two eigenvalues: ϕ and $\beta^{-1} - \gamma$. There is only one non-predetermined variables ($E_t\tilde{\pi}_{t+1}$). Since the second eigenvalue lies outside the unit circle if $\gamma < \beta^{-1} - 1$, our exercise confirms the partition of the parameter space introduced by Leeper (1991): The two policy parameters ϕ and γ determine these eigenvalues and, hence, the existence and uniqueness of stable rational expectations equilibria for this Fisherian economy. Let us review the four possible cases.

Monetary-Led Policy Mix. Suppose that the monetary authority conducts an *active monetary policy* by aggressively adjusting the interest rate to stabilize inflation. This policy is captured by setting $\phi > 1$ in the monetary policy rule (6). Furthermore, let us assume that the government systematically raises taxes to generate future primary surpluses so as to stabilize any the real stock of debt $\hat{b}_t$. This goal can be achieved by a fiscal authority that adjust primary surpluses sufficiently aggressively to debt fluctuations. More precisely, if the fiscal policy parameter γ is higher than $\beta^{-1} - 1$, then the root $\left(\beta^{-1} - \gamma\right)$ in the fiscal-block equation (15) is lower than one, implying stationary dynamics for the real debt $\hat{b}_t$. When policymakers follow this policy mix, there exists a unique stable rational expectations equilibrium.[7]

It should be noted that this kind of monetary and fiscal policy interactions leads policymakers to coordinate their policies in a *countercyclical* manner. As an inflationary shock (e.g., $\varepsilon_t^r > 0$) hits the economy, the central bank aggressively raises the interest rate. This aggressive monetary contraction leads to an increase in the debt service costs ($\hat{\imath}_t$) - equation (15) - and hence to a fiscal imbalance. The fiscal rule implies that the fiscal authority raises taxes aggressively ($\gamma > \beta^{-1} - 1$) to make sure that the higher real stock of debt will be reabsorbed. The opposite happens after a deflationary shock. We call this form of interaction *monetary-led*

[7] Active monetary policy induces an explosive root in the monetary-block equation. Since there is only one forward-looking variable, the Blanchard-Kahn conditions for determinacy are satisfied.

policy mix.

In our simple setting it is possible to characterize analytically the unique Rational Expectations equilibrium. In this equilibrium, the law of motion for inflation is as follows:

$$\hat{\pi}_t = \phi^{-1}\varepsilon_t^r - \phi^{-1}\varepsilon_t^m. \tag{17}$$

The dynamics of real government debt are given by the fiscal-block equation (15) after substituting the monetary policy rule to replace the interest rate.

Equation (17) reveals an important property of this equilibrium: fiscal shocks ε_t^τ do not affect inflation; they only affect fiscal variables (i.e., the debt and the primary surplus). Since the fiscal authority is committed to systematically adjust the stream of primary surpluses to repay its debt, inflation is completely insulated from the fiscal block and fiscal imbalances are never relevant for inflation determination. We call this feature *Monetary and Fiscal Dichotomy.* Again, the Dichotomy requires to assume that (*i*) the central bank will be striving to stabilize inflation, (*ii*) the government will be raising taxes to stabilize the path of real debt and (*iii*) agents believe that policymakers will carry out these policies in every state of the word. In his Jackson Hole speech, Sims claims that relaxing these assumptions and considering alternative ways policymakers can interact help understand some of the current policy issues and puzzles.

Fiscally-Led Policy Mix. Now suppose the monetary authority conducts a passive *monetary policy* by weakly adjusting the interest rate to stabilize inflation. This policy is captured by setting $\phi \leq 1$ in the monetary policy rule (6). Furthermore, we now assume that the fiscal adjustments implemented by the government are not large enough to guarantee the fiscal backing of fluctuations in government debt. This is captured by setting the fiscal policy parameter γ in the fiscal rule (9) strictly lower than the steady-state value of the net real rate $\left(\beta^{-1} - 1\right)$.[8] Now the root $\left(\beta^{-1} - \gamma\right)$ in the fiscal-block equation (15) is larger than one, implying that the government is not taking the necessary fiscal adjustments to stabilize the debt. This happens because the government fails to collect enough taxes to repay its debt. Therefore, when debt deviates from steady state, agents want to sell government liabilities in exchange for consumption goods because they understand that the government will not raises primary surpluses to repay its debt with consumption goods, which are the goods they care about. Consequently, the price of consumption goods must go up to clear the market.

In responding passively to inflation, the central bank accommodate this price adjustment that is necessary to stabilize the dynamics of real debt.[9] As a result, the dynamics of the forward-looking variable (i.e., inflation expectations) are pinned down by the need for making

[8] Leeper (1991) calls this policy mix passive monetary/active fiscal policy.

[9] In technical jargon, the passive monetary policy makes the monetary-block equation's root stable and, hence, the Blanchard and Kahn conditions for determinacy are satisfied.

real debt stationary and, hence, there exists a unique stable rational expectations equilibrium. The relationship between inflation expectations and the deviations of real debt from its steady state can be analytically characterized in this simple framework:

$$E_t\hat{\pi}_{t+1} = \frac{1}{b_*}\left[1 - \frac{\gamma}{\beta^{-1} - \phi}\right]\hat{b}_t. \tag{18}$$

This equation quantifies by how much inflation expectations have to adjust to keep real debt on a stable path and ensure uniqueness of stable rational expectations equilibria. The monetary authority de-emphasizes inflation stabilization in order to passively accommodate the fiscal authority's decisions of decoupling fiscal policy from the dynamics of the debt. Contrary to the monetary-led case, now it is the fiscal authority that dictates the tempo of monetary policy. We call this policy mix *fiscally-led policy mix*. Furthermore, equation (18) clearly breaks down the *Monetary and Fiscal Dichotomy*. Now inflation is no longer insulated from fiscal shocks.

Equation (18) is quite revealing about the interplay between monetary and fiscal policies in the PM/AF case. The active fiscal authority can disregard the level of debt because the passive monetary authority allows inflation to rise to stabilize fluctuations in the real value of debt. In this case, it is the fiscal authority that dictates the tempo of this coordinated policy mix. Unlike the AM/PF case, fiscal policy is no longer countercyclical under this alternative coordination scheme. As a result, this policy mix will lead to very different macroeconomic outcomes compared to the AM/PF case, as we shall show.

The Rational Expectation Equilibrium (REE) can be characterized by plugging equation (18) into the monetary-block equation (14) to get rid of inflation expectations. We obtain

$$\phi\hat{\pi}_t = \varepsilon_t^r + \xi\hat{b}_t - \varepsilon_t^m, \tag{19}$$

with $\xi \equiv \frac{1}{b_*}\left[1 - \frac{\gamma}{\beta^{-1}-\phi}\right]$ capturing the response of expected inflation needed to stabilize the real stock of debt. See equation (18). Combining this equation with equation (15) yields a system of linear equations that can be solved by simply inverting a 2×2 matrix. Some tedious but straightforward algebra allows us to characterize the unique REE solution under the PM/AF policy mix:

$$\begin{aligned}\begin{bmatrix}\tilde{\pi}_t \\ \hat{b}_t\end{bmatrix} &= \begin{bmatrix}0 & \xi \\ 0 & \phi\end{bmatrix}\begin{bmatrix}\tilde{\pi}_{t-1} \\ \hat{b}_{t-1}\end{bmatrix} \\ &+ \begin{bmatrix}\frac{1}{\beta^{-1}-\gamma} & -\frac{\xi}{\beta^{-1}-\gamma} & -\frac{1-\xi b_*}{\beta^{-1}-\gamma} \\ -\frac{b_*\left(\beta^{-1}-\phi\right)}{\beta^{-1}-\gamma} & -\frac{\phi}{\beta^{-1}-\gamma} & b_* - \frac{b_*\left(\phi-\beta^{-1}\right)[1-\xi b_*]}{\beta^{-1}-\gamma}\end{bmatrix}\begin{bmatrix}\varepsilon_t^r \\ \varepsilon_t^\tau \\ \varepsilon_t^m\end{bmatrix}\end{aligned} \tag{20}$$

Three features of the solution (20) are worthy emphasizing. First, contrary to the AM/PF case, inflation is generally not insulated from fiscal shocks ε_t^τ under this alternative policy mix. Second, the central bank's systematic response to inflation (ϕ) induce a persistent dynamics in inflation. This is strikingly different from the AM/PF case, in which inflation follows an i.i.d. process. The reason for this result is that contractionary monetary policy in response to inflationary shocks still brings about fiscal imbalances even though monetary policy is passive. These timid monetary contractions end up slowing down the inflation-driven reduction in the real value of debt and, in so doing, raise the amount of inflation that is necessary for stabilizing the stock of debt, everything else equal.

Passive Monetary and Fiscal Policies. So far we have considered situations in which policies are coordinated, in the sense that they are conducive to a unique equilibrium. In what follows, we are going to consider the possibility of lack of coordination between the two authorities. With this we mean a situation that if it were to persist for a long time would not be conducive to a unique equilibrium.

A first possibility is that both authorities engage in passive policies. This means that the monetary authority disapplies the Taylor principle ($\phi \leq 1$) and the fiscal authority adjusts the stream of future primary surpluses to stabilize its debt ($\gamma \geq \beta^{-1} - 1$). From the perspective of determining the inflation rate, this policy mix is not coordinated because monetary policy fails to anchor inflation expectations while fiscal policy does not require inflation to reabsorb fiscal imbalances, which are addressed by raising primary surpluses. As a result, inflation is indeterminate, meaning that there exist infinitely many stable paths for inflation that are consistent with the concept of rational expectations equilibrium.

2.3 Lack of Coordination and policy changes

Let us now consider the case that is the focus of this paper. Suppose that the central bank applies the Taylor principle ($\phi > 1$) and that the fiscal authority disregards the level of debt ($\gamma < \beta^{-1} - 1$). In this case, monetary and fiscal policies are not coordinated in the sense that monetary and fiscal policies are not geared toward the determination of the inflation rate. Rather, the two policy authorities are in a sort of *fight* to control inflation: the fiscal authority wants inflation to adjust to stabilize all fiscal imbalances whereas the central bank adjusts the interest rate aggressively to prevent inflation from deviating from its steady-state (target) level. These two objectives are clearly inconsistent. If this lack of coordination were to persist indefinitely, no stable Rational Expectations equilibrium would exist. However, this policy mix is still consistent with a stable equilibrium if it is not perceived to be permanent. We want to use the simple Fisherian model to study the macroeconomic implications of a situation in which both policymakers conduct active policies in a struggle to control inflation.

We assume that the economy is at its steady-state equilibrium when at time $t = 1$ is hit by a positive discount factor shock, $\varepsilon_t^r > 0$. At this point, the fiscal authority starts disregarding the level of debt ($\gamma = 0$) while the monetary authority is conducting active policy. When policymakers adopt the AM/AF policy mix, they are fighting for controlling inflation. On the one hand, the central bank wants to secure the full control over inflation, preventing fiscal imbalances from having any effects on inflation dynamics. On the other hand, the fiscal authority wants the central bank to let inflation adjust so as to accommodate the inflationary consequences of fiscal imbalances.

We assume that one of the two policymakers will lose the fight in period $t = 2$ and reverts to passive policy. We consider two cases: one in which the monetary authority wins and the other in which the fiscal authority eventually prevails. To make our analysis as simple as possible, we assume that agents know with certainty what policy mix is adopted by policymakers at time $t = 1$ and in every subsequent period. Later on we will relax this assumption.

Case 1 Conflict and Monetary-Led Resolution In this case, the monetary authority is fighting against the fiscal authority's decision of withdrawing its fiscal backing. In period $t = 2$, the fiscal authority will give up fighting and will adopt the passive fiscal policy. This case is illustrative of a situation in which agents expect that, after the initial period of conflict with the fiscal authority, the central bank will secure the fiscal backing for controlling inflation dynamics.

At time $t = 1$, agents know that policymakers will coordinate over the AM/PF policy mix and, hence, at time $t = 2$ inflation will depend only on future shocks (see equation (17)). Since the discount factor shock is i.i.d., it follows that $E_1\tilde{\pi}_2 = 0$. Consequently, REE inflation at time 1 is given by $\tilde{\pi}_1 = \phi_A^{-1}\varepsilon_1^r > 0$. The stock of real debt is determined by the following equation

$$\hat{b}_t = b_* \left(1 - \frac{\beta^{-1}}{\phi_A}\right) \varepsilon_1^r. \tag{21}$$

Notice that the behaviors of the fiscal authority have no implications whatsoever for REE outcomes in period 1. Agents know that the fiscal authority has withdrawn its backing only in the short term and soon it will revert to passive policy. Importantly, the fiscal imbalance that arises in period 1 does not influence the dynamics of inflation at time $t = 1$ and in any subsequent period. The stronger the monetary authority responds to inflation, the lower inflation in period 1. A proactive central bank will induce a larger fiscal imbalance, requiring the government to raise taxes more aggressively from period 2 onward. For sufficiently strong central bank's response to inflation, $\phi_A > \beta^{-1} \approx 1$, and assuming that steady-state debt is positive ($b_* > 0$), real debt responds positively to the inflationary shock. This is due to the fiscal effects of the contractionary monetary policy conducted in the first period.

Case 2: Conflict and Fiscally-Led Resolution In this case, policymakers fight for retaining the full control over inflation in the first period but, unlike in Case 1, the central bank is expected to lose the fight. This case sheds light on what happens when the central bank fights back against the fiscal authority's decision to remove its support for stabilizing inflation but agents expect that fiscal backing cannot be secured in the long run.

At time $t = 1$, agents know that policymakers will coordinate over the Fiscally-led policy mix and hence they expect that $E_1 \tilde{\pi}_2 = \xi \hat{b}_1$. Consequently, at time $t = 1$ the REE inflation must satisfy

$$\tilde{\pi}_1 = \phi_A^{-1} \varepsilon_1^r + \phi_A^{-1} \xi \hat{b}_1, \tag{22}$$

and the stock of real debt

$$\hat{b}_1 = b_* \left(\phi_A - \beta^{-1} \right) \tilde{\pi}_1. \tag{23}$$

We can solve the linear system of equations(22)-(23) and obtain

$$\tilde{\pi}_1 = \frac{1}{\xi b_* \beta^{-1} + \phi_A (1 - \xi b_*)} \varepsilon_1^r, \tag{24}$$

$$\hat{b}_1 = \frac{b_* \left(\phi_A - \beta^{-1} \right)}{\xi b_* \beta^{-1} + \phi_A (1 - \xi b_*)} \varepsilon_1^r, \tag{25}$$

where $\xi \equiv \frac{1}{b_*} \left[1 - \frac{\gamma_A}{\beta^{-1} - \phi_P} \right]$ and captures the response of inflation expectations that is necessary to stabilize the real stock of debt under the fiscally-led regime that is expected to arise from period 2 onward. See equation (18). This is a slightly more complex equilibrium to analyze than the previous ones because both authorities' behavior plays some role in shaping macroeconomic outcomes. Unlike Case 1, fiscal policy can now affect inflation outcomes.

Note that since $\gamma_A < \beta^{-1} - 1 \approx 0$, then $\xi b_* \approx 1$ and the denominator in equations (24)-(25) is positive. Hence, both inflation and real debt will rise after the shock. As in Case 1, this is due to active monetary policy that successfully raises fiscal imbalances in the first period. Figure 2 shows the propagation of an inflationary shock for a set of central bank's response to inflation in period 1, $\phi_A \in \{1.5, 2.0, 2.5\}$, and for a set of passive response in subsequent periods, $\phi_P \in \{0, 0.5\}$. We set the steady-state real interest rate $r_* = 1.01$, implying a discount factor $\beta = 0.9901$. Furthermore, we assume that the steady-state debt-to-output ratio b_* is equal to 0.6 and the fiscal authority's active response (γ_A) is equal to $0 < \beta^{-1} - 1$. We observe that the response of inflation in the first period is always around one regardless of how strong the response of the central bank, ϕ_A, in period 1. Again this is because $\xi b_* \approx 1$, for the reasons discussed earlier. Nevertheless, the more hawkish policy at time $t = 1$ heightens the stock of real debt at the end of period 1 by raising the interests the government has to pay on its debt. This larger stock of debt will lead to higher inflation in the following periods, when the central will give up and will engage in passive policies. Therefore, a more aggressive monetary policy

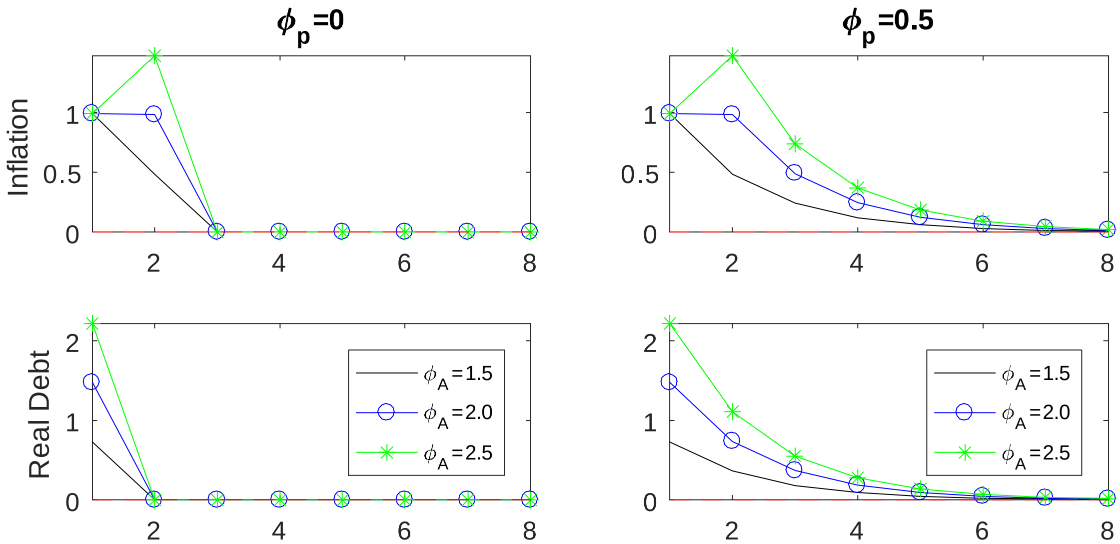

Figure 2: **Conflict and Fiscally-led Resolution.** Response of inflation and real debt to a discount factor shock for different central bank's responses to inflation in period 1 (different lines, see legend) and in period 2 and onward (left column $\phi_P = 0$ and right column $\phi_P = 0.5$). The steady-state real interest rate, r_*, is set to be equal to 1.01, implying a discount factor $\beta = 0.9901$. Fiscal policy is active in all periods.

in period 1 causes higher fiscal imbalances, which in turn bring about a higher inflation rate in subsequent periods. It is also worth noting that the response of debt in period 1, and hence the development of inflation from period 2 onward grow with the size of the initial stock of public debt (b_*). See equation (25).

Comparing the plots on the left with those on the right shows that how strongly the central bank will react to inflation in period 2 and onward (ϕ_P) affects the persistence of the fiscal imbalances and, consequently, how sluggishly inflation will adjust. This can also be seen in equation (20). When $\phi_P > 0$, the central bank keeps raising the rate (timidly) to respond to inflation. The contractionary monetary policy deteriorates the fiscal budget, making the dynamics of real public debt more persistent and hence requiring higher inflation to stabilize debt. This simple example shows how critical fiscal backing is for the monetary authority to be able to control inflation. Absent fiscal backing, hawkish monetary policy can backfire.

3 A New-Keynesian Model

In this section we build a more elaborate model by extending the basic new-Keynesian model employed by Clarida et al. (2000), Woodford (2003), Galí (2008), and Lubik and Schorfheide (2004) to include a fiscal rule and the possibility of *occasionally large recession* episodes that are associated with sizable debt accumulation. The economy consists of a continuum of monopolistic firms, a representative household, and a monetary policy authority (or central bank).

3.1 The Model

Households. The household derives utility from consumption C_t and disutility from labor h_t:

$$E_0\left[\sum_{t=0}^{\infty}\beta^t \exp\left(\zeta_d\right)\left[\log\left(C_t\right)-h_t\right]\right], \tag{26}$$

where β is the household's discount factor. The preference shock ζ_d is the sum of a continuous and discrete component: $\zeta_d = d_t + \overline{d}_{\xi_t^d}$. The continuous component d_t follows an AR(1) process: $d_t = \rho_d d_{t-1} + \sigma_d \varepsilon_{d,t}$. The discrete component $\overline{d}_{\xi_t^d}$ can assume two values: high or low ($\overline{d}_h$ or $\overline{d}_l$). The variable ξ_t^d controls the regime in place and evolves according to the transition matrix H^d:

$$H^d = \begin{bmatrix} p_{hh} & 1-p_{ll} \\ 1-p_{hh} & p_{ll} \end{bmatrix},$$

where $p_{ji} = P\left(\xi_{t+1}^d = j | \xi_t^d = i\right)$.

This specification is in the spirit of Christiano et al. (2011). However, in the current setup shocks to preferences are assumed to be recurrent, and agents take into account that these episodes can lead to unusual policymakers' responses, as discussed later on. The household budget constraint is given by:

$$P_t C_t + P_t^m B_t^m + P_t^s B_t^s = P_t W_t h_t + B_{t-1}^s + \left(1+\rho P_t^m\right) B_{t-1}^m + P_t D_t - T_t + TR_t$$

where D_t stands for real dividends paid by the firms, C_t is consumption, h_t is hours, W_t is the real wage, T_t is taxes, and TR_t stands for transfers. Following Woodford (2001), we assume that there are two types of government bonds: one-period government debt, B_t^s, in zero net supply with price P_t^s, and a more general portfolio of government debt, B_t^m, in non-zero net supply with price P_t^m. The former debt instrument satisfies $P_t^s = R_t^{-1}$. The latter debt instrument has payment structure $\rho^{T-(t+1)}$ for $T > t$ and $0 < \rho < 1$. The asset can be interpreted as a portfolio of infinitely many bonds with average maturity controlled by the parameter ρ. The value of such an instrument issued in period t in any future period $t+j$ is $P_{t+j}^{m-j} = \rho^j P_{t+j}^m$.

Firms. The representative firm j faces a downward-sloping demand curve, $Y_t(j) = \left(P_t(j)/P_t\right)^{-1/\upsilon} Y_t$, where the parameter $1/\upsilon$ is the elasticity of substitution between two differentiated goods. Firms take as given the general price level, P_t, and the level of real activity, Y_t. Whenever a firm changes its price, it faces a quadratic adjustment cost:

$$AC_t(j) = .5\varphi\left(P_t(j)/P_{t-1}(j) - \Pi\right)^2 Y_t(j) P_t(j)/P_t \tag{27}$$

where $\Pi_t = P_t/P_{t-1}$ is gross inflation at time t and Π is the corresponding deterministic steady state. The firm chooses the price $P_t(j)$ to maximize the present value of future profits:

$$E_t\left[\sum_{s=t}^{\infty} Q_s\left(\left[P_s(j)/P_s\right] Y_s(j) - W_s h_s\left(j\right) - AC_s(j)\right)\right]$$

where Q_s is the stochastic discount factor for the representative household. Labor is the only input in the firm production function, $Y_t(j) = A_t h_t^{1-\alpha}(j)$, where total factor productivity A_t evolves according to an exogenous process: $\ln\left(A_t/A_{t-1}\right) = \gamma + a_t$, $a_t = \rho_a a_{t-1} + \sigma_a \varepsilon_{a,t}$, $\varepsilon_{a,t} \sim N\left(0,1\right)$.

Government. Imposing the restriction that one-period debt is in zero net supply, the flow budget constraint of the government is given by:

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

where $P_t^m B_t^m$ is the market value of debt and T_t and E_t represent federal tax revenues and federal expenditures, respectively. Government expenditure is the sum of federal transfers and goods purchases: $E_t = P_t G_t + TR_t$. We rewrite the federal government budget constraint in terms of debt-to-output ratio $b_t^m \equiv \left(P_t^m B_t^m\right)/\left(P_t Y_t\right)$:

$$b_t^m = \left(b_{t-1}^m R_{t-1,t}^m\right)/\left(\Pi_t Y_t/Y_{t-1}\right) - \tau_t + e_t$$

where $R_{t-1,t}^m = \left(1 + \rho P_t^m\right)/P_{t-1}^m$ is the realized return of the maturity bond, all the variables are expressed as a fraction of GDP.

The linearized transfers as a fraction of GDP, $\widetilde{tr}_t$, follow the following process:

$$\widetilde{tr} = \rho_{tr}\widetilde{tr}_{t-1} + \left(1-\rho_{tr}\right)\phi_y\left(\widehat{y}_t - \widehat{y}_t^*\right) + \sigma_{tr}\varepsilon_{tr,t}$$

Transfers move around this trend component as a result of business cycle fluctuations captured by the log-linearized output gap $\left(\widehat{y}_t - \widehat{y}_t^*\right)$, where $\widehat{y}_t^*$ is potential output. The government also buys a fraction G_t/Y_t of total output. We define $g_t = 1/(1 - G_t/Y_t)$ and we assume that $\widetilde{g}_t = \ln(g_t/g)$ follows an autoregressive process: $\widetilde{g}_t = \rho_g \widetilde{g}_{t-1} + \sigma_g \varepsilon_{g,t}$, $\varepsilon_{g,t} \sim N\left(0,1\right)$.

Policy Rules. The monetary policy rule reads as follows:

$$R_t/R = \left(R_{t-1}/R\right)^{\rho_{R,\xi_t^d,\xi_t^p}}\left[\left(\Pi_t/\Pi\right)^{\psi_{\pi,\xi_t^d,\xi_t^p}}\left(Y_t/Y_t^*\right)^{\psi_{y,\xi_t^d,\xi_t^p}}\right]^{\left(1-\rho_{R,\xi_t^d,\xi_t^p}\right)} \quad (28)$$

where R is the steady-state gross nominal interest rate, Y_t^* is the output target, and Π is the deterministic steady-state level for gross inflation. The parameters $\psi_{\pi,\xi_t^d,\xi_t^p}$ and ψ_{y,ξ_t^d,ξ_t^p} capture the central bank's response to inflation and output gap, which depends on the policy mix ξ_t^p in place at time t and the state of demand ξ_t^d.

The fiscal authority moves taxes according to the following rule:

$$\widetilde{\tau}_t = \rho_{\tau,\xi_t^d,\xi_t^p}\widetilde{\tau}_{t-1} + \left(1 - \rho_{\tau,\xi_t^d,\xi_t^p}\right)\left[\delta_{b,\xi_t^d,\xi_t^p} \cdot \widetilde{b}_{t-1}^m + \delta_y\left(\widehat{y}_t - \widehat{y}_t^*\right)\right] \tag{29}$$

where $\widetilde{\tau}_t$ is the level of tax revenues with respect to GDP in linear deviations from the steady state. The parameter $\delta_{b,\xi_t^d,\xi_t^p}$ captures the fiscal authority's attitude toward debt stabilization, which depends on the type of policy mix ξ_t^p in place at time t and the state of demand ξ_t^d.

3.2 Policy Regimes

The Markov-switching process ξ_t^p determines the policy mix *conditional* on the state of demand ξ_t^d. This exogenous variable captures the complex interplay between monetary and fiscal authority in reduced form. The fact that the state of demand is discrete makes it easier to condition the type of monetary and fiscal policies adopted, which is captured by ξ_t^p, on the state of demand, which is captured by ξ_t^d. Agents are rational and they understand that recessions and expansions affects the way in which the monetary and fiscal authorities coordinate their policy.[10]

When the state of the demand is high ($\xi_t^d = \bar{d}_h$), three possible policy mixes can arise depending on ξ_t^p. Policymakers can conduct a *monetary-led policy mix ($\xi_t^p = M$)*, with monetary policy geared toward inflation stabilization ($\psi_\pi = \psi_{\pi,M} > 1$) and fiscal policy aimed at adjusting primary surpluses to stabilize the debt-to-output ratio ($\delta_b = \delta_{b,M} > \beta^{-1} - 1$). When demand is high, policymakers can also follow a *fiscally-led policy mix ($\xi_t^p = F$)*, with the monetary authority that de-emphasizes inflation stabilization ($\psi_\pi = \psi_{\pi,F} \leq 1$) and the fiscal authority that disregards the level of debt ($\delta_b = \delta_{b,F} \leq \beta^{-1} - 1$). Finally, policymakers can conduct a *non-coordinated* (or *conflict*) *policy mix ($\xi_t^p = C$)*, with the monetary authority that is committed to stabilize inflation ($\psi_\pi = \psi_{\pi,C} > 1$) and the fiscal authority that disregards debt stabilization ($\delta_b = \delta_{b,C} \leq \beta^{-1} - 1$). As shown in the Fisherian model, the third policy mix leads to no stable Rational Expectations equilibria when considered in isolation. In this case, the government wants inflation to adjust to stabilize debt whereas the central bank does not want to let inflation go and adjusts aggressively the policy rate. Thus, this regime captures the possibility that the monetary and fiscal authorities go through a conflict over the determination of the rate of inflation.

When the state of demand is low ($\xi_t^d = \bar{d}_l$), we assume that the monetary authority de-emphasizes inflation stabilization and the government carries out a fiscal stimulus by momentarily disregarding the level of debt. Therefore, when the state of demand is low, the policy

[10]Leeper's results for the Fisherian model would apply to this New Keynesian model if the policy regimes were not allowed to change. With Markov-switching, the analysis of global stability of the system is more complicated. We will focus on parameterizations that ensure mean square stability of the model.

mix if fiscally led ($\psi_\pi = \psi_{\pi,F} \leq 1$ and $\delta_b = \delta_{b,F} \leq \beta^{-1} - 1$).

More formally, the joint dynamics of demand and policy regimes is captured by the following transition matrix Q:

$$Q = \begin{bmatrix} p_{hh}Q^H & (1-p_{ll}) \cdot Q^O \\ (1-p_{hh})\, Q^I & p_{ll} \cdot Q^L \end{bmatrix}$$

The columns of this matrix sum to one. The matrix Q^H controls the dynamics of policy regime ξ_t^p conditional on being in high state of demand; that is, whether the policy mix is monetary led, fiscally led, or a conflict between breaks out. Q^L is the transition matrix that governs the evolution of regimes during the large recession triggered by the discrete demand shock ξ_t^d. These regimes are all characterized by the fiscally-led policy mix. However, the regimes differ in terms of the policies that are likely to prevail once the negative preference shock is reabsorbed. These possible outcomes are captured by the transition matrix Q^O. The matrix Q^I controls the policy regime dynamics when the low state of demand materializes ($\xi_t^d = \bar{d}_l$).

This modelling framework captures rational agents' uncertainty about the response of policymakers to the potentially large accumulation of debt that occurs in response to a large contractionary shock. As we shall see, agents' beliefs about what will happen after a large recession are critical in shaping macroeconomic dynamics during the recession. These beliefs are captured by the matrix Q^O. The Gaussian shocks ($\varepsilon_{d,t}$, $\varepsilon_{a,t}$, $\varepsilon_{g,t}$,$\varepsilon_{tr,t}$) are assumed to be small and, hence, recessions caused by these shocks are assumed not to give rise to relevant fiscal strains.

3.3 Monetary and Fiscal Policy Coordination

We contemplate scenarios in which agents expect that the fiscal authority can disregard the level of debt (active fiscal policy) while the central bank remains committed to stabilize inflation (active monetary policy). We call this active monetary/active fiscal policy non-coordinated because it is inconsistent with uniquely determining the rate of inflation. In fact, if this policy mix were followed forever, Leeper (1991) shows that there is no stable rational expectations equilibria. To see why, suppose that inflation is above target and that the Federal Reserve tries to push it down by increasing the federal funds rate more than one-to-one in response to the observed deviation. This action prompts an increase in the real interest rate, a contraction in output and consequently an acceleration in the rise of the debt-to-output ratio. This acceleration in the dynamic of the debt-to-ratio ratio would require an increase in taxation, but agents know that this is not going to happen because the fiscal authority is active. Therefore, the adjustment has to come through an increase in inflation that triggers an even larger increase in the interest rate and so on. Clearly, the economy is on an explosive path, and if this situation were to persist, no *stationary* solution exists. However, if the conflict (AM/AF)

Parameter	Value	Parameter	Value
$\psi_{\pi,M}$	1.7890	p_{hh}	0.9999
$\psi_{y,M}$	0.4413	p_{ll}	0.9465
$\rho_{R,M}$	0.8697	p_{MM}	0.9902
$\delta_{b,M}$	0.0778	p_{FF}	0.9932
$\rho_{\tau,M}$	0.9666	p_{CC}	0.9000
$\psi_{\pi,F}$	0.6903	δ_y	0.2814
$\psi_{y,F}$	0.2655	ϕ_y	-2.0000
$\rho_{R,F}$	0.6576	ρ_{tr}	0.4620
$\delta_{b,F}$	0.0000	$\overline{d}_h$	0.0429
$\rho_{\tau,F}$	0.6501	$\overline{d}_l$	-0.1500
$\psi_{\pi,C}$	2.0000	κ	0.0072
$\psi_{y,C}$	0.0000	$\hat{b}_0/4$	0.7700
$\delta_{b,C}$	0.0000	$100 \ln \gamma$	0.4120
$\rho_{R,C}$	0.0000	$100 \ln \Pi$	0.5000
$\rho_{\tau,C}$	0.6501	$100 \ln R$	1.0628

Table 1: Parameter choices of the DSGE parameters and of the transition matrix elements.

regime is expected to eventually end, the model can still admit a stable and unique Rational Expectations equilibrium. As we shall see, the properties of this equilibrium are determined by which authority agents expect to eventually give up and to switch to passive policy. We refer to this type of policy mix as non-coordinated in the sense that policymakers fail to explain how they will resolve the problem of keeping debt on a stable path.

4 The Effects of Lack of Policy Coordination

Table 1 shows the parameter values used in this paper. We denote the probability of staying in the monetary-led, fiscally-led, and conflict policy mix as p_{MM}, p_{FF}, and p_{CC}, respectively. These parameter values and transition probabilities are obtained from previous estimation of the model in Bianchi and Melosi (2016). Nonetheless, the magnitude of the negative demand shock is three times smaller than the shock that caused the Great Recession based on the estimates of that paper. We set the value of the negative demand shock to be smaller in order to avoid the issue of the zero lower bound constraint for the nominal interest rate. This addition would strengthen the results of the paper but at the costs of making the exposition of the key mechanisms unnecessarily more complicated. We will consider what happens when the zero lower bound binds later in the paper. We assume that during the conflict the central bank responds even more strongly to inflation than in the monetary-led case ($\psi_{\pi,C} = 2.0 > \psi_{\pi,M}$). Furthermore, the central bank is totally focused on controlling inflation and completely disregards the level of real activity $\psi_{y,C} = 0$. In all the exercises that we analyze, the initial debt-to-GDP ratio ($\hat{b}_0$)

is calibrated to 77.0% on annualized basis, which reflects the value of the U.S. debt at the end of 2016.

The probability that a large recession hits in every high-demand period is very tiny, since the probability p_{hh} is very close to one. While this parameterization is certainly extreme, it simplifies the analysis substantially by implying that once the economy exits the recession, the coordinated policy mix (i.e., the monetary-led and the fiscally-led policy mix) is expected to prevail for a prolonged period of time and agents attach little probability to a further contractionary shock.

In this section, we use the calibrated model to run some experiments to study situations in which agents lose their trust in the government's commitment to take the necessary fiscal adjustment to stabilize debt. Apart from the initial debt-to-output ratio, which is above its steady state level, we assume that the economy is at steady state when is hit by a negative discrete demand shock that triggers a large recession. Policymakers adopt a fiscally-led policy mix in an attempt to carry out an effective fiscal stimulus. The debt-to-output ratio increases and agents expect one of the following post-recession outcomes: (i) the government is committed to take the necessary fiscal adjustments to stabilize the growing debt-to-output ratio (monetary-led policy mix); (ii) the government is not committed to stabilize the post-recession debt and the central bank is expected to accommodate the government by de-emphasizing inflation stabilization (fiscally-led policy mix); (iii) the government is not committed to stabilize the post-recession debt and the central bank is expected to fight back against fiscal policy in an attempt to stabilizing inflation. This institutional conflict lasts only temporarily and agents form expectations about which authorities will eventually emerge victorious from the conflict. If agents expect that the fiscally-led (monetary-led) policy mix will be adopted following the conflict, we say that the fiscal (monetary) authority wins the fight for controlling the rate of inflation. To simplify the exposition of the results, we assume that these agents' beliefs turn out to be correct.

These four possible post-recession scenarios ($\xi_t^p = M$, $\xi_t^p = F$, $\xi_t^p = C$ and the fiscal authority is expected to win, and $\xi_t^p = C$ and the monetary authority is expected to win) are modeled by introducing eight regimes. The first two regimes capture the coordinated policy mixes under the high state of demand. The third and fourth regimes are conflict regimes that differ in their probability of moving to the monetary-led as the conflict ends. The third regime is assumed to lead to the monetary-led policy mix, whereas the fourth regime is assumed to lead to the fiscally-led policy mix. During the recession, there are four fiscally-led regimes that differ in the probability of moving to the four high-demand policy combinations. Therefore, the evolution of these eight regimes is captured by the following transition matrix for regimes

(ξ_t^d,ξ_t^p):

$$Q = \begin{bmatrix} p_{hh}Q^H & (1-p_{ll})\cdot I_4 \\ (1-p_{hh})\, 0.25\cdot \mathbf{1}_{4\times 4} & p_{ll}\cdot I_4 \end{bmatrix},$$

where $\mathbf{1}_{4\times 4}$ is a 4×4 matrix of ones, I_n denotes the $n\times n$ identity matrix, and the dynamics of policy regimes when the recession is over (or more precisely, when the state of demand is high $\xi_t^d = \bar{d}_h$) is given by

$$Q^H = \left[\begin{array}{cc|cc} p_{MM} & 1-p_{FF} & 1-p_{CC} & 0 \\ 1-p_{MM} & p_{FF} & 0 & 1-p_{CC} \\ \hline 0 & 0 & p_{CC} & 0 \\ 0 & 0 & 0 & p_{CC} \end{array}\right].$$

Agents take into account the possibility of large recessions and the consequent changes in policy makers' behavior.

4.1 Macroeconomic Dynamics with Lack of Coordination

Figure 3 shows the macroeconomic dynamics of the output gap, inflation, the federal funds rate, and debt-to-GDP ratio under the following sequence of events. At time $t = 0$, the economy is at its ergodic steady state and the (annualized) debt-to-GDP ratio is 77.0%. At time $t = 1$ the economy is hit by the negative demand shock until time $t = 10$ ($\xi_t^d = \bar{d}_l$ for $1 \leq t \leq 10$). From period $t = 11$ through period $t = 30$, the economy switches back to the high state of demand. We consider two cases. First, during the low-state of demand, agents expect that policymakers will conduct a fiscally-led policy mix (coordination) once the recession is over. This case is captured by the blue dashed line. Second, during the low-state of demand, agents expect that policymakers will compete for the control over inflation once the recession is over. We assume that agents expect that the fiscal authority will eventually prevail. In other words, when the conflict will be over, the central bank is expected to change policy and the fiscal and monetary policy mix becomes fiscally-led. This second case is captured by the blue solid line.

We assume that the fight regime lasts for ten quarters and then the fiscally-led policy mix will stay in place from period 21 through period 30. The period of conflict between the two authorities is highlighted by the red area in Figure 3. Agents do not know ex-ante the exact duration of the recession (grey area), how many periods the post-recession institutional conflict will last (red area), and how long the high state of demand will persists (red area and white area). However, agents observe the regime in place and know their likely durations.

Conflict and Fiscally-led resolution. When agents expect an institutional conflict followed by the fiscally-led policy mix, agents largely anticipate that the large and growing

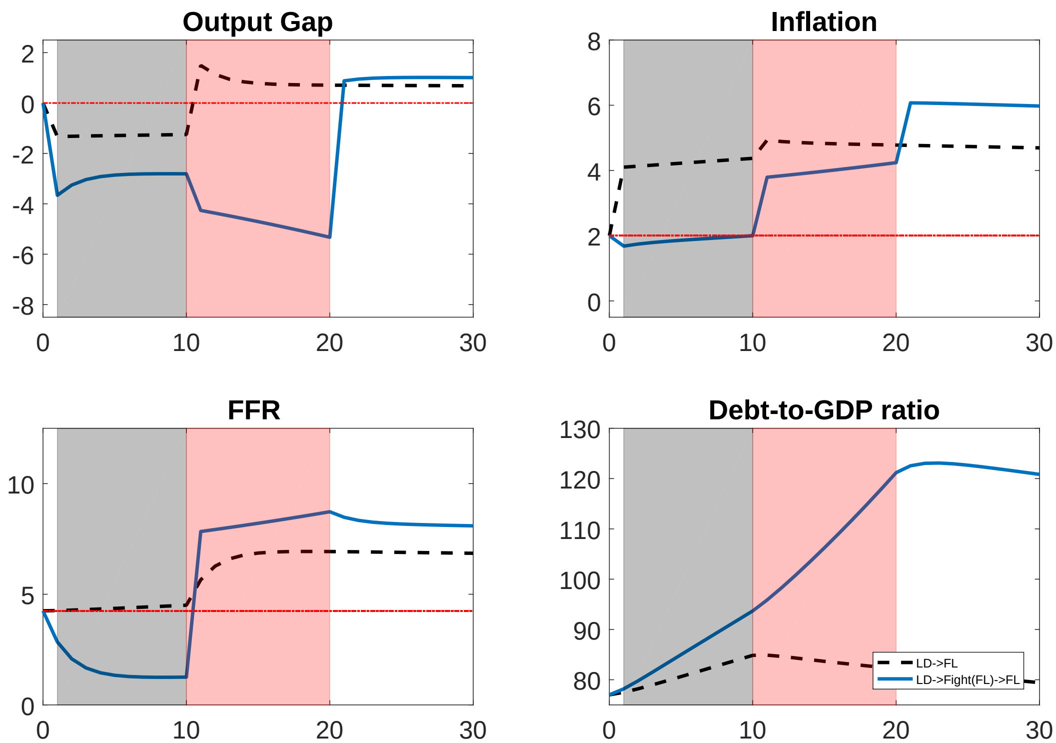

Figure 3: Dynamics of the output gap, inflation, the federal funds rate (FFR), and the debt-to-GDP ratio when a negative discrete demand shock occurs in period 1 and persists until period 10 (grey area). The discrete demand shock switches back to high from period 11 through 30. The black dashed line captures the macroeconomic dynamics when agents expect that policymakers will coordinate to follow the fiscally-led policy mix once the discrete demand shock switches back to high. The blue dashed line captures the situation when agents expect a conflict between the two authorities to break out right after the end of the low demand shock period. The conflict is assumed to last until period 20 (red area) and agents expect that the fiscal authority will win; that is, the policymakers will engage in fiscally-led policies from period 21 on. Initial debt is set to 77 percent.

stock of debt will be inflated away. Hence, inflation expectations and inflation rise. During the conflict period ($11 \leq t \leq 20$) the central bank applies the Taylor principle to rein in these inflationary pressures. This monetary policy gives rise to two main effects. On the one hand, the aggressive monetary tightening conducted during the conflict raises the debt service costs and, in doing so, exacerbates the fiscal imbalance. This, in turn, strengthens the inflationary pressures because agents expect the government to keep disregarding debt for a long time. But higher inflation calls for further monetary tightening that ends up further deteriorating the fiscal imbalance. Therefore, when agents expect a conflict between policymakers, a vicious spiral of higher debt, higher inflation, higher interest rate, higher debt arises. On the other hand, the hawkish monetary policy raises the real rate during the conflict and, consequently, leads to a double-dip recession. It should be noticed that the second recession is entirely due to policymakers' behaviors because from period $t = 11$ on the discrete demand shock has switched back to the high state. Interestingly, the dynamics of the four variables depicted in Figure 3 are temporarily explosive during the conflict period (red regions). During the recession period from time 1 through time 10, forward-looking and rational agents anticipate the macroeconomic dynamics that will occur during the conflict. Therefore, expecting an institutional conflict causes the economic crisis to be more severe and gives rise to upward pressures on inflation during the recession period (grey area).

What is very concerning is that during the institutional conflict (red area), the central bank is incapable of reining in inflation. The monetary authority follows the Taylor principle and raises the interest rate aggressively to lower inflation. Nonetheless, inflation keeps growing. The lesson we learn is that when the central bank lacks the necessary fiscal backing, hawkish monetary policy is not only ineffective, but also counterproductive, leading to a spiral of low output and high inflation. The explosive dynamics of the interest rate and inflation during the institutional conflict can make the Federal Reserve an easy target for the media that could question the central bank's ability of controlling inflation and the soundness of the implemented policies.

If agents expect that policymakers will coordinate on the fiscally-led policy mix as the recession is over, the large stock of debt gives rises to heightened and persistent inflation. Since heightened inflation expectations reduce the real value of debt, debt-to-GDP ratio grows only moderately during the recession. Furthermore, the dovish monetary policy keeps the real interest rate low, which contributes to mitigating the severity of the recession and leads to an economic boom when the discrete demand shock becomes positive again ($t \geq 11$).

The outcomes of both the coordinated and the uncoordinated strategies are clearly far from being desirable. While the coordinated strategy clearly dominates the non-coordinated both in terms of output stabilization and in terms of achieving a lower inflation rate, in both cases policymakers miss their objective of keeping inflation low. The vertical difference between the solid line and the dashed line in Figure 3 captures the effects of expecting a conflict followed by the fiscally-led policy mix on the macroeconomy. These effects are fairly large. The recession is more severe and prolonged and the larger stock of debt pushes inflation on higher path.

Conflict and Monetary-led resolution. Figure 4 compares two scenarios in which agents expect that a conflict between the two authorities will arise after the recession. In one case, agents expect that the fiscal authority will win (the solid blue line) and in the other case, agents expect that the monetary authority will succeed (black dotted line). The former case has been discussed earlier and is reproduced in the graph for comparison. In the latter case, the fiscal stimulus is ineffective to boost the economy during the recession and the economy goes through a large output contraction and deflation for the periods the state of the demand remains low. Inflation goes back on target once the demand shock switches back to high state. Nonetheless, the central bank tries to fight the persistent inflation that arises after the recession and, in

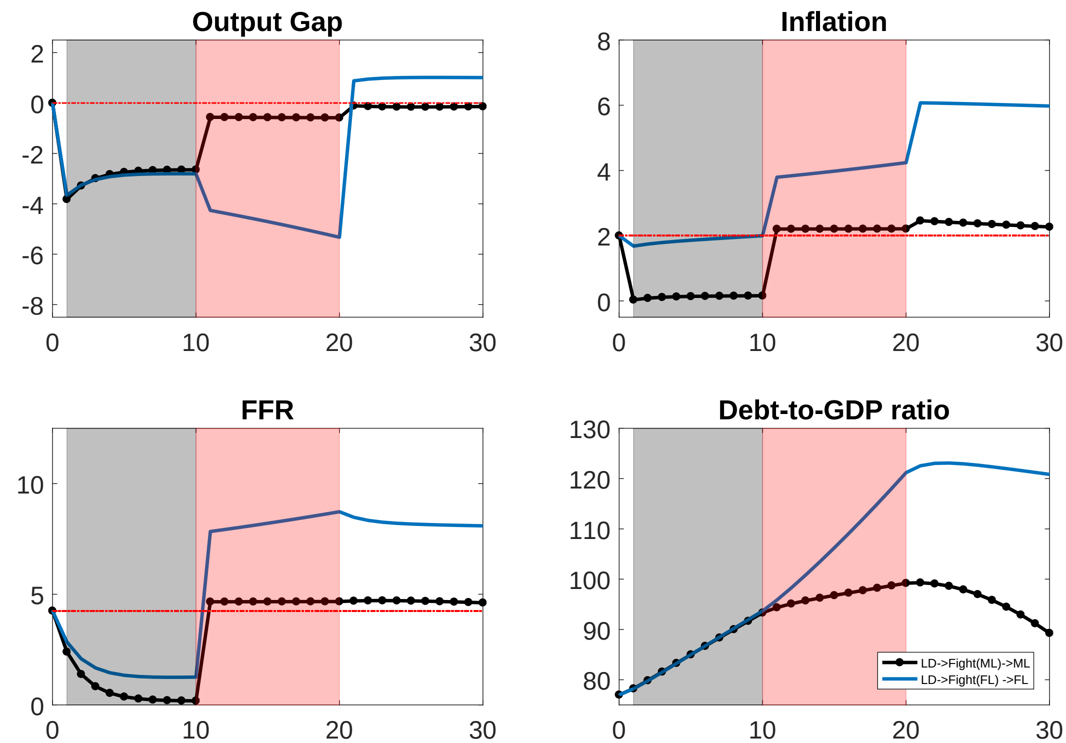

Figure 4: Dynamics of the output gap, inflation, the federal funds rate (FFR), and the debt-to-GDP ratio when a negative discrete demand shock occurs in period 1 and persists until period 10 (grey area). The discrete demand shock switches back to high from period 11 through 30. Agents expect a conflict between the two authorities following the end of the low demand shock period. The conflict is assumed to last until period 20 and is highlighted by the red area. The blue solid line captures the case in which agents expect that the fiscal authority will win the conflict and hence the policy mix is expected to be fiscally-led after the conflict. The black dotted line captures the case in which the monetary authority is expected to prevail and hence the policy mix is expected be monetary-led after the conflict period. Initial debt is set to 77 percent.

doing so, impairs the economic activity, with the output gap that remains in negative territory for the duration of the institutional conflict. Once the government gives up and switches to passive fiscal policy, economic activity improves but still remains in negative territory. This is because the central bank conducts an active policy and tries to rein in inflation that remains persistently above target. Inflation is slightly above target because of the large stock of debt accumulated during the recession and the institutional conflict. Since agents are aware of regime changes, they understand that the government can always renege on its commitment to stabilize the large stock of debt by raising taxes and move to the fiscally-led policy mix. However, the probability of this event is quite small probability: $1 - p_{MM} = 0.68\%$.[11] When the stock of debt is low, a low probability that the government will give up stabilizing debt does not raise inflation expectations significantly. Nonetheless, when the stock of debt is so

[11]Furthermore, agents take into account that should a large recession happens again, the policy mix will turn to fiscally led. The probability that the demand shock switches to the low state in every period is negligible.

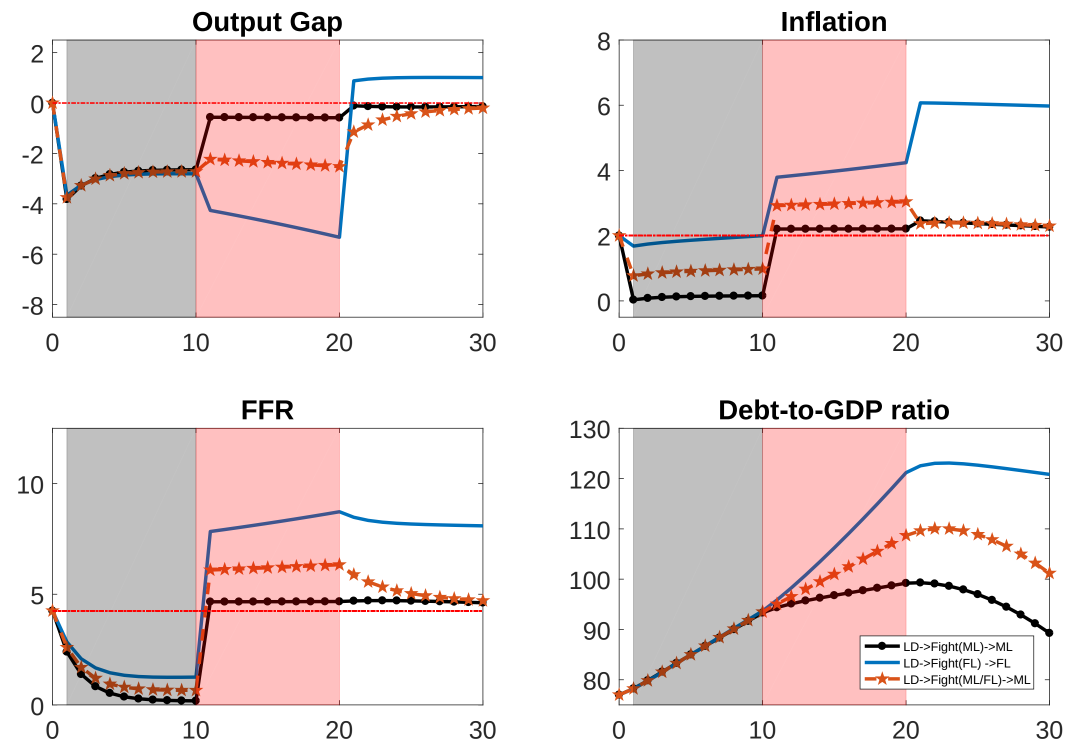

Figure 5: Dynamics of the output gap, inflation, the federal funds rate (FFR), and the debt-to-GDP ratio when a negative discrete demand shock occurs in period 1 and persists until period 10 (grey area). The discrete demand shock switches back to high from period 11 through 30. Agents expect a conflict between the two authorities following the end of the low demand shock period. The conflict is assumed to last until period 20 and is highlighted by the red area. The blue solid line captures the case in which agents expect that the fiscal authority will win the conflict and hence the policy mix is expected to be fiscally-led after the conflict. The black dotted line captures the case in which the monetary authority is expected to prevail and hence the policy mix is expected be monetary-led after the conflict period. The starred line captures the case in which agents expect that the monetary authority will prevail with 50 percent of probability. Initial debt is set to 77 percent.

high as in Figure 4, inflation remains above its steady-state value even though the probability that policymakers will engage in the fiscally led policy mix in the future is tiny. This is for two reasons. First, such a large stock of debt can be stabilized only over a long period of time and the probability that policymakers will switch to the fiscally led during this long period of time is not so small. Second, if the switch to fiscally-led policies happen when debt is high, the inflationary consequences will be very severe.

Conflict and uncertain resolution. Figure 5 shows the two extreme cases that we just analyzed, together with a scenario in which agents attach 50% of probability that the fiscal authority will win the conflict and 50% of probability that the monetary authority will succeed.[12] The vertical difference between the blue solid line and the black dotted line during

[12] This requires to add one additional conflict regime that has 50% of probability to move to the monetary-led regime and 50% to move to the fiscally led conditionally on the conflict to be resolved. Furthermore, we add an

the recession and the conflict period spans the set of possible outcomes. The exact outcomes depend on private sector's beliefs about which authority will eventually emerge victorious from the conflict. The set of possible outcomes is fairly large, including deflation and high inflation, severe recessions with the output gap plummeting to -5% and moderate economic contractions with the output gap falling to less than one percentage point. The bigger this set of beliefs-driven outcomes, the larger the degree of vulnerability of the economy to changes in private sector's beliefs when an institutional conflict is expected to arise after the recession. If beliefs about which authority will win the conflict move erratically, the macroeconomic volatility during the recession and the following conflict period may be quite large.

To summarize, if the government's commitment to take the necessary fiscal adjustments to stabilize a large stock of debt is questioned by the private sector, the central bank has two options. The central bank can accommodate these beliefs by abandoning its anti-inflationary stance or can fight back and reaffirms its commitment to keep inflation low and stable. In the former case, inflation increases substantially and remains persistently high during and after the recession. In the latter case, an institutional conflict is expected to happen after the recession and economic outcomes are largely driven by private sector's expectations about which authority will change its policy to end the conflict. We find that institutional conflicts lead inevitably to bad outcomes and are accompanied by large macroeconomic volatility. If the central bank is expected to lose the conflict by switching to passive policies, a vicious spiral of low output, high inflation, and high debt will arise during the conflict period, which exacerbates the economic crisis and raises inflation during the recession. Quite interestingly, the central bank raises the policy rate but fails to rein in inflation, which actually accelerates during the conflict period. If the central bank is expected to win the conflict, the economy experiences a deflation during the recession and a large stock of debt, as well as a persistently higher than target inflation after the recession.

In the next section, we study a coordinated strategy that can be implemented when markets lose confidence about the government's ability/willingness to stabilize debt through fiscal adjustments. This strategy commits the central bank to accept just enough higher inflation to stabilize *a prearranged portion of debt.* The government remains committed to take the necessary fiscal adjustments to guarantee long-run fiscal backing.

additional low-demand regime that leads to this new conflict regime once the demand turns back to the high regime. As before, conditional on the discrete demand shock to be negative, the probability of moving to one of the five low-demand regimes is the same (20%).

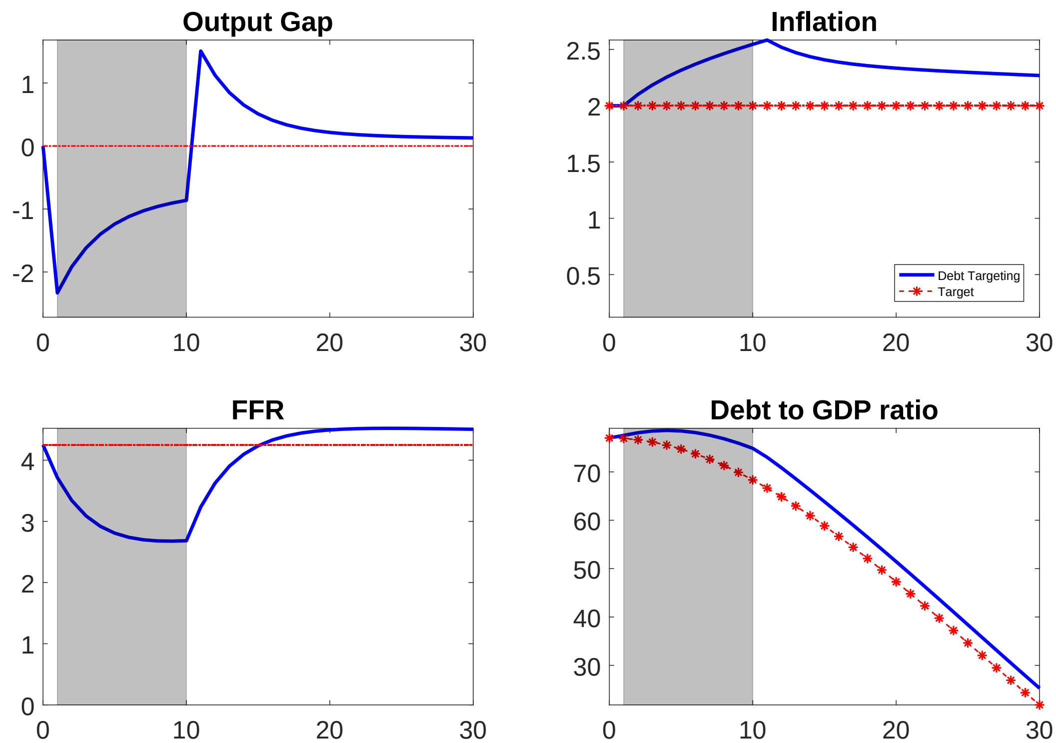

Figure 6: Dynamics of the output gap, inflation, federal funds rate (FFR), and debt-to-GDP ratio after a low state of demand that starts in period 1 and ends in period 10 (grey area). After the recession the state of demand switches to the high regime from period 11 through period 30. The blue solid line captures the dynamics when the inflation/debt targeting rule is implemented. The red starred line captures the dynamic targets for inflation and debt-to-GDP ratio. Initial debt is set to 77 percent.

5 Debt Targeting

In this section, we study the effects of a coordinated policy strategy in which policymakers commit to inflate away *only* the amount of debt resulting from the large preference shock. This coordinated policy strategy is reminiscent of the U.S. President Franklin Delano Roosevelt's decision of running two types of budget deficits to fight the dire consequences of the Great Depression: A "regular budget" that he committed to balance and an "emergency budget" that he did not clearly commit to balance.

5.1 General case

We modify the model and assume that policymakers behave according to the monetary-led policy mix all the time, except when responding to the discrete demand shock ξ_t^d. Specifically, we assume that the response of the nominal interest rate to inflation and of primary surpluses to debt are both zero *if* movements in these variables result from that large demand shock.

Policymakers respond to all other fluctuations driven by Gaussian shocks by following the monetary-led policy mix. As explained earlier, Gaussian shocks are assumed to be too small to raise fiscal strains that can fuel expectations that the government may be incapable to take the necessary fiscal adjustments to stabilize its debt. We also assume that policymakers will follow the monetary-led policy mix in response to fluctuations originated from the initial stock of debt; that is, the stock of debt existing when this coordinated strategy is introduced.

In order to implement this policy we construct a *shadow economy* to keep track of the amount of debt and inflation deriving from the discrete preference shock. If we denote debt and inflation of the shadow economy in which discrete preference shocks are shut down as b_t^{nd} and π_t^{nd}, we can write the linearized policy rules as follows:

$$\begin{aligned} \widetilde{s}_t &= \delta_b^M \widetilde{b}_{t-1}^{nd} + \delta_b^E \left(\widetilde{b}_{t-1} - \widetilde{b}_{t-1}^{nd} \right) + \dots \ , \\ \widetilde{R}_t &= (1-\rho_R) \left(\psi_\pi^M \widetilde{\pi}_t^{nd} + \psi_\pi^E \left(\widetilde{\pi}_t - \widetilde{\pi}_t^{nd} \right) \right) + \dots \ , \end{aligned}$$

where we assume $\delta_b^E = \psi_b^E = 0$.[13] This implies that future fiscal adjustments are not enough to stabilize the entire stock of debt $\widetilde{b}_{t-1}$, but only $\widetilde{b}_{t-1}^{nd}$: The amount $\widetilde{b}_{t-1} - \widetilde{b}_{t-1}^{nd}$ is going to be inflated away. At the same time, the central bank accommodates the resulting increase in inflation $\widetilde{\pi}_t - \widetilde{\pi}_t^{nd}$. This is the increase of inflation necessary to inflate away the additional amount of debt resulting from the recession induced by the negative discrete demand shock. The shadow economy is initialized by setting the initial stock of debt equal to the one in the actual economy. This implies that policymakers are committed to adopt the monetary-led policy mix in response to macroeconomic fluctuations owing to the large initial stock of debt.

The blue solid line in Figure 6 captures the macroeconomic implications of adopting the coordinated strategy. The red starred line shows the time-varying target for inflation and the debt-to-GDP ratio. These targets are the dynamics of inflation and debt-to-GDP ratio in the shadow economy. Contrary to the non-coordinated case, this coordinated strategy successfully raises inflation expectations during the recession by promising that the debt resulting from the economic downturn will be inflated away. Consequently, the real interest rate is lower and the drop in the output gap is mitigated compared to the cases where an institutional conflict is expected to break out after the recession. Given that the recession is contained, the above-target debt $\left(\widetilde{b}_t - \widetilde{b}_t^{nd} \right)$ grows only moderately. As a result, the amount of inflation necessary to stabilize the emergency budget is also quite low. As the debt-to-GDP slowly converges to its target, the price dynamics slow down and inflation gets closer to its two-percent target. Finally, it is important to emphasize that the dynamics of the output gap, inflation, and the nominal rate are totally unaffected by the pre-crisis size of the debt-to-GDP ratio, which will

[13] Appendix B explains more thoroughly how we model this coordinated policy strategy.

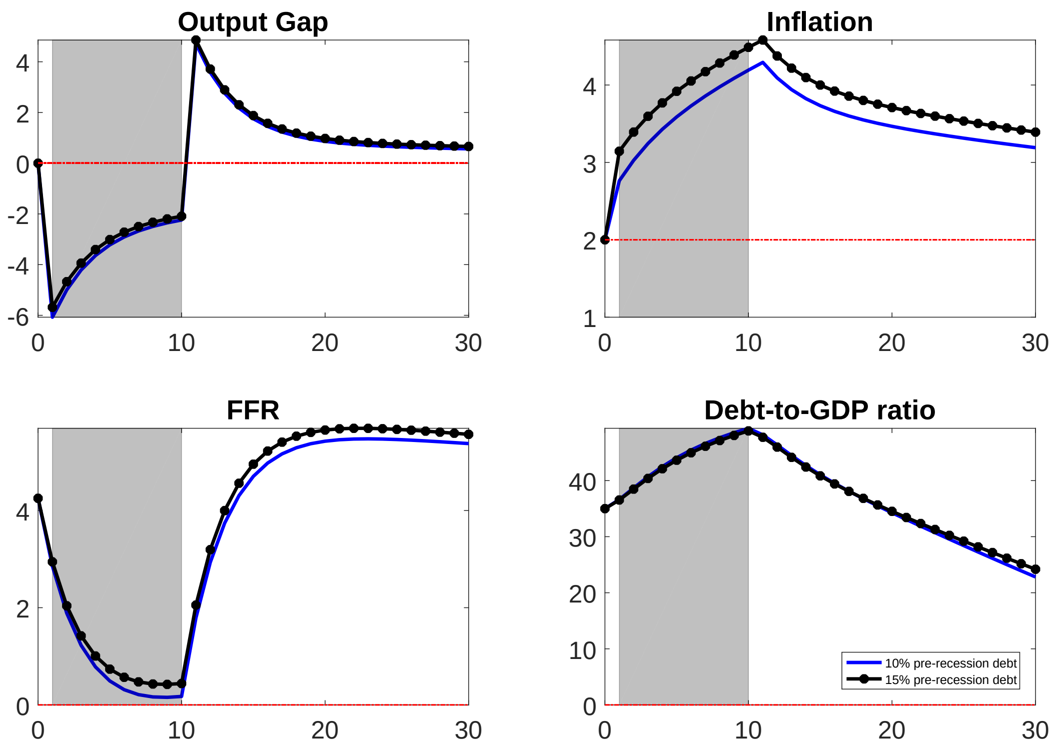

Figure 7: Dynamics of the output gap, inflation, federal funds rate (FFR), and debt-to-GDP ratio after a low state of demand that starts in period 1 and ends in period 10 (grey area). The magnitude of this shock is comparable to the demand shock that caused the Great Recession. After the recession the state of demand switches to the high regime from period 11 through period 30. The blue solid line captures the dynamics when the inflation/debt targeting rule is implemented. The red starred line captures the dynamic targets for inflation and debt-to-GDP ratio. Initial debt is set to 35 percent

be stabilized by taking the necessary fiscal measures.[14] This makes clear that the proposed policy separates the issue of long-run fiscal sustainability from the need of intervening during exceptional events.

5.2 Avoiding Liquidity Traps

The zero floor for nominal interest rates can be a significant constraint on the ability of a central bank to combat deflation. The commitment to inflate away *only* the amount of debt resulting from the large demand shock determines a sort of *automatic stabilizer* that can be very useful in this case. The large demand shock can potentially cause a deep recession and a corresponding large increase in debt. The expectation that this extra amount of debt is going to be inflated away determines an increase in inflation expectations and a corresponding drop in the real interest rate. This stimulates real economic activity, reducing the size of the output

[14]See Appendix C.

contraction. This mechanism can be strong enough to prevent the economy from hitting the zero lower bound. At the same time, agents understand that the increase in inflation is the result of a well-defined, exceptional contractionary event, which policymakers are not responsible for, while policy strategies to cope with business cycle disturbances are unchanged.

Figure 7 shows the dynamics of the output gap, inflation, federal funds rate, and debt-to-GDP ratio to a very large negative demand shock, which is calibrated to be as big as the one that caused the Great Recession based on estimates by Bianchi and Melosi (2016). We calibrate the initial debt to 35%, which was the debt-to-GDP ratio in the U.S. before the Great Recession according to CBO's estimates.[15] The blue solid line captures the macroeconomic dynamics when policymakers are not committed to stabilize 10 percentage points of the debt-to-GDP ratio along with the whole debt-to-GDP ratio resulting from the large recession.[16] This coordinated commitment allows the central bank to avoid the zero lower bound by raising inflation expectations. The more debt is pledged to be inflated away, the higher the rate of inflation, and the less severe the recession. The black dotted line shows the implications of announcing to inflating away 15 percentage point of the debt-to-GDP ratio on top of the debt that results from the large recession. Pledging to inflate away a larger fraction of debt-to-output ratio leads to higher inflation expectations, lower real interest rate, and, hence, less negative output gap and higher inflation.

Krugman (1998) and Eggertsson and Woodford (2003) suggest to use forward guidance when monetary policy is constrained by the zero lower bound. Forward guidance is an announcement about the likely future path for the policy rate. Krugman (1998) and Eggertsson and Woodford (2003) show that forward guidance can be used to promise inflation at the end of a large recession. In doing so, forward looking agents' inflation expectations fall less during the recession, lowering the real interest rate, which has the effect of mitigating the fall in output. Our coordinated strategy can be regarded as an alternative way to promise higher inflation after a large recession. The novelty of the proposed approach is to promise future inflation by targeting a portion of the existing debt-to-GDP ratio.

Our coordinated monetary and fiscal policy strategy is in line with the policies advocated by Sims (2016b) who suggests to replace ineffective monetary policies at the zero lower bound with an "effective fiscal policy". According to Sims, effective fiscal policy at the zero lower bound requires that both the monetary and the fiscal authorities clearly announce that fiscal accommodation will not be removed until inflation will attain a given inflation target. He has also argued that a commitment to generate inflation that involves the fiscal authority might also be more credible than one that only relies on the behavior of the monetary authority, given

[15]Changing the size of the initial debt-to-GDP ratio is inconsequential for the results that follow.

[16]This policy strategy can be implemented by setting the initial debt-to-output ratio in the shadow economy to be 90% of the actual debt-to-output ratio.

the time that it takes to revert fiscal decisions. We consider this as an interesting direction for future research.

6 Conclusions

This paper studies the implication of the lack of coordination between the monetary and fiscal policies. With lack of coordination we have in mind a situation in which both authorities are trying to control inflation. In the language of Leeper (1991), both polices are active. When agents expect that policymakers will not coordinate their policies after a large recession, two outcomes can arise. One possible outcome is that policymakers appear to be incapable of raising inflation expectations to rescue the economy from the recession. The other possible outcome is that inflation quickly grows out of control while the economy remains in recession. Which case will prevail depends on which policymaker is expected to change its policy to coordinate with the other.

We then consider a coordinated policy strategy that is capable of mitigating the recession by raising inflation expectations in an orderly manner. This strategy consists of a commitment to inflating away only the portion of debt that exceeds an announced target. This target is defined as the debt-to-output ratio that would have prevailed absent the large contractionary shock. In practice, an approximate measure of such debt-to-GDP ratio can be obtained by projecting the pre-recession stock of debt in the future. The central bank allows inflation to rise just the exact amount needed to inflate away the off-target debt. This strategy succeeds in mitigating deep recessions because it affects agents' beliefs about policymakers' *long-run* behavior in response to a specific large shock. In fact, policymakers are committing to *never* increase taxes in response to the amount of debt accumulated during deep recessions and, at the same time, not to fight the resulting increase in inflation. This policy triggers an increase in *short-run* inflation expectations and an immediate increase in inflation as large demand shocks hit the economy. This coordinated strategy can be used to promise inflation after a severe recession so as to avoid hitting the zero lower bound for the nominal interest rate. Finally, the proposed strategy has the virtue of clearly separating short-run policy interventions from the issue of long-run fiscal sustainability.

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Appendix

A A Simple Model of Government debt

Steady state Let us assume that the real surplus in steady state is given by $\tau_* = b_*^\gamma$, then the steady state can be derived as follows:

$$
\begin{aligned}
i_* &= r_* \Pi_* && (30)\\
\tau_t + i_t^{-1} b_t &= \frac{b_{t-1}}{\Pi_t} \\
\tau_* + i_*^{-1} b_* &= \frac{b_*}{\Pi_*} \\
\tau_* &= \left[\frac{1}{\Pi_*} - \frac{1}{i_*}\right] b_* && (31)\\
b_* &= \tau_* \left[\frac{1}{\Pi_*} - \frac{1}{i_*}\right]^{-1} \\
b_* &= \tau_* \left[1 - \frac{\Pi_*}{i_*}\right]^{-1} \Pi_* && (32)\\
b_* &= \tau_* \frac{r_*}{r_* - 1} \Pi_* && (33)\\
\frac{b_*}{\Pi_*} &= \frac{r_*}{r_* - 1} \tau_* && (34)
\end{aligned}
$$

Notice that inflation or real government debt cannot be separately pinned down.

Model Solution Under Fiscal Dominance If $\phi \leq 1$ and $\gamma < 1$ (PM/AF), the system of equations (16) has one explosive eigenvalues associated with the fiscal equation. Unlike the previous case, inflation expectations directly affect the dynamics of real debt as the autoregressive matrix in equation (16) is lower triangular. This implies that the unique stable REE does not necessarily imply that $\hat{b}_t = 0$ at all times t. In fact, debt dynamics is made stable by the action of inflation expectations.

To find the stable REE, we take the Jordan decomposition of the autoregressive matrix[17] of the dynamic system (16) and define the vector

---

[17] $\begin{bmatrix} \phi & 0 \\ b\left(\phi - \beta^{-1}\right) & \beta^{-1} - \gamma \end{bmatrix} =$

$$\begin{bmatrix} \frac{1}{b\phi - b\beta^{-1}} \left(\gamma - \beta^{-1} + \phi\right) & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} \phi & 0 \\ 0 & r - \gamma \end{bmatrix} \begin{bmatrix} b\frac{\phi}{\gamma - \beta^{-1} + \phi} - b\frac{\beta^{-1}}{\gamma - \beta^{-1} + \phi} & 0 \\ b\frac{\beta^{-1}}{\gamma - \beta^{-1} + \phi} - b\frac{\phi}{\gamma - \beta^{-1} + \phi} & 1 \end{bmatrix}$$

$$\begin{bmatrix} p_t \\ \beta_t \end{bmatrix} \equiv \begin{bmatrix} \frac{b}{\gamma-\beta^{-1}+\phi}\left(\phi-\beta^{-1}\right) & 0 \\ \frac{b}{\gamma-\beta^{-1}+\phi}\left(\beta^{-1}-\phi\right) & 1 \end{bmatrix} \begin{bmatrix} E_t\tilde{\pi}_{t+1} \\ \hat{b}_t \end{bmatrix}.$$

The system (16) can then be equivalently written as

$$\begin{aligned} \begin{bmatrix} p_t \\ \beta_t \end{bmatrix} &= \begin{bmatrix} \phi & 0 \\ 0 & \beta^{-1}-\gamma \end{bmatrix} \begin{bmatrix} p_{t-1} \\ \beta_{t-1} \end{bmatrix} \\ &+ \begin{bmatrix} \frac{b}{\beta\left(\gamma+\phi-\frac{1}{\beta}\right)} - b\frac{\phi}{\gamma+\phi-\frac{1}{\beta}} & 0 & b\frac{\phi}{\gamma+\phi-\frac{1}{\beta}} - \frac{b}{\beta\left(\gamma+\phi-\frac{1}{\beta}\right)} \\ b\frac{\phi}{\gamma+\phi-\frac{1}{\beta}} - \frac{b}{\beta\left(\gamma+\phi-\frac{1}{\beta}\right)} & -1 & b + \frac{b}{\beta\left(\gamma+\phi-\frac{1}{\beta}\right)} - b\frac{\phi}{\gamma+\phi-\frac{1}{\beta}} \end{bmatrix} \begin{bmatrix} \varepsilon_t^r \\ \varepsilon_t^\tau \\ \varepsilon_t^m \end{bmatrix} \\ &+ \begin{bmatrix} -\phi\left(\frac{b}{\beta\left(\gamma+\phi-\frac{1}{\beta}\right)} - b\frac{\phi}{\gamma+\phi-\frac{1}{\beta}}\right) \\ \phi\left(\frac{b}{\beta\left(\gamma+\phi-\frac{1}{\beta}\right)} - b\frac{\phi}{\gamma+\phi-\frac{1}{\beta}}\right) + b\left(\phi-\frac{1}{\beta}\right) \end{bmatrix} \eta_t. \end{aligned} \tag{35}$$

Now the laws of motion for p_t and β_t are disjoint equations (one stable and one unstable) and hence for stability we need to impose $\beta_t = 0$ at all times. Inflation expectations move so as to keep real debt on stable path. The exact link between these two endogenous variables can be obtained by the following equation

$$\beta_t \equiv \begin{bmatrix} \frac{b}{\gamma-\beta^{-1}+\phi}\left(\beta^{-1}-\phi\right) & 1 \end{bmatrix} \begin{bmatrix} E_t\tilde{\pi}_{t+1} \\ \hat{b}_t \end{bmatrix} \overset{!}{=} 0 \tag{36}$$

which implies equation (18) in the main text.

Assuming $\gamma - \beta^{-1} + \phi \neq 0$, then the following holds true

$$E_t\tilde{\pi}_{t+1} = \frac{\gamma-\beta^{-1}+\phi}{b\left(\phi-\beta^{-1}\right)}\hat{b}_t \tag{37}$$

Now that we know the law of motion for inflation expectations we can use the monetary-block equation (14) to work out the law of motion for inflation, which is

$$\tilde{\pi}_t = \phi^{-1}\frac{\gamma-\beta^{-1}+\phi}{b\left(\phi-\beta^{-1}\right)}\hat{b}_t + \phi^{-1}\varepsilon_t^r - \phi^{-1}\varepsilon_t^m. \tag{38}$$

Combining this equation with equation (15) yields:

$$\tilde{\pi}_t = \underbrace{\frac{\gamma-\beta^{-1}+\phi}{b\left(\phi-\beta^{-1}\right)}}_{\xi}\hat{b}_{t-1} - \frac{\xi}{\beta^{-1}-\gamma}\varepsilon_t^\tau + \left[\beta^{-1}-\gamma\right]^{-1}\varepsilon_t^r - \left[\beta^{-1}-\gamma\right]^{-1}\left[1-\xi b_*\right]\varepsilon_t^m. \tag{39}$$

Analogously, combining the law of motion for inflation with the fiscal block equation (15) we obtain

$$\hat{b}_t = \left[\left(\beta^{-1}-\gamma\right)+b_*\left(\phi-\beta^{-1}\right)\xi\right]\hat{b}_{t-1}+b_*\left(\phi-\beta^{-1}\right)\left[-\gamma+\beta^{-1}\right]^{-1}\varepsilon_t^r + \quad (40)$$

$$-\left[1+\frac{\xi b_*\left(\phi-\beta^{-1}\right)}{\left[-\gamma+\beta^{-1}\right]}\right]\varepsilon_t^\tau + b_*\left[1-\left(\phi-\beta^{-1}\right)\left[-\gamma+\beta^{-1}\right]^{-1}\left[1-\xi b_*\right]\right]\varepsilon_t^m. \quad (41)$$

Note that

$$\left[\left(\beta^{-1}-\gamma\right)+b_*\left(\phi-\beta^{-1}\right)\xi\right]=\phi$$

$$\begin{aligned}\left[1+\frac{\xi b_*\left(\phi-\beta^{-1}\right)}{\left[-\gamma+\beta^{-1}\right]}\right] &= \left[1+\frac{\gamma-\beta^{-1}+\phi}{\left[-\gamma+\beta^{-1}\right]}\right]\\ &= \left[\frac{\phi}{-\gamma+\beta^{-1}}\right]\end{aligned}$$

Therefore,

$$\begin{aligned}\hat{b}_t &= \phi\hat{b}_{t-1}-\frac{b_*\left(\beta^{-1}-\phi\right)}{\beta^{-1}-\gamma}\varepsilon_t^r + \quad (42)\\ &\quad -\left[\frac{\phi}{-\gamma+\beta^{-1}}\right]\varepsilon_t^\tau + b_*\left[1-\left(\phi-\beta^{-1}\right)\left[-\gamma+\beta^{-1}\right]^{-1}\left[1-\xi b_*\right]\right]\varepsilon_t^m.\end{aligned}$$

The system of linear equations (39)-(42) can be written in matricial form as follows:

$$\begin{bmatrix}\hat{\pi}_t\\ \hat{b}_t\end{bmatrix} = \begin{bmatrix}0 & \xi\\ 0 & \phi\end{bmatrix}\begin{bmatrix}\hat{\pi}_{t-1}\\ \hat{b}_{t-1}\end{bmatrix}$$

$$+\begin{bmatrix}\frac{1}{\beta^{-1}-\gamma} & -\frac{\xi}{-\gamma+\beta^{-1}} & -\left[-\gamma+\beta^{-1}\right]^{-1}\left[1-\xi b_*\right]\\ -\frac{b_*\left(\beta^{-1}-\phi\right)}{\beta^{-1}-\gamma} & -\left[\frac{\phi}{-\gamma+\beta^{-1}}\right] & b_*\left[1-\left(\phi-\beta^{-1}\right)\left[-\gamma+\beta^{-1}\right]^{-1}\left[1-\xi b_*\right]\right]\end{bmatrix}\begin{bmatrix}\varepsilon_t^r\\ \varepsilon_t^\tau\\ \varepsilon_t^m\end{bmatrix}$$

A.1 Log-linearization of the DSGE model

The Markov-switching process for d_t represents a non-Gaussian shock. In order to log-linearize the model, we follow these steps (see Schorfheide 2005; Liu, Waggoner, and Zha 2011; Bianchi and Ilut 2014; and Bianchi, Ilut, and Schneider 2014 for more details):

1. Compute the ergodic mean $\overline{d}$ for the preference shock d_t.

2. Verify that the zero lower bound is not binding at $\overline{d}$.

3. Define the regimes in terms of policymakers' behavior and the value for the preference shock: $\xi_t \equiv \left(\xi_t^d, \xi_t^p\right)$.

4. Conditional on each regime, linearize/log-linearize all equations around the deterministic steady state and define deviations of the preference shock from its ergodic mean as $\widetilde{d}_t = d_t - \overline{d}$ and $\widetilde{\overline{d}}_{\xi_t^d} = \overline{d}_{\xi_t^d} - \overline{d}$. Notice that $\widetilde{d}_t$ can assume only two values $\widetilde{\overline{d}}_h$ and $\widetilde{\overline{d}}_l$ and that the non-linearity associated to a regime change is retained.

5. Use the methods developed by Farmer et al. (2009) to solve the model. The solution algorithm returns a MS-VAR whose parameters depend on the probability of moving across regimes H, the structural parameters θ, and the current state ξ_t:

$$Z_t = c\left(\xi_t, H, \theta\right) + T\left(\xi_t, H, \theta\right) Z_{t-1} + R\left(\xi_t, H, \theta\right) Q\varepsilon_t$$

   where Q is a diagonal matrix that contains the standard deviations of the structural shocks and Z_t is a vector with all variables of the model.

Unlike other papers that have used the technique described here, our model allows for non-orthogonality between policymakers' behavior and a discrete shock. This allows us to solve a model in which agents take into account that a large preference shock leads to an immediate change in policy, the zero lower bound, and, potentially, to further changes. This proposed method is general and can be applied to other cases in which a shock induces a change in the structural parameters.

B Shock-Specific Policy Rules

In this appendix, we detail the DSGE model used to perform the analysis of Section 5, in which policymakers do not respond to movements in debt deriving from the discrete preference shocks ξ_t^d. This DSGE model can be expressed as follows:

THE ACTUAL ECONOMY:

$$\widetilde{\pi}_t = \beta E_t(\widetilde{\pi}_{t+1}) + \kappa(\widetilde{y}_t - z_t), \tag{43}$$

$$\widetilde{y}_t = E_t\left(\widetilde{y}_{t+1}\right) - \left(\widetilde{R}_t - E_t\left(\widetilde{y}_{t+1}\right)\right) + \widetilde{d}_t - \mathbf{E}_t\left(\widetilde{d}_{t+1}\right), \tag{44}$$

$$\widetilde{b}_t = \beta^{-1}\widetilde{b}_{t-1} + b\beta^{-1}\left(\widetilde{R}_{t-1} - \widetilde{\pi}_t - \Delta\widetilde{y}_t\right) - \widetilde{s}_t, \tag{45}$$

$$\widetilde{s}_t = \delta_b^M b_{t-1}^{nd} + \delta_b^E\left(b_{t-1} - b_{t-1}^{nd}\right) + \delta_y\left(\widetilde{y}_t - z_t\right) + x_t, \tag{46}$$

$$\widetilde{R}_t = \rho_R\widetilde{R}_{t-1} + (1-\rho_R)\left(\psi_\pi^M \pi_t^{nd} + \psi_\pi^E\left(\pi_t - \pi_t^{nd}\right) + \psi_y\left[\widetilde{y}_t - z_t\right]\right). \tag{47}$$

THE SHADOW ECONOMY

$$\widetilde{\pi}_t^{nd} = \beta E_t(\widetilde{\pi}_{t+1}^{nd}) + \kappa(\widetilde{y}_t^{nd} - z_t), \tag{48}$$
$$\widetilde{y}_t^{nd} = E_t\left(\widetilde{y}_{t+1}^{nd}\right) - \left(\widetilde{R}_t^{nd} - E_t\left(\widetilde{y}_{t+1}^{nd}\right)\right), \tag{49}$$

$$\widetilde{b}_t^{nd} = \beta^{-1}\widetilde{b}_{t-1}^{nd} + b\beta^{-1}\left(\widetilde{R}_{t-1}^{nd} - \widetilde{\pi}_t^{nd} - \Delta\widetilde{y}_t^{nd}\right) - \widetilde{s}_t^{nd}, \tag{50}$$

$$\widetilde{s}_t^{nd} = \delta_b^{nd}\widetilde{b}_{t-1}^{nd} + \delta_y\left(\widetilde{y}_t^{nd} - z_t\right) + x_t, \tag{51}$$

$$\widetilde{R}_t^{nd} = \rho_R\widetilde{R}_{t-1}^{nd} + (1-\rho_R)\left(\psi_\pi^{nd}\widetilde{\pi}_t^{nd} + \psi_y\left[\widetilde{y}_t^{nd} - z_t\right]\right). \tag{52}$$

EXOGENOUS PROCESSES

$$\widetilde{d}_t = \widetilde{\overline{d}}_{\xi_t^d}, \tag{53}$$

$$z_t = \rho_z z_{t-1} + \sigma_z\varepsilon_{z,t}, \tag{54}$$

$$x_t = \rho_x x_{t-1} + \sigma_x\varepsilon_{x,t}. \tag{55}$$

It should be noted that the equations governing the behavior of the shadow economy (48)-(52) differ from those of the actual economy (43)-(47) in only one dimension: While the actual economy is buffeted by all types of shocks (i.e., ξ_t^d, $\varepsilon_{r,t}$, $\varepsilon_{z,t}$, and $\varepsilon_{x,t}$), the shadow economy is not hit by the discrete preference shock ξ_t^d. The equations of the shadow economy work as a device to keep track of the changes in the policy targets (i.e., the stock of debt b_{t-1}^{nd} and the rate of inflation π_t^{nd}) in equations (46) and (47). Finally, it is important to point out that equations (43)-(55) constitute a system of linear rational expectations equations with fixed coefficients that can be easily solved using one of the many solvers available (e.g., *Gensys* by Sims 2002).

C Higher Initial Debt-to-Output Ratio

Figure 8 shows the dynamics of the output gap, inflation, the federal funds rate, and the debt-to-GDP ratio when the coordinated strategy of inflating away only the portion of debt resulting from the recession is implemented. We consider two cases that differ from the initial level of debt. As one can see, the initial level of debt does not affect the dynamics of the output gap, inflation, and interest rate whatsoever. This is because policymakers are committed to follow the monetary-led policy mix to stabilize the pre-existing level of debt. Since taxation is assumed to be non-distorsive, there is no consequences of fiscal adjustments for the macroeconomy in these cases.

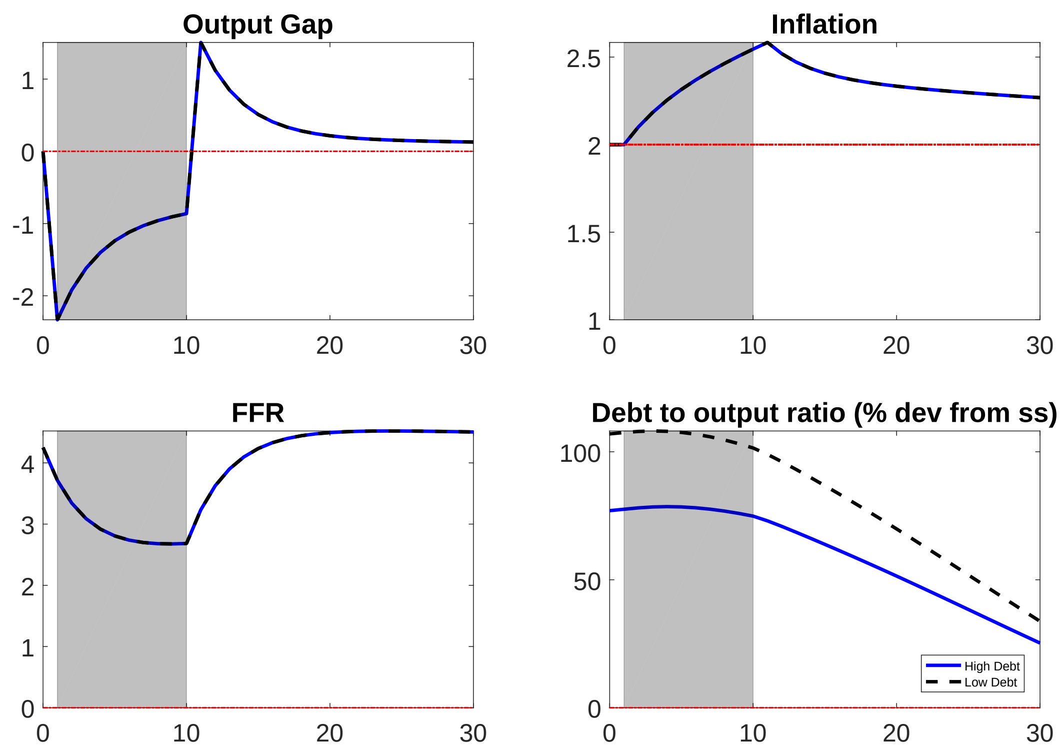

Figure 8: Dynamics of the output gap, inflation, federal funds rate (FFR), and debt-to-GDP ratio after a low state of demand that starts in period 1 and ends in period 10 (grey area). After the recession the state of demand switches to the high regime from period 11 through period 30. The lines capture the dynamics when the inflation/debt targeting rule is implemented. The economy described by the black dashed line starts with a higher initial debt.