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

Francesco Bianchi
Duke University
CEPR and NBER

Leonardo Melosi
FRB of Chicago

This draft: February 2017

Abstract

We study the problem of coordination between the monetary and the fiscal authorities at the zero lower bound. Lack of coordination between the monetary and fiscal authorities can lead to an explosive dynamics of inflation and large output losses. Policy makers can achieve the goal of mitigating the recession without giving up on long-run macroeconomic stability by committing to inflate away only the portion of debt resulting from an unusually large recession.

JEL Codes: E31, E52, E62, E63, D83

Keywords: Monetary and fiscal policies, fiscal and monetary policy coordination, emergency budget, Markov-switching models.

*Emails: francesco.bianchi@duke.edu, lmelosi@frbchi.org. The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Federal Reserve Bank of Chicago or any other person associated with the Federal Reserve System.

1 Introduction

Since the onset of the Great Recession, the U.S. monetary policy has operated with exceptionally low interest rates and the Federal Reserve's balance sheet has been enlarged to unprecedented levels. One of the main goals of this policy strategy is to raise inflation expectations so as to lower the real interest rates and to stimulate the sluggish economic recovery. Despite these extraordinary policy interventions, inflation and inflation expectations have remained subdue, even after the economy has exited the recession and the labor market has improved substantially. In Europe and in Japan, the same type of policies have led to similar dismal outcomes.

The recent crisis has also led to severe fiscal imbalances in many advanced countries. These large increases in the fiscal burden have been invariably accompanied by governments' announcements that the necessary fiscal adjustments will be taken in the medium and long term. After an initially expansionary fiscal policy in the U.S., President Barack Obama created the National Commission on Fiscal Responsibility and Reform in 2010 to identify "policies to improve the fiscal situation in the medium term and to achieve fiscal sustainability over the long run." Furthermore, he signed the Budget Control Act, which introduced automatic budget sequestrations, into law in 2011. Countries in the Euro area, despite a variety of opinions, have implemented repeated fiscal adjustments meant to guarantee long-run fiscal stability. The national governments of the Euro Area strengthened their commitment to keep their budget in balance or surplus by signing the Fiscal Compact in 2012. This treaty was introduced with the objective of putting the brakes on the growing fiscal imbalances at the national level. In Japan, during the autumn of 2013, the government made the decision to proceed with the first stage of the increase in the consumption tax rate from 5 to 8 percent in April 2014. In 2015 it publicly committed to balance its budget by 2020.[1] Finally, the governor of the Bank of Japan has explicitly stated that debt stabilization is the exclusive responsibility of the fiscal authority.

In this paper, we show that central banks' failure to raise inflation expectations at the zero lower bound can be explained by the lack of coordination between the monetary and the fiscal authorities. By lack of coordination, we mean that monetary and fiscal policies are not properly coordinated to achieving a desired rate of inflation. We also study the effects of a coordinated policy strategy aimed at stabilizing a part of the U.S. fiscal burden through higher inflation. We find that this policy strategy succeeds in raising inflation expectations by a moderate amount and in stimulating the economy without jeopardizing the long-run macroeconomic stability.

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

[1] While this goal is widely recognized as too ambitious, this announcement has clearly underscored the government's will to stabilize its finances as soon as the Japanese economy recovers.

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.

We then build a more elaborate model by extending the basic new-Keynesian model to include a fiscal rule and the possibility of recurrent zero lower bound episodes. 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 the 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, the hawkish monetary policy is not only unable to keep inflation low, but has also the perverse effect of significantly depressing economic activity. Nevertheless, if agents believe that eventually fiscal policy will revert back to fiscal discipline, the non-coordinated announcement leads to an even deeper recession, extraordinarily high debt and persistently low inflation.

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 policy strategy has its historical precedent in U.S. president Franklin Delano Roosevelt's decision of running an *emergency budget* that the fiscal authority does not explicitly commit to balance. Our model predicts that this coordinated policy mix effectively mitigates the recession while inflation rises by only a moderate amount. Since the recession is attenuated, the public debt increases only moderately and so does the inflation that is necessary to stabilize it.

This coordinated policy strategy closely resembles the policy that Chris Sims has advocated in his speech at the Jackson Hole meeting (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." Finally, our results are related to the work of Benhabib et al. (2001, 2002), who show that active monetary policy rules can lead to a liquidity trap, while monetary and fiscal policies can be designed in order to rule out deflationary spirals.

More broadly, our work is related to the vast theoretical literature on the zero lower bound. Wolman (1998), Krugman (1998), and Orphanides and Wieland (1998, 2000) are among the first to study the zero lower bound and monetary policy in an intertemporal framework. Eggertsson and Woodford (2003) show that optimal monetary policy at the zero lower bound involves a commitment to generate future inflation. Eggertsson (2006) argues that such a policy can suffer from a time-inconsistency problem, while Eggertsson (2008), using a model in which taxation is costly, shows that President Franklin Delano Roosevelt was able to make the promise of future inflation credible by expanding fiscal deficits. Correia et al. (2013) show how distortionary taxes can be used to replicate the effects of negative nominal interest rates and completely circumvent the zero bound problem. Werning (2012) works in a deterministic environment and shows that the effectiveness of policies at the zero lower bound crucially depends on what agents expect after the constraint is not binding anymore. Fernandez-Villaverde et al. (2014) show how supply-side policies may play a role in preventing an economy from hitting the zero lower bound. Schmitt-Grohe and Uribe (2012) present a model that can account for a recession associated with a protracted liquidity trap and a jobless recovery. Coibion et al. (2012) study the optimal inflation target in a new-Keynesian model in which the policy rate occasionally gets constrained by the zero lower bound.

Our work differs from each of those papers in one or more of the following dimensions. First, we work in a stochastic environment (not perfect foresight/deterministic) with a standard new-Keynesian model augmented with a fiscal block. This makes our framework suitable for a quantitative assessment of the different exit strategies. Second, zero lower bound episodes are recurrent, and agents take this into account when forming expectations. In contrast, the literature generally considers situations in which the economy is currently at the zero lower bound and it will never be there again. Moreover, our paper proposes an alternative way for modeling recurrent zero-lower-bound events in microfounded dynamic stochastic general equilibrium (DSGE) models to those of Gust et al. (2016) and Aruoba et al. (2013), and is related to the growing literature that allows for parameter instability in DSGE models (Justiniano and Primiceri 2008). Finally, our results are based on the possibility of generating an increase in inflation expectations through a change in the monetary/fiscal policy combination and do not require the use of distortionary taxation.

This paper is related to a research agenda that aims to understand the role of fiscal policy in explaining changes in the reduced form properties of the macroeconomy. Using a Markov-switching DSGE model, Bianchi and Ilut (2014) show that the rise and fall of U.S. inflation can be explained in light of a change in the monetary/fiscal policy mix that occurred a few years after the appointment of Paul Volcker as Federal Reserve Chairman. 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 absence of inflation during the recovery from the Great Recession. Second, we explicitly address the perils related to a lack of coordination between the monetary and fiscal authorities. 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 then related to the study of the interaction between monetary and fiscal policies in determining inflation dynamics (Sargent and Wallace 1981; Leeper 1991; Sims 1994; Woodford 1994, 1995, 2001; Schmitt-Grohe and Uribe 2000; Cochrane 1998, 2001; among many others).

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 (2011); Sims (1994); Woodford (2001). Let us 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. We assume that government liabilities are the numeraire and, hence, P_t is the price of goods. 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 deficits $\{\tau_1, \tau_2\}$ and nominal debts (B_0, B_1), the government's budget constraint pins down the price level:[2]

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

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

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

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

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

This is the valuation equation of the government debt. The real value of the 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, a higher debt must be backed by future higher real surpluses. Otherwise, the relative price of the less abundant consumption goods to the 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.

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 $i_t = q_t^{-1}$ by using the rule

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

where ε_t^m is an Gaussian iid process with zero mean and the starred variables denotes 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

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

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

The government raises primary surpluses τ_t so as to finance maturing government bonds B_{t-1} as described by equation (1), which we equivalently re-write as

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

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

Fiscal policy controls the government's ability or willingness to raise primary real surpluses τ_t across periods. We assume that fiscal policy is captured by the following fiscal rule (expressed in real terms):

$$\tau_t = b_{t-1}^{\gamma} \exp\left(\varepsilon_t^{\varsigma}\right) \tag{9}$$

where $\varepsilon_t^{\varsigma}$ follows an iid zero-mean exogenous process: $E\left(e_t^{\varsigma}\right) = 0$. 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 log-linearized the model equations around the steady-state equilibrium, which is derived in Appendix . The monetary block can be expressed as follows:

$$\begin{aligned} \hat{\imath}_t &= \varepsilon_t^r + E_t \hat{\pi}_{t+1}, & (10) \\ \hat{\imath}_t &= \phi \hat{\pi}_t + \varepsilon_t^m. & (11) \end{aligned}$$

The fiscal block becomes:

$$\left(r_* - 1\right) \hat{\tau}_t + \left(\hat{\imath}_t + \hat{b}_t\right) = r_* \left(\hat{b}_{t-1} - \hat{\pi}_t\right). \tag{12}$$

$$\hat{\tau}_t = \gamma \hat{b}_{t-1} + \varepsilon_t^{\varsigma}. \tag{13}$$

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

$$\phi\hat{\pi}_t = \varepsilon_t^r + E_t\hat{\pi}_{t+1} - \varepsilon_t^m, \tag{14}$$

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

$$\hat{b}_t = [r_* - (r_* - 1)\gamma]\,\hat{b}_{t-1} - (r_* + \phi)\,\hat{\pi}_t - (r_* - 1)\,\varepsilon_t^\varsigma - \varepsilon_t^m, \tag{15}$$

which we will refer to as the fiscal-block equation.

Defining the rational expectations errors $\eta_t \equiv \pi_t - E_t\pi_t$ and replacing $\hat{\pi}_t$ with $E_{t-1}\hat{\pi}_t + \eta_t$ in both equations (14)-(15) yield

$$\phi\,(E_{t-1}\hat{\pi}_t + \eta_t) = \varepsilon_t^r + E_t\hat{\pi}_{t+1} - \varepsilon_t^m \tag{16}$$

and

$$\hat{b}_t = [r_* + \gamma\,(1 - r_*)]\,\hat{b}_{t-1} - (r_* + \phi)\,(E_{t-1}\hat{\pi}_t + \eta_t) - (r_* - 1)\,\varepsilon_t^\varsigma - \varepsilon_t^m \tag{17}$$

Equations (16) and (17) can written in matricial form as follows:

$$\begin{aligned}\begin{bmatrix} E_t\hat{\pi}_{t+1} \\ \hat{b}_t \end{bmatrix} &= \begin{bmatrix} \phi & 0 \\ -r_* - \phi & r_* - (r_* - 1)\,\gamma \end{bmatrix}\begin{bmatrix} E_{t-1}\hat{\pi}_t \\ \hat{b}_{t-1} \end{bmatrix} \\ &\quad + \begin{bmatrix} -1 & 0 & 1 \\ 0 & 1 - r_* & -1 \end{bmatrix}\begin{bmatrix} \varepsilon_t^r \\ \varepsilon_t^\varsigma \\ \varepsilon_t^m \end{bmatrix} + \begin{bmatrix} \phi \\ -r_* - \phi \end{bmatrix}\hat{\eta}_t\end{aligned} \tag{18}$$

This system has two eigenvalues: ϕ and $r_* + \gamma\,(1 - r_*)$. There is only one non-predetermined variables $(E_t\hat{\pi}_{t+1})$. Since the second eigenvalue lies outside the unit circle if $\gamma < 1$, our exercise confirms the partition of the parameter space introduced by Leeper (1991): There are four possible scenarios:

First, if $\phi > 1$ and $\gamma \geq 1$ (Active Monetary/Passive Fiscal; AM/PF), then the only explosive equation is in the monetary-block equation (16) and, hence, the unique stable rational expectations equilibrium (REE) is given by imposing $-\phi\hat{\eta}_t = -\phi\hat{\pi}_t \stackrel{!}{=} -\varepsilon_t^r + \varepsilon_t^m$. This implies a REE dynamics of inflation as follows:

$$\hat{\pi}_t = \frac{1}{\phi}\varepsilon_t^r - \frac{1}{\phi}\varepsilon_t^m \tag{19}$$

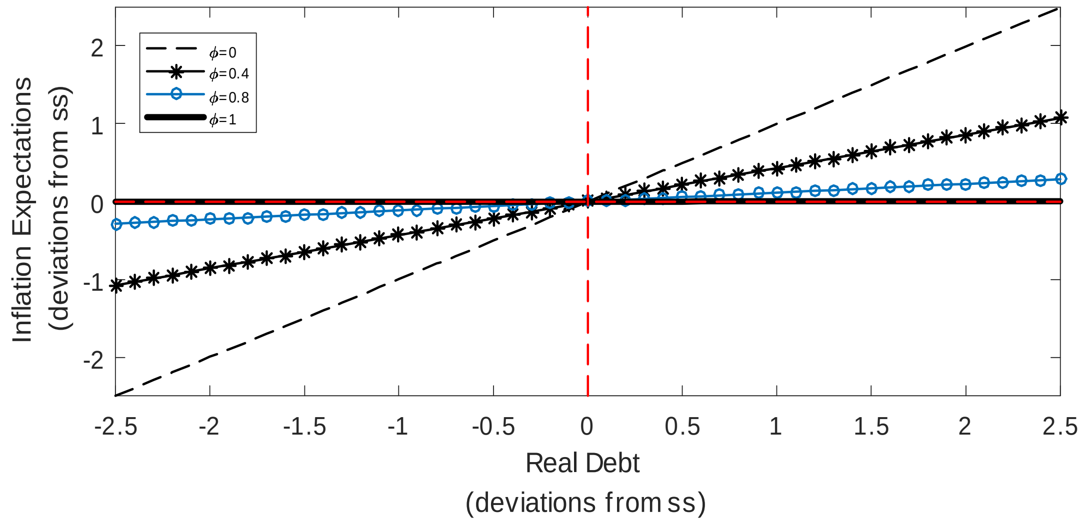

Figure 1: **Implied Inflation Expectations to Keep Debt on Stable Path.** Change in inflation expectations needed to keep real debt on a stable path as the central bank's response to inflation varies.

and for the debt

$$\hat{b}_t = [r_* - (r_* - 1)\,\gamma]\,\hat{b}_{t-1} - \frac{r_* + \phi}{\phi}\varepsilon_t^r - (r_* - 1)\,\varepsilon_t^{\varsigma} + \left(\frac{r_* + \phi}{\phi} - 1\right)\varepsilon_t^m \tag{20}$$

It is important to notice that fiscal shocks $\varepsilon_t^{\varsigma}$ do not affect inflation (and hence the nominal interest rate); they only affect the fiscal variables (i.e., the debt $\hat{b}_t$ and the primary surplus $\hat{\tau}_{t+1}$). Furthermore, inflation is completely independent of the fiscal block. This implies that fiscal imbalances are never relevant for inflation determination.

Second, if $\phi \leq 1$ and $\gamma < 1$ (Passive Monetary/Active Fiscal; PM/AF), then the only explosive equation is fiscal-block equation (17), whereas inflation expectations $E_t\hat{\pi}_{t+1}$ follows a stable law of motion. Blanchard and Khan's conditions ensure that there is a unique stable REE. The unique stable REE can be characterized by finding the law of motion for inflation expectations that makes real debt to follow a stable path, which is as follows: (assuming $r_* + \gamma - \phi - r\gamma \neq 0$):[3]

$$E_t\hat{\pi}_{t+1} = \frac{r_* + \gamma - \phi - r\gamma}{r_* + \phi} \cdot \hat{b}_t. \tag{21}$$

We refer the interested reader to the appendix for a formal derivation of equation (21).

We can plot this relationship between inflation expectations and real debt as a function of the interest rate response to inflation (ϕ) for some parameter value. Let us set $r_* = 1.01$ (i.e., $\beta_* = 0.9901$) and $\gamma = 0$ (no response of fiscal policy to the stock of debt). Results for a number of responses of the monetary authority to inflation are reported in Figure 1. This plot shows how much inflation expectations have to adjust to keep debt on a stable path. It is important

[3] See Appendix A.1.

to notice that when monetary policy does not (or cannot) respond to inflation ($\phi = 0$) inflation expectations move more to keep real debt on the unique stable REE path. As the central bank becomes more and more aggressive toward inflation stabilization, inflation expectations adjust to a lesser extent. When the central bank responds one-to-one with inflation ($\phi = 1$), inflation stops adjusting to deviations of real debt from its steady-state value.

The REE solution can be characterized by plugging equation (21) to get rid of inflation expectations in the monetary-block equation (14). We obtain

$$\phi \hat{\pi}_t = \varepsilon_t^r + \xi \hat{b}_t - \varepsilon_t^m, \tag{22}$$

with $\xi \equiv \frac{r_* + \gamma - \phi - r_* \gamma}{r_* + \phi}$. 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:

$$\begin{bmatrix} \hat{\pi}_t \\ \hat{b}_t \end{bmatrix} = \begin{bmatrix} 0 & \xi \\ 0 & \phi \end{bmatrix} \begin{bmatrix} \hat{\pi}_{t-1} \\ \hat{b}_{t-1} \end{bmatrix} + \begin{bmatrix} \frac{1}{r_* - \gamma(r_* - 1)} & \xi \frac{1 - r_*}{r_* - \gamma(r_* - 1)} & -\frac{1 + \xi}{r_* - \gamma(r_* - 1)} \\ -\frac{r_* + \phi}{r_* - \gamma(r_* - 1)} & \phi \frac{1 - r_*}{r_* - \gamma(r_* - 1)} & \frac{r_*}{r_* - \gamma(r_* - 1)} \end{bmatrix} \begin{bmatrix} \varepsilon_t^r \\ \varepsilon_t^\varsigma \\ \varepsilon_t^m \end{bmatrix} \tag{23}$$

Two features of the solution (23) are worthy emphasizing. First, contrary to the AM/PF case, inflation is generally not insulated from fiscal shocks ς_t under this alternative REE.

Second, the need of stabilizing the dynamics of the real stock of debt induces a persistent dynamics in inflation. In the AM/PF case, inflation follows an iid process. The stronger the monetary authority's response to inflation, the more persistent the dynamics of (real) debt and inflation.

Third, if $\phi \leq 1$ and $\gamma > 1$ (Passive Monetary/Passive Fiscal; PM/PF), then there is no explosive eigenvalue and the system admits infinitely many stable REE solutions (indeterminacy).

Fourth, if $\phi > 1$ and $\gamma < 1$ (Active Monetary/Active Fiscal; AM/AF), then there is two explosive eigenvalues and only one non-predetermined variable. Thus, the system has no stable REE solution.

Lack of Coordination Now we want to use this simple Fisherian model to study what are the macroeconomic implications of not coordinating monetary and fiscal policies to attain a determinate inflation rate. Let us build an experiment where the economy is at its steady-state equilibrium when at time $t = 1$ is hit by a negative iid shock to the discount factor, $\varepsilon_t^r < 0$.

Agents know with certainty what policy mix is adopted by the policymakers at time $t = 1$ and in every following period. We make four cases

1. Policymakers adopt a PM/PF policy mix at time $t = 1$ and then follow an AM/PF policy mix from period $t = 2$ on.

2. Policymakers adopt a AM/AF policy mix at time $t = 1$ and then follow an AM/PF policy mix from period $t = 2$ on.

3. Policymakers adopt a PM/PF policy mix at time $t = 1$ and then follow an PM/AF policy mix from period $t = 2$ on.

4. Policymakers adopt a AM/AF policy mix at time $t = 1$ and then follow an PM/AF policy mix from period $t = 2$ on.

As shown, when policymakers adopt a PM/PF policy combination forever, REE is indeterminate. Heuristically, both policymakers forgo controlling inflation. The monetary authority disregards inflation by not adjusting the nominal rate strongly enough. The fiscal authority takes the necessary fiscal adjustments to stabilize the dynamics of debt and in doing so prevent fiscal imbalances from affecting inflation. When policymakers adopt AM/AF, they are fighting for controlling inflation. On the one hand, the central bank wants to secure the full control over inflation, requiring that fiscal imbalances do not have any effects on inflation dynamics. On the other hand, the fiscal authority wants the central bank to let inflation to adjust so as to accommodate the inflationary consequences of fiscal imbalances. Therefore, in all these four cases, at time $t = 1$ policymakers fail to coordinate on a policy mix that can deliver a determinate REE path for inflation and the real debt in the long run.

We want to study the effects of this lack of coordination on macroeconomic outcomes. Given that lack of coordination lasts only for one period and then one of the two policymakers adjust its policy, the REE path for the real debt and inflation exists and is unique. It turns out that this path can be analytically characterized for our simple economy. We denote policymakers' response to their targets as (γ_A, ϕ_A) for active policies and (γ_P, ϕ_P) for passive policies.

Case 1: PM/PF and AM/PF Resolution In this case, the monetary authority does not respond strongly to deflation owing to the shock to the discount factor and the fiscal authority disregards the rise in the real debt. From period $t = 2$ on, the monetary authority adjusts its policy by starting conducting an active policy and this action is backed by the fiscal authority, which keeps conducting its passive policy. Recall that, under AM/PF policy mix, the REE outcomes are given by:

$$\hat{\pi}_t = \frac{1}{\phi}\varepsilon_t^r - \frac{1}{\phi}\varepsilon_t^m, \tag{24}$$

and for the debt

$$\hat{b}_t = [r_* - (r_* - 1)\gamma]\,\hat{b}_{t-1} - \frac{r_* + \phi}{\phi}\varepsilon_t^r - (r_* - 1)\,\varepsilon_t^{\varsigma} + \left(\frac{r_* + \phi}{\phi} - 1\right)\varepsilon_t^m. \tag{25}$$

Since the shock to the real interest rate is iid and agents know that policymakers will coordinate over the AM/PF policy mix, at time 1 agents will expect $E_1\hat{\pi}_2 = 0$. Consequently, the monetary-block equation (14) implies that REE inflation at time 1 is $\hat{\pi}_1 = \phi_P^{-1}\varepsilon_1^r$, and the fiscal-block equation (15) pins down the stock of real debt as follows:

$$\hat{b}_1 = -\left(\frac{r_*}{\phi_P} + 1\right)\varepsilon_1^r. \tag{26}$$

The negative shock causes inflation to go down and the debt to go up. Two important results. First, the more weakly the monetary authority responds to inflation, the larger the effect of the shock on inflation and to on the public debt is. Second, fiscal authority's behaviors have no effect on REE outcomes.

Case 2 AM/AF and AM/PF Resolution In this case, the monetary authority is fighting against fiscal authority's decision of withdrawing its backing, which allows allow the central bank to fully control inflation. In period $t = 2$, the fiscal authority is assumed to give up the fight and 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.

As in Case 1, at time $t = 1$, agents know that policymakers will coordinate over the AM/PF policy mix and hence inflation at time $t = 2$ will depend only on future shocks (see equation (19)). Since the shock is iid, it follows that $E_1\hat{\pi}_2 = 0$. Consequently, REE inflation at time 1 $\hat{\pi}_1 = \phi_A^{-1}\varepsilon_1^r$. The stock of real debt is determined by the following equation

$$\hat{b}_1 = -\left(\frac{r_*}{\phi_A} + 1\right)\varepsilon_1^r. \tag{27}$$

Notice that the inflation and debt outcomes mimic the ones obtained in Case 1, where a PM/PF policy mix is followed by an AM/PF resolution strategy. As in Case 1, the behaviors of the fiscal authority have no implications whatsoever for REE outcomes in period 1. Nevertheless, when policymakers conduct active policies in period 1, inflation and real debt unambiguously respond less to the shock in period 1 because $\phi_A > \phi_P$.

Case 3: PM/PF and PM/AF Resolution Now when the shock hits the economy, the monetary authority de-emphasizes the rate of inflation while the fiscal authority takes fiscal adjustments in an attempt to stabilize the dynamics of real debt. Unlike Case 1, here we entertain the case in which agents expect that eventually the monetary authority will lose the fiscal backing. In other words, agents expect that the fiscal authority will disregard the level of debt and in so doing will force the central bank to let inflation go so as to stabilize fiscal imbalances.

Recall that, under PM/AF policy mix, the REE outcomes are given by equation (23). At time $t = 1$, agents know that policymakers will coordinate over the PM/AF policy mix and hence they expect that $E_1\hat{\pi}_2 = \frac{r_*+\gamma_A-\phi_P-r_*\gamma_A}{r_*+\phi_P} \cdot \hat{b}_1$. Consequently, the monetary-block equation (14) implies that at time $t = 1$ the REE inflation must satisfy

$$\hat{\pi}_1 = \phi_P^{-1}\varepsilon_1^r + \phi_P^{-1}\frac{r_* + \gamma_A - \phi_P - r_*\gamma_A}{r_* + \phi_P} \cdot \hat{b}_1, \tag{28}$$

and the fiscal-block equation (15) implies that the stock of real debt at time 1 is given by

$$\hat{b}_1 = -(r_* + \phi_P)\,\hat{\pi}_1. \tag{29}$$

We can solve the linear system of equations (28)-(29) and obtain

$$\hat{\pi}_1 = \frac{1}{r_* + \gamma_A(1 - r_*)}\varepsilon_1^r, \tag{30}$$

$$\hat{b}_1 = -\frac{r_* + \phi_P}{r_* + \gamma_A(1 - r_*)}\varepsilon_1^r. \tag{31}$$

Two results are worth emphasizing. First, in period 1 inflation is not affected by monetary authority's behavior. Agents fully anticipate the implications of the central bank losing the fiscal backing in the next periods. Second, stronger monetary authority's responses to inflation leads to a higher debt for given inflation at the end of period 1 and a more persistent dynamics of such debt in subsequent periods. Both of these outcomes result in a heightened path for the real debt and hence a heightened path of inflation after the negative shock to the discount factor.[4] Notice that the dynamics of inflation after period 1 differ from that in the two previous cases in which inflation is always stabilized at its steady-state value and the debt will follow a stationary mean-reverting process. Note also that inflation respond always positively upon the

[4]This result requires that $r_* > \phi_P + (r_* - 1)\gamma_A$; which it is always assumed to hold in our analysis. It should be noted that a plausible calibration of the discount factor at steady state, which makes $(r_* - 1)$ fairly close to zero, and a passive policy that implies a sufficiently weak response to inflation make this condition to hold. When this condition does not hold, we do not have the typical effects of the fiscal theory of the price level according to which a level of debt above (below) its steady-state value is stabilized through higher (lower) inflation.

shock.[5]

Case 4: AM/AF and PM/AF Resolution In this case, policymakers fight for retaining the full control over inflation in the first period but, unlike Case 2, 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 the fiscal backing cannot be secured in the long run.

As in Case 3, at time $t = 1$, agents know that policymakers will coordinate over the PM/AF policy mix and hence they expect that $E_1\hat{\pi}_2 = \frac{r_* + \gamma_A - \phi_P - r_*\gamma_A}{r_* + \phi_P} \cdot \hat{b}_1$. Consequently, at time $t = 1$ the REE inflation must satisfy

$$\hat{\pi}_1 = \phi_A^{-1}\varepsilon_1^r + \phi_A^{-1}\frac{r_* + \gamma_A - \phi_P - r_*\gamma_A}{r_* + \phi_P} \cdot \hat{b}_1, \tag{32}$$

and the stock of real debt

$$\hat{b}_1 = -\left(r_* + \phi_A\right)\hat{\pi}_1. \tag{33}$$

We can solve the linear system of equations(32)-(33) and obtain

$$\hat{\pi}_1 = \frac{1}{\zeta r_* + (\zeta - 1)\,\phi_A}\varepsilon_1^r, \tag{34}$$

$$\hat{b}_1 = -\frac{(r_* + \phi_A)}{\zeta r_* + (\zeta - 1)\,\phi_A}\varepsilon_1^r, \tag{35}$$

where $\zeta \equiv \left[r_* - \phi_P + (1 - r_*)\,\gamma_A\right] / \left(r_* + \phi_P\right)$. 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 3, monetary policy can affect inflation outcomes.

Let us keep fixed what the policymakers do when they coordinate in period 2 and focus on what the macroeconomic effects of the central bank's behavior are when the central bank fights back the decision of the fiscal authority to not provide fiscal backing to monetary policy. We consider the case in which the monetary authority's passive response to inflation in period 2 is small enough so that $\phi_A < \frac{\zeta r_*}{1-\zeta}$.[6]

[5] For this to be true it requires

$$r_* + \gamma_A\left(1 - r_*\right) > 0 \iff \gamma_A < \frac{r_*}{r_* - 1}.$$

Since $r_* > 1$, then $\frac{r_*}{r_*-1} > 1$. Thus, γ_A needs to be higher than a value larger than one, which is always true ($\gamma_A < 1$).

[6] When $\phi_A > \frac{\zeta r_*}{1-\zeta}$, the response of inflation and debt to the natural rate in equations (34)-(35) flip their sign. Technically speaking, there exists an asimptotote such that if $\phi_A > \frac{\zeta r_*}{1-\zeta}$,then inflation (debt) reacts negatively (positively) to shocks to the natural rate of interest. We think that this result is a bit counterintuitive and is not very helpful to understand the key mechanisms at play in this simple economy.

The most remarkable result is that a stronger monetary authority's response to inflation ends up *accelerating* the response of inflation to shocks to the discount factor.[7] The implications go as follows: If the monetary authority energetically tries to rein in deflation without fiscal backing, the outcome of such a policy is, in fact, a larger deflation. At the same time, the more proactive the central bank is, the higher the real debt at the end of time 1. As a result, in subsequent periods we will observe a heightened path for inflation as a result of the monetary policy conducted in period 1. These results suggest that lack of coordination between monetary and fiscal policies can be associated with periods of high inflation volatility.

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 *recurrent* zero lower bound episodes.

3.1 The Model

The economy consists of a continuum of monopolistic firms, a representative household, and a monetary policy authority (or central bank). The household derives utility from consumption C_t and disutility from labor h_t:

$$E_0\left[\sum_{t=0}^{\infty}\beta^t \exp\left(d_t\right)\left[\log\left(C_t\right)-h_t\right]\right], \tag{36}$$

where β is the household's discount factor and the preference shock $d_t = \overline{d}_{\xi_t^d}$ 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

[7]To see these effects, take the derivative of the inflation response to the shock in period 1 with respect to the policy parameter ϕ_A to find that

$$\frac{\partial\partial\hat{\pi}_1/\partial\varepsilon_1^r}{\partial\phi_A} = -\frac{\zeta-1}{\left[\zeta r_* + \left(\zeta-1\right)\phi_A\right]^2} > 0,$$

because $\zeta < 1$. It can also be easily shown that the response of inflation to the shocks grows exponentially as ϕ_A increases.

later on. The household budget constraint is given by:

$$P_tC_t + B_t + P_tT_t = P_tW_th_t + R_{t-1}B_{t-1} + P_tD_t, \tag{37}$$

where B_t represents bond holdings, D_t captures dividends paid by firms, W_t is the real wage, T_t is a net lump sum tax, P_t is the price level, and R_t is the one-period gross interest rate.

Each of the monopolistically competitive firms faces a downward-sloping demand curve:

$$Y_t(j) = (P_t(j)/P_t)^{-1/v}\, Y_t, \tag{38}$$

where $P_t(j)$ is the price chosen by firm j and the parameter $1/v$ is the elasticity of substitution between two differentiated goods. The firms take as given the general price level P_t and level of real activity Y_t. Whenever a firm wants to change its price, it faces quadratic adjustment costs represented by an output loss:

$$AC_t(j) = (\varphi/2)\,(P_t(j)/P_{t-1}(j) - \Pi)^2\, Y_t(j), \tag{39}$$

where Π is the deterministic steady-state level for gross inflation.

The firm chooses the price $P_t(j)$ to maximize the present value of future profits:

$$E_0\left[\textstyle\sum_{t=0}^{\infty} Q_t\left(P_t(j)Y_t(j)/P_t - W_th_t(j) - AC_t(j)\right)\right],$$

where Q_t is the household's stochastic discount factor. Labor is the only input in a linear production function, $Y_t(j) = A_th_t(j)$, where the growth rate of total factor productivity $z_t = \ln(A_t/A)$ follows an autoregressive process: $z_t = \rho_z z_{t-1} + \sigma_z\epsilon_{z,t}$, $\epsilon_{z,t} \sim N(0,1)$.

The central bank follows the rule:

$$\frac{R_t}{R} = \left(1 - Z_{\xi_t^d}\right)\left(\frac{R_{t-1}}{R}\right)^{\rho_R}\left[\left(\frac{\Pi_t}{\Pi}\right)^{\psi_{\pi,\xi_t^p}}\left(\frac{Y_t}{Y_t^n}\right)^{\psi_y}\right]^{(1-\rho_R)} e^{\sigma_R\epsilon_{R,t}} + \frac{Z_{\xi_t^d}}{R}$$

where $\epsilon_{R,t} \sim N(0,1)$, R is the steady-state gross nominal interest rate, Y_t^n is natural output, the level of output that would prevails in absence of nominal rigidities, and the dummy variable $Z_{\xi_t^d}$ controls if the economy is in or out of the zero lower bound. When $\overline{d}_{\xi_t^d} = \overline{d}_h$, the economy is out of the zero lower bound and monetary policy is not constrained ($Z_{\xi_t^d} = 0$). In this case the evolution of the policy mix can be described by Markov switching process ξ_t^p. This variable follows a discrete Markov-switching process that captures the stochastic outcome of a game between the monetary and fiscal authorities that is not explicitly modeled in this paper. The properties of the transition matrix and those of the regimes will be described later. When $\overline{d}_{\xi_t^d} = \overline{d}_l$, the zero lower bound is binding, given that a standard Taylor rule would require a negative nominal interest.[8] In this case, policymakers abandon the policy mix that they were following and set the net nominal interest rate to zero ($Z_{\xi_t^d} = 1$).

The government budget constraint is given by:

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

where $b_t = B_t / \left(P_t Y_t \right)$ and $s_t = S_t / \left(P_t Y_t \right)$ are the debt-to-GDP ratio and the primary-surplus-to-GDP ratio, respectively. We assume that the government only moves lump-sum taxes and provides a subsidy. In other words, we exclude government purchases and we assume that the primary surplus coincides with net lump-sum taxes ($T_t = S_t$). This will allow us to completely isolate the effects of fiscal shocks deriving from the lack of fiscal discipline. Introducing government purchases (G_t) would not modify the mechanism outlined here, but would make the interpretation of the results less immediate. The fiscal authority moves the primary surplus according the following rule

$$\begin{aligned} (s_t - s) &= \left(1 - Z_{\xi_t^d}\right) \left[\delta_{b,\xi_t^p} \left(b_{t-1} - b \right) \right] + \delta_y \left(y_t - y_t^n \right) + x_t, & (40) \\ x_t &= \rho_x x_{t-1} + \sigma_x \epsilon_{x,t}, \;\; \epsilon_{x,t} \sim N\left(0,1\right), & (41) \end{aligned}$$

where $y_t = \ln \left(Y_t \right)$ and $y_t^n = \ln \left(Y_t^n \right)$. We will refer to $\epsilon_{x,t}$ as a fiscal shock. The fiscal authority disregards the level of debt when the economy is hit by the negative discrete demand shocks and hence the dummy variable $Z_{\xi_t^d}$ equals 1. When the large negative demand shock hits the economy, fiscal authority's primary concern is to lower taxes so as to mitigate the consequences of the recession on real activity and to postpone tax increases to stabilize debt. Also, notice that the parameter controlling the response of primary surpluses to debt out of the zero-lower-bound period, δ_{b,ξ_t^p}, depends on ξ_t^p.

3.2 Linearization

The model is solved and linearized around the deterministic steady state. We first compute the ergodic mean $\bar{d}$ for the preference shock and verify that the zero lower bound does not bind in this case. We then compute the steady state associated with this value and linearize around it.

[8] We assume that whenever the negative preference shock hits, policymakers move to the zero-lower-bound regime described later on and we choose the parameters values in a way that the zero lower bound is binding with high probability when $\bar{d}_{\xi_t^d} = \bar{d}_l$. Our approach to model the zero lower bound differs from the conventional one (e.g., see Eggertsson and Woodford 2003; Benhabib, Schmitt-Grohe, and Uribe 2002), which implies $R_t = \max\left(0, R_t^*\right)$, where R_t^* is the interest rate implied by the Taylor rule. While our approach cannot rule out that there exist some unlikely states of the world in which the nominal rate R_t assumes negative values, it has the advantage of making the model tractable and allows us to study the consequences of policy uncertainty.

From now on, all variables should be interpreted as deviations from steady state.[9]

The private sector can be described by the following system of equations:

$$\begin{aligned}
\widetilde{\pi}_t &= \beta E_t(\widetilde{\pi}_{t+1}) + \kappa(\widetilde{y}_t - z_t), && (42)\\
\widetilde{y}_t &= E_t\left(\widetilde{y}_{t+1}\right) - \left(\widetilde{R}_t - E_t\left(\widetilde{y}_{t+1}\right)\right) + \widetilde{d}_t - E_t\left(\widetilde{d}_{t+1}\right), && (43)\\
\widetilde{d}_t &= \widetilde{\overline{d}}_{\xi_t^d}, && (44)\\
z_t &= \rho_z z_{t-1} + \sigma_z \epsilon_{z,t},\ \epsilon_{z,t} \sim N(0,1), && (45)
\end{aligned}$$

where $\widetilde{d}_t = d_t - \overline{d}$ and $\widetilde{\overline{d}}_{\xi_t^d} = \overline{d}_{\xi_t^d} - \overline{d}$. Inflation dynamics are described by the New-Keynesian Phillips curve (42) with slope κ. Equation (43) is the linearized intertemporal Euler equation describing the households' optimal choice of consumption and bond holdings.

The linearized government budget constraint is given by:

$$\widetilde{b}_t = \beta^{-1}\widetilde{b}_{t-1} + b\beta^{-1}\left(\widetilde{R}_{t-1} - \widetilde{\pi}_t - \Delta\widetilde{y}_t\right) - \widetilde{s}_t, \tag{46}$$

where $\widetilde{b}_t$ and $\widetilde{s}_t$ represent now debt and surplus in terms of GDP in linear deviations from the steady state. The fiscal policy mix is given by:

$$\begin{aligned}
\widetilde{s}_t &= \left[1 - Z_{\xi_t^d}\right]\delta_{b,\xi_t^p}\widetilde{b}_{t-1} + \delta_y\left(\widetilde{y}_t - z_t\right) + x_t, && (47)\\
x_t &= \rho_x x_{t-1} + \sigma_x \epsilon_{x,t},\ \epsilon_{x,t} \sim N(0,1), && (48)
\end{aligned}$$

while the linearized monetary policy policy mix is:

$$\begin{aligned}
\widetilde{R}_t = {} & \left[1 - Z_{\xi_t^d}\right]\left[\rho_R \widetilde{R}_{t-1} + (1-\rho_R)\left(\psi_{\pi,\xi_t^p}\widetilde{\pi}_t + \psi_y\left[\widetilde{y}_t - z_t\right]\right) + \sigma_R \epsilon_{R,t}\right] \\
& - Z_{\xi_t^d}\log(R),
\end{aligned} \tag{49}$$

where $\epsilon_{R,t} \sim N(0,1)$.

The zero lower bound imposes a constraint on policymakers' behavior. Nevertheless, agents' beliefs about the exit strategy and policy uncertainty are not constrained and are going to be key to understanding what occurs at the zero lower bound. To capture this feature, the number of regimes at the zero lower bound needs to be expanded to reflect agents' beliefs about policymakers' future behavior. Therefore, for each of the zero-lower-bound regimes we will have to specify the entering probability, the probability of moving to another zero-lower-bound regime, and policymakers' exit strategy. Therefore, the evolution of policymakers' behavior can be de-

[9] We linearize with respect to debt and primary surpluses, given that these variables can change sign, while we log-linearize with respect to all the others. Appendix A.2 provides additional details on how we handle the Markov-switching preference shock.

scribed by a transition matrix obtained by combining the transition matrix H^d, which describes the evolution of the preference shock; the transition matrix H^p, which describes policymakers' behavior out of the zero lower bound; the matrix H^i, which describes the probability of entering each of the zero-lower-bound regimes; the matrix H^z, which describes the probability of moving across the zero-lower-bound regimes; and the matrix H^o, which describes the exit strategy for each of the zero-lower-bound regimes:

$$H = \begin{bmatrix} p_{hh} H^p & (1 - p_{ll}) H^o \\ (1 - p_{hh}) H^i & p_{ll} H^z \end{bmatrix}.$$

We will be more specific on the set of possible policy regimes that can emerge out of the zero lower bound and the associated transition probabilities (H^p) in the next section.

The model can be solved with any of the solution methods developed for Markov–switching DSGE models. We use the solution method of Farmer et al. (2009). It is worth emphasizing that in our model, agents form expectations while taking into account the possibility of entering the zero lower bound. Furthermore, they understand that entering the zero lower bound is an event induced by an exogenous shock that can modify policymakers' behavior even once the constraint stops binding. In other words, our approach allows us to model recurrent zero-lower-bound episodes and to capture the impact of different exit strategies for policymakers' behavior at the zero lower bound.

4 The Effects of Lack of Monetary and Fiscal Coordination

In this section, we show that lack of coordination between the monetary and fiscal authorities can lead to disastrous outcomes. In the context of our model, lack of coordination arises when monetary and fiscal policies are not properly geared toward determining inflation. Let us give an example of non-coordinated announcements. Since the beginning of the crisis the Federal Reserve has repeatedly stated that the exceptional measures taken during the current crisis should not be interpreted as evidence of a lack of commitment to keep inflation low and stable once the economy has fully recovered. At the same time, the explosive projections for the debt-to-GDP ratio that are routinely presented by the Congressional Budget Office (CBO 2016) suggests that future increases in taxes might not be large enough to balance the fiscal budget.

Monetary and fiscal policies lack coordination because the ability of the Federal Reserve to control inflation critically relies on the willingness of the fiscal authority to keep debt under control. In Leeper's (1991) parlance, both policymakers are, implicitly or explicitly, communicating to the public that they will conduct active policies (AM/AF) once the recession is over.

When the announced AM/AF regime is sufficiently persistent in expectation, the model has no (mean-square-stable) Rational Expectations equilibrium. 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 rise of the debt-to-GDP ratio. This acceleration in the dynamic of the debt-to-GDP 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 no *stationary* solution exists. If the AM/PF regime is not very long-lasting -in expectation-, the model can still have a stable and unique Rational Expectations equilibrium but, 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 call this type of announcements non-coordinated in the sense that policymakers fail to explain how they will coordinate to determine inflation once the economy has recovered.

To model the possibility of non-coordinated announcements, we introduce four policy regimes to characterize policymakers' behavior out of the zero lower bound and five zero-lower-bound regimes, which differ in their respective probabilities of switching to each of the four out-of-the-zero-lower-bound regimes. Out of the zero lower bound, we have four possible policy mixes. There is a Regime M ($\xi_t^p = M$) - the *monetary-led regime* - under which the Taylor principle is satisfied and fiscal policy passively accommodates the behavior of the monetary authority. In terms of policy parameters, this implies that $\psi_{\pi,M} > 1$ and $\delta_{b,M} > \beta^{-1} - 1$. There is a Regime F ($\xi_t^p = F$) - the *fiscally-led regime* - under which the central bank reacts less than one-for-one to inflation and the fiscal authority does not move surpluses in response to movements in government debt: $\psi_{\pi,F} < 1$ and $\delta_{b,F} < \beta^{-1} - 1$. There are two Active Monetary/Active Fiscal regimes - the *fight regimes*. These two fight regimes are characterized by different probabilities about which authority eventually will give up fighting and revert to passive policy. For simplicity, we assume that one fight regime leads for sure to the monetary-led regime while the other one leads for sure to the fiscally-led regime.

At the zero-lower-bound, we have five regimes to capture the following scenarios: (i) Two scenarios in which the policymakers make a coordinated announcement that they will switch to either the monetary-policy mix or the fiscally-led policy mix once the large demand shock will be reabsorbed; (ii) Two scenarios in which policymakers do not coordinate their announcements and agents expect that one of the authorities will prevail the fight for determining inflation; (iii) a scenario in which policymakers do nothing and leave agents uncertain about which of the four exit strategy will be followed. A detailed description of the transition matrix H for the regimes is available in Appendix A.3.

Parameter	Value	Parameter	Value	Parameter	Value
$\psi_{\pi,M}$	2.00	p_{MM}	99%	ρ_z	0.90
$\psi_{\pi,F}$	0.80	p_{FF}	99%	ρ_x	0.90
$\delta_{b,M}$	0.03	κ	0.035	$\overline{d}_h$	0
ψ_y	0.10	β	0.995	$\overline{d}_l$	$-.1$
ρ_R	0.75	$100\sigma_R$	0.20	p_{hh}	98%
δ_y	0.50	$100\sigma_x$	0.50	p_{ll}	80%
b	1.00	$100\sigma_z$	0.70		

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

4.1 Macroeconomic Dynamics with Lack of Coordination

We set the model parameters as shown in Table 1. The persistence of the fight regime is set to 0.86. These parameter values for the model are broadly in line with the estimates obtained by Bianchi and Melosi (2016) and ensure that the model is mean square stable. Figure 2 reports the evolution of the variables of interest in an economy that is hit by the large negative preference shock ($\xi_t^d = l$) at time 10 and is assumed to switch back to the high preference shock at time 20. For the sake of clarity, we report results for three of the five possible scenarios. The case in which policymakers explicitly announce that fiscal discipline will be abandoned (red dotted line) represents the coordinated case. This coordinated strategy leads to a situation in which inflation is on target and the economy goes through a recession.

We also report two non-coordinated cases in which the fiscal authority announces that fiscal discipline will be abandoned, while the monetary authority insists that it will keep seeking a low and stable target for inflation. Let us start with the case in which agents expect that after the fight regime the monetary authority will prevail and fiscal discipline is reestablished (black dashed line). We assume that the *fight regime* starts at time 20 and ends at time 30. Inflation drops substantially during the recession and even though the fiscal authority has announced that fiscal adjustments will not be implemented once the economy is out of the zero lower bound, inflation is still on target. Furthermore, the fiscal authority's announcement fails stimulating economy activity at the zero lower bound. To understand why, notice that in the period characterized by a fight between the two authorities, debt keeps accumulating because the fiscal authority is not adjusting taxes to stabilize debt. However, there are no effects on output and inflation as agents understand that eventually taxes will be raised and debt will be repaid. The attempts of the fiscal authority are simply not effective at raising inflation expectations and stimulating the economy out of the recession because agents are convinced that debt will eventually be repaid.

The solid blue line reflects the non-coordinated case when agents anticipate the conflict between the two authorities will be followed by the fiscally-led regime. Again, we assume that

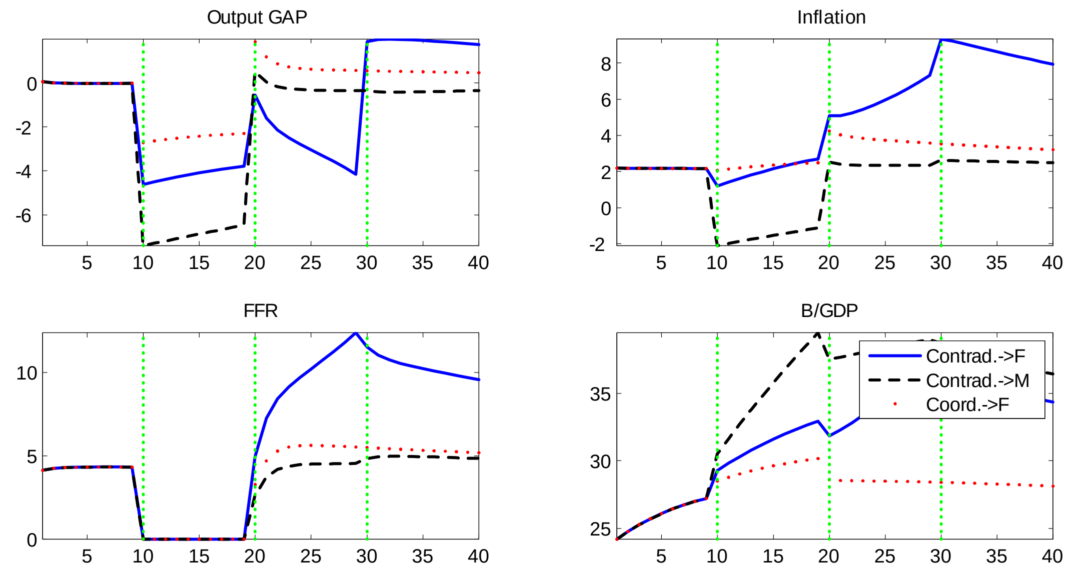

Figure 2: **Macroeconomic Dynamics with Lack of Coordination on Announcements:** Behavior of an economy that enters the zero lower bound with an above-steady-state amount of debt. Three cases are considered: (1) and (2) non-coordinated announcements that induce agents to anticipate a fight between the two authorities; (3) policymakers make coordinated announcements that the Monetary led regime will be abandoned (Coord.->F). In the first scenario (Contrad. ->M), agents anticipate that the monetary authority will prevail; in the second scenario (Contrad.->F), agents anticipate that the fiscal authority will prevail. In the simulations, the conflict between the two authorities last ten quarters. The first two vertical green dotted lines indicate the period in which the economy is at the zero lower bound. The second and third vertical green dotted lines indicate the duration of the *fight regime*.

the *fight regime* starts at time 20 and ends at time 30. At the zero lower bound, policymakers are not able to avoid the recession, even if agents understand that in the very long run debt will be inflated away. To understand why, we have to focus on what happens once the economy exits the zero lower bound. Agents expect that eventually debt will be inflated away, so inflation starts increasing during the period characterized by the conflict between the two authorities. The monetary authority tries to push inflation down, causing a recession. The recession and the high real interest lead to an increase in the debt-to-GDP ratio. Since the fiscal authority does not make the necessary fiscal adjustments and agents expect that eventually the monetary authority will give up stabilizing inflation, the additional stock of debt immediately generates inflationary pressure. Therefore, the increase in real interest rates has the perverse effect of generating even more inflation. This creates a *vicious circle* that causes inflation and the nominal interest rate to drift up, while at the same time the recession becomes deeper and deeper. Agents anticipate this chain of events coming, and their anticipation has an immediate negative impact on the level of real economic activity at the zero lower bound. Finally, when the fight between the two authorities is resolved, the monetary authority gives up and accommodates a jump in inflation. The real interest rate falls deeply, inducing an increase in real economic activity.

While the government's lack of commitment to raise taxes to repay debt is successful in

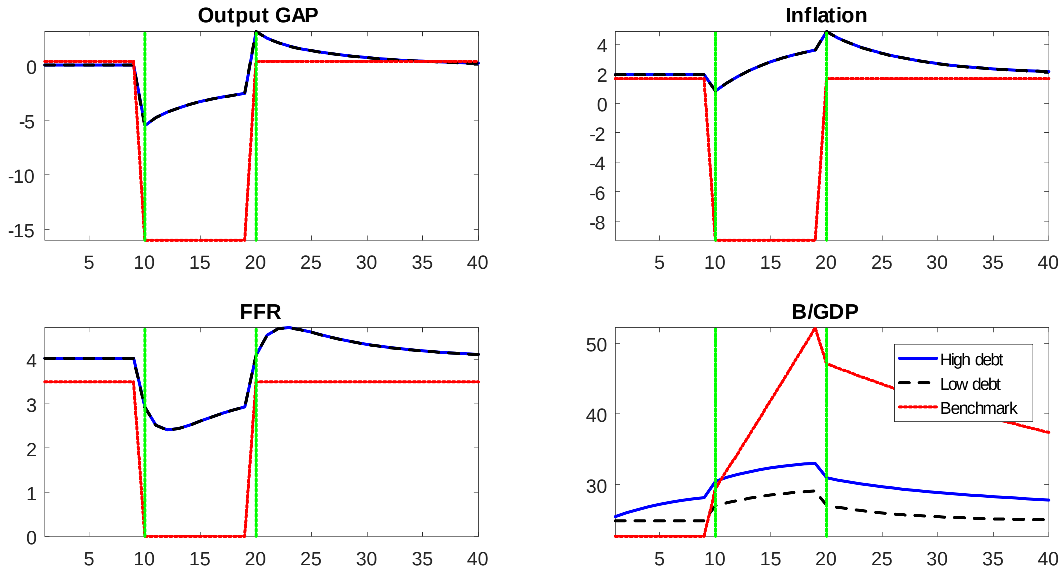

Figure 3: **Macroeconomic Dynamics when Policymakers Relies on the Emergency-Budget Policy**: Response to a large contraction in aggregate demand. The solid blue line and black dashed assume that policymakers inflate away all the debt deriving from the large preference shock, while they are committed to repay all pre-existing debt. In the first case (High debt), debt is above its steady-state level; in the second case, (Low debt), debt is initially at the steady state. Following this strategy allows policymakers to avoid the zero lower bound. The red dotted line corresponds to the benchmark case in which the monetary led regime is always in place and the zero lower bound is binding. The vertical green dotted lines indicate the period in which the economy is at the zero lower bound.

raising inflation expectations, price dynamics become undisciplined for a number of quarters and reach fairly high values. In the next section, we will show an alternative policy that allows the policymakers to raise inflation expectations without totally losing their control over inflation. This policy requires coordination between the two policymakers.

These results suggest that policymakers should be very cautious in choosing the way that they communicate with the public, especially if their statements could induce agents to believe that a conflict between the monetary and fiscal authorities will arise. Lack of coordination of monetary and fiscal policies can dramatically impair policymakers' ability to stimulate economic activity and to control inflation dynamics. It is worthy emphasizing that these detrimental effects would also arise not only if policymakers make contradictionary announcements but also if the public just fears that lack of coordination could materialize in the future.

5 Emergency Budgets

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. At same time, policymakers would commit to fully repay the pre-existing amount of debt and to follow the monetary-led rule in response to all other *business cycle shocks* ($\epsilon_{z,t}$, $\epsilon_{x,t}$, and

$\epsilon_{R,t}$). 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 which he committed to balance and an "emergency budget" that he did not clearly commit to balance.

The commitment to inflate away *only* the amount of debt resulting from the large preference shock determines a sort of *automatic stabilizer*. The large preference 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 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. Therefore, the level of uncertainty once out of the recession immediately returns to the pre-crisis levels.

To illustrate these points, 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 preference shock d_t. 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 the preference shock. In response to all the other fluctuations, policymakers instead follow the monetary-led policy mix. 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:

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

where we assume $\delta_b^E = \psi_b^E = 0$.[10] 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 preference shock.

In Figure 3, we consider two scenarios. In the first one (solid blue line), when the negative preference shock hits, debt is above its steady state level. In the second case (black dashed line),

[10] Appendix A.4 explains more thoroughly how we model the shock-specific policy rule.

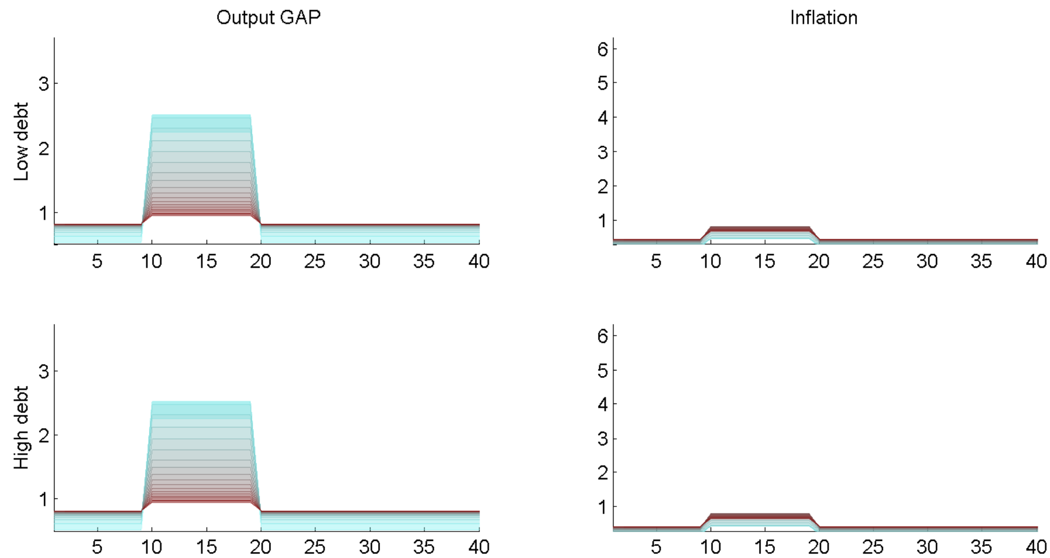

Figure 4: **Evolution of Uncertainty when Policymakers Relies on the Emergency-Budget Policy**: Evolution of uncertainty in response to a large contraction in aggregate demand when policymakers systematically inflate away all the debt deriving from the large preference shock, while they are committed to repay all pre-existing debt. In the first case ("Low debt"), debt is initially at the steady state; in the second case ("High debt"), debt is above steady state. The zero-lower-bound period lasts from period $t = 11$ through period $t = 20$.

debt is instead assumed to be at the steady state. For comparison, we report the benchmark new-Keynesian model in which policymakers follow the monetary-led policy mix all the time.[11] The drop in real economic activity is substantially smaller than the drop observed in the benchmark model, and we do not observe deflation in the two scenarios. This is due to the mechanism outlined earlier: The increase in expected inflation prevents a large drop in inflation today and determines a decline in the path of the real interest rate. Notice that the resulting increase in inflation after the economy exits the zero lower bound is relatively modest. Unlike what we saw when non-coordinated announcements are made, inflation dynamics never appear to become out of control. This is because the recession is largely mitigated, implying that the amount of debt that needs to be inflated away turns out to be small. Finally, it is important to point out that the behavior of the macroeconomy does not depend on the level of debt prevailing when the economy entered the zero lower bound because the preexisting amount of debt is always backed by future fiscal adjustments.

The fact that policymakers inflate away only an amount of debt that can be imputed to the large negative preference shock has important consequences for the level of uncertainty and macroeconomic volatility faced by agents in the model. Figure 4 illustrates the evolution of uncertainty across different horizons for the three scenarios presented above and using the same simulation for the discrete preference shock. We consider horizons from 1 quarter (light

[11] See Appendix A.3 for the precise specification of this model.

blue) to 5 years (dark red).[12] Short-run uncertainty sharply increases when entering the zero lower bound. This is mainly because agents does not know when exactly the economy will exit the recession (i.e., when the discrete demand shock turns high). As the large demand shock is reabsorbed, uncertainty returns to its lower pre-recession level because policymakers have not changed their behavior with respect to business cycle shocks. Business cycle shocks are always stabilized according to the monetary-led policy mix. Thus, the proposed policy is not affected by the trade-off between mitigating the effects of a severe recession on economic activity and retaining the long-run macroeconomic volatility that characterized the coordinated policy announcements studied in Bianchi and Melosi (2016).

An important question is how the policy presented here could be implemented in practice. As is common in the literature, we assume that agents have perfect information and can observe the shocks hitting the economy. In reality, policymakers and agents might not have the possibility of exactly disentangling the contribution of the different shocks to the evolution of the macroeconomy. In that case, a simpler policy would consist of announcing a target for the debt-to-GDP ratio based on the pre-crisis level of debt. Policymakers would commit to raise enough taxes to repay the pre-existing level of debt or a projection of this value, but they would not respond to *any* movement in the debt-to-GDP ratio that occurs during the crisis. The part of debt above the announced target would then be inflated away. Policymakers would then return to the monetary-led regime once the crisis is over. This approach implies that *any* business cycle shock that occurs during the crisis would also change the level of debt that is going to be inflated away, while in the policy presented in this paper only the amount of debt deriving from the discrete preference shock would be inflated away. As a result, this more realistic approach is associated with a slightly higher uncertainty during the crisis than the shock-specific strategy we outlined, but it would have the important advantage of being relatively easier to communicate.

Finally, in our model, the shock-specific policy occurs in response to a large negative preference shock. In reality there might be many disturbances that could require a similar change in policy. Furthermore, there might be disagreement among policymakers about whether a realized shock is large enough to trigger the policy change. A simple criterion would consist of following this alternative policy in response to all those disturbances that would drive the nominal interest rate to negative territory under the monetary-led policy mix.

[12] Uncertainty is computed taking into account the possibility of regime changes and future Gaussian shocks (Bianchi 2016). For a variable X_t and a horizon q, it corresponds to the conditional standard deviation $sd_t(X_{t+q})$.

6 Conclusions

This paper studies the implication of the lack of coordination between the monetary and fiscal authorities, with particular emphasis on the recent zero-lower-bound period. Lack of coordination is when policymakers announce that they will pursue two active policies. When non-coordinated announcements of this nature are made, two outcomes can arise. One possible outcome is that policymakers appear 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 agents expect to switch to passive policy.

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 gearing monetary and fiscal policy towards the common objective of inflating away only the part of the debt resulting from deep recessions. 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 preference shocks hit the economy. At the same time, the proposed policy preserves long-run macroeconomic stability because policymakers are still committed to fully repay any preexisting stock of debt and to fully neutralize all other present and future disturbances affecting the debt-to-GDP ratio.

References

Aruoba, S., P. Cuba-Borda, and F. Schorfheide (2013). Macroeconomic Dynamics Near the Zero Lower Bound: A Tale of Two Countries. NBER working paper 19248.

Benhabib, J., S. Schmitt-Grohe, and M. Uribe (2001). The Perils of Taylor Rules. *Journal of Economic Theory 96*(1-2), 40–69.

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

Bianchi, F. (2016). Methods for Measuring Expectations and Uncertainty in Markov-switching Models. *Journal of Econometrics 190*(1), 79 – 99.

Bianchi, F. and C. Ilut (2014). Monetary/Fiscal Policy Mix and Agents' Beliefs. NBER working paper 20194.

Bianchi, F., C. Ilut, and M. Schneider (2014). Uncertainty Shocks, Asset Supply and Pricing over the Business Cycle. NBER Working Paper No. 20081.

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

Bianchi, F. and L. Melosi (2016). Escaping the Great Recession. American Economic Review, Forthcoming.

Christiano, L., M. Eichenbaum, and S. Rebelo (2011). When is the Government Spending Multiplier Large? *Journal of Political Economy 119*(1), 78–121.

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

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

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

Coibion, O., Y. Gorodnichenko, and J. Wieland (2012). The Optimal Inflation Rate in New Keynesian Models: Should Central Banks Raise Their Inflation Targets in Light of the Zero Lower Bound? *Review of Economic Studies 79*(4), 1371–1406.

Correia, I., E. Farhi, J. P. Nicolini, and P. Teles (2013). Unconventional Fiscal Policy at the Zero Bound. *American Economic Review 103*(4), 1172–1211.

Eggertsson, G. B. (2006). The Deflation Bias and Committing to Being Irresponsible. *Journal of Money, Credit, and Banking 38*(2), 283–321.

Eggertsson, G. B. (2008). Great Expectations and the End of the Depression. *American Economic Review 98*(4), 1476–1516.

Eggertsson, G. B. and M. Woodford (2003). The Zero Interest-rate Bound and Optimal Monetary Policy. Brookings Panel on Economic Activity.

Farmer, R. E., D. F. Waggoner, and T. Zha (2009). Understanding Markov-Switching Rational Expectations Models. *Journal of Economic Theory 144*, 1849–1867.

Fernandez-Villaverde, J., P. Guerron-Quintana, and J. F. Rubio-Ramirez (2014). Supply-Side Policies and the Zero Lower Bound. *IMF Economic Review 62*(2), 248–260.

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

Gust, C., E. Herbst, D. Lopez-Salido, and M. Smith (2016). The Empirical Implications of the Interest-Rate Lower Bound. Finance and Economcis Discussion Paper 2012-083, Divisions of Research and Statistics and Monetary Affairs Federal Reserve Board, Washington, D.C.

Justiniano, A. and G. Primiceri (2008). The Time Varying Volatility of Macroeconomic Fluctuations. *American Economic Review 98*(3), 604–41.

Krugman, P. R. (1998). It's baaack: Japan's slump and the return of the liquidity trap. *Brookings Papers on Economic Activity 29*(2), 137–206.

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

Leeper, E. M. and T. B. Walker (2011, November). Perceptions and misperceptions of fiscal inflation. BIS Working Papers 364, Bank for International Settlements.

Liu, Z., D. Waggoner, and T. Zha (2011). Sources of the Great Moderation: A Regime-Switching DSGE Approach. *Quantitative Economics 2*(2), 251–301.

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

Orphanides, A. and V. Wieland (1998). Price stability and monetary policy effectiveness when nominal interest rates are bounded at zero. Finance and Economics Discussion Series 1998-35, Board of Governors of the Federal Reserve System (U.S.).

Orphanides, A. and V. Wieland (2000). Efficient monetary policy design near price stability. *Journal of the Japanese and International Economies 14*(4), 327–365.

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

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

Schmitt-Grohe, S. and M. Uribe (2012). The Making Of A Great Contraction With A Liquidity Trap And A Jobless Recovery. Columbia University working paper.

Schorfheide, F. (2005). Learning and Monetary Policy Shifts. *Review of Economic Dynamics 8*(2), 392–419.

Sims, C. (2016). Fiscal Policy, Monetary Policy And Central Bank Independence. Working paper, Economic Symposium at Jackson Hole, Wy.

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

Sims, C. A. (2002). Solving Linear Rational Expectations Models. *Computational Economics 20*(1), 1–20.

Werning, I. (2012). Managing a Liquidity Trap: Monetary and Fiscal Policy. MIT working paper.

Wolman, A. L. (1998). Staggered price setting and the zero bound on nominal interest rates. *Economic Quarterly* (Fall), 1–24.

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

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

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

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

A Technical details

A.1 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:

$$\begin{aligned}
i_* &= r_* \Pi_* && (50)\\
\tau_t + i_t^{-1} b_t &= \frac{b_{t-1}}{\Pi_t}\\
\tau_* + i_*^{-1} b_* &= \frac{b_*}{\Pi_*}\\
b_* &= \frac{\tau_*}{\Pi_*^{-1} - i_*^{-1}}\\
b_* &= \frac{\tau_*}{\Pi_*^{-1} - r_*^{-1}\Pi_*^{-1}} && (51)\\
b_* &= \frac{\tau_*}{1 - r_*^{-1}} \frac{1}{\Pi_*^{-1}} && (52)\\
\frac{b_*}{\Pi_*} &= \frac{r_*}{r_* - 1}\tau_* && (53)
\end{aligned}$$

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

From the fiscal rule, it follows that

$$\tau_* = b_*^\gamma$$

Hence for given Π_*,

$$b_* = \left[\Pi_* \frac{r_*}{r_* - 1}\right]^{\frac{1}{1-\gamma}}$$

If $\gamma = 0$, then $\tau_* = 1$ and then

$$\frac{b_*}{\Pi_*} = \frac{r_*}{r_* - 1}$$

Model Solution Under Fiscal Dominance If $\phi \leq 1$ and $\gamma < 1$ (PM/AF), the system of equations (18) 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 (18) 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[13] of the dynamic system (18) and define the vector

$$\begin{bmatrix} p_t \\ \beta_t \end{bmatrix} \equiv \begin{bmatrix} \frac{r_*}{r_*+\gamma-\phi-r\gamma} + \frac{\phi}{r_*+\gamma-\phi-r\gamma} & 0 \\ -\frac{r_*}{r_*+\gamma-\phi-r\gamma} - \frac{\phi}{r_*+\gamma-\phi-r\gamma} & 1 \end{bmatrix} \begin{bmatrix} E_t\hat{\pi}_{t+1} \\ \hat{b}_t \end{bmatrix}.$$

The system (18) can then be equivalently written as

$$\begin{aligned} \begin{bmatrix} p_t \\ \beta_t \end{bmatrix} &= \begin{bmatrix} \phi & 0 \\ 0 & r_* + \gamma - r\gamma \end{bmatrix} \begin{bmatrix} p_{t-1} \\ \beta_{t-1} \end{bmatrix} \\ &+ \begin{bmatrix} -\frac{r_*}{r_*+\gamma-\phi-r\gamma} - \frac{\phi}{r_*+\gamma-\phi-r\gamma} & 0 & \frac{r_*}{r_*+\gamma-\phi-r\gamma} + \frac{\phi}{r_*+\gamma-\phi-r\gamma} \\ \frac{r_*}{r_*+\gamma-\phi-r\gamma} + \frac{\phi}{r_*+\gamma-\phi-r\gamma} & 1 - r_* & -\frac{r_*}{r_*+\gamma-\phi-r\gamma} - \frac{\phi}{r_*+\gamma-\phi-r\gamma} - 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^r \\ \varepsilon_t^\varsigma \\ \varepsilon_t^m \end{bmatrix} \\ &+ \begin{bmatrix} \phi\left(\frac{r_*}{r_*+\gamma-\phi-r\gamma} + \frac{\phi}{r_*+\gamma-\phi-r\gamma}\right) \\ -r_* - \phi - \phi\left(\frac{r_*}{r_*+\gamma-\phi-r\gamma} + \frac{\phi}{r_*+\gamma-\phi-r\gamma}\right) \end{bmatrix} \eta_t. \end{aligned} \tag{54}$$

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

$$\beta_t \equiv \begin{bmatrix} -\frac{r_*}{r_*+\gamma-\phi-r\gamma} - \frac{\phi}{r_*+\gamma-\phi-r\gamma} & 1 \end{bmatrix} \begin{bmatrix} E_t\hat{\pi}_{t+1} \\ \hat{b}_t \end{bmatrix} \overset{!}{=} 0 \tag{55}$$

which implies equation (21) in the main text.

A.2 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 $\overline{d}$.

[13] $$\begin{bmatrix} \phi & 0 \\ -r-\phi & r-(r-1)\gamma \end{bmatrix} = \underbrace{\begin{bmatrix} \frac{r+\gamma-\phi-r\gamma}{r+\phi} & 0 \\ 1 & 1 \end{bmatrix}}_{C^{-1}} \underbrace{\begin{bmatrix} \phi & 0 \\ 0 & r+\gamma-r\gamma \end{bmatrix}}_{J} \underbrace{\begin{bmatrix} \frac{r}{r+\gamma-\phi-r\gamma} + \frac{\phi}{r+\gamma-\phi-r\gamma} & 0 \\ -\frac{r}{r+\gamma-\phi-r\gamma} - \frac{\phi}{r+\gamma-\phi-r\gamma} & 1 \end{bmatrix}}_{C}$$

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.

A.3 Matrices used in the simulations

We here describe the matrices used in the simulations reported in the paper.

A.3.1 Benchmark New-Keynesian model

In the benchmark New-Keynesian model, policymakers always follow the monetary-led regime when out of the zero lower bound. Furthermore, there is only one zero lower bound regime from which agents expect to return to the monetary-led regime:

$$H^i = H^z = H^o = H^p = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}, \; H^d = \begin{bmatrix} p_{hh} & 1-p_{ll} \\ 1-p_{hh} & p_{ll} \end{bmatrix}.$$

A.3.2 Non-Coordinated announcements

At zero lower bound, we distinguish three cases, based on the exit strategy:

1. Policy uncertainty (no announcement is made).
2. Policymakers announce that they will move to the monetary-led regime once the economy is out of the zero lower bound.
3. Policymakers announce that they will move to the fiscally-led regime once the economy is out of the zero lower bound.
4. Non-coordinated announcements leading to a conflict between monetary and fiscal authorities will be resolved in favor of the monetary authority.
5. Non-coordinated announcements leading to a conflict between monetary and fiscal authorities will be resolved in favor of the fiscal authority.

We assume that the five cases are equally likely and their probabilities do not depend on the regime that was in place when the negative preference shock hits. We then have:

$$H^p = \begin{bmatrix} .99 & .01 & .14 & \\ .01 & .99 & & .14 \\ & & .86 & \\ & & & .86 \end{bmatrix}, \; H^o = \begin{bmatrix} .25 & 1 & & & \\ .25 & & 1 & & \\ .25 & & & 1 & \\ .25 & & & & 1 \end{bmatrix},$$

$$H^i = \begin{bmatrix} .20 & .20 & 0 & 0 \\ .20 & .20 & 0 & 0 \\ .20 & .20 & 0 & 0 \\ .20 & .20 & 0 & 0 \\ .20 & .20 & 0 & 0 \end{bmatrix}, \; H^z = \begin{bmatrix} .98 & .005 & .005 & .005 & .005 \\ .005 & .98 & .005 & .005 & .005 \\ .005 & .005 & .98 & .005 & .005 \\ .005 & .005 & .005 & .98 & .005 \\ .005 & .005 & .005 & .005 & .98 \end{bmatrix},$$

$$H^d = \begin{bmatrix} .98 & .20 \\ .02 & .80 \end{bmatrix},$$

where the third and fourth out-of-the-zero-lower-bound regimes are both characterized by both monetary and fiscal authorities to be active and only differ in terms of the authority that will eventually prevail.

A.4 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:

$$\widetilde{\pi}_t = \beta E_t(\widetilde{\pi}_{t+1}) + \kappa(\widetilde{y}_t - z_t), \tag{56}$$

$$\widetilde{y}_t = E_t(\widetilde{y}_{t+1}) - \left(\widetilde{R}_t - E_t(\widetilde{y}_{t+1})\right) + \widetilde{d}_t - \mathbf{E}_t\left(\widetilde{d}_{t+1}\right), \tag{57}$$

$$\widetilde{b}_t = \beta^{-1}\widetilde{b}_{t-1} + b\beta^{-1}\left(\widetilde{R}_{t-1} - \widetilde{\pi}_t - \Delta\widetilde{y}_t\right) - \widetilde{s}_t, \tag{58}$$

$$\widetilde{s}_t = \delta_b^M b_{t-1}^{nd} + \delta_b^E\left(b_{t-1} - b_{t-1}^{nd}\right) + \delta_y(\widetilde{y}_t - z_t) + x_t, \tag{59}$$

$$\widetilde{R}_t = \rho_R\widetilde{R}_{t-1} + (1-\rho_R)\left(\psi_\pi^M \pi_t^{nd} + \psi_\pi^E\left(\pi_t - \pi_t^{nd}\right) + \psi_y\left[\widetilde{y}_t - z_t\right]\right) + \sigma_R\epsilon_{R,t}. \tag{60}$$

THE SHADOW ECONOMY

$$\widetilde{\pi}_t^{nd} = \beta E_t(\widetilde{\pi}_{t+1}^{nd}) + \kappa(\widetilde{y}_t^{nd} - z_t), \tag{61}$$

$$\widetilde{y}_t^{nd} = E_t\left(\widetilde{y}_{t+1}^{nd}\right) - \left(\widetilde{R}_t^{nd} - E_t\left(\widetilde{y}_{t+1}^{nd}\right)\right), \tag{62}$$

$$\widetilde{b}_t^{nd} = \beta^{-1}\widetilde{b}_{t-1}^{nd} + b\beta^{-1}\left(\widetilde{R}_{t-1}^{nd} - \widetilde{\pi}_t^{nd} - \Delta\widetilde{y}_t^{nd}\right) - \widetilde{s}_t^{nd}, \tag{63}$$

$$\widetilde{s}_t^{nd} = \delta_b^{nd}\widetilde{b}_{t-1}^{nd} + \delta_y\left(\widetilde{y}_t^{nd} - z_t\right) + x_t, \tag{64}$$

$$\widetilde{R}_t^{nd} = \rho_R\widetilde{R}_{t-1}^{nd} + (1-\rho_R)\left(\psi_\pi^{nd}\widetilde{\pi}_t^{nd} + \psi_y\left[\widetilde{y}_t^{nd} - z_t\right]\right) + \sigma_R\epsilon_{R,t}. \tag{65}$$

EXOGENOUS PROCESSES

$$\widetilde{d}_t = \widetilde{\overline{d}}_{\xi_t^d}, \tag{66}$$

$$z_t = \rho_z z_{t-1} + \sigma_z\epsilon_{z,t}, \tag{67}$$

$$x_t = \rho_x x_{t-1} + \sigma_x\epsilon_{x,t}. \tag{68}$$

It should be noted that the equations governing the behavior of the shadow economy (61)-(65) differ from those of the actual economy (56)-(60) in only one dimension: While the actual economy is buffeted by all types of shocks (i.e., ξ_t^d, $\epsilon_{r,t}$, $\epsilon_{z,t}$, and $\epsilon_{x,t}$), 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 (59) and (60). Finally, it is important to point out that equations (56)-(68) 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).