# Understanding Lowflation

David Andolfatto and Andrew Spewak

Central banks are viewed as having a demonstrated ability to lower long-run inflation. Since the Financial Crisis, however, the central banks in some jurisdictions seem almost powerless to accomplish the opposite. In this article, we offer an explanation for why this may be the case. Because central banks have limited instruments, long-run inflation is ultimately determined by fiscal policy. Central bank control of long-run inflation therefore ultimately hinges on its ability to gain fiscal compliance with its objectives. This ability is shown to be inherently easier for a central bank determined to lower inflation than for a central bank determined to accomplish the opposite. Among other things, the analysis here suggests that for the central banks of advanced economies, any stated inflation target is more credibly viewed as a ceiling. (JEL: E31, E52, E58, E62, E63)

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## 1 INTRODUCTION

Inflation has remained stubbornly below target in many countries since the Financial Crisis of 2008, a phenomenon that the International Monetary Fund has aptly labeled "lowflation."[1] In the United States, this is especially evident since 2012—ironically, the year the Federal Reserve adopted an official 2 percent personal consumption expenditures (PCE) inflation target.[2] As shown in Figure 1, both core and headline measures of PCE inflation have remained persistently and significantly below a supposedly symmetric target.

A puzzling aspect of this recent lowflation episode is that by many measures, Federal Reserve policy has been perceived to be unusually "accommodative." The effective federal funds rate, for example, averaged roughly 10 basis points over the period 2009-15. Over the period 2008-14, the liabilities of the Federal Reserve increased from less than $1 trillion to roughly $4.5 trillion.

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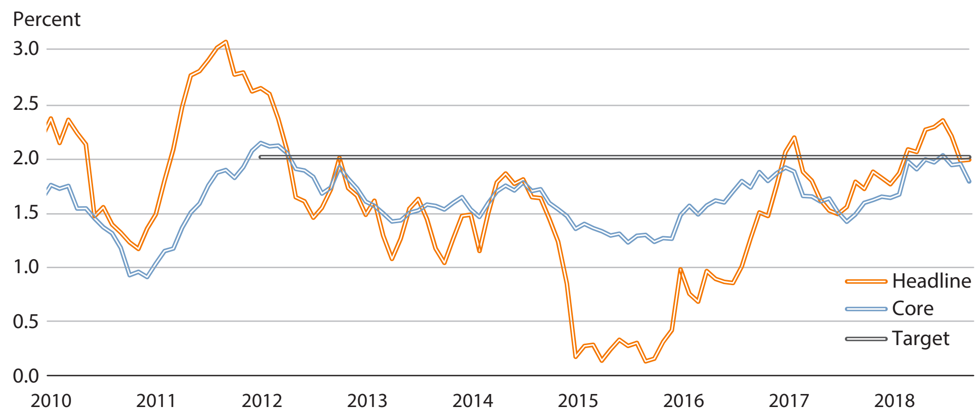
## Figure 1

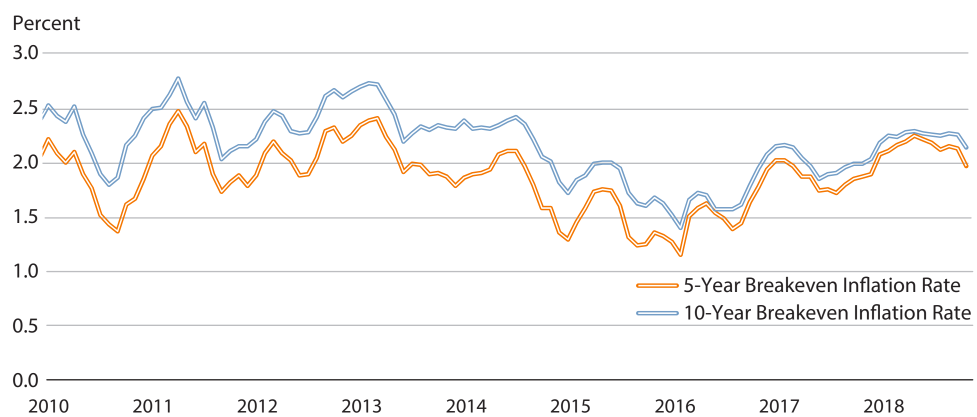
**PCE Inflation, January 2010–October 2018**




SOURCE: Bureau of Economic Analysis (BEA).

## Figure 2

**Market-Based Inflation Expectations, January 2010–November 2018**




SOURCE: Board of Governors of the Federal Reserve System (BOG).

The puzzle is further compounded when viewed through the lens of the Phillips curve theory of inflation. That is, after peaking at 10 percent in 2009, the civilian unemployment rate in the United States declined steadily to approximately 4 percent today. Conventional wisdom suggests that a low unemployment rate should portend higher future inflation. And yet, as shown in Figure 2, measures of inflation expectations have, if anything, declined since 2010.

What is going on here? Isn't high inflation supposed to be easy to get? Didn't Zimbabwe give us a modern day lesson in creating inflation? Isn't Venezuela providing us the lesson in real time?[3] Didn't former Federal Reserve Chair Paul Volcker demonstrate how a sufficiently determined central bank can lower inflation? If so, then why does it appear so difficult for Federal Reserve officials to accomplish the reverse today?

We address these questions using a monetary-fiscal theory of inflation that is based on an overlapping-generations model in the spirit of Diamond (1965). The model features physical capital investment and an outside asset consisting of nominal government debt that can take the form of money (in the form of interest-bearing reserves) and bonds. The fiscal authority determines the path of government spending and taxation—and hence, the path of the nominal debt. The monetary authority determines the nominal interest rate paid on reserves and government debt—and hence, implicitly, the composition of the outstanding government debt between central bank reserves and government bonds in the hands of the public outside the central bank. Monetary and fiscal policy can have a persistent (even permanent) effect on the level of investment and output.

Control of the monetary aggregate in our model translates into control over the long-run inflation rate. Despite this "monetarist" aspect of our model, the central bank cannot unilaterally dictate the long-run inflation rate. The central bank can, however, determine the path of the price level (and hence, inflation) in the short run by manipulating the yield on bonds via open market operations when reserves are scarce and via the interest paid on reserves when reserves are held in excess of the statutory minimum. The real effects of monetary policy in the model are consistent with conventional views of the monetary transmission mechanism.

We use our model to identify what, if any, limits are faced by a monetary authority intent on pursuing a long-run inflation policy in the face of an uncooperative fiscal authority. We consider two thought experiments. Both experiments begin with the economy in a stationary state where the bond yield is higher than the interest paid on reserves (so that reserves are scarce) and where both the monetary and fiscal authorities agree on a long-run inflation target. Fiscal policy is "Ricardian" in the sense that, for any given monetary policy, the intertemporal government budget constraint is satisfied through adjustments in the real primary budget surplus. In the first thought experiment, the central bank suddenly lowers its preferred long-run inflation target, trying to keep inflation at the lower rate for as long as it can. In the second thought experiment, the opposite is considered—the central bank suddenly raises its preferred inflation target. The central issue is how the resulting conflicts are likely to be resolved in the long run. Our analysis suggests that a central bank is more likely to win the first contest and lose the second.

Despite the conventional "monetarist" flavor of our model, there are two reasons why a central bank may not have unilateral control over the long-run inflation rate. First, central banks are normally constrained to create money out of Treasury securities. They are not typically allowed to engage in monetary transfers (helicopter drops) or to tax. Because this is so, the supply of central bank money cannot grow more rapidly than the public debt for an indefinite period.[4] Second, the relevant monetary base may at times include the total public debt and not just the fraction of it monetized by a central bank. When central bank reserves and Treasury securities are viewed as close substitutes (as evidenced, for example, by a small spread on their respective yields), then the effective base money supply constitutes the total supply of outside assets—an object that is controlled by the fiscal authority rather than the monetary authority.

Despite these restrictions, a central bank need not be completely impotent in terms of influencing the price level and even the eventual path of long-run inflation. Under normal conditions (i.e., when bonds dominate money in rate of return), the central bank of our model can influence real economic activity and the price level through open market operations. Although our central bank cannot determine the long-run inflation rate without fiscal cooperation, it can influence the path of the price level for at least a finite period of time. Over the course of this finite time interval, the central bank pressures the fiscal authority along two dimensions. First, in an attempt to, say, lower inflation through a restrictive monetary policy, the central bank depresses real economic activity. Second, the implied higher interest rate associated with tight monetary policy has the effect of increasing the interest expense of the public debt, necessitating politically painful fiscal adjustments.

The idea we promote below is reminiscent of Wallace's "game of chicken," which Sargent (1986) used as an interpretation of the Reagan deficits. In that interpretation, the administration cut taxes and encouraged tight monetary conditions to induce Congress to cut spending. As we explain below, our reading of the evidence suggests rather less cooperation between the Federal Reserve and the administration, with elements of Congress divided between them. Nevertheless, the implications of our game vis-a-vis the Wallace game appear to be the same; in particular,

> While the authorities are playing this game of chicken, we would observe large net-of-interest government deficits, low rates of monetization of government debt (low growth rates for the monetary base), and maybe also high real interest rates on government debt. (Sargent, 1986, pg. 10)

Of course, back in the 1980s, the issue of monetary-fiscal coordination was discussed in the context of a high-inflation environment. Proponents of central bank independence frequently cast the scenario as the need for a sober and committed monetary authority to check a naturally profligate fiscal authority (Waller, 2011). Because high inflation is almost always the problem, few thought to ask what a policy coordination game might look like in the context of lowflation.

Our theory of inflation suggests the pressure that a central bank can bring to bear on the fiscal authority—and hence, the leverage it has to ultimately sway the course of fiscal policy—is asymmetric across high versus low inflation regimes. In the former case, lowering inflation requires a contractionary monetary policy that, among other things, increases the interest expense of the public debt. In the latter case, increasing inflation requires an expansionary monetary policy which, as a side benefit, lowers the interest expense of the public debt. Moreover, when expansionary monetary policy takes the form of Treasury purchases, the nominal interest rate can fall only as low as the interest paid on reserves. Central bank purchases of Treasury securities become increasingly ineffectual as the spread on bond yields and reserves narrows. In the limit, when they are equal, further asset purchases are inconsequential except insofar as they result in a buildup of excess reserves.

Our article proceeds as follows. In Section 2, we develop our theoretical framework and describe some of its key properties. In Section 3, we perform our first thought experiment of lowering the inflation target, with an application to the Volcker disinflation. In Section 4, we perform the thought experiment of increasing the inflation target, with an application to the recent lowflation phenomenon. Section 5 provides a summary and some thoughts on the future of inflation in light of some recent developments in U.S. fiscal policy.

## 2 THE MODEL ECONOMY

We want to use a modeling framework that can help us formalize the interaction between monetary and fiscal policy and help us investigate how this interaction affects economic incentives and macroeconomic outcomes. At the same time, we want the analysis to remain analytically tractable. For these reasons, we make use of the overlapping generations framework of Allais (1947), Samuelson (1958), and Diamond (1965). The version of the model we employ here is based on Andolfatto (2003, 2015).

### 2.1 Preferences and Technology

Time is discrete and denoted $t = 1,2,\ldots,\infty$. The economy is populated by a sequence of two-period-lived overlapping generations. Let $N_t$ denote the number of people entering the economy at date $t \geq 1$. Population growth is exogenous, $N_t = n_t N_{t-1}$, where $N_0$ denotes an initial population that lives for one period only (the *initial old*).

The objective of all individuals is to maximize consumption when old. Formally, their preferences are given by $U_t = c_{t+1}$, for $t \geq 0$. Given these preferences, the young will want to save all their income. While the consumption-saving decision is rendered trivial, the young will face a nontrivial portfolio-choice problem.[5]

The young are endowed with $y_t$ units of output. The young also possess an investment technology, where $k_t$ units of output invested at date $t$ yields $x_{t+1}f(k_t)$ units of output at date $t+1$, where $x_{t+1}$ is an exogenous productivity shock influencing the future return to capital spending. Assume that the investment-return function yields a rate of return $f'(k) > 0$ that diminishes with the scale of the investment, $f''(k) < 0$.[6]

In what follows, we think of $y_t$ and $x_{t+1}$ as "supply" and "demand" shocks, respectively.[7] Although we do not make extensive use of these shocks in our analysis below, we introduce them to let the reader know the model can potentially account for the boom-bust cycle.

### 2.2 Monetary and Fiscal Policy

There are two types of government securities. One is issued by the central bank in the form of interest-bearing reserves, and the other is issued by the Treasury in the form of interest-bearing debt. Both securities are denominated in dollars. Let $M_t$ denote the supply of reserves at date $t$, and let $B_t$ denote the supply of bonds held by the private sector at date $t$. The total public debt at date $t$ is denoted $D_t = M_t + B_t$. For simplicity, assume that both reserves and bonds are perpetual instruments that yield gross nominal rates of return equal to $R_t^m$ and $R_t^b$, respectively.[8] Government securities are nominally risk free.

In what follows, we assume that the central bank is delegated control over $\{R_t^b, R_t^m, \theta_t\}$, where the variable $\theta_t \equiv M_t / D_t$ represents the fraction of public debt monetized by the central bank. The fiscal authority is responsible for tax and spend decisions, which we denote $T_t$ and $G_t$, respectively. Here, $T_t$ denotes tax revenue net of transfers and $G_t$ denotes government purchases of goods and services. The primary deficit (surplus, if negative) is given by $G_t - T_t$. The fiscal authority chooses the path of the primary deficit and rate at which to issue new debt, $\mu_t \equiv D_t / D_{t-1}$. The consolidated government budget constraint is given by

$$G_t + R_{t-1}^m M_{t-1} + R_{t-1}^b B_{t-1} = T_t + M_t + B_t \tag{1}$$

for all $t \geq 1$. The left-hand side of (1) represents government expenditures on purchases and maturing debt. The right-hand side of (1) represents government revenue from net taxes and new debt issuance.

Let $P_t$ denote the price level and define $N_{t-1}\tau_t \equiv T_t / P_t$, $N_{t-1}g_t \equiv G_t / P_t$, $N_t d_t \equiv D_t / P_t$. Using the definitions $M_t \equiv \theta_t D_t$ and $\mu_t \equiv D_t / D_{t-1}$, it is convenient to rewrite (1) as follows:

$$g_t - \tau_t = \left[1 - \hat{R}_{t-1} / \mu_t\right] n d_t, \tag{2}$$

where $\hat{R}_{t-1} \equiv \theta_{t-1} R_{t-1}^m + \left(1 - \theta_{t-1}\right) R_{t-1}^b$ is a weighted average of the interest rate paid on the outstanding stock of public debt. The right-hand side of (2) represents seigniorage revenue. Notice that seigniorage includes the revenue generated by both money and bond issuance. If $\hat{R}_{t-1} < \mu_t$, then the right-hand side of (2) is positive and the government can use its seigniorage revenue to finance a primary budget deficit ($g_t - \tau_t > 0$). Alternatively, if $\hat{R}_{t-1} > \mu_t$, then the government is compelled to run a primary budget surplus to finance the carrying cost of its debt.

In what follows, we set $g_t = 0$ for all $t \geq 1$ so that $\tau_t$ represents both net tax revenue and the primary surplus (per old person). For simplicity, we assume that $\tau_t$ represents a lump-sum tax (transfer, if negative) that is applied to the old only.[9] Moreover, we assume that the initial stock of debt $M_0 + B_0 = D_0$ is in the hands of the initial old.

A *government policy* consists of a sequence $\{R_t^b, R_t^m, \theta_t, \mu_t, \tau_t\}_{t=1}^{\infty}$ satisfying (2). A *stationary government policy* is defined to be a time-invariant government policy; that is, $\{R_t^b, R_t^m, \theta_t, \mu_t, \tau_t\}$ $= \{R^b, R^m, \theta, \mu, \tau\}$. We assume throughout that $R_t^b \geq R_t^m$.

As mentioned earlier, monetary policy determines $\{R_t^b, R_t^m, \theta_t\}$. If $R_t^b = R_t^m$, then the choice of $\theta_t$ becomes inconsequential. In this latter case, the composition of the public debt does not matter and monetary policy basically boils down to determining the interest paid on reserves. If $R_t^b > R_t^m$, then the composition of the public debt will turn out to matter. An open market operation that changes $\theta_t$ will have consequences for the equilibrium bond yield $R_t^b$. Alternatively, the monetary authority can determine $R_t^b$ and let the market determine its preferred combination of money and bonds.

As for fiscal policy, we assume that it is *Ricardian* in the sense that it adjusts its real primary surplus $\{\tau_t\}$ to satisfy the government budget constraint (2) for a given nominal debt-issuance rate $\{\mu_t\}$. While this assumption is standard, it is not innocuous. We might alternatively have assumed a non-Ricardian fiscal policy that targets the real primary surplus and instead lets the rate of nominal debt issuance adjust to satisfy (2). We discuss the implications of this alternative specification of fiscal policy below.

### *2.3 Individual Decisionmaking*

The young enter the economy with real earnings $y_t$ and zero financial wealth. Because they have no desire to consume when young, they will save all their earnings. There are three options available: private investment, money, and bonds, so that $P_t y_t = P_t k_t + \hat{M}_t + \hat{B}_t$. Define $\hat{m}_t \equiv \hat{M}_t / P_t$ and $\hat{b}_t \equiv \hat{B}_t / P_t$ (the hats on the variables are meant to distinguish individual choices from aggregates). Then the budget constraint for a young individual at date $t$ is given by

$$\hat{m}_t + \hat{b}_t + k_t = y_t. \tag{3}$$

What governs the portfolio-choice problem? The young are presumed to choose a portfolio that they like best, which in the present context means a portfolio $\{\hat{m}_t, \hat{b}_t, k_t\}$ that maximizes utility $U_t = c_{t+1}$ subject to the constraint (3). To calculate future consumption, we refer to the following budget constraint facing an old individual:

$$P_{t+1} c_{t+1} = P_{t+1} x_{t+1} f(k_t) + R_t^b \hat{B}_t + R_t^m \hat{M}_t - T_{t+1} / N_t.$$

Define the gross inflation rate $\Pi_{t+1} \equiv P_{t+1} / P_t$ and rewrite the expression above as follows:

$$c_{t+1} = x_{t+1} f(k_t) + \left(R_t^b / \Pi_{t+1}\right) \hat{b}_t + \left(R_t^m / \Pi_{t+1}\right) \hat{m}_t - \tau_{t+1}. \tag{4}$$

That is, a given portfolio $\{\hat{m}_t, \hat{b}_t, k_t\}$ generates a future after-tax real return equal to (4).

Note that, because reserves and bonds here are distinguished only by their rates of return, investors are naturally drawn to hold the security that offers the highest rate of return. Historically, the yield on bonds has been positive ($R_t^b > 1$) and the yield on reserves zero ($R_t^m = 1$). For this return structure, the demand for reserves would fall to zero in our model. To generate a demand for reserves when they are dominated in rate of return, we follow Smith (1991) and assume that investors structure their wealth portfolios in a manner that respects a "reserve requirement" $\hat{M}_t \geq \sigma_t P_t k_t$, or

$$\hat{m}_t \geq \sigma_t k_t. \tag{5}$$

Here, $0 < \sigma_t < 1$ is a parameter that may be interpreted as either a legislated minimum reserve requirement (investors are required to hold a minimum amount of cash against their private sector investments) or as a reduced-form way of capturing some other unmodeled use for reserves (e.g., as the unique settlement instrument used to clear interbank payments).

Using (3) we have $\hat{b}_t = y_t - \hat{m}_t - k_t$, which when combined with (4) and (5) yields the Lagrangian,

$$\mathcal{L}_t = x_{t+1} f(k_t) + \left(R_t^b / \Pi_{t+1}\right)\left[y_t - \hat{m}_t - k_t\right] + \left(R_t^m / \Pi_{t+1}\right) \hat{m}_t - \tau_{t+1} + \lambda_t \left[\hat{m}_t - \sigma_t k_t\right],$$

where $\lambda_t \geq 0$ is the Lagrange multiplier. Maximizing $\mathcal{L}_t$ through the choice of $\{\hat{m}_t, k_t\}$ yields the following optimality conditions:

$$\lambda_t = \left(R_t^b - R_t^m\right) / \Pi_{t+1} \tag{6}$$

$$x_{t+1} f'\left(k_t\right) = \left(R_t^b / \Pi_{t+1}\right) + \sigma_t \lambda_t . \tag{7}$$

Condition (6) tells us that the reserve requirement binds if and only if $R_t^b > R_t^m$. In this case, $\hat{m}_t = \sigma_t k_t$ and $\hat{b}_t = y_t - (1 + \sigma_t)k_t$. If $R_t^b = R_t^m$, then individual investors are willing to hold "excess" reserves in the sense that $\hat{m}_t > \sigma_t k_t$ is consistent with optimization.[10] The second condition defines the demand for investment. This can be seen more clearly by combining (6) and (7) to form

$$x_{t+1} f'\left(k_t\right) = \left[\left(1 + \sigma_t\right) R_t^b - \sigma_t R_t^m\right] / \Pi_{t+1} . \tag{8}$$

Condition (8) is essentially the Fisher equation, which equates the real interest rate (marginal product of capital) to the inflation-adjusted rate of return on government debt. The equation also defines the investment demand schedule. Investment demand is increasing in news $x_{t+1}$, expected inflation $\Pi_{t+1}$, and the interest paid on reserves $R_t^m$ (when the reserve requirement is slack). Investment demand is decreasing in the interest paid on bonds $R_t^b$ and the reserve requirement $\sigma_t$ (when the reserve requirement binds).

### *2.4 Equilibrium*

In equilibrium, the market for reserves and bonds must clear. The market-clearing conditions are given by

$$M_t = P_t N_t \hat{m}_t \tag{9}$$

$$B_t = P_t N_t \hat{b}_t \tag{10}$$

for all $t \geq 1$. Alternatively, since $D_t = M_t + B_t$, we must have $D_t = P_t N_t \hat{d}_t$ or, recalling the definition of $N_t d_t \equiv D_t / P_t$, market clearing implies $d_t = \hat{d}_t$ for all $t \geq 1$. Defining $N_t m_t \equiv M_t / P_t$ and $N_t b_t \equiv B_t / P_t$, market clearing also implies $m_t = \hat{m}_t$ and $b_t = \hat{b}_t$ for all $t \geq 1$.

Since $P_t = D_t / (N_t d_t)$ for all $t \geq 1$, it follows that the inflation rate $\Pi_t = P_t / P_{t-1}$ must satisfy

$$\Pi_t = \left(\mu_t / n_t\right)\left(d_{t-1} / d_t\right) \tag{11}$$

for all $t \geq 1$, where recall $\mu_t \equiv D_t / D_{t-1}$.

In equilibrium, the old must pay taxes $\tau_t$ consistent with satisfying the government budget constraint (2). Combining (2) with the individual budget constraint (4), we have

$$c_t = x_t f\left(k_{t-1}\right) + \left(R_{t-1}^b / \Pi_t\right)\hat{b}_{t-1} + \left(R_{t-1}^m / \Pi_t\right)\hat{m}_{t-1} - \left(\hat{R}_{t-1} / \mu_t - 1\right) n_t d_t ,$$

where recall $g_t = 0$ for all $t \geq 1$ and $\hat{R}_{t-1} \equiv \theta_{t-1}R^m_{t-1}+(1-\theta_{t-1})R^b_{t-1}$. Combine the equilibrium conditions $m_t = \hat{m}_t$ and $b_t = \hat{b}_t$, the definitions $m_t = \theta_t d_t$ and $b_t = (1-\theta_t)d_t$, and the expression for inflation (11) with the condition above to derive an expression for the equilibrium level of consumption,

$$c_t = x_t f\left(k_{t-1}\right)+n_t d_t. \tag{12}$$

Note that if we combine (12) with the resource constraint

$$N_{t-1}c_t + N_t k_t = N_t y_t + N_{t-1}x_t f\left(k_{t-1}\right), \tag{13}$$

we recover a young individual's budget constraint $k_t = y_t - d_t$.

Next, combine (11) with (8) to form

$$\mu_{t+1}x_{t+1}f'\left(y_t - d_t\right) = \left[\left(1+\sigma_t\right)R^b_t - \sigma_t R^m_t\right]n_t d_t / d_{t+1}. \tag{14}$$

Condition (11) tells us that the inflation rate depends in part on exogenous growth $n_t$, in part on fiscal policy $\mu_t$, and in part on what determines the *growth* in private demand for consolidated debt $d_t/d_{t-1}$. Condition (14) tells us that desired real debt holdings at any point in time depend on the expected path of exogenous variables, including the path of interest rates. To simplify the analysis, assume that $x_t = x$, $y_t = y$, $n_t = n$, and $\sigma_t = \sigma$. In what follows, we restrict attention to stationary government policies and stationary equilibria.

Consider a stationary government policy (recall $R^b \geq R^m$). A nondegenerate steady-state equilibrium satisfies $d_t = d^* > 0$ for all $t$. By condition (11), the inflation rate is given by $\Pi^* = \mu/n$ in a steady state. If a nondegenerate steady-state equilibrium exists, it must satisfy

$$xf'\left(y - d^*\right) = \left[\left(1+\sigma\right)R^b - \sigma R^m\right]\left(n/\mu\right). \tag{15}$$

If $\lim_{d\to y} xf'\left(y-d\right) = \infty$, then a stationary equilibrium will exist for an arbitrarily high real interest rate on public debt.[11] On the other hand, the right-hand side of (15) cannot be made too small. For public debt to possess value in this environment, it must be the case that $xf'\left(y\right) < \left[\left(1+\sigma\right)R^b - \sigma R^m\right]\left(n/\mu\right)$. Notice that when $R^b = R^m = \mu = 1$, this condition reduces to $xf'\left(y\right) < n$, which is a standard condition for dynamic inefficiency.[12]

**2.4.1 Scarce Reserves.** By scarce reserves we mean a scenario where the reserve requirement binds; that is, $R^b > R^m$. Imagine that the economy is initially in a steady state as described by condition (15). Imagine further that the central bank surprises individuals by suddenly raising its policy rate $R^b$. Assume further that the policy rate is expected to remain at this higher level for the foreseeable future. Then condition (15) reveals that this monetary policy shock results in a one-time increase in $d^*$, the real demand for public debt. Since the price level is determined by $P_t = D_t/(N_t d^*)$, the effect here is to cause a one-time decline in the price level (a *transitory disinflation*). Moreover, since $k^* = y - d^*$, the new policy results in a permanent contraction in investment.[13] Note that a permanently higher nominal interest rate is consistent here with no change in the long-run inflation rate. That is, while the Fisher equation (15) holds, the neo-Fisherian proposition does not.[14]

There is an alternative way of thinking about the experiment of increasing the interest rate $R^b$. Imagine, instead, that $R^b$ is market determined and that the monetary authority influences the interest rate through open market sales/purchases of government debt. That is to say, imagine that the central bank chooses $\theta$ instead of $R^b$. Since $m = \sigma k$, $d = y - k$, and $m = \theta d$, it follows that

$$d = \left( \frac{\sigma}{\sigma + \theta} \right) y. \tag{16}$$

Then, for a given $\theta$, condition (15) determines the equilibrium interest rate $R^b$. In this case, a permanent increase in $R^b$ can be achieved through a permanent reduction in $\theta$. The reduction in $\theta$ corresponds to a contraction in the supply of reserves. Because reserves are scarce, capital investment will decline. At the same time, the private sector is required to absorb a relatively larger supply of bonds, which further contributes to the crowding out of private investment. For individuals to be willing to hold this extra supply of bonds, the bond price must fall—that is, the yield must rise.

**Result 1.** A *persistent* increase in the policy rate $R^b$ leads to a *persistent* decline in the money-to-debt ratio $\theta$ and a *transitory* disinflation (a persistent decline in the price level). Alternatively, a persistent decline in $\theta$ leads to a persistent increase in $R^b$ and a transitory disinflation.

The implication of Result 1 is that, for a given $(\mu/n)$, a central bank can raise/lower the inflation rate in a *persistent* manner only through a *rising/falling* nominal interest rate policy. Alternatively, the central bank must be willing to grow the monetary base at a faster/slower pace than $(\mu/n)$ for an *indefinite* period of time. Recall that $(\mu/n)$ is outside the control of the monetary authority. The fiscal authority controls the pace at which the nominal debt grows $(\mu)$, and macroeconomic growth $(n)$ determines the pace at which the demand for the debt grows.

We report three other comparative statics associated with condition (15). The first is a negative supply shock (a persistent decline in $y$), which we associate with the oil-supply shocks of the 1970s. The second is a persistent negative demand shock (a persistent decline in $x$), which we associate with the Great Recession from 2007 to 2009. The third is a persistent increase in the rate at which the demand for debt grows (a persistent increase in $n$).

**Result 2.** A persistent decline in $y$ leads to a persistent decline in capital investment and a transitory increase in inflation. For a given money-to-debt ratio $\theta$, the nominal interest rate $R^b$ rises. For a given nominal interest rate, the money-to-debt ratio falls (investors substitute private investment with bonds).

**Result 3.** A persistent decline in $x$ leads to a persistent decline in capital investment and a transitory disinflation. For a given money-to-debt ratio $\theta$, the nominal interest rate $R^b$ declines. For a given nominal interest rate, the money-to-debt ratio falls (investors substitute private investment with bonds).

Negative supply and demand shocks both generate recession-like phenomena in the model. Both shocks lead to a contraction in investment, the former through a decline in savings and the latter through a decline in the expected return on investment. As such, a negative supply shock puts upward pressure on the nominal interest rate and inflation, while a negative demand shock does the opposite.

**Result 4.** A persistent increase in $n$ leads to a persistent disinflation.

Note that in the model, $n$ corresponds to the long-run real GDP growth rate, which is related to the growth in the demand for real money/debt balances. The steady-state expression of the determination of the inflation rate $\Pi = \mu/n$ is consistent with the quantity theory of money with a constant velocity. In an open-economy version of this model where foreigners value the domestic government security, an increase in the growth rate of foreign demand would have a similar effect on domestic inflation while contributing to persistent current-account deficits. This seems an especially relevant consideration for the United States since 2000 and likely has some role to play in determining the current lowflation phenomenon.

**2.4.2 Excess Reserves.** Beginning in a world with scarce reserves, imagine a sufficiently severe sequence of negative demand shocks that (by Result 3) causes the market bond yield $R^b$ to fall to its lower bound $R^m$, so that $R^b = R^m = R$. In this case, the reserve requirement becomes slack and condition (15) becomes

$$xf'\left(y-d^*\right)=R\left(n/\mu\right). \tag{17}$$

A few things are worth noting here. First, increasing the interest rate on reserves is now contractionary instead of expansionary (see condition (15)). That is, $R^m$ now has the same effect as $R^b$ did when reserves were scarce. Thus, Result 1 continues to hold in this case except that the composition of the public debt $\theta$ now plays no role (except to determine the level of excess reserves). Results 2 to 4 continue to hold as well.

When $R^b = R^m$, the central bank loses control of the monetary aggregate, which now consists of the entire public debt $D_t$ and not just central bank liabilities $M_t$. Open market purchases of government securities have no consequences in this case because such operations entail a swap of reserves and bonds that are viewed as perfect substitutes by investors.[15] Note that the quantity theory of money continues to hold here, but with the proviso that the relevant quantity of money is in this case determined by the fiscal authority, not the monetary authority. Nevertheless, the monetary authority can still exert some control over the price level by adjusting its policy rate—in this case, interest on reserves.

## 3 LOWERING THE INFLATION TARGET

Consider the following thought experiment. Imagine that the economy is initially in a steady state with scarce reserves. Since $d_t = d^*$ in a steady state, condition (11) tells us the inflation rate is equal to $\Pi^* = \mu/n$. That is, for a stationary government policy, the nominal debt grows at rate $\mu = D_t/D_{t-1}$ and, since $M_t = \theta D_t$, the money supply grows at rate $\mu$ as well.

Imagine next that the central bank wants to lower inflation to some target $\hat{\Pi} < \Pi^*$. If this target inflation rate is to be achieved, then it must satisfy condition (11); that is,

$$\hat{\Pi} = \Pi^*\left(d_{t-1}/d_t\right) < \Pi^*. \tag{18}$$

For a given $(\mu/n)$, the only way to achieve this objective is to conduct monetary policy in a way that influences the private demand for real debt over time. In particular, we need $d_t = (\Pi^*/\hat{\Pi})d_{t-1}$, which implies that $d_t$ must grow over time. Using (16) with (18), the implied path for $\theta_t$ satisfies

$$\hat{\Pi} = \Pi^*\left(\frac{\sigma+\theta_t}{\sigma+\theta_{t-1}}\right), \tag{19}$$

or

$$\theta_t = \max\left\{\left(\hat{\Pi}/\Pi^*\right)\theta_{t-1} - \sigma\left(1-\hat{\Pi}/\Pi^*\right), 0\right\} \tag{20}$$

for all periods following the date at which this policy is announced.

Condition (20) tells us that to implement the lower inflation target, the central bank must progressively lower the fraction of the public debt that is monetized. In this way, the supply of reserves grows at a slower rate than the nominal debt. Notice that since $\theta_t$ is bounded below, the central bank *must* eventually fail in achieving its preferred inflation target *if* the fiscal authority remains steadfast.[16] Suppose that the monetary and fiscal authorities remain committed to their respective policies. What are the economic consequences?

To begin, what does this monetary policy imply for the path of interest rates? Because inflation is being held fixed in the interim, the real interest rate moves in the same direction as the nominal interest rate. To derive an expression for this latter object, use (8) with $\Pi_{t+1} = \hat{\Pi}$ to derive

$$R_t^b = (1+\sigma)^{-1}\left[f'(k_t)\hat{\Pi} + \sigma R^m\right]. \tag{21}$$

Recall that $k_t = y - d_t$ and that $d_t$ is rising over time. Since $k_t$ is declining over time, diminishing returns to capital spending implies that the real rate of return on (the marginal product of) capital is rising. For a given inflation rate $\hat{\Pi}$, the nominal interest rate $R_t^b$ rises as well.

The economic mechanism at work here is as follows. By monetizing a smaller fraction of the debt (the total stock of which continues to grow unabated), private investors are compelled to hold a larger fraction of the debt in their wealth portfolios. In order for investors to willingly hold this larger quantity of the public debt, the inflation-adjusted yield on bonds must rise. At the same time, an increase in the amount of debt held in the private sector crowds out private sector investment, so that economic activity contracts. As investment shrinks over time, the real demand for reserves falls (since the reserve requirement is binding). By itself, this effect puts upward pressure on the inflation rate, but the effect is overwhelmed by the slower pace of money growth.[17]

In its quest to rein in inflation, the central bank here has induced a recession. Moreover, the recession becomes progressively more severe if the monetary and fiscal authorities both stick to their guns. But matters are even worse than this for the fiscal authority because the higher real interest on its debt increases the government's interest expense. Recall that the fiscal policy considered here adjusts the primary surplus to satisfy the government budget constraint (2). In the initial steady state, $\tau^* = [\hat{R}/\mu^H - 1]nd^*$, where $\hat{R} = \theta^* R^m + (1 - \theta^*)R^b$. Following the monetary tightening shock, the primary surplus in the transition satisfies

(22) $$\tau_t = \left[\hat{R}_{t-1}/\mu - 1\right]nd_t,$$

where $\hat{R}_t = \theta_t R^m + (1 - \theta_t)R_t^b$. As $\hat{R}_t$ and $d_t$ are both increasing along the transition, so is the primary surplus. That is, as this scenario unfolds over time, the fiscal authority is compelled to increase taxes (or cut transfers and/or spending) to finance the growing interest expense on government debt.[18]

In this thought experiment, the central bank is inflicting pain on the fiscal authority along two dimensions. First, its tight-money policy is driving the economy into recession; and second, it is forcing the government to raise taxes and/or cut transfers.[19] The question is how might a fiscal authority react to a determined inflation-fighting central bank?

One could imagine a few different responses. First, because a central bank is usually an institution created by the government, the government could take a heavy-handed approach and simply absorb central bank operations within its Treasury department.[20] Second, if the reserve requirement is a legal restriction, the government could relax it to include Treasury debt as reserves. Third, instead of steadfastly maintaining nominal debt issuance at rate $\mu$ and raising taxes to finance the interest expense, the government could instead keep the primary surplus fixed and *increase* the rate of nominal debt issuance. In this latter scenario—which describes a non-Ricardian fiscal policy—the government is effectively financing the interest expense by printing nominal liabilities, which increases the inflation rate. Finally, the fiscal authority could capitulate to the monetary authority's desire for lower long-run inflation. While this latter action would entail some fiscal adjustments (higher taxes and/or lower spending), it has the benefit of ending the monetary-fiscal conflict and permitting the economy to operate in a low-inflation and low-interest-rate regime.

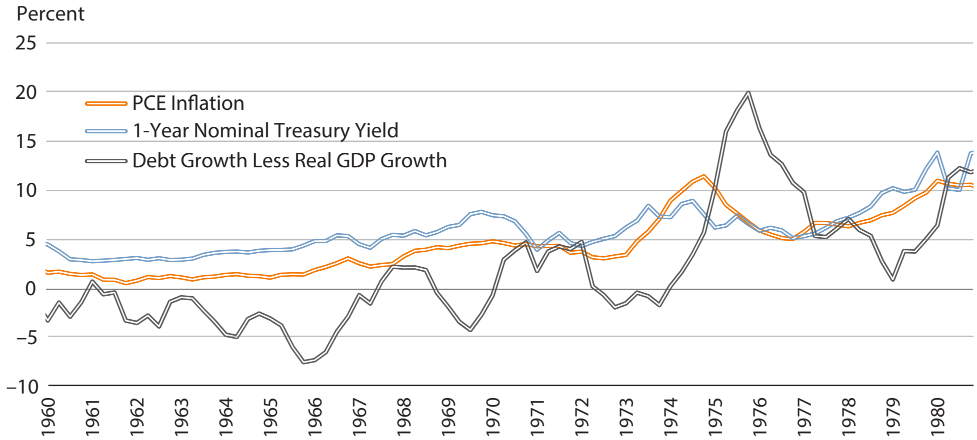
### *3.1 The Volcker Disinflation*

Starting in the mid-1960s, the trend growth rate of U.S. nominal debt rose noticeably and continued to do so throughout the 1970s. The trend PCE inflation rate rose more or less in tandem (Figure 3).

According to Meltzer (2005), the secular rise in inflation beginning in the mid-1960s had its roots in that decade's persistent government budget deficits combined with a Federal Reserve policy largely geared to supporting the U.S. Treasury in its security sales. In the context of our model, think of $\mu$ rising over time, with monetary policy accommodating the rise. There was also a significant oil price shock in 1973 and then again in 1979, both of which were associated with recessions. In the context of our model, think of a decline in $y$, which, according to Result 2, should contribute to transitory inflationary forces. The upward trajectory of the budget deficit was propelled by a significant tax cut in 1975.[21] The real interest rate on short-term government securities turned negative (Figure 4), which suggests that Federal Reserve policy remained accommodative throughout the period, despite the concern over rising inflation (Burns, 1979).

## Figure 3

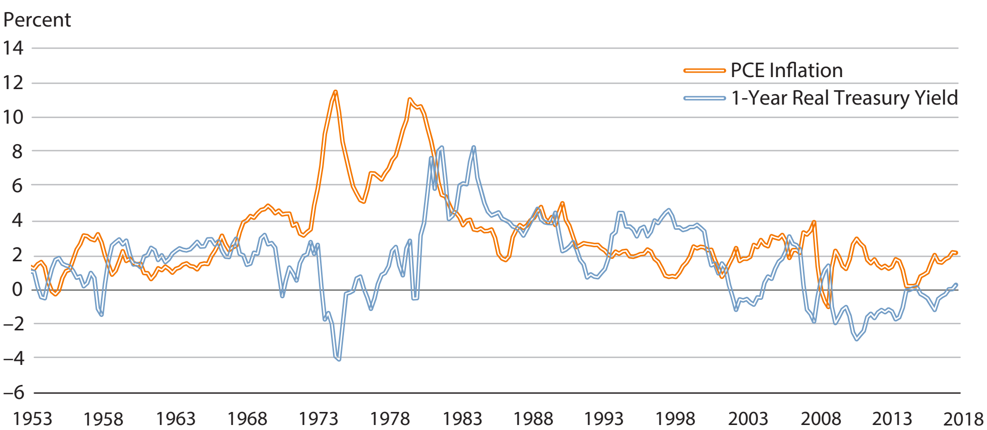
**Inflation, the Nominal Interest Rate, and Debt, 1960:Q1-1980:Q4**




SOURCE: BEA and BOG.

## Figure 4

**Inflation and the Real Interest Rate, 1953:Q2-2018:Q3**

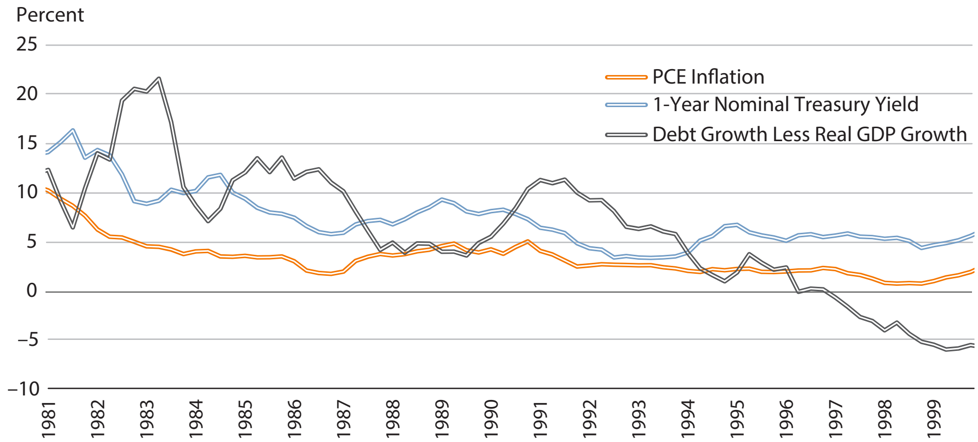



SOURCE: BEA and BOG.

In 1979, President Jimmy Carter appointed Paul Volcker—a well-known inflation hawk—as Federal Reserve Chair. In 1981, Ronald Reagan became president of the United States, which set the table for conflict between monetary and fiscal policy. Specifically, Volcker viewed his mandate as lowering the long-run inflation target and drove real interest rates to very high levels to achieve this goal (consistent with Result 1 above). While the Reagan administration was nominally in favor of lower inflation, members of the administration publicly complained

## Figure 5

**Inflation, the Nominal Interest Rate, and Debt, 1981:Q1-1999:Q4**




SOURCE: BEA and BOG.

that Volcker's high interest rate policy (which drove the United States into a sharp recession) was circumventing the objective of fiscal policy which, through the Economic Recovery Act of 1981 (the famous Reagan tax cut), was designed to stimulate growth. The combination of the tax cut and recession led to ballooning government budget deficits.

While the Federal Reserve raised the short-term interest rate sharply through the modest recovery over the second half of 1980 to the second half of 1981, it then began to loosen monetary conditions as the recession worsened (the federal funds rate declined from 19 percent in July 1981 to 9 percent in November 1982). But by early 1982, the tension between the Federal Reserve and the administration (in particular, Secretary of the Treasury Donald Regan) was palpable. From the *New York Times*:

> Paul A. Volcker, chairman of the Federal Reserve Board, said today that big Government budget deficits were the cause of high interest rates. He added that continued heavy Federal borrowing would jeopardize any sustained economic recovery from the recession…
>
> President Reagan said at a news conference last month that the Federal Reserve was sending "the wrong signals" to the financial markets. Treasury Secretary Donald T. Regan complained that erratic growth of the money supply not only had "confused" the markets but also had contributed to the recession. (Farnsworth, 1982)

On February 15, 1982, Volcker met Reagan for the fourth time in 12 months. Again, from the *New York Times*:

> Senator Howard H. Baker Jr., the Senate majority leader, recently called for a meeting between Mr. Reagan and Mr. Volcker to coordinate economic policy, and some Democrats have suggested that the Fed and the Administration work openly to mesh their policies.

> Many economists outside the Government say that the Fed and the Administration are on a collision course on economic policy because the tight monetary policy promised by the Fed will not allow for the relatively strong economic growth the President has forecast will begin by the second half of this year…
>
> Mr. Volcker also has taken pains not to criticize the Administration's 1983 budget directly. It projects a deficit of $98.6 billion in 1982, $91.5 billion in 1983 and $82.9 billion in 1984. At the same time, the chairman has strongly suggested that the Congress try to reduce the 1984 deficit by $20 billion, which the chairman said would make the outlook for the economy "safer."
>
> In response to questions about his meetings with the President, Mr. Volcker, in testimony last week, asserted his and the Fed's independence over monetary policy. "It is our responsibility to make up our minds about these things, and we do so. Forget about what the Administration says at the moment." (Fuerbringer, 1982)

The portrait that emerges from these snippets is a resolutely hawkish central banker at loggerheads with a frustrated administration trying to promote economic growth through a program of deficit-financed tax cuts in the course of a sharp recession. At the same time, members of the administration supported the broader goal of lower inflation. The rapid rise in the budget deficit created concern among many members of Congress. This concern led to the passage of the Tax Equity and Fiscal Responsibility Act of 1982 in September of that year, which rescinded some of the earlier tax cuts and raised other tax rates. Over the course of the recession of 1981:Q2 to 1982:Q4, the PCE inflation rate dropped from 9 percent to 5 percent.

But there was no guarantee—and indeed, likely even less expectation—that the inflation rate would remain at this relatively low level, let alone drop any further. Keep in mind that in their recent experience, the American people witnessed inflation at 10 percent early in 1975, which then dropped to 5 percent in late 1976 before rebounding back to near 11 percent by the end of 1980. This was clearly an era of highly volatile inflation. Judging by the near 12 percent yield on the 10-year U.S. Treasury security in 1983:Q4, investors were likely factoring in a long period of high and volatile inflation, despite the fact that actual inflation was running closer to 4 percent.

As Volcker's four-year term was nearing an end in early 1983, there was considerable uncertainty over his reappointment.[22] Reported front-runners to replace Volcker included Alan Greenspan, Paul McCracken, and Preston Martin. But at the end of the day, no one could dispute Volcker had presided over the much-desired decline in inflation. Partly as a result of this success, he had the broad support of the financial community and Reagan's advisers. On June 18, 1983, President Reagan announced Volcker's reappointment.[23]

From 1983 to 1986, the year-over-year growth rate of the public debt remained above 15 percent. From 1983:Q2 to 1984:Q3, the 10-year bond yield rose from 10.5 percent to 12.9 percent, suggesting that inflation expectations were, if anything, rising even as actual inflation was falling. Longer-term interest rates did not begin to decline until late 1984 and did not fall below 10 percent until 1985.

No one knows how history would have unfolded had one of the other potential candidates been appointed instead, but from 1983:Q1 to 1984:Q3, the federal funds rate rose from 8.7 percent to 11.4 percent even as PCE inflation continued to fall from 4.6 percent to 3.5 percent.

It is worth noting that the unemployment rate in 1983:Q1 stood at 10.4 percent and declined only to 7.4 percent by 1984:Q3. The hawkish Democrat central banker stood resolute against a dovish Republican administration, preventing the rapid pace of nominal debt growth from manifesting itself as inflation (though not expected inflation) and almost surely mitigating the intended expansionary effect of the administration's fiscal policies.

It seems plausible to view Volcker's determined refusal to monetize the growing national debt as having spurred Congress to act on the budget sooner than it otherwise might have. For one thing, the interest expense of the debt had grown to a sizeable fraction of the budget. There were also fiscally conservative members of Congress worried about the prospect of deficit spending through an economic expansion. These concerns manifested themselves as the Balanced Budget and Emergency Control Act of 1985. From 1986 to the end of 1987, the year-over-year growth rate of nominal debt declined from around 15 percent to around 9 percent, where it remained until the next recession.

Volcker was replaced by Alan Greenspan in 1987, but the Federal Reserve's determination to keep a lid on inflation remained intact. Apart from a temporary increase associated with the 1990 to 1991 recession, the growth rate of nominal debt issuance continued to decline until the turn of the century. The long struggle to lower the long-run inflation rate had finally succeeded through fiscal reforms spurred on in part by a resolutely hawkish monetary policy regime.

### *3.2 Was the Disinflation Inevitable?*

Common lore is that Paul Volcker was unilaterally responsible for ending the great peacetime inflation. This view is in all likelihood an exaggeration. Must it be the case that a sufficiently determined central bank can determine the long-run inflation rate independent of fiscal policy? The answer to this latter question is not immediately obvious.

To begin, Volcker's reappointment in 1983—in the midst of a severe recession that he was largely blamed for—was hardly inevitable. Given what we know now, had Greenspan succeeded him, Federal Reserve policy would likely have retained its hawkish stance. However, had Preston Martin succeeded him instead, it is quite likely that monetary policy would have taken on a more dovish tone.[24] The administration clearly had the power to replace Volcker with a more accommodative alternative. The fact that it did not points to a more fundamental force responsible for the success of disinflation policy.

One might go so far as to say that there were too many fiscally conservative elements embedded in the U.S. Congress for the disinflation not to have occurred eventually, even if it did happen to be spurred along by a hawkish monetary policy. At the same time, the strength of the U.S. economy following the early-1980s recessions played its part in helping bring the fiscal house in order. Whether the 1980s growth episode was incidental or linked to the policies employed at the time is difficult to say.

How might the Federal Reserve's disinflation policy have failed? Sargent and Wallace (1981) provide an early theoretical example of how a hawkish monetary policy may fail to curtail inflation. In general, one needs only to think of a non-Ricardian fiscal policy where the growing interest expense of the public debt is met with higher rates of nominal debt creation, rather than adjustments in the primary deficit.[25] This is not merely a theoretical possibility: Loyo (1999) suggests rather strongly that this latter scenario plausibly explains how tight monetary policy contributed to the 1980s inflation in Brazil. Had the U.S. economy remained weak throughout the 1980s and had the U.S. Congress been populated with less fiscally conservative members, the fight against lowering long-run inflation may have been lost.

## 4 RAISING THE INFLATION TARGET

In this thought experiment, imagine once again that the economy is initially in a steady state with scarce reserves. As before, the inflation rate is a number equal to $\Pi^* = \mu/n$. Suppose, however, that this long-run inflation rate is lower than the central bank target, so that $\hat{\Pi} > \Pi^*$. As before, the monetary and fiscal authorities have conflicting long-run goals, except with their respective preferences reversed. Suppose that the central bank wants to "fight" the fiscal authority and attempt to raise inflation to its preferred target. If this target inflation rate is to be achieved, then it must satisfy condition (11); that is,

$$\hat{\Pi} = \Pi^* \left(d_{t-1}/d_t\right) > \Pi^*. \tag{23}$$

For a given $(\mu/n)$, the only way to achieve this objective is to conduct monetary policy in a way that influences the demand for real debt over time. In particular, we need $d_t = (\Pi^*/\hat{\Pi})d_{t-1}$, which implies that $d_t$ must decline over time. Using (16) with (18), the implied path for $\theta_t$ satisfies (19), or

$$\theta_t = \min\left\{\left(\hat{\Pi}/\Pi^*\right)\theta_{t-1} - \sigma\left(1-\hat{\Pi}/\Pi^*\right), 1\right\} \tag{24}$$

with $\theta_0 = \theta < 1$, assuming that the policy is implemented (as a surprise) at date $t = 1$.

Condition (24) tells us that to implement the higher inflation target, the central bank must progressively increase the fraction of the public debt that is monetized. The operation here will look somewhat like the quantitative easing programs undertaken by the Federal Reserve since 2008. Notice that condition (24) assumes that the central bank's balance sheet is bounded above by the supply of government debt ($\theta_t \leq 1$). If this is the case, then $\theta_t$ cannot rise indefinitely.[26] But suppose the central bank doggedly undertakes this expansionary monetary policy. What is likely to happen in the interim?

Let us begin by establishing what such a policy implies for the path of the interest rate $R_t^b$. Here, we can appeal to the logic described in the previous scenario, but in reverse. That is, the real and nominal interest rates must progressively decline over time to make the price level rise at a faster rate. The economic mechanism at work here is the same as above, only in reverse. But while there was no upper bound on how high the interest rate could rise in the hawkish scenario, there is a lower bound that may become relevant in the dovish scenario. In particular, the constraint $R_t^b \geq R^m$ is likely to bind before the constraint $\theta_t \leq 1$ is likely to. In fact, we can generally identify a $0 < \hat{\theta} < 1$ that satisfies (21) for $R_t^b = R^m$:

$$R^m = (1+\sigma)^{-1}\left[f'\left(y - d\left(\hat{\theta}\right)\right)\hat{\Pi} + \sigma R^m\right],$$

where $d(\hat{\theta})$ is determined by (16) for $\theta_t = \hat{\theta}$. Rearranging the expression above, we get condition (17), or $R^m = f'(y - d(\hat{\theta}))\hat{\Pi}$. Thus, if $d(\hat{\theta}) < y$, then the equilibrium allocation remains invariant to any $\theta \geq \hat{\theta}$. In words, any further increases in the size of the central bank's balance sheet will have no impact on the economy, apart from expanding the size of excess reserves investors hold in their wealth portfolios. At this point, the central bank could resort to lowering the interest paid on reserves. But in this case as well, there is likely to be an economic (or political) lower bound that will eventually be breached. When this lower bound is hit, inflation must decline to its original level, assuming that the fiscal authority remains steadfast.

The question here, as before, is whether the fiscal authority is likely to remain steadfast in keeping the rate of nominal debt issuance lower than what is needed for the central bank to achieve its higher inflation target. The situation here is decidedly asymmetric. Recall in the earlier scenario that a hawkish central bank inflicted fiscal pain along two dimensions: economic contraction and higher debt service costs. In the present scenario, a doggedly dovish central bank inflicts not pain, but pleasure on the fiscal authority. That is, expansionary monetary policy lowers the cost of debt service. It seems difficult to imagine why a fiscal authority would want to capitulate in the face of such pressure. Indeed, a more likely fiscal reaction could take the form of *reducing* $\mu$ as the interest expense of the debt falls. Such a reaction would be consistent with the neo-Fisherian view that persistently low nominal interest rates engender low inflation (Williamson, 2016).

### 4.1 The Bernanke-Yellen Lowflation

As mentioned in the introduction, despite the spectacular increase in the level of central bank money and government debt since 2008, the inflation rate in the United States has for several years remained below target. In the context of the model above, there has been a large and persistent increase in $\theta$ and a large but *transitory* increase in $\mu$ ( Figure 6).

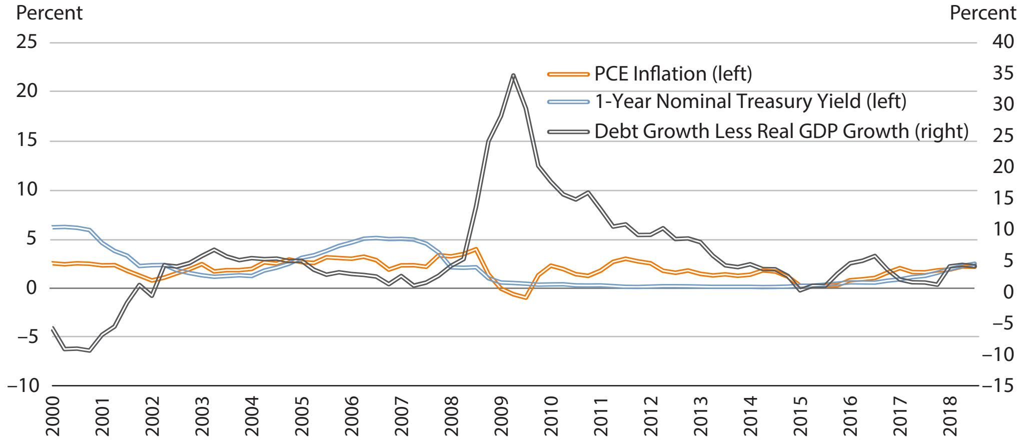
The key to understanding these developments, in our view, is to consider how the *demand* for money and debt evolved over the period in question. Of course, demand is not directly observable—but one can make reasonable inferences as to how money *demand* must be evolving in view of how quantities and prices are evolving.

The United States has—at least until recently—been subject to several important deflationary forces. A number of secular forces have been in place that are driving the demand for U.S. Treasury securities (and safe assets in general; see Gorton and Ordoñez, 2013). The rapid expansion of the use of the U.S. Treasury securities as collateral in credit derivatives markets and shadow banking is documented in Gorton (2010). Layered on top of this is the growing world demand for U.S. Treasury debt as a safe store of value, especially in emerging economies (Figure 7). In particular, as Figure 7 shows, from 2002 to 2014, foreign holdings of U.S. Treasury securities increased sixfold, from around \$1 trillion to around \$6 trillion. Most of that increase has occurred since 2008.

The Financial Crisis of 2008 further enhanced the demand for U.S. Treasury debt as a safe store of value. More recently, regulations from the Dodd-Frank Act and Basel III have created demand for U.S. Treasury debt. In the context of the model, these developments could be captured by persistent increases in the parameter $n$ and (throughout the Great Recession

## Figure 6

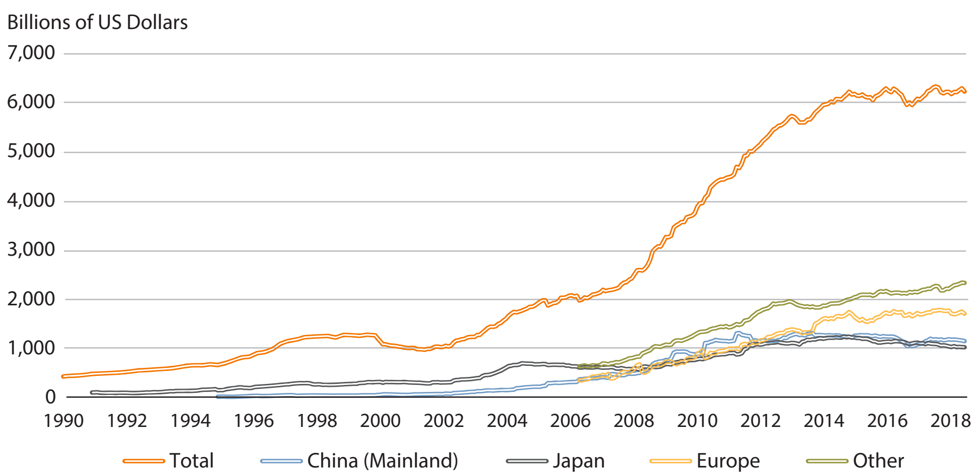
### Inflation, the Nominal Interest Rate, and Debt, 2000:Q1-2018:Q3




SOURCE: BEA and BOG.

## Figure 7

### Foreign Holdings of Treasury Securities, January 1990–September 2018




SOURCE: U.S. Treasury.

and slow recovery) persistent declines in the parameter $x$ (see Results 4 and 3, respectively); see Andolfatto (2015).

Thus, our interpretation of the recent lowflation phenomenon is as follows. To begin, while the growth of nominal debt issuance has increased significantly since the turn of the century, it displays no obvious upward trend and has averaged about 8 percent year-over-year since 2000. True, there was a massive spike in the deficit during the Great Recession when there was falling inflation, but this is a completely normal business cycle relationship.[27] Standard monetary theory interprets recessions as "money demand shocks" (in our model, a sequence in downward revisions over the expected return to capital spending, as indexed by the parameter $x$). That is, as bad news begins to accumulate, investors seek "safe haven" assets such as dollars and Treasury securities, the effect of which is to drive the price level and bond yields down.[28] The fact that the supply of money and bonds tends to rise during these episodes reflects both discretionary and built-in countercyclical fiscal policies. Absent these interventions, the decline in prices and yields would presumably have been much larger.

The transitory (but persistent) decline in investment demand in 2008 was mirrored by a corresponding increase in the demand for U.S. dollars and U.S. Treasury debt (both domestically and from abroad). The effect of this shock was to put downward pressure on both inflation and bond yields, the latter of which was accommodated by Fed policy (Andolfatto, 2015). In this way, the Federal Reserve did what was in its power to do during the crisis to mitigate the ensuing deflationary pressure: It lowered the policy rate as far as it could go. As for the apparent irrelevance of central bank open market operations since 2010, this is exactly what theory predicts when bank reserves and government bonds are viewed by market participants as close substitutes; see Krugman (2000) and Andolfatto (2003). In the limiting case, reserves and Treasuries are viewed as perfect substitutes (in the model above, when $R^b$ declines to its lower bound, $R^m$). At this point, the relevant quantity of "money" is determined by the fiscal authority and monetary policy is limited to adjusting the interest rate on reserves, which up until late 2015 remained at its effective lower bound of 25 basis points.

Following the Financial Crisis, Congressional concerns over the large increase in the public debt manifested as "debt ceiling" controversies and a significant slowing in the rate of nominal debt issuance. Fiscal policy remained "tight" in the sense that the growth in the global demand for U.S. Treasuries appeared to continue unabated (fueled in part by the demand stemming from the Dodd-Frank Act and Basel III regulations). At this point, lowering the Federal Reserve's policy rate any further was not a practical possibility. Open market purchases of Treasury debt were conducted in close-to liquidity trap conditions. Open market purchases of high-grade interest-bearing mortgage-backed securities are not in theory inflationary (Cochrane, 2014) and, indeed, they appeared not to be in practice.

Thus, the situation in which the Federal Reserve found itself post 2008 is one where it appeared to have little ability to raise inflation persistently back to target. Fiscal policy remained (whether for good or ill) too tight for inflationary pressures to emerge. And though it would have been technically possible to lower the interest on reserves, this option was a practical impossibility. In any case, throughout the period in question, monetary policy discussion focused not on easing but rather on tightening (or "normalizing" the policy rate) so as to nip any incipient inflation in the bud. Indeed, "lift off" finally did occur in December 2015 and interest rates have been gradually increased since then. According to the theory presented above, this type of policy action is disinflationary. In light of these considerations, the recent experience of lowflation seems unsurprising.

## 5 SUMMARY AND CONCLUSION

Given the role of the U.S. dollar as a world reserve currency, many of the factors influencing the growth in the demand for U.S. Treasury debt will be external to the U.S. economy. However, the supply of U.S. dollars and Treasuries is determined domestically and, hence, apart from the temporary disruptions that external factors may bring, the long-run inflation rate remains under domestic control.

In this article, we have suggested that the long-run supply of base money is determined primarily by fiscal factors, either directly because government debt is viewed as a substitute for central bank reserves or indirectly because various agencies (central and private) are compelled for one reason or another to monetize some fraction of the national debt.

The run-up in inflation that occurred in the 1960s and 1970s may have been preventable by a sufficiently hawkish central bank, but likely not without sufficient fiscal support. In light of the political upheavals and commodity price shocks throughout the 1970s, a hawkish monetary policy would have surely added to the economic turbulence of the period. The Federal Reserve under Paul Volcker was willing to bear the intense public and political backlash associated with its disinflation policy. While inflation and inflation expectations did eventually decline, they did so only as it became progressively clearer that the pace of nominal debt expansion was decelerating. It is by no means clear that Volcker would have succeeded had this not been the case.

We have suggested reasons for why raising the long-run inflation rate in our recent era of lowflation presents an even greater challenge for the Federal Reserve. In days gone by, the Federal Reserve had no authority to pay interest on reserves and the interest rate differential between reserves and Treasuries was measured in several hundred basis points. Consequently, (even the threat of) open market operations could be expected to have a measurable impact on the federal funds rate. In the world we live in today, the Federal Reserve is permitted to pay interest on reserves, with the yield differential between reserves and Treasuries often very much less than 100 basis points. Federal Reserve purchases of U.S. Treasuries are not likely to have the same quantitative impact they would once have had.

The primary tool left at the Federal Reserve's disposal is interest on reserves. Our theory suggests that to promote inflation in the face of a tight fiscal policy, the policy rate needs to be lowered in a systematic manner. Needless to say, the exact opposite has happened and so, as such, it should not come as much of a surprise to be witnessing the lowflation depicted in Figure 1. For inflation to pose a significant threat, the nominal debt-issuance rate has to accelerate and/or the growth in the global demand for U.S. debt must subside.

This is not to suggest that the Federal Reserve has necessarily been following the wrong policy in relation to its dual mandate. Several voices on the Federal Open Market Committee have argued that "normalizing" the policy rate is necessary in order to "get ahead of the curve." The justification for this policy has gained some traction since the arrival of a new administration in Washington, D.C., early in 2017. We can identify at least three potential inflationary forces.

First, the economy is booming. This could result in a reallocation of dollars and Treasuries into higher-risk asset classes. The resulting decline in the demand for money is inflationary. Second, the new administration passed a significant tax-cut legislation that is projected to increase the national debt significantly over the next decade. A greater pace of nominal debt-issuance is likely to be inflationary—especially if fiscal policy is increasingly perceived to be non-Ricardian. Finally, as evidenced in Figure 7, growth in the world demand for U.S. Treasury debt appears to be waning. If U.S. economic growth weakens, these three forces could conspire to create the perfect inflation storm and it is not entirely clear what the Federal Reserve might do to combat it should inflation start rising significantly above target. ■

## NOTES

1 See Moghadam, Teja, and Berkmen (2014).

2 While an official inflation target was adopted by the Federal Reserve in 2012, it was widely perceived to have had an unofficial 2 percent target well before that date (Bullard, 2018).

3 As of December 2017, inflation in Venezuela was estimated to be over 4,000 percent; see Smith (2017). Zimbabwe recently experienced hyperinflation over the period 2000-08, with the inflation rate peaking in November 2008 at 79.6 *billion* percent.

4 Even if central banks are permitted to monetize securities other than Treasury debt, political considerations are likely to impose *de facto* limits on central bank balance-sheet size.

5 While it would be easy to incorporate a consumption-saving decision for the young, we choose not to here since doing so only complicates the analysis without adding anything to the essential points we want to make.

6 One can alternatively follow Diamond (1965) and model an aggregate production function with competitive factor markets where the rate of return on capital spending from an individual perspective is linear in individual holdings. Our main conclusions are unaffected by the simpler approach we take here.

7 We assume that $x_{t+1}$ is known at date $t$ so that a change in $x_{t+1}$ can be interpreted as a "news shock" (Beaudry and Portier, 2014). Because a news shock can influence investment demand without any change in contemporaneous production capacity, the label *demand shock* seems appropriate.

8 Prior to 2008, the Federal Reserve had no legal authority to pay interest on reserves, so $R_t^m = 1$ by legislation. The authority to pay interest on reserves was granted by Congress in 2008.

9 The assumption of who pays taxes (or receives transfers) is not innocuous here since this is a heterogeneous-agent model so that income distribution matters.

10 If we interpret $\sigma_t$ as a legal reserve requirement, then $\hat{m}_t > \sigma_t k_t$ corresponds to "excess reserves" as measured in the data. However, if $\sigma_t$ represents a source of money demand that emanates (say) from "fear," then an exogenous increase in $\sigma_t$ may result in private agencies holding more cash than the statutory minimum (say, $\sigma_t > \sigma_{\min}$). In this latter case, it only appears that private agencies are holding "excess" reserves. But as long as $R_t^b > R_t^m$, the reserve constraint (5) binds whether or not reserves are held in excess of the statutory minimum.

11 Recall that the interest expense of the debt—which accrues to the old—is financed with a lump-sum tax on the old so that what is paid with one hand is removed with the other.

12 In a competitive equilibrium without government debt, all savings are invested in capital ($k = y$). The equilibrium interest rate is given by the marginal product of capital $f'(y)$. If $f'(y) < n$, then capital is being over accumulated relative to what is Pareto optimal. The introduction of a constant supply of zero-interest debt in this case can

improve economic welfare for everyone. The initial old are made better off because they are recipients of a debt transfer, which they can spend on goods. The future generations of young are made better off because they earn a higher rate of return ($n$) on their savings.

[13] We can use condition (12) to determine the planned consumption for the old in the initial steady state, $c^* = f(k^*) + nd^*$. Since $k^*$ here is equal to $k_{t-1}$, the return to maturing investment is not affected by the monetary policy shock. The real value of public debt $d^*$, however, rises on impact (because the price level falls). Hence, the monetary policy shock entails an unexpected transfer of wealth from the young to the old. Whether the young are also made better off depends on whether the economy is dynamically efficient.

[14] The neo-Fisherian proposition is the claim that a central bank can control the long-run inflation rate by its choice of the nominal interest rate; see, for example, Williamson (2016). Andolfatto and Martin (2018) demonstrate that the proposition holds only under a special set of circumstances.

[15] This is admittedly an extreme assumption, but the ineffectiveness of central bank balance-sheet policy continues to hold (at least approximately) if government debt is viewed as a close substitute for interest-bearing reserves.

[16] An alternative policy of holding the money supply fixed is sustainable indefinitely. However, it can be shown that for this policy, the inflation rate falls initially and then rises monotonically to its original level. If the fiscal authority remains steadfast, the result is still an ever-worsening depression.

[17] Instead of monetizing a smaller fraction of the debt, the central bank could have raised the interest rate. Doing so induces a portfolio substitution out of capital and into bonds. The money-to-bond ratio in this case would adjust through the portfolio decisions made by investors.

[18] This assumes, of course, that the government does not default on its obligations.

[19] Note that we have modeled taxes as lump sum. If taxes were instead distortionary, there would be the added negative effect of reducing the after-tax return on capital spending.

[20] Instead of folding the central bank into Treasury operations, government representatives could simply claim that they are "auditing" central bank policy to ensure its policies are "better aligned" with the preferences of the people.

[21] In March 1975, President Ford signed into law a bill that provided individuals with a 10 percent rebate on their 1974 tax liability, a fattened standard deduction, and a temporary $30 tax credit for each taxpayer and dependent. For companies, the investment tax credit was temporarily increased to 10 percent.

[22] Among other considerations, Volcker was a Democrat.

[23] See Weisman (1983).

[24] Martin was a staunch Reagan loyalist and a harsh critic of Volcker's anti-inflation policies.

[25] It seems possible that a non-Ricardian fiscal policy is a more politically attractive option in a weak economy. If so, then the strength of the U.S. economy after 1983 may help to explain why a Ricardian fiscal policy remained in place.

[26] In reality, there are also political constraints that limit the size of central bank balance sheets. All that matters here is that some practical upper bound exists.

[27] The only exceptions to this pattern are to be found in the 1973 to 1975 recession and the brief recession in 1980. Both of those episodes were characterized by positive oil-price shocks.

[28] The Financial Crisis of 2008 was associated with a large reduction in the supply of high-grade private-label collateral securities; see Figure 1 in Andolfatto and Williamson (2015).

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