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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)

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.” 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. 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.
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
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. 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.

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, \( f''(k) < 0 \).

In what follows, we think of \( y_t \) and \( x_{t+1} \) as “supply” and “demand” shocks, respectively.

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 \( R_m \) and \( R_b \), respectively. 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 \( \theta_t = M_t/D_t \) 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, \( \mu_t = D_t/D_{t-1} \). The consolidated government budget constraint is given by

\[
G_t + R_t^m M_{t-1} + R_t^b B_{t-1} = T_t + M_t + B_t
\]

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 \( N_{t-1} \equiv T_t/P_t, N_{t-1} G_t \equiv G_t/P_t, N_{t-1} \mu_t \equiv D_t/P_t \). 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:

\[
g_t - \tau_t = \left[ 1 - \hat{R}_{t-1} / \mu_t \right] nd_t,
\]

where \( \hat{R}_{t-1} \equiv \theta_{t-1} R_{t-1}^m + (1 - \theta_{t-1}) R_{t-1}^b \) 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. 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 \( R^b_0 \geq R^m_0 \).

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

\[
\hat{m}_t + \hat{b}_t + k_t = y_t.
\]

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:

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

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

\[
c_{t+1} = x_{t+1} f (k_t) + R_b^b \hat{B}_t + (R_m^m / \Pi_{t+1}) \hat{M}_t - \tau_{t+1}.
\]

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 \( (R_b^b > 1) \) and the yield on reserves zero \( (R_m^m = 1) \). 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

\[
\hat{m}_t \geq \sigma_t k_t.
\]

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,

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

$$\lambda_t = \left( R^b_t - R^m_t \right) / \Pi_{t+1}$$

(6)

$$x_{t+1}f'(k_t) = \left( R^b_t / \Pi_{t+1} \right) + \sigma_t \lambda_t.$$  

(7)

Condition (6) tells us that the reserve requirement binds if and only if $R^b_t > R^m_t$. In this case, $\hat{m}_t = \sigma_t k_t$ and $\hat{b}_t = y_t - (1 + \sigma_t) k_t$. If $R^b_t = R^m_t$, 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

$$x_{t+1}f'(k_t) = \left[ (1 + \sigma_t) R^b_t - \sigma_t R^m_t \right] / \Pi_{t+1}.$$  

(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 $R^m_t$ (when the reserve requirement is slack). Investment demand is decreasing in the interest paid on bonds $R^b_t$ 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

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

(9)

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

(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 $N_t d_t = D_t / P_t$, market clearing implies $d_t = \hat{d}_t$ for all $t \geq 1$. Defining $N_t m_t = M_t / P_t$ and $N_t b_t = B_t / P_t$, 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

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

(11)

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

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

$$c_t = x_t f(k_{t-1}) + \left( R^b_{t-1} / \Pi_t \right) \hat{b}_{t-1} + \left( R^m_{t-1} / \Pi_t \right) \hat{m}_{t-1} - \left( \hat{R}_{t-1} / \mu_{t-1} - 1 \right) n_t d_t,$$
where recall \( g_t = 0 \) for all \( t \geq 1 \) and \( \dot{R}_{t-1} \equiv \theta_{t-1}R_m^* + (1 - \theta_{t-1})R_b^* \). Combine the equilibrium conditions \( m_t = \dot{m}_t \) and \( b_t = \dot{b}_t \), 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,

\[
c_i = x_t f(k_{t-1}) + n_t d_t.
\]

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

\[
N_{t-1}c_t + N_t k_t = N_t y_t + N_{t-1} x_t f(k_{t-1}),
\]

we recover a young individual’s budget constraint \( k_t = y_t - d_t \).

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

\[
\mu_{t+1} x_{t+1} f(y_{t+1} - d_{t+1}) = \left[ (1 + \sigma_t)R_b^* - \sigma_t R_m^* \right] n_t d_t / d_{t+1}.
\]

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

\[
\frac{d^*}{n} < \frac{\Pi^*}{\mu}.
\]

If \( \lim_{d^* \to y} x f(y - d^*) \to \infty \), 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 \( x f(y) \leq \left( (1 + \sigma)R_b^* - \sigma R_m^* \right)(\Pi^* / \mu) \). Notice that when \( R_b^* = R_m^* = \mu = 1 \), this condition reduces to \( x f(y) < n \), 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 consis-
tent here with no change in the long-run inflation rate. That is, while the Fisher equation (15) holds, the neo-Fisherian proposition does not.\textsuperscript{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

\begin{equation}
    d = \left( \frac{\sigma}{\sigma + \theta} \right) y.
\end{equation}

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

\[
x f'(y - d) = R(n/\mu). \tag{17}
\]

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 \( \hat{\Pi} \). If this target inflation rate is to be achieved, then it must satisfy condition (11); that is,
\( \hat{\Pi} = \Pi^* (d_{t-1}/d_t) < \Pi^* \).

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

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

or

\[
\theta_t = \max \left\{ \left( \frac{\hat{\Pi}}{\Pi^*} \right) \theta_{t-1} - \sigma \left( 1 - \frac{\hat{\Pi}}{\Pi^*} \right), 0 \right\}
\]

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. 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

\[
R^b_t = (1 + \sigma)^{-1} \left[ f'(k_t) \hat{\Pi} + \sigma R^m \right].
\]

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 \(R^b_t\) 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.

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, \( \tau^* = \left[ \hat{R}/\mu - 1 \right] nd^* \), where \( \hat{R} = \theta \hat{R}_m + (1 - \theta) \hat{R}_b \).

Following the monetary tightening shock, the primary surplus in the transition satisfies

\[
\tau_t = \left[ \hat{R}_t/\mu - 1 \right] nd_t,
\]

where \( \hat{R}_t = \theta_t \hat{R}_m + (1 - \theta_t) \hat{R}_b \). 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).
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
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. 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.

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 cre-
ation, rather than adjustments in the primary deficit.\textsuperscript{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,

\begin{equation}
\hat{\Pi} = \Pi^* \left( \frac{d_{t-1}}{d_t} \right) > \Pi^*.
\end{equation}

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

\begin{equation}
\theta_t = \min \left\{ \left( \frac{\hat{\Pi}}{\Pi^*} \right) \theta_{t-1} - \sigma \left( 1 - \frac{\hat{\Pi}}{\Pi^*} \right), 1 \right\}
\end{equation}

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.\textsuperscript{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 $R_t^b = R_m$:

\begin{equation}
R_m = (1+\sigma)^{-1} \left[ f'(y - d(\hat{\theta}))\hat{\Pi} + \sigma R_m \right].
\end{equation}
where \(d(\hat{\theta})\) is determined by (16) for \(\theta = \hat{\theta}\). 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

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. 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. 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 is known at date so that a change in 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 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 as a legal reserve requirement, then then represents a source of money demand that emanates (say) from “fear,” then an exogenous increase in may result in private agencies holding more cash than the statutory minimum (say, ). In this latter case, it only appears that private agencies are holding “excess” reserves. But as long as , 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 ( ). The equilibrium interest rate is given by the marginal product of capital , . If , 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
Andolfatto and Spewak

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.

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.

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.

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.

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.

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.

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

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.

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.

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.

Among other considerations, Volcker was a Democrat.

See Weissman (1983).

Martin was a staunch Reagan loyalist and a harsh critic of Volcker’s anti-inflation policies.

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.

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.

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.

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).
REFERENCES


How Have Shanghai, Saudi Arabia, and Supply Chains Affected U.S. Inflation Dynamics?

Kristin J. Forbes

This article is based on the Homer Jones Memorial Lecture delivered at the Federal Reserve Bank of St. Louis, May 16, 2018.

Understanding and forecasting inflation has always been a key focus of macroeconomics and monetary policymaking. Historically, many macroeconomists and central banks have relied on the “Phillips curve” framework for this purpose. Recently, however, the Phillips curve framework has not been performing well. This article examines a number of possible explanations for the breakdown of the “Phillips curve” relationship between slack and inflation. These explanations include the possibility that the curve may have flattened or shifted, that standard measures may not be capturing key aspects of the relationship, or that a series of “unfortunate” and unprecedented events may have obscured the underlying relationship. Each of these explanations has some merit and support, but each seems unable to explain how inflation dynamics have evolved over the past decade. This article suggests that what is missing is a more comprehensive treatment of how globalization has affected domestic prices, through channels such as increased trade flows, the greater economic heft of emerging markets, and increased ease of using global supply chains to shift parts of production to cheaper locations. This greater role for globalization in explaining inflation, however, does not mean that the standard Phillips curve framework is “dead.” Rather, macroeconomists and monetary policymakers should update their existing models in two key ways: to include global parameters more explicitly and allow these parameters to adjust over time with the world economy. (JEL E13, E37, E52, F44, F62)

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I INTRODUCTION

Understanding and forecasting inflation has always been a key focus of macroeconomics—and central for institutions setting monetary policy. Recently, however, the basic frameworks and models used to understand inflation have not been performing very well. When the global Financial Crisis hit in 2008 and growth collapsed around the world, why didn’t inflation fall further? How did the world avoid a period of deflation, as occurred during the synchronized...
collapse in global economic output during the Great Depression? And more recently, as gross domestic product (GDP) growth has picked up in most advanced economies and unemployment has fallen—reaching record lows in some—why has inflation remained so low? Is this a sign of deep-seated vulnerabilities, such as the “secular stagnation” that was the theme of Larry Summers’s (2016) recent Homer Jones lecture?

Figure 1 shows these puzzling patterns in a graph of annual real GDP growth and consumer price index (CPI) inflation for advanced economies. Why have the fluctuations in GDP growth over the past 15 years seemed to have so little effect on prices? There has been no shortage of speeches, commentary, and economic research trying to understand this disconnect. One of my favorite titles was “And Yet it Moves”—a reference to Galileo’s famous quote “Eppur si muove”—that he used when arguing that the earth moved around the sun. And just as the earth actually does move, the past few years have highlighted that inflation also moves, albeit not necessarily in the ways that our models have predicted.

A closer look at the distribution of CPI inflation rates in advanced economies (Figure 2) clearly shows this movement. Although the global economy has grown above 2 percent per year each year since 2009—and averaged growth of about 2¾ percent in 2014-15—CPI inflation was below 1 percent in over half of the advanced economies in 2014, 2015, and 2016. In 2015, CPI inflation was below 1 percent in over 80 percent of advanced economies and below zero (deflation) in over 30 percent. This is a sharp change from inflation hovering around 2 percent for much of the decade before the crisis. This is also a sharp change from 2008, when over 80 percent of the advanced economies had inflation over 3 percent.

Granted, optimists may focus on the last bar in the graph (for 2017), which suggests that the period of undesirably low inflation may be ending. In 2017, although inflation was still
lower than many central banks’ targets, it averaged between 1 percent and 3 percent for about 80 percent of the advanced economies.\(^2\) A meaningful part of this recovery in headline inflation rates, however, reflects a temporary boost from higher energy prices. What happens when energy prices stabilize?

As the International Monetary Fund (IMF) highlighted in its April 2018 World Economic Outlook (Figure 3), core inflation, which tends to be a better determinant of underlying and sustainable inflation rates, is still only averaging about 1½ percent in advanced economies. There is still a lack of underlying inflationary pressures, despite unemployment being at the lowest level in a decade in many countries and below what is believed to be the NAIRU (non-accelerating inflation rate of unemployment) in a number of major economies.\(^3\)

What is perhaps most disconcerting for economists is the seeming breakdown of traditional models and economic relationships that are assumed to underpin the inflation process. Most prominent is the apparent breakdown of the Phillips curve. Throughout this article, I will use the term “Phillips curve” relationship broadly—not just to capture the relationship between unemployment and wage growth shown by William Phillips in his original curve—but instead to capture the more general relationship between the amount of slack (or spare
capacity) in the economy and price inflation. There are a number of ways of measuring these concepts, details I’ll get into below. But the basic concept is intuitive and at the core of most models of inflation. When most people who want to work are working, and there is little spare capacity in an economy, resource constraints tend to drive up wages and prices.

This Phillips curve relationship may sound obvious but has recently been hard to see in the data. Figure 4 shows a recent graph from The Economist that makes this point. The dots show one variant of this Phillips curve relationship—the relationship between cyclical unemployment and core inflation in advanced economies since the 1970s. The expected negative relationship between these measures of slack and unemployment existed from 1975-84 (the dark blue dots), but then weakened over the subsequent decade (the light blue dots), and further faded during the most recent period (the yellow dots). The relationship has recently been so weak that it almost disappears—or “flatlines”—so that the heading for the graph chosen by The Economist was “The Phillips curve may be broken for good.”

Granted, this is not the first time that there has been soul searching about the accuracy of the Phillips curve. Figure 5A shows an early variant of the Phillips curve—graphed for the United States just as the concept became popular at the end of the 1960s. This clearly shows the expected negative relationship between unemployment and wage inflation. Figure 5B, however, shows what happened to this relationship over the next few decades. The Phillips curve appeared even more “broken” than today.
These earlier breakdowns, however, were quickly explained with modest extensions to the framework—such as controlling for oil price shocks (or other supply shocks) that caused the Phillips curve to shift. More recently, concerns that the Phillips curve framework is no longer “fit for purpose” are more deep-seated. A Google search for articles that include the terms “dead” and “Phillips curve” yields over 1,000 hits. Is the Phillips curve framework broken for good?

This is the key theme that I will explore in the rest of this article. Has something changed so that the framework central for thinking about inflation dynamics is no longer useful? Have changes in the global economy—in Shanghai (i.e., emerging markets), in Saudi Arabia (i.e., oil and commodity markets), and in supply chains (i.e., production processes)—affected inflation dynamics? If these changes in the global economy are incorporated into our frameworks for understanding inflation—do the old relationships still apply? Can we simply extend our old frameworks rather than throw them away?

In order to answer these questions, the remainder of the article is divided into four sections. Section II briefly summarizes key arguments why the Phillips curve framework may appear broken today. Section III proposes an alternative explanation: the need to add a more comprehensive treatment of changes in the global economy. Section IV provides some empirical evidence to support the growing role of international factors and globalization in explaining inflation dynamics. Section V concludes, tying together the pieces of evidence that suggest a better incorporation of the roles of “Shanghai, Saudi Arabia, and Supply Chains” can go some way toward improving our understanding of recent inflation dynamics.
II CHALLENGES TO THE CURRENT PHILLIPS CURVE FRAMEWORK

At the core of most inflation models are three key variables: the amount of slack in the domestic economy (often measured by the output gap or unemployment gap), inflation expectations (and/or lagged inflation), and supply shocks (usually measured by oil prices or import prices). This basic framework has worked fairly well during some periods, but at other times has been less successful, generating a number of ideas for improvement. For example, Ball and Mazumder (2015) highlight the need to add time variation to the relationship between unemployment and inflation, while Krueger, Cramer, and Cho (2014) suggest focusing on short-run unemployment instead of long-run unemployment to capture slack. Recently, Coibion and Gorodnichenko (2015) suggest focusing on household inflation expectations instead of other measures, and Stock and Watson (2018) suggest focusing on more “cyclically sensitive” measures of inflation. After reviewing this literature, one cannot help but sympathize with the interpretation in Stock and Watson (2010), that the history of the Phillips curve is “one of apparently stable relationships falling apart upon publication” (p. 212).

What can explain the recent breakdown of the basic Phillips curve relationship between economic slack and inflationary pressures? The current state of debate focuses on five (partially overlapping) explanations: the relationship is dead, the curve has flattened, key concepts are not measured accurately, the curve has shifted, and the relationship has been obscured by a series of “unfortunate events.” Let me take each explanation in turn.

1. **Dead.** The first explanation is that the “Phillips curve” tradeoff between economic slack and inflation no longer exists. People supporting this argument often suggest we should discard the old framework and start afresh. I don’t believe this argument—for reasons that I will discuss in more detail below—so I will not spend very much time on it. Intuitively, there must be some point at which a lack of people to fill job vacancies causes companies to start to pay more, eventually translating into higher wage and price inflation. If there are no more resources (whether workers or other materials) to produce items that people want to buy, and companies are running at maximum capacity, it is hard to believe that they will not eventually start to raise prices. This basic relationship may have evolved over time, and may be hard to measure, but I find it hard to believe that it is entirely “dead.”

2. **Flattened.** A second possible explanation is that the Phillips curve has flattened, such as indicated in Figure 4. There are a number of reasons why this might be happening. For example, the nature of work is changing. Unions have become less powerful in some countries (such as the United States). Fewer jobs are long-term relationships between one company and a set of workers, and instead more jobs are part of the “sharing economy,” such as people driving for Uber. This more disperse nature of work and greater disconnect between workers and their employees would reduce workers’ bargaining power. Also, as populations age, older workers may be more reticent to switch jobs, reducing their bargaining power in wage negotiations as their threat of leaving and switching jobs is less credible. These are only a few examples, but any of these effects could weaken the relationship between unemployment and wage growth, causing the Phillips curve to “flatline.”
3. **Data and Measurement Issues.** A third set of arguments is that the relationship between unemployment and inflation still exists (whether “flatter” or not), but we are not measuring key variables correctly. For example, in the United States, slack is usually assessed using the unemployment rate—which is currently very low and suggests little (if any) slack in the economy. This statistic misses a large pool of “discouraged” workers, however, who have stopped actively looking for work and are therefore no longer counted as being in the labor force. These workers could still be available for certain jobs and therefore reduce the pressure for companies to raise wages despite the low reported unemployment rate. In the United Kingdom, as the unemployment rate has fallen, the most recent hires have tended to have less experience, skills, education, and training—traits which are all reflected in lower wages. When these new hires are added to the average wage pool, this mechanically lowers average wages and wage growth. Work by the Bank of England shows that when you adjust for these types of relative skill differentials in the composition of the labor force, it can explain a meaningful portion of the seeming puzzle of “missing” wage growth. These technical measurement issues can therefore be important and help explain some of the Philips curve puzzle.

4. **Shifted.** A fourth set of explanations for the apparent breakdown in the Phillips curve is that it may have “shifted” rather than “flattened”—as happened during the oil price shocks in the 1970s and 1980s (shown in Figure 5B). The Phillips curve could be shifting for a number of reasons. For example, productivity growth has fallen sharply in most advanced economies, and since pay is partly determined by how productive workers are each year, the fall in productivity growth would lower wage growth for any level of unemployment. Stricter requirements on access to unemployment benefits or income support could have increased the incentive to work, also shifting down the curve. Saunders (2018) provides graphical evidence from the United Kingdom that the Phillips curve has been “shifting” as well as flattening, suggesting that the relationship between unemployment and wages still exists, but just moves around over time.

5. **“Unfortunate Events.”** A final set of theories explaining the seeming breakdown in the Phillips curve relationship is what I refer to as a “series of unfortunate events” for shorthand—a reference to the famous book series by Lemony Snicket. The past decade has certainly been an era of unprecedented and unexpected events—even if all are not “unfortunate.” For example, consider the three years when I was serving on the Monetary Policy Committee at the Bank of England. My term began in the summer of 2014, just as oil prices had begun to plunge (and would continue to drag on inflation for over two years) and just before the Scottish referendum on remaining in the United Kingdom. Less than a year later, there was a tight U.K. general election followed by an acceleration of capital outflows from China (which raised concerns about the global economy) and a period of tense negotiations with Greece on debt restructuring (which raised concerns about the future of the euro area). Then the United Kingdom announced a referendum on remaining in the European Union, and the surprising vote for “Brexit” prompted a leadership change and another general election. Each of these events generated a substantial degree of uncertainty—likely making companies more reluctant
to agree to higher wages or raise prices. These types of events undoubtedly weakened the usual relationship between slack and inflation.

These different explanations for why the Phillips curve relationship between unemployment and inflation may have seemed to break down each appear to have some merit. Each has some empirical support in various research papers. The combination of the last four arguments undoubtedly goes some way to explaining the seeming breakdown in the expected relationship between slack and inflation. There is one important set of issues missing from this list, however, as well as from most discussions of the breakdown of the Phillips curve: changes in the global economy.

III ROLE OF GLOBALIZATION

Over the past few decades, globalization has proceeded at a rapid pace. Many changes in Shanghai, Saudi Arabia, and supply chains could influence the inflation process—including in ways that are not currently captured in the standard Phillips curve framework. This section discusses how various aspects of globalization, such as the greater role for emerging markets, increase in global trade flows, and greater use of supply chains, have been affecting commodity markets, worker bargaining power, and producer pricing decisions. The next section provides empirical evidence that this impact of globalization on inflation is not just theoretical—but important and growing over time.

This idea that globalization may be affecting the inflation process is not new. In the mid-2000s, several prominent policymakers gave speeches questioning whether increased globalization was helping moderate inflation pressures at that time.9 The corresponding discussion generally concluded that although globalization was an important phenomenon, it appeared to have had only limited effects on the inflation process. Ball (2006, abstract) summarizes the current debate in an essay on whether the “globalization of the U.S. economy has changed the behavior of inflation” and summarizes the results of his tests as “no, no, and no.” The role of globalization in inflation dynamics received less attention during and after the global Financial Crisis. Only recently, as inflationary pressures have remained muted in a number of economies despite minimal slack and a broad-based recovery, is the role of globalization in inflation dynamics beginning to regain attention.10

One of the most striking changes in the global economy since the early 1990s has been the increased role of emerging economies. In 1990, advanced economies produced about 64 percent of global GDP and emerging markets about 36 percent.11 In 2018, the IMF has predicted that this will almost reverse—with advanced economies producing only about 40 percent of global GDP and emerging markets about 60 percent. Emerging markets have accounted for over 75 percent of global growth since the crisis, with just one emerging market—China—responsible for about one-third of global growth since then. Emerging markets also tend to use natural resources and commodities more intensively and are the key source of demand for commodities, contributing to a stronger link between global commodity prices and the growth dynamics in emerging markets.12 This link between commodity prices and cyclical
activity in major emerging markets has contributed to sharp swings in commodity prices and increased the role of commodities in inflation dynamics—especially as the effects of commodity prices on inflation tend to be nonlinear and larger after sharper price swings.¹³

A related change in the global economy is the notable increase in global trade flows over the past 25 years—and not just through trade with emerging economies. According to the IMF, total global trade (exports plus imports) as a share of global GDP has increased from about 39 percent in 1990 to 56 percent in 2016. As the role of exports increases for a given economy, demand in global markets will likely play a greater role in national income and price setting by domestic companies. Similarly, as the role of imports increases, domestic inflation will be more affected by global prices, as imported goods constitute a larger share of the basket of goods purchased by consumers (and used to calculate inflation). A larger role for traded goods could also cause exchange rate movements to have larger effects on domestic prices and the pricing decisions by local companies.

Other closely related aspects of globalization are the ease of developing supply chains around the world, as well as the increased competition from foreign companies (and especially low-cost items from emerging markets). Both of these changes affect companies’ pricing power and decisions on how to structure production. For companies that export or compete with imports, pricing decisions must take greater account of prices from foreign competitors. Even holding trade flows constant, greater “contestability” from global products will matter (Benigno and Faia, 2010). As it becomes easier to shift activities abroad—even just small stages of the production process—domestic costs will be more closely aligned with foreign costs.¹⁴ This ease of shifting production to where it can be done at the lowest cost could particularly affect the bargaining power of workers. Increased imports from low-wage countries and more competition in traded goods could make it more difficult for domestic companies to raise prices and wages—even when there is little slack in local labor markets.¹⁵ The increased mobility of workers, including the possibility of increased immigration to help fill job vacancies, could further reduce worker bargaining power.

Each of these aspects of globalization could change the relationship between slack and inflation—developments not currently incorporated in standard Phillips curve models. These changes in the global economy could even imply that slack in your own economy is a less important determinant of inflation and, instead, slack and labor market dynamics in the rest of the world may be increasingly relevant.¹⁶

Put slightly differently, instead of simply focusing on dynamics in the local economy when modeling inflation, has globalization made it more important to consider global developments? For example, is rapid growth in other countries generating increased demand for a country’s products? Is there excess capacity in the rest of the world—so that a local company could shift production elsewhere to keep costs down? Should “slack” be measured on a global basis, instead of just in the domestic economy? How is the increased competition in global markets, and greater volatility in commodity prices, affecting how companies set prices? And last, but certainly not least, if these different global factors are becoming more important in the inflation process, are they simultaneously reducing the role of domestic variables—such as domestic slack and the bargaining power of domestic workers?
It is noteworthy that despite the substantial amount of attention paid to globalization in a wide array of venues, there has been little attempt to better incorporate these changes in the global economy into standard frameworks for modeling inflation. The most common approach for modeling inflation (shown in more detail in the next section) continues to be to control for domestic slack, inflation expectations, and import prices (or just oil prices). The assumption underlying this approach is that these variables are “sufficient statistics” to capture any changes in the global economy that could affect pricing dynamics.  

The range of ways in which globalization could be affecting inflation discussed in this section, however, suggests that this “sufficient statistic” treatment is unlikely to be “sufficient.” Foreign prices may act as a counterweight on domestic pricing, even if goods are not traded and therefore not captured in import prices. Measures of slack in the domestic economy may not capture the expected evolution of slack in other economies that will affect import prices going forward, or the ease of shifting parts of production elsewhere if workers bargain for higher wages. Separately controlling for energy prices from non-energy commodity prices could better identify changes in import prices corresponding to global demand rather than just oil prices (which can be affected by geopolitical events). This should better capture the increased volatility in commodity prices linked to changes in demand by emerging markets. A more explicit and comprehensive treatment of these types of changes in the global economy could be important for understanding inflation dynamics.

IV EMPIRICAL EVIDENCE: THE ROLE OF GLOBALIZATION

There are convincing arguments why globalization could be affecting inflation dynamics, but is there empirical evidence? This section uses two very different empirical approaches to provide support for the role of globalization in inflation dynamics: principal components and regression analysis. These empirical results are drawn from a longer and more comprehensive analysis in Forbes (2018), which includes details on the sample, data, and estimation techniques.

To begin, Figure 6 shows the first principal component for four different measures of inflation for a sample of advanced economies and major emerging markets over five-year windows since 1990. The “principal component” is basically the shared movement in changes in the countries’ quarterly inflation rates. The measures of inflation are CPI, core inflation (CPI inflation less food and energy prices), producer price inflation (PPI), and wage inflation.

The principal component for the CPI—the main measure of inflation on which most central banks focus—is about 60 percent at the end of the sample. This means that 60 percent of the movement in each country’s inflation rate is synchronized, that is, shared globally with the other countries in the sample. This indicates a substantial amount of comovement in CPI inflation rates around the world at the end of the sample. The line for PPI inflation bounces around 60 percent for the entire period, also suggesting a high degree of comovement in the prices producers have been paying for inputs since 1990. This is not surprising given the international market for many inputs for production (such as steel and oil). In contrast, the principal components for wages and core inflation end the sample at much lower levels—between...
20 percent to 30 percent since 2010—indicating that these prices move more independently across countries.

What is perhaps most interesting, however, is how these estimated principal components have evolved over time. The shared principal component of CPI inflation was quite low in the early 1990s, at about 30 percent, but has more than doubled since to about 60 percent. This suggests that something has changed in the dynamics of headline inflation rates. Headline inflation rates move more in sync now than in the 1990s. A majority of the movements in a country’s headline inflation rate correspond to movements in the rest of the world. Yet in contrast, core inflation and wage inflation move more independently in countries around the world—with the degree of synchronization falling instead of rising over time.

This analysis doesn’t provide answers to why certain measures of inflation are more synchronized, however, or why the shared global components have changed over time for some measures. To understand these patterns and divergent trends, it is useful to shift to more formal regression analysis. This would allow tests if different variables—and especially different global variables—could explain these trends in the comovement of inflation rates around the world. Is globalization an important factor driving synchronized movements in CPI inflation rates in so many countries? Have changes in the global economy caused some of these changes over time?

More specifically, and building on the discussion in the previous section, what is the impact of the greater heft of emerging markets and corresponding increase in commodity price volatility? What is the impact of the increased share of trade relative to GDP and corresponding increase in trade competition and use of supply chains? Is there a greater role for
global slack—and possibly reduced role for domestic slack? How have Shanghai (i.e., emerging markets), Saudi Arabia (i.e., oil and commodity markets), and supply chains (i.e., changes in production patterns) affected inflation?

To capture these various ways in which globalization may be affecting the inflation process, I estimate a standard Phillips curve model but add a set of variables to more comprehensively control for changes in the global economy. More specifically, I estimate inflation in different countries as a function of three standard Phillips curve variables: the domestic output gap (the key variable on which most discussion focuses), inflation expectations, and lagged inflation. Then I add five global variables: exchange rates, the world output gap, oil prices, commodity prices, and a measure of global producer price dispersion (to capture the role of supply chains, as in Auer, Levchenko, and Sauré, 2016).

I estimate the model for quarterly CPI and core inflation from 1990 to 2017 for a cross-section of mainly advanced economies. Table 1 shows the results, replicated from Forbes (2018) for both CPI and core inflation. The positive and significant coefficients on inflation expectations, lagged inflation, and domestic slack all suggest that these standard domestic variables included in most inflation models still play a significant role in explaining inflation dynamics. The significant coefficients on almost all of the global variables, however, suggest that these global factors are also important. More specifically, exchange rate depreciations, larger world output gaps, higher oil and commodity price inflation, and less competitive producer pricing are all correlated with higher CPI and core inflation.

One challenge with these results, however, is that they treat the effects of each of the variables (both domestic and global) as constant over time. Yet the discussion in Section III

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NOTE: Regressions of quarterly, annualized, seasonally adjusted inflation from 1990-2017 for a sample of 43 countries with fixed coefficients over the full period. *** is significant at the 1 percent level and ** at the 5 percent level. Standard errors are in parentheses.

highlighted how globalization may have changed the relationship between the global factors and inflation, and the discussion in Section II highlighted how even the relationships between the domestic factors and inflation may have changed over time. A number of academic studies have also highlighted the instability of the coefficients in Phillips curve models.24

To test for changes in the role of the global factors affecting inflation, I estimate the same Phillips curve model from Table 1, except now estimate rolling regressions over eight-year windows instead of assuming that the relationships are fixed over time. This extension confirms that the role of many of these variables changes over time. To take one example, Figure 7 shows the resulting rolling coefficients on commodity price inflation (the role of “Shanghai”). The figure shows the median coefficient estimate when the model is estimated separately for each country for which data are available, with the dashed lines showing the coefficient estimates for 33 percent and 66 percent of the distribution. This coefficient on commodity prices increases sharply after the global Financial Crisis and then increases again in the later part of the sample. The relationship between a given change in commodity prices and CPI inflation has increased over the past decade.25 Similar graphs for the other variables also show sharp movements over time.

These types of figures (with the full set shown in Forbes, 2018) suggest that global factors can significantly affect inflation, but that their role (as well as that of domestic factors) can change meaningfully over time. More formal regression analysis that tests for any significant change in the role of the global variables over time further supports the increased role of these global factors in explaining CPI inflation over the past decade.

For example, if I repeat the regression of Figure 7, but now allow the role of the different variables to change over the more recent period from 2007-17, statistical tests indicate that the role of the global variables has increased significantly for CPI inflation.26 More specifically, the world output gap and world commodity prices appear to have had a stronger positive impact on CPI inflation over the past decade. In fact, when the role of these two global variables is allowed to change over time, global slack and commodity prices are generally not estimated to be important in the pre-crisis period, but are significant over the past decade (or even just over the past few years). This could be why global variables were not a focus of Phillips curve-based inflation models before the Financial Crisis; their role was less important.
Finally, it is worth noting that although the world output gap and commodity prices appear to have had a greater role in determining CPI inflation in the past decade, these global variables do not appear to have played a significantly greater role in driving core inflation. This could explain the divergent patterns in the global principal component for different inflation rates shown in Figure 6. The greater role of global variables to CPI inflation over the past decade could have driven the increased synchronization in CPI inflation rates over this period, but since the role of these global variables was smaller and changes less for core inflation (as well as wage inflation), they would not have generated the same increase in comovement. This does not mean, however, that global variables are unimportant for explaining core inflation. Instead, the regression results that allow the role of the different factors to change over the past decade continue to find an important role for exchange rates in driving core inflation. Since exchange rates often move in different directions in different countries, this could also explain the less synchronized movements in core inflation in countries around the world.

V CONCLUSIONS

Standard frameworks for understanding inflation have not been performing well. There are a number of possible explanations for the seeming breakdown of the “Phillips curve” relationship between slack and inflation: The curve may have flattened or shifted, standard measures may not be capturing key aspects of the relationship, or a series of “unfortunate” and unprecedented events may have obscured the underlying relationship. Each of these explanations has some merit and support—but something still seems to be missing from our understanding of inflation dynamics over the past decade.

This article suggests that the missing component is a more comprehensive treatment of globalization. The global economy has evolved in many ways, such as through increased trade flows, a greater heft of emerging markets, and increased use of supply chains. Many of these changes will affect inflation dynamics, in both how companies make pricing decisions and how effectively workers can bargain for higher wages. These changes in the global economy are multifaceted—from the functioning of commodity and oil markets, to the role of exchange rate movements and global slack, to how companies can more easily shift parts of production around the world.

This greater role for globalization in explaining inflation, however, does not mean that the standard Phillips curve framework is “dead.” It does not imply that we should discard our old models. Instead, we should update the models to include global parameters more explicitly and allow these parameters to adjust over time with the world economy. Just as emerging markets, commodity markets, and patterns of production have evolved over time, it is time to more explicitly include a role for “Shanghai, Saudi Arabia, and supply chains” in our inflation frameworks.
NOTES

1. Miles et al. (2017).

2. Economies are defined as "advanced" based on IMF definitions.

3. This low rate of underlying inflation is also evident when inflation is decomposed into a slow-moving "trend" and shorter-term "cyclical" component, as shown in Forbes (2018) for a cross-section of countries using a model developed in Forbes, Kirkham, and Theodoridis (2018).


5. For recent overviews and key arguments, see Ball and Mazumder (2015); Blanchard (2018); Gordon (2013); Miles et al. (2017); and Stock and Watson (2010).


7. See Abel et al. (2016).

8. See Forbes (2017) for more detail on this series of "unfortunate events" in the United Kingdom.

9. For example, see Bean (2006), Kohn (2006), and Yellen (2006). Also see Gamber (2001) and Ihrig et al. (2010).

10. See Borio (2017) for an overview of ways globalization may have changed the inflation process over time.

11. Based on IMF definitions and adjusting for purchasing power parity, which puts greater weight on emerging market output.

12. See World Bank (2018) and Miles et al. (2017) for additional evidence.

13. See Hamilton (2010) or a standard sticky-price model to explain these effects, such as Ball and Mankiw (1995).


17. For an example of this line of reasoning, see Eickmeier and Pijnenbrug (2013).

18. The sample is primarily advanced economies but also includes a number of major emerging markets. The sample size ranges from 26 to 43 countries based on the year and measure of inflation. Also see Hakkio (2009) for another example of principal component analysis to understand inflation dynamics.

19. One notable exception is the United States, where the U.S. Federal Reserve focuses on core personal consumption expenditures.

20. Inflation expectations are the five-year-ahead forecast from the IMF's World Economic Outlook. The domestic output gap is measured as a principal component of seven measures of domestic slack. See Forbes (2018) for more details on variable definitions, sources, and summary statistics.

21. Exchange rates incorporate a global and domestic component; but as they are usually not explicitly included in Phillips curve regressions, I include them as part of the nontraditional set of "global" variables. The exchange rate is the percent change in the real exchange rate index relative to two years earlier.

22. The world output gap is reported by the Organisation for Economic Co-operation and Development. Oil and commodity prices are measured relative to the CPI or core inflation. The dispersion in producer prices is the change in the quarterly variance in PPI prices relative to four quarters earlier for all countries in the sample.

23. It is important to note, however, that although the variables in Figure 7 are significant in the pooled cross-section results, when the same model is estimated for individual countries, the coefficients are less often significant, reflecting the diversity of country experiences. See Forbes (2018) for more detail on results by country.

24. For example, see Albuquerque and Baumann (2017), Blanchard et al. (2015), and IMF (2016).

25. Some of the shifts in the coefficients correspond to sharp movements in commodity prices, which would be consistent with nonlinear effects and sticky-price models in which firms are more likely to adjust prices after larger price movements. Some of the estimated effects of commodity price movements may also capture changes in growth prospects in emerging markets, a link that has increased over time (see World Bank, 2018).

26. This involves adding interactions of each of the variables with a dummy variable equal to 1 for the past period.
REFERENCES


International Monetary Fund. World Economic Outlook: Cyclical Upswing, Structural Change. April 2018.


In this article, we document that the Organisation for Economic Co-operation and Development (OECD) and the Conference Board’s Total Economy Database (TED) have substantially revised their measures of hours worked over time. Relying on the data used by Rogerson (2006) and Ohanian et al. (2008), we find that, for 2003, hours worked per person in Europe is 18 percent lower than hours worked in the United States. Using the 2016 releases of the same data for 2003 yields a gap that is 40 percent smaller—that is, only 11 percent lower. Using labor force survey data, which are less subject to data revisions, we find a Europe-U.S. hours gap of –19 percent. (JEL C82, E24, J21, J22)
different results originate mainly from revisions of the hours worked per employed series used in the calculation of hours worked per person. Next to Rogerson (2006) and Ohanian et al. (2008), the implied Europe-U.S. hours worked per person gaps in Prescott (2004) and McDaniel (2011) are also subject to such revisions. Using labor force survey data, which are less subject to data revisions, we find a Europe-U.S. hours gap of –19 percent. We further show that the different formulas used to calculate hours worked per person in these articles have only negligible effects on the estimated Europe-U.S. hours worked per person gap.

2 LITERATURE OVERVIEW

In this section, we provide a brief overview of how hours worked per person have been calculated in the literature and which data sources have been used. The upper panel of Table 1A lists the main articles that explain differences in hours worked between a large set of European countries and the United States. Column 2 states the formula used in each article to calculate hours worked per person, while column 3 lists the respective time period covered. The first four articles calculate hours worked per person by multiplying average hours worked per employed with various measures of the civilian employment-to-population ratio. The first three articles calculate the latter as civilian employment without an age limit divided by the population aged 15 to 64, with Prescott (2004) also including non-civilian employment. Ragan (2013) restricts the employment-to-population ratio to the age group 25 to 64. Henceforth, we use the term employment rate interchangeably for these employment-to-population ratios. McDaniel (2011) differs from these articles by directly dividing total hours worked by the population aged 15 to 64. We exclude Alesina et al. (2005) and Faggio and Nickell (2007) from Table 1, because their measure of hours worked per employed are based on data published in a special section of the OECD’s Economic Outlook 2004. These data are not part of the OECD’s general database and are as such not subject to their usual maintenance and revisions. Moreover, their measure of hours worked per employed was obtained from labor force surveys (LFS), which are usually not subject to larger revisions.

In Bick et al. (2018), we construct internationally comparable hours-worked measures for the United States and 18 European countries on a more disaggregate level—for example, by gender and education—using national LFS. Such detailed measures of hours worked have not been available so far. The article discusses in detail the strategy of how we achieve comparability of hours worked across countries and over time, a task far from trivial. We also contrast the aggregate hours implied by the LFS data with those from the National Income and Product Accounts (NIPA). For both types of data sources, we use conceptually the same formula (see the lower panel of Table 1A). Here, we intentionally use the product formulation—that is, hours worked per employed times the respective employment-to-population ratio—because it highlights that in our calculation employment cancels out, as in McDaniel (2011). For the first four studies listed in Table 1A this is not necessarily the case. We do not know whether the denominator in average hours worked per employed referred to total or civilian employment in earlier data releases. Thus, it may or may not be equal to the numerator in the respective employment-to-population ratio. We elaborate on this further below.
# Table 1

## Overview of the Macro Literature on Cross-Country Differences in Hours Worked per Person

### A: Hours Worked per Person Formulas and Time Period Covered

<table>
<thead>
<tr>
<th>Reference</th>
<th>Hours worked per person</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prescott (2004)</td>
<td>( \text{Avg. hours worked per employed} \times \frac{\text{Civilian + Non-civilian employment}}{\text{Population 15-64}} )</td>
<td>Avg. 1970-73 and 1993-96</td>
</tr>
<tr>
<td>Rogerson (2006)</td>
<td>( \text{Avg. hours worked per employed} \times \frac{\text{Civilian employment}}{\text{Population 15-64}} )</td>
<td>2003</td>
</tr>
<tr>
<td>Ohanian et al. (2008)</td>
<td>( \text{Avg. hours worked per employed} \times \frac{\text{Civilian employment}}{\text{Population 15-64}} )</td>
<td>1956-2004</td>
</tr>
<tr>
<td>Ragan (2013)</td>
<td>( \text{Avg. hours worked per employed} \times \frac{\text{Civilian employment 25-64}}{\text{Population 15-64}} )</td>
<td>Avg. 1998-2003</td>
</tr>
<tr>
<td>McDaniel (2011)</td>
<td>( \frac{\text{Total hours}}{\text{Population 15-64}} )</td>
<td>1960-2004</td>
</tr>
</tbody>
</table>

#### B: Data Sources

<table>
<thead>
<tr>
<th>Reference</th>
<th>Hours</th>
<th>Employment</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ohanian et al. (2008)</td>
<td>TED [2008]</td>
<td>Various issues of the OECD’s Economic Outlook and Main Economic Indicators</td>
<td></td>
</tr>
<tr>
<td>McDaniel (2011)</td>
<td></td>
<td>OECD</td>
<td></td>
</tr>
<tr>
<td>Bick et al. (2018)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NIPA (OECD)</td>
<td>OECD NA Database* [2016]</td>
<td>OECD ALFS† [2016]</td>
<td></td>
</tr>
<tr>
<td>NIPA (TED)</td>
<td>TED [2016]</td>
<td>OECD ALFS† [2016]</td>
<td></td>
</tr>
<tr>
<td>LFS</td>
<td>National Labor Force Surveys [2016]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The upper panel of Table 1B states the data sources exactly as specified in each of the five articles. Numbers in parentheses refer to the year of publication of each article, whereas numbers in brackets refer to the year of the data release if provided by the authors in the respective article. Employment and population figures are always taken from the OECD, while average hours worked per employed are taken from either the OECD or different TED releases, which in earlier years was maintained jointly by the Conference Board and the Groningen Growth and Development Centre.

The lower panel of Table 1B states the data sources used in Bick et al. (2018). We report here two NIPA measures, which only differ in their source for hours worked per employed. We take total hours and total employment from either the OECD’s National Accounts Database, downloaded in March 2016, or the May 2016 TED release. We denote both measures by NIPA because for most years and countries both data sources report exactly the same numbers. We normalize both NIPA measures with the population aged 15 to 64 from the OECD’s Annual Labour Force Statistics, downloaded in August 2016. We calculate our LFS measure of hours worked per person using only information from the national LFS for hours worked, employment, and population. We use CPS data for the United States, downloaded in August 2016 from the NBER’s website, and use the European Union Labor Force Survey as provided to us by Eurostat in 2014. The LFS also undergo revisions, but these are minor revisions concentrated on certain quarters and countries and for only a few variables at a time.

Both the OECD and TED also report average hours worked per employed as a separate variable, which is used in the articles by Prescott (2004), Rogerson (2006), Ohanian et al. (2008), and Ragan (2013). The TED’s average hours worked per employed is simply total hours worked divided by total employment from the TED. The OECD’s Average Annual Hours Worked per Employed series can be found in the OECD’s Labour Database under the section Labour Force Statistics. Similar to the TED estimate, this estimate is equal to total hours worked divided by total employment from the OECD’s National Account Database, although there are small differences for a few countries in some years. We are not entirely sure whether in earlier releases of the data, hours worked per employed were similarly calculated as total hours divided by total employment; in the September 2006 TED release, hours worked per employed are defined as “total hours divided by persons engaged.”

In our analysis of the effects of data revisions, we draw data for civilian employment from the OECD’s Labour Database under the section Labour Force Statistics. Two data series are available: one under the category LFS by sex and age (LFSsa) and one under the category Annual Labour Force Statistics (ALFS). As we show further below, the differences between LFSsa and ALFS employment are small for most countries. The difference with total employment from NIPA data is, however, non-negligible for both series. Hence, at least for the 2016 data release, employment does not cancel out in the formulas used by the first four articles in Table 1A. We come to this conclusion because average hours worked per employed, directly available from the OECD and TED, are largely based on total hours and total employment, as discussed above. If we add non-civilian employment, which is available for a subset of countries in the ALFS, to civilian employment from the LFSsa or ALFS, we do not arrive at total employment from NIPA, such that for the formula used by Prescott (2004), employment also does not cancel out.
3 Evaluating Differences in Labor Supply Measures Originating from Different Data Releases

In this section, we evaluate the role of revisions between different data releases for the measurement of hours worked based on OECD and TED data. Because the data used by Rogerson (2006) for 2003 were not published along with his study, we conduct our comparison based on the data used in his companion article with Ohanian and Raffo (Ohanian et al., 2008). These are available online in the *Journal of Monetary Economics*. Note that Ohanian et al. (2008) focus only on the cross-country comparisons of trends. Therefore, in principle, our study relates to the article by Rogerson (2006), but we use the data from Ohanian et al. (2008) for the analysis. We restrict our attention to the United States and the set of 15 European countries that are part of the Ohanian et al. (2008) sample and the Bick et al. (2018) sample. We report all results for 2003, the latest year available in the Ohanian et al. (2008) dataset with information for all variables. In our conclusion, we briefly discuss the remaining articles listed in Table 1.

Rogerson (2006) and Ohanian et al. (2008) calculate hours worked per person as the product of hours worked per employed from the TED and the employment rate from the OECD. In a first step, we investigate the effect of different data releases on each separate component. Then, we look at how hours worked per person are affected by the different releases and how important each margin is in shaping such potential differences. We want to stress again that in all these comparisons, the numbers are reported for 2003 but are based on data released in different years.

3.1 Employment Rates and Hours Worked per Employed

The first column of Table 2 lists the employment rate \( e_{ORR} \) using the Ohanian et al. (2008) data. The next two columns show the percentage differences between the employment rates based on civil employment from the OECD’s ALFS and LFSsa, respectively, and the Ohanian, Raffo, and Rogerson (ORR) employment rate. In each case the employment rate is given by civil employment divided by the population aged 15 to 64 for 2003, as available in August 2016 from the OECD’s website. For example, in Spain, the country with the largest differences, the ALFS employment rate is 3.9 percent (2.3 percentage points) higher than the ORR employment rate, whereas the LFSsa employment rate is 4.4 percent (2.6 percentage points) higher than the ORR employment rate. On average, in European countries the absolute differences between the ORR employment rate and the ALFS and LFSsa employment rates are 1.2 percent and 1.9 percent, respectively, and in the United States the absolute differences for the OECD series are both 0.4 percent. While the differences with the ORR employment rate are already not that large on average, the differences between the ALFS and LFSsa employment rates are even smaller, as can be indirectly inferred from comparing columns 2 and 3 in the table. (Switzerland is the only exception.)

The fourth column of Table 2 lists the average hours worked per employed using the Ohanian et al. (2008) data, which come from the 2008 TED release. While for civil employment we have access to only the 2016 OECD data release, we have several TED data releases
available. Columns 5 to 8 show the percentage differences between average hours worked per employed from these different TED releases, each time compared with the 2008 release. While the 2011 TED release and all subsequent releases are available on the Conference Board’s website, the September 2006 release was shared with us by Cara McDaniel. For many countries there are no differences at all between the 2006 TED release and 2008 TED release—that is, the data available from Ohanian et al. (2008). The mean absolute difference is only 0.6 percent, and the largest difference is present for the Netherlands: Average hours worked per employed in the 2006 release exceed those from the 2008 release by 4.1 percent. This changes drastically when we compare the 2011 release with the 2008 release. More than half of the countries have (absolute) differences that are larger than 4.1 percent (the largest difference between the 2006 and 2008 releases). Austria, Ireland, Italy, and Portugal display double-digit percentage differences. The mean absolute average amounts to 6.9 percent for the European countries, with

### Table 2

**Employment Rate and Average Hours Worked per Employed Differences for 2003**

<table>
<thead>
<tr>
<th>Country</th>
<th>Employment rate</th>
<th>Average hours worked per employed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$e_{\text{ORR}}^{}$</td>
<td>$\Delta_{\text{ALFS},2016\text{Rel.}}^{}$</td>
</tr>
<tr>
<td>Austria</td>
<td>68.7</td>
<td>-0.4</td>
</tr>
<tr>
<td>Belgium</td>
<td>58.6</td>
<td>2.1</td>
</tr>
<tr>
<td>Denmark</td>
<td>74.6</td>
<td>1.4</td>
</tr>
<tr>
<td>France</td>
<td>62.5</td>
<td>3.3</td>
</tr>
<tr>
<td>Germany</td>
<td>63.2</td>
<td>2.4</td>
</tr>
<tr>
<td>Greece</td>
<td>59.7</td>
<td>-1.1</td>
</tr>
<tr>
<td>Ireland</td>
<td>66.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Italy</td>
<td>56.3</td>
<td>0.9</td>
</tr>
<tr>
<td>Netherlands</td>
<td>73.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Norway</td>
<td>75.5</td>
<td>0.0</td>
</tr>
<tr>
<td>Portugal</td>
<td>71.2</td>
<td>1.4</td>
</tr>
<tr>
<td>Sweden</td>
<td>72.8</td>
<td>0.0</td>
</tr>
<tr>
<td>Spain</td>
<td>57.8</td>
<td>3.9</td>
</tr>
<tr>
<td>Switzerland</td>
<td>83.9</td>
<td>-0.2</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>72.3</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Mean absolute</strong></td>
<td>67.7</td>
<td>-1.2</td>
</tr>
<tr>
<td>United States</td>
<td>70.9</td>
<td>-0.4</td>
</tr>
</tbody>
</table>

**NOTE:** The percentage deviations of the ALFS and LFSsa employment rates (each taken from the 2016 data release) from the Ohanian, Raffo, and Rogerson (ORR) employment rate for 2003 are $\Delta_{\text{ALFS},2016\text{Rel.}}^{}$ and $\Delta_{\text{LFSsa},2016\text{Rel.}}^{}$, respectively. The employment rate is measured as civilian employment divided by the population aged 15 to 64. The percentage deviation of average hours worked per employed from the TED release in year $Y$ from the ORR average hours worked per employed (2008 TED release) for 2003 is $\Delta_{Y\text{Rel.}}^{}$.

most countries having a positive difference. In contrast, the average hours worked per employed for the United States from the 2011 release are 5.9 percent lower than those from the 2008 release. The large differences with the 2008 release persist for the European countries in the 2013 and 2016 releases, even though there are some substantial changes between the more recent releases (e.g., for France between 2011 and 2013 and for Denmark between 2013 and

Table 3

<table>
<thead>
<tr>
<th>Country</th>
<th>$H_{ORR}$</th>
<th>$H_{2016,Rel.}$</th>
<th>$\Delta_{2016,Rel.}$</th>
<th>$\Delta_e$</th>
<th>$\Delta_{H^E}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>1,028.8</td>
<td>1,220.0</td>
<td>18.6</td>
<td>18.6</td>
<td>102.1</td>
</tr>
<tr>
<td>Belgium</td>
<td>948.2</td>
<td>943.7</td>
<td>−0.5</td>
<td>−0.5</td>
<td>544.4</td>
</tr>
<tr>
<td>Denmark</td>
<td>1,133.6</td>
<td>1,121.2</td>
<td>−1.1</td>
<td>−1.1</td>
<td>228.0</td>
</tr>
<tr>
<td>France</td>
<td>892.5</td>
<td>957.8</td>
<td>7.3</td>
<td>7.3</td>
<td>55.1</td>
</tr>
<tr>
<td>Germany</td>
<td>910.7</td>
<td>921.6</td>
<td>1.2</td>
<td>1.2</td>
<td>−98.6</td>
</tr>
<tr>
<td>Greece</td>
<td>1,152.3</td>
<td>1,235.5</td>
<td>7.2</td>
<td>7.2</td>
<td>115.4</td>
</tr>
<tr>
<td>Ireland</td>
<td>1,090.8</td>
<td>1,251.4</td>
<td>14.7</td>
<td>14.7</td>
<td>96.7</td>
</tr>
<tr>
<td>Italy</td>
<td>905.4</td>
<td>1,031.3</td>
<td>13.9</td>
<td>13.9</td>
<td>93.4</td>
</tr>
<tr>
<td>Netherlands</td>
<td>989.9</td>
<td>1,056.0</td>
<td>6.7</td>
<td>6.7</td>
<td>83.4</td>
</tr>
<tr>
<td>Norway</td>
<td>1,008.9</td>
<td>1,060.2</td>
<td>5.1</td>
<td>5.1</td>
<td>100.0</td>
</tr>
<tr>
<td>Portugal</td>
<td>1,211.2</td>
<td>1,360.6</td>
<td>12.3</td>
<td>12.3</td>
<td>89.0</td>
</tr>
<tr>
<td>Sweden</td>
<td>1,131.0</td>
<td>1,151.5</td>
<td>1.8</td>
<td>1.8</td>
<td>100.2</td>
</tr>
<tr>
<td>Spain</td>
<td>1,039.0</td>
<td>1,054.0</td>
<td>1.4</td>
<td>1.4</td>
<td>−170.0</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1,289.7</td>
<td>1,363.0</td>
<td>5.7</td>
<td>5.7</td>
<td>102.9</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1,174.0</td>
<td>1,206.4</td>
<td>2.8</td>
<td>2.8</td>
<td>101.1</td>
</tr>
<tr>
<td>Mean</td>
<td>1,060.4</td>
<td>1,129.0</td>
<td>6.5</td>
<td>6.5</td>
<td>126.7</td>
</tr>
<tr>
<td>United States</td>
<td>1,287.5</td>
<td>1,268.2</td>
<td>−1.5</td>
<td>−1.5</td>
<td>101.1</td>
</tr>
</tbody>
</table>

NOTE: The percentage deviation of $H_{2016\,Rel.}$ from $H_{ORR}$ is $\Delta_{2016\,Rel.}$; that is, $\frac{H_{2016\,Rel.} - H_{ORR}}{H_{ORR}}$. The decomposition in columns 4 and 5 is constructed as follows:

$$
\begin{align*}
H_{2016\,Rel.} - H_{ORR} &= e_{ALFS} \times H_{2016\,Rel.}^E - e_{ORR} \times H_{ORR}^E, \\
H_{2016\,Rel.} - H_{ORR} &= e_{ALFS} \left( H_{2016\,Rel.}^E - H_{ORR}^E \right) + H_{ORR} \left( e_{ALFS} - e_{ORR} \right), \\
1 &= \frac{e_{ALFS} \left( H_{2016\,Rel.}^E - H_{ORR}^E \right)}{H_{2016\,Rel.} - H_{ORR} \left( e_{ORR} \right)} + H_{ORR} \left( e_{ALFS} - e_{ORR} \right) \\
\Delta_e &= \frac{H_{2016\,Rel.} - H_{ORR} \left( e_{ORR} \right)}{\Delta_{H^E} \left( e_{ORR} \right)}, \\
\Delta_{H^E} &= \frac{H_{2016\,Rel.} - H_{ORR} \left( e_{ORR} \right)}{\Delta_e \left( e_{ORR} \right)}.
\end{align*}
$$

where $\Delta_e$ is the fraction of $H_{2016\,Rel.} - H_{ORR}$ accounted for by differences between the ALFS and ORR employment rates, and $\Delta_{H^E}$ is the fraction of $H_{2016\,Rel.} - H_{ORR}$ accounted for by differences between hours worked per employed from the 2016 and 2008 TED releases. Note that this decomposition is not unique. We weight the hours worked per employed difference by $e_{ALFS}$ and the employment rate difference by $H_{ORR}$. Using as weights $e_{ORR}$ and $H_{2016\,Rel.}$ leaves the results virtually unchanged.

2016). For the United States, the 2016 release is much closer to the 2008 release than are the 2011 and 2013 releases. These results already make clear that data revisions affect the measurement of hours worked per employed substantially but the measurement of the employment rate only slightly. We will back this up more formally further below.

3.2 Hours Worked per Person

We now use the formula in Rogerson (2006) and Ohanian et al. (2008) to calculate hours worked per person for 2003. We compare the hours worked per person directly obtained from Ohanian et al. (2008), $\text{H}_{\text{ORR}}$, with those from the 2016 data releases, $\text{H}_{2016 \text{Rel.}}$. Specifically, we calculate the latter by multiplying average hours worked per employed from the May 2016 TED release with the ALFS employment rate (downloaded in August 2016 from the OECD’s website).2

As a reminder, we report the hours for 2003 based on data released in different years. The first column of Table 3 shows $\text{H}_{\text{ORR}}$, the second column shows $\text{H}_{2016 \text{Rel.}}$, and the third column shows the percentage deviations of $\text{H}_{2016 \text{Rel.}}$ from $\text{H}_{\text{ORR}}$. For the European countries, hours worked per person are, on average, 6.5 percent larger in the 2016 data than those in the Ohanian et al. (2008) data, while for the United States, hours worked per person are 1.5 percent lower in the 2016 data than those in the Ohanian et al. (2008) data. The last two columns show what fraction of the hours worked per person difference is accounted for by differences in both the employment rate and hours worked per employed. Equation (1) in Table 3 states the formula for these calculations.

For Belgium, Denmark, Germany, Sweden, and Spain, this decomposition is less informative because the (weighted) differences in hours worked per employed and employment rates are divided by the small difference in hours worked per person (less than 2 percent in absolute value). We therefore do not show the mean across all European countries. For France for 2003, the difference in hours worked per employed accounts for 55 percent of the difference in hours worked per person—between the ORR data based on the 2008 TED release and the 2016 TED release. For the other countries, the differences in hours worked per employed account for at least 83 percent of the difference in hours worked per person.

4 THE EUROPE-U.S. HOURS WORKED PER PERSON GAP: THE EFFECT OF DIFFERENT DATA RELEASES AND FORMULAS

In this section, we analyze the role of using different data releases and different formulas for the measurement of the Europe-U.S. hours gap for 2003. In addition, we contrast those findings with the Europe-U.S. hours gap constructed with the LFS by Bick et al. (2018).

The first two columns in Table 4 show the hours worked per person gap relative to the United States for $\text{H}_{\text{ORR}}$ (using the original Ohanian et al., 2008, data; i.e., column 1 in Table 3) and for $\text{H}_{2016 \text{Rel.}}$ (using the 2016 release of the same Ohanian et al., 2008, data; i.e., column 2 in Table 3) for 2003. Constructing hours worked per person as in Rogerson (2006) and Ohanian et al. (2008) but using the 2016 release yields a much smaller gap of −11.0 percent between Europe and the United States, compared with −17.6 percent based on the original
ORR data. As shown in Table 3, this is mostly driven by major revisions of the hours worked per employed TED data between the 2008 release and later releases. Column 3 in turn shows hours worked per person using the NIPA formula (McDaniel, 2011, and Bick et al., 2018) and the TED data. This implies that employment refers to total employment in hours worked per employed and the employment rate. Hence, the only difference between columns 2 and 3 is that the employment figures cancel out in column 3 but not in column 2. This has only a small effect on the Europe-U.S. hours gap of, on average, 1.1 percentage points. Germany and Italy stand out with large differences. Column 4 shows our calculations if we use the OECD hours rather than the TED hours. The Europe-U.S. hours gap differs only by 1.3 percentage points, which is mostly driven by a higher estimate in the TED revisions of hours worked per person in the United States. As the last column of Table 4 shows, the Europe-U.S. hours gap in the original Ohanian et al. (2008) data set is quite similar to the one we find in LFS data.

In Bick et al. (2018), we provide a detailed discussion of the potential forces behind the different NIPA and LFS estimates using the 2016 OECD release. LFS and NIPA data differ conceptually along two dimensions. First, LFS data cover only civilian, non-institutionalized residents aged 15 and older, while the NIPA does not impose these restrictions, to ensure that the labor inputs are consistent with the measurement of gross domestic output. Second, the
NIPA estimates are usually constructed in country-specific ways from multiple data sources (administrative data, social security data, employer surveys, labor force surveys, census data, etc.). We show suggestive evidence that the differences in population coverage are not very important. For the United States, Abraham et al. (2013) investigate which features of the underlying data sources drive the differences between NIPA and LFS employment estimates, and Eldridge et al. (2004) and Frazis and Stewart (2010) do the same for hours worked per employed. While the details are specific to the United States, these articles highlight advantages and disadvantages of household survey data used in the LFS estimates vs. administrative data used in the NIPA estimates. The combination of multiple data sources might deliver more accurate estimates of employment and hours worked for a given country. The downside is that cross-country comparability suffers, despite the efforts to harmonize measurement through the System of National Accounts (see Fleck, 2009). In fact, the OECD remarks on its website that “The [hours worked] data are intended for comparisons of trends over time; they are unsuitable for comparisons of the level of average annual hours of work for a given year, because of differences in their sources” and recommends using employment rates based on national LFS for cross-country comparisons: “National Labour Force Surveys are the best way to capture unemployment and employment according to the ILO guidelines that define the criteria for a person to be considered as unemployed or employed...While data from LFS make international comparisons easier compared to a mixture of survey and registration data, there are some differences across countries in coverage, survey timing, etc., that may affect international comparisons of labour market outcomes.”

The approach in Bick et al. (2018) deals with one of the main differences in the cross-country comparability of the LFS, namely the survey timing. If one is interested in hours worked for different demographic subgroups, the LFS is the only option. For aggregate applications only, researchers should be aware of the differences between the LFS and NIPA data on the one hand and the potential for major revisions of the latter over time on the other.

**5 CONCLUSION**

In this article, we compare the effect of different formulas used in the macro literature for calculating hours worked per person and the effect of different data releases on the hours estimates. In doing so, we focus on the data provided by Ohanian et al. (2008). We show that the TED revisions of hours worked per employed have a large impact on the conclusions drawn. Put differently, if Rogerson (2006) would have had the 2016 data release, he would have found a close to 40 percent lower Europe-U.S. hours gap (−11.0 percent) than what he found with the data available in the mid-2000s (−17.6 percent). Using labor force survey data, which are less subject to data revisions, we find a Europe-U.S. hours gap of −19 percent.

Since McDaniel (2011) uses the 2007 TED data release, the facts in her article are affected by revisions in a similar way as those in Rogerson (2006) and Ohanian et al. (2008). Ragan (2013), in turn, uses the OECD average hours worked per employed and is thus not affected by any TED data revisions. However, the OECD average hours worked per employed also underwent revisions. For the (smaller) set of European countries in Ragan’s data, the average
absolute difference in hours worked per employed between the release she used and the 2016 release of the same data is 3.8 percent (see Table A.2 in the online Appendix, https://alexbick.weebly.com/uploads/1/0/1/3/101306056/bbf_note_onlineappendix.pdf). This is a smaller difference than that between the TED releases, but it is still substantial. Moreover, the OECD revisions are not due to a change in guidelines in the System of National Accounts (SNA 93 vs. SNA 2008). The OECD provides NIPA employment and NIPA hours under both guidelines on its website. For the 2016 release, the differences are small for most countries, with the exception of the Netherlands, Portugal, and Spain (see Table A.3 in the online Appendix). Finally, like Ragan (2013), Prescott (2004) uses hours worked per employed directly from the OECD. Using the same set of countries (the United States, France, Italy, Germany, and the United Kingdom) and time period (1993-96) as Prescott does, we qualitatively reconfirm our findings from the comparison with Rogerson (2006) and Ohanian et al. (2008) for 2003; for a detailed discussion, see the online Appendix. Relying on the OECD and TED 2016 data releases yields a smaller Europe-U.S. hours gap than when using data from the same sources available to researchers in the early 2000s.

Finally, as we show in online Appendix B, the data revisions also affect the measurement of time trends in hours worked per person. While the secular decrease in European hours worked per person between 1956 and 2003 is present in both the Ohanian et al. (2008) data and the 2016 release of the same data, the decline in the sample of European countries is 27 percent (6.1 percentage points) smaller in the 2016 release. In turn, hours worked per person in the United States increased by 3.6 percent using the 2016 data release and by only 0.4 percent using the Ohanian et al. (2008) data.

NOTES

1 Ragan (2013) is an exception. While the underlying data she used were subject to non-negligible revisions on the country level, the average Europe-U.S. hours gap is nearly left unchanged.

2 Hours worked per employed and weeks worked in the OECD Economic Outlook 2004, which is used by Alesina et al. (2005) and Faggio and Nickell (2007), are constructed in a similar way as those in Bick et al. (2018). Both approaches are based on national LFS and use external data sources for annual leave and public holidays to estimate weeks worked per year. The key difference lies in the treatment of weekly hours lost (relative to usual hours worked) for reasons other than annual leave and public holidays. In our approach, these reduce weekly hours worked per employed but do not affect weeks worked per year, whereas in the OECD Economic Outlook 2004 it is the other way around.

3 To ensure the comparability across countries and over time, we need to make an adjustment using external data sources for public holidays and annual leave, to overcome differences in the sets of weeks sampled across countries and over time. For details, we refer the reader to Bick et al. (2018).

4 The first draft of this article was written in August 2016. Since then, both the OECD and TED have updated their data. There were no major revisions in those releases relative to the data available in August 2016.

5 Using the data from Ohanian et al. (2008) for 2003 yields the same results as presented in Table 1 in Rogerson (2006).

6 We drop Finland from the Ohanian et al. (2008) sample and the Czech Republic, Hungary, and Poland from the Bick et al. (2018) sample.

7 We use the ALFS employment rate rather than the LFSsa employment rate because the former shows a smaller mean absolute difference with the employment rate used by Ohanian et al. (2008).
Both quotes we retrieved from the OECD’s website on August 29, 2018:

Other reasons impeding the comparability across time and countries of the LFS, which we cannot adjust for, are the revision of population figures used for population adjustment on the basis of new population censuses, as well as changes in the sampling design, and content or order of the questionnaire. For details, see http://ec.europa.eu/eurostat/statistics-explained/index.php/EU_labour_force_survey (retrieved on March 10, 2017).

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Pork-Barrel Politics and Polarization

Aaron Hedlund

This article explores how earmarks shape the ideological composition of elected officials in Congress. Relative to the classic median voter theorem, the framework developed here introduces multiple legislative districts and incorporates a desire for local earmarks in the specification of voter preferences. The main theoretical result demonstrates that competition among politicians to “bring home the bacon” substantially reduces Congressional polarization. Data from after the earmark ban of 2011 provide supporting evidence for this mechanism. (JEL D72, E62, D78, H41)

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1 INTRODUCTION

Casual observation and an abundance of research reveal a trend of growing political polarization in the United States over the past few decades.¹ To some observers, polarization impedes effective governance and poses a risk to economic performance. In support of this view, Mian, Sufi, and Trebbi (2014) provide evidence from a large sample of countries showing that, following a financial crisis, heightened ideological polarization weakens ruling coalitions and creates legislative gridlock that hampers reform efforts. In addition, Baker et al. (2014) attribute a rise in U.S. policy uncertainty to political polarization and Azzimonti (2018) links higher partisan conflict to depressed investment. By showing that causality also runs in the opposite direction, Algan et al. (2018) raise the specter of a feedback loop between poor economic performance and polarization that gets worse over time. Searching for potential causes, voices from across the political spectrum—including President Trump himself—have attributed some of the partisan rancor to the 2011 federal earmark ban that remains in place.² After all, the number of bills passed into law immediately following the moratorium dropped to its lowest level in 20 years.³

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Ironically, there are also polarized views on the consequences and desirability of polarization itself. While some lament a decline in legislative accomplishments, others praise the reduction in political horse trading and spending on “pet projects,” such as the controversial $400 million “Bridge to Nowhere” in Alaska that lawmakers eventually scuttled after the ensuing public uproar. For better or worse, the earmark ban has undoubtedly removed one of the major sources of leverage Congressional leadership can use to enforce party discipline—as described in Grossman and Helpman (2005)—thus paving the way for ideology to play a greater role in the political process.

Putting aside any normative concerns, this article analyzes the link between pork-barrel spending (equivalently, earmarks)—defined as appropriations secured for the express purpose of bringing money to a legislator’s local district—and Congressional polarization. Theoretically, I consider an environment with multiple districts where voters have a preference both for ideological compatibility with their elected legislator and for greater earmark spending in their district. Once elected, legislators who are closer to the ideological mean of Congress receive a greater share of pork-barrel funding, regardless of the overall distribution of voter ideologies. The median voter in each district—who is effectively in the position of kingmaker—balances ideology with the ability to “bring home the bacon” when selecting his or her preferred political candidate, taking as given what happens elsewhere. I characterize the equilibrium and show that earmarks significantly compress the ideological distribution of Congress relative to that of the population. Empirically, evidence from after the 2011 earmark ban supports these theoretical findings.

Figure 1

Evidence of Rising Voter Polarization Over the Past Two Decades

![Graph](image)

NOTE: Ideological consistency based on a scale of 10 political values questions (see Appendix A in the source). The blue area in this chart represents the ideological distribution of Democrats and the red area of Republicans. The overlap of these two distributions is shaded purple. Republicans include Republican-leaning independents: Democrats include Democratic-leaning independents (see Appendix B in the source).

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2 EMPIRICAL TRENDS

A recent Pew Research study by Dimock et al. (2014) documents the increasing polarization of the American electorate. As seen in Figure 1, the amount of overlap between Democratic and Republican voters has fallen dramatically since the mid-1990s. Back in 1994, 36 percent of Republicans were to the political left of the median Democrat, and 30 percent of Democrats were to the right of the median Republican. In 2004, those measures of ideological overlap fell to 8 percent and 6 percent, respectively. Furthermore, the data show that polarization has accelerated over the past decade.

This heightened polarization has also crossed over into legislatures. Figure 2 shows the time series for DW-NOMINATE, which is a commonly used index of polarization developed by Poole and Rosenthal (1984) based on Congressional voting records. At the federal level, the left panel shows that ideological polarization has increased in both the U.S. House and Senate, with a notable acceleration over the past 15 years. Based on the work of Azzimonti (2018), the Federal Reserve Bank of Philadelphia maintains a measure of U.S. political disagreement called the Partisan Conflict Index, which exhibits a notable rise starting in the late 2000s (middle panel). State legislatures have not been immune to these political winds either. Using data from the Vote Smart Political Courage Test (formerly the Project Vote Smart National Political Awareness Test), Shor and McCarty (2011) develop a state-level index of polarization. The right panel of Figure 2 plots the histogram of changes in this index across the states between 1993 and 2014; in the overwhelming majority of states, polarization has increased. Using a different methodology, Andris et al. (2015) show that partisan division has increased in the U.S. Congress while cross-party collaboration has fallen. Figure 3 gives a visual representation of these striking trends.
As polarization has gone up, measures of federal legislative productivity have fallen, whether for better or worse. As documented in the left panel of Figure 4, the number of bills passed by the U.S. Senate has exhibited a downward trend since the 1970s, and McCarty (2016) shows that legislative delays for appropriations bills have risen substantially. McCarty (2016) also runs counterfactuals and predicts that, had polarization remained constant, the passage of Mayhew laws—a measure of landmark legislation—would have been considerably higher over the past 20 years. In each of these cases, the decline in legislative productivity appears to have accelerated in the late 2000s.

In fact, from the mid-1990s to the mid-2000s, legislative productivity actually temporarily stabilized. According to data from the organization Citizens Against Government Waste (CAGW) shown in Figure 4, spending on earmark projects escalated dramatically during
this interlude. However, in response to voter backlash, Congress eventually instituted a one-year moratorium on earmarks in 2007 followed by a ban in 2011 that remains in effect today.

The next section formalizes a model where competition over pet-project funding moderates the ideological distribution of elected officials relative to the voter population. However, if voter preferences change over time in a way that places more weight on ideology over elected officials’ ability to “bring home the bacon,” earmarks lose their salience and legislative polarization rises. In this sense, the outcry over earmarks and subsequent ban is a natural consequence of more ideological voting.

3 THE MODEL

Consider an environment with $n$ legislative districts, $\{1, 2, \ldots, n\}$, where the median voter in district $i$ has ideology $\mu_i \in [0,1]$ in a one-dimensional issue space. As in the classic median voter theorem, voters care about how closely the ideology of their elected official, $x_i$, aligns with their own views. However, voters also value earmarks spent in their district, $t_i$. I assume that $t_i$ is the net transfer to district $i$, which implies that $t_i$ may be either positive or negative. Voter preferences over ideology and pork-barrel funds are given by

$$ U(x_i, t_i; \mu) = \beta t_i - (1 - \beta)(x_i - \mu_i)^2, $$

where $\beta \in [0,1]$ is the relative weight placed on earmarks.

3.1 Competition for Earmarks

After an election, earmarks are awarded disproportionately to elected officials who are closest to the unweighted ideological mean of the legislature, $\bar{x}$, regardless of the allocation.
of voters to legislative districts. For example, in the U.S. federal government, the population of each state impacts its representation in the House but not in the Senate. In addition, I impose two other restrictions on earmarks. First, because earmarks are the net fiscal transfer to each district, they must sum to zero; that is, \( \sum t_i \left( \{x_j \}_{j=1}^n \right) = 0 \). Second, I assume that identical districts are treated identically; that is, \( t_i (x_i, x_j; \bar{x}) = t_j (x_j, x_i; \bar{x}) \) whenever \( x_i = x_j \), where \( x_j \equiv \{x_k \}_{k \neq i} \). To be concrete, I assume the following function:

\[
(2) \quad t_i (x; \bar{x}) = \frac{1}{n-1} \sum_{j \neq i} (x_j - \bar{x})^2 - (x_i - \bar{x})^2,
\]

where the coefficient \( \frac{1}{n-1} \) ensures that net transfers sum to zero. Intuitively, this formula states that legislators who deviate substantially from the average position of their colleagues receive fewer pork-barrel funds, perhaps because they have less influence or do not “go along to get along.” To reiterate, this arrangement stands in contrast to one in which legislators are punished for straying from the mainstream of voters. Here, a conservative (liberal) Congress would not punish members simply for sitting ideologically to the right (left) of the population at large.

### 3.2 Election Outcomes

Given \( k_i \) candidates, the median voter in district \( i \) chooses his or her preferred candidate—who ends up being the winner—by solving

\[
(3) \quad \max_{x_i \in [x_i^1, x_i^2, \ldots, x_i^k]} U(x_i, t_i(x_i, x_{-i}; \bar{x}); \mu_i).
\]

In words, the median voter chooses the candidate that offers the best combination of ideological compatibility and ability to attract earmarks, as determined by the transfer function \( t_i \). Note that, in general, the presence of a finite number of candidates makes this problem discrete and not amenable to solving with first-order conditions. However, if candidates are first able to choose their position and care only about winning, then in a subgame perfect equilibrium, the winner stakes his or her ideological claim exactly where the median voter’s first-order condition is satisfied.

### 4 RESULTS

This section solves for the electoral equilibrium and analyzes how earmarks affect the ideological composition of Congress. For generic \( U_i (x_i, t; \mu_i) \) and \( t_i (x; \bar{x}) \), the first-order condition of the median voter is

\[
0 = \frac{\partial U}{\partial x_i} + \frac{\partial U}{\partial t_i} \left( \frac{\partial t_i}{\partial x_i} + \frac{1}{n} \frac{\partial t_i}{\partial \bar{x}} \right).
\]
The first term represents the direct marginal contribution of \( x_i \) to utility, and the second term reflects the indirect effect of \( x_i \) on utility as transfers respond to the shifting gap between \( x_i \) and the legislator mean \( \bar{x} \), which itself changes by a factor of \( 1/n \) to any movements in \( x_i \).

For specific functions (1) and (2), the terms in (4) become

\[
\frac{\partial U}{\partial x_i} = -2(1-\beta)(x_i - \mu_i)
\]

\[
\frac{\partial U}{\partial t_i} = \beta
\]

\[
\frac{\partial t_i}{\partial x_i} = -2(x_i - \bar{x})
\]

\[
\frac{\partial t_i}{\partial \bar{x}} = \frac{-2\sum_{j\neq i} x_j}{n-1} + 2x_i.
\]

Substituting these terms into (4) gives the final first-order condition,

\[
0 = -2(1-\beta)(x_i - \mu_i) + \beta \left\{ -2(x_i - \bar{x}) + \frac{1}{n} \left[ \frac{-2\sum_{j\neq i} x_j}{n-1} + 2x_i \right] \right\}.
\]

A bit of algebra gives the ideological position of the winner in district \( i \):

\[
x_i = \left( \frac{1-\beta}{1-\beta + \beta \left( \frac{n-2}{n} \right)} \right) \mu_i + \left( \frac{\beta \left( \frac{n-2}{n} \right)}{1-\beta + \beta \left( \frac{n-2}{n} \right)} \right) \bar{x},
\]

where \( \bar{x}_{-i} \) is the ideological average of the elected officials outside district \( i \).

Note that \( x_i = \mu_i \) if voters care only about ideology (i.e., \( \beta = 0 \)), as one would expect.

Similarly, if voters only value earmarks, then \( x_i = \bar{x}_{-i} \). Therefore, pork-barrel spending causes the elected official from district \( i \) to have an ideology in between that of the median voter in district \( i \) and the average of the other legislators. Before discussing the Nash equilibrium in Section 4.2, the analysis can be simplified by examining the limiting case with infinitely many legislative districts.

### 4.1 Limit Analysis

As \( n \to \infty \), the median voter’s choice of winning candidate simplifies to

\[
x_i = (1-\beta)\mu_i + \beta \bar{x},
\]

where \( \bar{x}_{-i} = \bar{x} \) in the limit.

From this equation, the legislator mean \( \bar{x} \) must satisfy

\[
\bar{x} = (1-\beta)\bar{\mu} + \beta \bar{x},
\]
which readily implies that $\bar{x} = \bar{\mu}$. Therefore, legislator ideology in district $i$ is

$$(7) \quad x_i = (1 - \beta)\mu_i + \beta\bar{\mu}.$$ 

In words, the ideology of district $i$’s elected official is a weighted average of the median voter in district $i$ and the average of median voters across all of the districts. Thus, while pork-barrel spending has no impact on average legislator ideology, Theorem 1 shows that it reduces ideological variance relative to the population.

**Theorem 1. (Earmarks Reduce Partisanship)** A preference for pork-barrel spending—that is, $\beta > 0$—reduces ideological variance in Congress:

$$(8) \quad \frac{\text{var}(x)}{\text{var}(\mu)} = (1 - \beta)^2 < 1.$$ 

**Proof.** The result follows directly from equation (7). $\blacksquare$

Intuitively, the stronger a preference voters have for earmarks, the more they have to ensure that their elected representative is aligned with the ideology of all the other representatives. With this motive acting symmetrically in every district, the result is a mean-preserving compression of the ideological distribution in the legislature.

**4.2 The Finite Case**

With a finite number of legislative districts, the election outcome is determined by the static Nash equilibrium of the game where each of the $n$ median voters selects his or her preferred candidate according to equation (4), taking as given what occurs in all other districts. Mathematically, the vector of legislator ideologies $\mathbf{x}$ solves the following system of equations:

$$(9) \quad \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} = (1 - \alpha(n)) \begin{bmatrix} \mu_1 \\ \mu_2 \\ \vdots \\ \mu_n \end{bmatrix} + \alpha(n) \begin{bmatrix} \frac{1}{n-1} \sum_{j=1}^{n} x_j \\ \frac{1}{n-1} \sum_{j=2}^{n} x_j \\ \vdots \\ \frac{1}{n-1} \sum_{j=n}^{n} x_j \end{bmatrix},$$

where $1 - \alpha(n)$ is the coefficient on $\mu_i$ in equation (5). Theorem 2 explicitly solves for the equilibrium given arbitrary $n$.

**Theorem 2. (Electoral Equilibrium)** The equilibrium vector of legislator ideologies is given by

$$(10) \quad \mathbf{x} = (1 - \theta)\mu + \frac{\theta}{n-1}(\mathbf{P} - 1)\mu,$$
where $\theta = \frac{(n-1)\alpha(n)}{n-1+\alpha(n)} = \frac{\beta(n-2)(n-1)}{n(n-1-\beta)}$, $P$ is an $n \times n$ matrix of ones, and $I$ is the $n \times n$ identity matrix.

**Proof.** The expression (9) can be written in matrix form as

$$x = (1-\alpha(n))\mu + \left(\frac{\alpha(n)}{n-1}\right)(P-I)x.$$  

Collecting all the $x$ terms gives

$$\begin{bmatrix} -\alpha(n) \\ -\frac{\alpha(n)}{n-1} \end{bmatrix} P + \left(1+\frac{\alpha(n)}{n-1}\right) I x = (1-\alpha(n))\mu,$$

which after some algebra is equivalent to

$$\begin{bmatrix} bP+(a-b)I \end{bmatrix} x = (n-1)(1-\alpha(n))\mu,$$

where $b = -\alpha(n)$ and $a = n-1$.

Inverting the matrix on the left gives the equilibrium legislator ideologies,

$$x = \left[bP+(a-b)I\right]^{-1}(n-1)(1-\alpha(n))\mu,$$

where it can be shown that

$$\left[bP+(a-b)I\right]^{-1} = \frac{-b}{(a-b)(nb+a-b)} P + \frac{1}{a-b} I.$$

Substituting this expression into the previous equation gives

$$x = \left[\frac{\alpha(n)}{n-1+\alpha(n)} P + \frac{(n-1)(1-\alpha(n))}{n-1+\alpha(n)} I\right] \mu.$$

Lastly, defining $\theta = \frac{(n-1)\alpha(n)}{n-1+\alpha(n)}$ and doing some algebra completes the proof. □

The scalar representation of equation (10) makes it clear that the ideology of each legislator is the convex combination of the ideology of the median voter in his or her district and the average of the ideologies of the median voters everywhere else:

$$x_i = (1-\theta)\mu_i + \theta\mu.$$

### 4.3 A Numerical Example

To provide further intuition, I simulate some numerical examples with $n = 435$ legislative districts, just as in the U.S. House of Representatives. Figure 5 shows different scenarios for the equilibrium ideological distribution of Congress compared with that of voters. In the top
row, I randomly draw voter ideologies from a truncated normal distribution and compute the electoral equilibrium. In the top-left panel, I consider the case where voters place a relatively low weight on earmarks, $\beta = 0.33$. Even in this scenario, the presence of earmarks compresses the ideological distribution of Congress. In the top-right panel, I increase the weight to $\beta = 0.67$, which markedly squeezes the Congressional ideological distribution still further. In the bottom panels, I repeat the exercise for a bimodal voter distribution and similar lessons emerge.

5 CONCLUSIONS

By creating competition for local funds between legislators in different districts, the process for earmarking partially replaces the role of ideology in policymaking with a “bring home
the bacon” motive, thereby reducing polarization in Congress, whether for better or worse. However, there are several issues I abstract from in this analysis—particularly regarding the details of political institutions—that preclude making any immediate policy recommendations. For example, the presence of two dominant parties possessing well-established institutional power may produce different outcomes than would a parliamentary system in which numerous small parties continuously jockey for control. I leave this issue and others for future work.

NOTES
1 For example, see Boxell, Gentzkow, and Shapiro (2017); Gentzkow, Shapiro, and Taddy (2017); Autor et al. (2017); and Martin and Yurukoglu (2017).

2 President Trump has stated the following (DeBonis, 2018): “And I hear so much about earmarks, the old earmark system, how there was a great friendliness when you had earmarks...In the old days of earmarks...they went out to dinner at night, and they all got along, and they passed bills. That was an earmark system. And maybe we should think about it.”

3 A deeper analysis is required to determine whether this correlation represents causation.

4 For more information on the “Bridge to Nowhere” debate, see https://www.washingtontimes.com/news/2015/nov/8/alaska-kills-bridge-to-nowhere-that-helped-put-end/.


6 CAGW deems a piece of legislation pork-barrel spending if it meets at least two of the following seven criteria: (i) requested by only one chamber of Congress; (ii) not specifically authorized; (iii) not competitively awarded; (iv) not requested by the president; (v) greatly exceeds the president’s budget request or the previous year’s funding; (vi) not the subject of Congressional hearings; and (vii) serves only a local or special interest.

7 This assumption is consistent with a wide body of theoretical and empirical work summarized in Alexander, Berry, and Howell (2016).

8 An equivalent formulation of the earmark function is \( t_i(x; \tau) = \text{var}(x) - \frac{N}{n-1} (x_i - \bar{x})^2 \). None of the results change if transfers sum to a constant other than zero. It is also possible that earmarks could create positive aggregate spill-overs, for example, by financing productive investment, but it is unclear to what extent voters internalize them when voting and, thus, how much the results might change.

REFERENCES


