Volume Title: The Great Inflation: The Rebirth of Modern Central Banking

Volume Author/Editor: Michael D. Bordo and Athanasios Orphanides, editors

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-006695-9, 978-0-226-06695-0 (cloth)

Volume URL: http://www.nber.org/books/bord08-1

Conference Date: September 25-27, 2008

Publication Date: June 2013

Chapter Title: The Great Inflation Drift

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Chapter URL: http://www.nber.org/chapters/c9168

Chapter pages in book: (p. 181 - 209)

3

The Great Inflation Drift

Marvin Goodfriend and Robert G. King

3.1 Introduction

Between 1952 and 1965, the annual average US inflation rate ranged between 0 and 4 percent. Over the next fifteen years, it rose systematically and substantially, twice peaking above 10 percent in 1975 and 1980.

What economic forces led to this increase? Any explanation of inflation dynamics must involve an understanding of how a central bank interacts with the private economy and the real shocks that hit it. We use two basic ideas about Federal Reserve behavior—that the US central bank, like others around the world, was concerned with smoothing the path of short-term nominal interest rates and with maintaining a relatively small output gap—

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The chapter was prepared for the Great Inflation conference sponsored by the National Bureau of Economic Research in Woodstock, Vermont, September 25–27, 2008. The chapter benefitted from preliminary presentations at the June 2007 Kiel Symposium on the Phillips Curve and the Natural Rate of Unemployment, the June 2008 North American Econometric Society Summer Meetings, and a July 2008 seminar at the Federal Reserve Bank of New York. The ideas were developed initially in a paper prepared for the November 2004 Carnegie Rochester Policy Conference. This chapter also benefitted from presentations at Cornell University, the Federal Reserve Bank of Kansas City, the Institute for International Economic Studies at Stockholm University, and the Swedish Riksbank. We thank Susanto Basu for providing us with a time series on aggregate technical change; Torsten Persson, Mathias Trabandt, and Michael Woodford for valuable discussions on related matters; Michael Siemer for research assistance; and Lars Svensson for discussing our paper at the conference. Goodfriend thanks the Gailliot Center for Public Policy at the Tepper School of Business for financial support. For acknowledgments, sources of research support, and disclosure of the authors' material financial relationships, if any, please see http://www.nber.org/chapters/c9168.ack.

to explain why a time-varying inflation trend would have become part of the US inflation process during this period and, more specifically, why there would have been a rise in trend inflation.

In adopting this approach, we focus on implications of these two basic ideas about central bank behavior and abstain from incorporating other forces that arguably may be very important for the Great Inflation in the United States and other countries. We combine these central banking assumptions with three postulates about the interaction of the central bank and the macroeconomy. First, we assume that there is a Phillips curve that is vertical in the long run and that the central bank understands this structural feature of the economy as well as the level of capacity output at each point in time. Our analysis utilizes a simple New Keynesian form of the Phillips curve modified to allow for a time-varying inflation trend. Second, we assume that private agents understand the nature of the central bank's decision rules and the consequences that they have for the inflation process. Third, we assume that the central bank adopts fully credible policy rules. Other accounts of the rise of inflation in the United States highlight departures from these assumptions and, indeed, our prior investigation of the Volcker disinflation stressed the role of imperfect credibility and private sector learning during that episode.[1]

In constructing our model and interpreting history, we thus view the US central bank as typically giving prominence to two objectives, stabilization of economic activity and avoidance of large period-to-period changes in short-term interest rates. We portray the Federal Reserve as maintaining these objectives in the face of real developments that affected the level of output and the level of the real interest rate, thus making inflation variable. We show that a very simple modern macroeconomic model, which we take as embodying key elements in many contemporary models, makes the prediction that inflation contains a "stochastic trend component" in the language of modern time series econometrics. Thus, the upward drift in US inflation from 1966 through 1979 arises as a consequence of a series of adverse real shocks hitting the macroeconomy and the central bank allowing inflation to randomly walk upward. This viewpoint explains, in one sense, how there could come to be no "nominal anchor" for US monetary policy by August 1979 when Paul Volcker became chairman of the Federal Reserve Board.

Since our model has a very simple form for trend inflation and since this form is one that has been long used to forecast inflation (Nelson and Schwert 1977) and has recently been found to be quite successful vis-à-vis competitors (Stock and Watson 2007), we are able to produce a detailed link between our theory and empirical work on inflation.

We also see the inflation process as at times more complicated than our simple trend model, during intervals in which there is inflation-fighting by

1. Goodfriend and King (2005).

the central bank, and we discuss these in detail later. The idea that there are episodic components of inflation that are not described by the stochastic trend model, during which there are forecastable linkages between inflation and real activity, also accords with further recent empirical work by Stock and Watson (2008). We see the Great Inflation as a low frequency variation, overlain by these business cycle components, although we do not provide a theory that fully integrates the trend and cycle. That said, our theory does link the inflation trend to underlying real developments in the macroeconomy, as we discuss further below. We illustrate these linkages by considering how the inflation trend responds to changes in productivity growth as measured by Basu, Fernald, and Kimball (2006). More generally, our theory emphasizes the link between innovations in the inflation trend and innovations to the natural rate of interest, which opens the door for fluctuations in saving and investment to drive the inflation trend within a richer dynamic model.

The organization of the chapter is as follows. In section 3.2, we describe the components of the model. In section 3.3, we discuss monetary policy and motivate the inclination of central banks to pursue what we call "business as usual"—the stabilization of output at capacity and a continuity of the short-term nominal interest rate. In section 3.4, we derive equilibrium outcomes and show how "business as usual" gives rise to a stochastic inflation trend. In section 3.5, we discuss how alternative central bank operating rules could bring about "business as usual" outcomes. In section 3.6, we list the empirical implications of our hypothesis, and then turn in section 3.7 to a detailed evaluation of the Great Inflation from the perspective of our model. Among other things, we describe episodes during the Great Inflation that appear to require an integrated model of the business cycle and inflation trends. A final section provides a brief conclusion.

3.2 Model Components

We work with a simple linear model that incorporates five components from modern macroeconomics: New Keynesian pricing, a real business cycle core, a Fisher equation, an Euler equation, and the term structure of interest rates.

3.2.1 New Keynesian Pricing

New Keynesian macroeconomics has developed a battery of models to explain price setting by forward-looking firms. The simplest of these models, embedding price adjustment opportunities along the lines of Calvo (1983), leads to a "new Keynesian pricing" equation that links inflation (π_t) and real output (y_t),

$$\pi_t = \beta E_t \pi_{t+1} + h(y_t - y_t^*). \tag{1}$$

In this expression, y_t^* is a measure of capacity output, so that $y_t - y_t^*$ is a measure of the output gap, and $E_t\pi_{t+1}$ is the expected inflation rate. The parameter h can be related to structural features such as the frequency of price adjustment, the elasticity of marginal cost with respect to output, and so forth.

As has been much stressed in the recent literature,[2] the New Keynesian approach indicates that the relevant measure of capacity output is the level of output that would prevail if nominal prices were flexible. That is, it is a level of output that can be modeled along the lines of real business cycle analysis and that therefore is expected to fluctuate through time in response to a range of macroeconomic shocks, including productivity, government expenditures, tax rates, and energy prices.

We use a version of this model due to Woodford (2008) that allows for time-varying trend inflation, so that the inflation dynamics are written as

$$\pi_t = \bar{\pi}_t + \beta E_t[\pi_{t+1} - \bar{\pi}_{t+1}] + h(y_t - y_t^*), \tag{2}$$

where $\bar{\pi}_t$ is a time-varying trend rate of inflation, which satisfies

$$\bar{\pi}_t = \lim_{k\to\infty} E_t\pi_{t+k}. \tag{3}$$

That is, $\bar{\pi}_t$ is the stochastic trend rate of inflation in the sense of Beveridge and Nelson (1981).

This specification of New Keynesian pricing exhibits a short-run Phillips curve relationship, so that a monetary stimulus raises both inflation and real variables such as output and employment, if there are no changes in expected inflation.[3] But, at the same time, there is no long-run Phillips curve relationship, so that a permanent increase in money growth and in inflation has no quantitatively significant effect on employment or output.

3.2.2 The Real Business Cycle Core

The model has a "real business cycle core," in which macroeconomic activity would respond to a variety of real shocks in the absence of nominal frictions. Such a component is critical, we believe, on both the short-run and long-run fronts. Quarter-to-quarter, there are many changes in current and prospective real conditions that are important for output and the real interest rate. In the longer term, the evolution of economic activity is dominated by growth in productivity.

To model the RBC core of the economy, we assume that "capacity output growth" evolves according to

2. See Goodfriend and King (1997), Goodfriend (2002), and Woodford (2003).

3. As originally presented in our November 2004 Carnegie Rochester paper, the results relating trend inflation variability to interest-rate smoothing and output stabilization (which are derived in section 3.4) also hold for two alternative specifications: a Phillips curve derived from Calvo (1983) with $\beta = 1$ and a Phillips curve with structural inflation persistence in the style of Fuhrer and Moore (1995) that involves no long-run trade-off between inflation and output. See the appendix.

$$\Delta y_t^* = \rho \Delta y_{t-1}^* + \nu_t, \tag{4}$$

which is a simple difference stationary stochastic process of the form estimated by Nelson and Plosser (1982), which allows for shocks to the level of economic activity and also to the expected growth rate.[4] (We use the notation Δ to denote such differences throughout the chapter: $\Delta x_t = x_t - x_{t-1}$ for any variable x.) This simple specification cannot adequately capture the changes in trend productivity growth that we believe to have occurred over the postwar period, but it has the desirable property that it does let us approximate the comovement of output and the real interest rate in response to permanent shocks to the level of productivity within a more fully articulated model.

3.2.3 The Fisher Equation

There is a Fisherian relationship in the model that links the nominal interest rate (R_t) to the real interest rate (r_t) and expected inflation ($E_t\pi_{t+1}$). Such a specification is critical to understanding the evolution of the nominal interest rate in the United States and other countries. The Fisher equation is

$$R_t = r_t + E_t\pi_{t+1}. \tag{5}$$

In our study, this linkage will play a key role.

3.2.4 The Euler Equation

There is a transmission mechanism between real interest rates and real economic activity that includes additional expectational elements, because optimizing theories of consumption and investment suggest the importance of this feature and because both consumption and investment appear to be substantially influenced by expectations in the US economy. Expectations are important determinants of aggregate demand and output in a model with Keynesian features, such as ours. According to modern consumption theory, the expected growth rate of consumption should be related to the real interest rate, which we write as

$$r_t = \sigma(E_t y_{t+1} - y_t) + r, \tag{6}$$

where $r > 0$ represents positive time preference. The "natural rate of interest" is defined as

$$r_t^* = \sigma(E_t y_{t+1}^* - y_t^*) + r. \tag{7}$$

The capacity output process implies that the "natural rate of interest" evolves as

$$r_t^* = \sigma\rho\Delta y_t^* + r, \tag{8}$$

4. Our model does not distinguish between consumption and investment, a key aspect of RBC models.

so that we have built in a positive comovement of the real interest rate and output growth present in studies of real business cycle (RBC) models with stochastic productivity trends.

3.2.5 The Term Structure of Interest Rates

The model contains the expectations theory of the term structure. While it has been criticized as an incomplete description of long-term yields, we think that the expectations theory nevertheless contains the essential features of bond-pricing for our purposes. In our model, we include specifications of the real and nominal returns on a long-term discount bond; that is, one with L periods to maturity. The first specification governs the real term structure,

$$r_{Lt} = \frac{1}{L}\sum_{j=0}^{L-1} E_t r_{t+j} + (r_L - r) = \sigma \frac{1}{L}(E_t y_{t+L} - y_t) + r_L, \tag{9}$$

and the second specification governs the nominal term structure,

$$R_{Lt} = \frac{1}{L}\sum_{j=0}^{L-1} E_t R_{t+j} = r_{Lt} + \frac{1}{L}\sum_{j=1}^{L} E_t \pi_{t+j}. \tag{10}$$

It is important to stress that longer-term yields reflect permanent variations, as these are dominant in such an expected future average. Accordingly, we will frequently employ the idea that variations in long-term nominal yields are dominated by "expected inflation trends."

3.3 Monetary Policy

We must specify the objectives of monetary policy in order to close the model. In this regard, Section 2A of the Federal Reserve Act says that "The Board of Governors of the Federal Reserve System and the Federal Open Market Committee shall maintain long run growth of the monetary and credit aggregates commensurate with the economy's long run potential to increase production, so as to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates." In terms of our model, we translate the abovementioned goals into an "output gap stabilization objective" $y_t = y_t^*$, and "a low inflation objective" $\pi_t = \pi \approx 0$, noting that the low inflation objective takes care of the low long-term interest rate objective.

Interestingly enough, the title of the original Federal Reserve Act of 1913 emphasized a different set of objectives: "to furnish an elastic currency, to afford a means of rediscounting commercial paper, and to establish a more effective supervision of banking in the United States." At the time, the United States was on the gold standard, which itself maintained price stability, and the Federal Reserve was set up to provide financial stability. This it did, by improving banking supervision and by smoothing short-term interest rates. The period between the Civil War and the founding of the Federal Reserve was marked by a number of recessions associated with sudden, sharp, and sustained spikes in short-term interest rates. Interest rate spikes of over 10 percentage points occurred on eight occasions, four of which were associated with major banking panics in 1873, 1884, 1893, and 1907. By providing currency and bank reserves through its discount window or by buying securities in the open market, the Fed introduced a degree of continuity into short-term nominal interest rates and eliminated the kind of interest rate spikes seen earlier. Between 1890 and 1910, the three-month nominal rate was quickly mean-reverting and highly seasonal. By contrast, between 1920 and 1933, the three-month nominal rate was close to a random walk.[5]

"Continuity of the short rate" quickly became and has remained a routine feature of monetary policy. Short rate continuity is today reflected in the Fed's use of an interest rate policy instrument rather than a bank reserves policy instrument, and in the fact that the Fed likes to prepare markets for federal funds rate target changes. Interest rate continuity is reinforced by the fact that maintaining a given policy stance often means keeping the federal funds rate target fixed for months at a time.[6] Interest rate continuity is not mentioned explicity, or even implicitly anymore, as an objective of the Federal Reserve partly because it is so widely accepted, and partly because until 1994 the Federal Reserve deliberately obscured its management of short-term interest rates to deflect public criticism for high interest rates produced periodically to control inflation.[7] Nevertheless, the Federal Reserve maintains a degree of short rate continuity as a matter of routine practice. The "interest rate continuity objective" in our model is an attenuation by the central bank of one-period-ahead forecast errors in the short-term nominal interest rate, $R_t - E_{t-1}R_t$.

To sum up, we think of the central bank as having three fundamental objectives: output gap stabilization, interest rate continuity, and low inflation. In retrospect, the lesson of the Great Moderation period following the Volcker disinflation of the early 1980s was that monetary policy best stabilizes the output gap and maintains low and stable interest rates by putting a priority on price stability. However, that lesson had not yet been learned during the Great Inflation. Our contention is that the failure of monetary policy in the Great Inflation was due, in part, to the inclination of central banks (including the Federal Reserve) to put stabilization of the output gap and continuity of the short-term interest rate ahead of price stability. This was understandable. Prior to the Great Inflation, inflation in the United States was relatively low. Protracted inflation had never before been a problem in the United States in peacetime. The importance of monetary policy

5. See Mankiw, Miron, and Weil (1987).
6. See Goodfriend (1991), Meltzer (2003), and Poole (1991).
7. Goodfriend (2003) and Meltzer (2003).

for inflation and inflation expectations was not then recognized fully. Later, the Fed lacked confidence that tight monetary policy could bring inflation down at any politically acceptable cost. We denote "business as usual" as the inclination of central banks to pursue output gap stabilization and interest rate continuity. We work out the implications of business-as-usual monetary policy for understanding the Great Inflation in the balance of the chapter.

3.4 Equilibrium Outcomes with "Business as Usual"

In this section we characterize the equilibrium behavior of inflation, output, and interest rates in a macromodel that combines New Keynesian pricing, the real business cycle core, the Fisher equation, the Euler equation, the term structure of interest rates, and business-as-usual monetary policy. The macroeconomic model that we develop gives rise to a time-varying trend rate of inflation, a "stochastic trend" component to inflation in the language of modern time series econometrics.

3.4.1 Trend Inflation Variability

To analyze the evolution of trend inflation, we begin by noting that the "law of iterated expectations" implies that

$$\bar{\pi}_t = E_t\bar{\pi}_{t+1} \tag{11}$$

since $E_t\bar{\pi}_{t+1} = E_t[\lim_{k\to\infty}E_{t+1}\pi_{t+1+k}] = [\lim_{k\to\infty}E_t\pi_{t+1+k}] = \bar{\pi}_t$. This is a useful observation, as it allows us to write (2) as

$$\pi_t = (1-\beta)\bar{\pi}_t + \beta E_t\pi_{t+1} + h(y_t - y_t^*). \tag{12}$$

Hence, with a fixed or slowly evolving inflation trend, inflation at each point in time should resemble that under (1). For example, inflation should depend importantly on expected future output gaps, as stressed in much recent literature,

$$\pi_t = \bar{\pi}_t + h\sum_{j=0}^{\infty}\beta^j E_t(y_{t+j} - y_{t+j}^*). \tag{13}$$

Thus, as one looks across various periods of high and low inflation, the general level of inflation would be fully explained by the trend.

To explore the origins of the inflation trend, suppose that the central bank fully stabilizes the output gap as part of its business-as-usual practices. Zero output gaps at all dates imply that

$$\pi_t - \bar{\pi}_t = \beta(E_t\pi_{t+1} - E_t\bar{\pi}_{t+1}) \tag{14}$$

mechanically from (2). However, since $\bar{\pi}_t = E_t\bar{\pi}_{t+1}$, this condition is equivalently that

$$\pi_t = E_t\pi_{t+1} = \bar{\pi}_t. \tag{15}$$

A striking feature of this simple model is that inflation is *only* the stochastic trend. (We add a transitory component in section 3.7.1.) The simple model serves to stress that output stabilization delivers a stochastic trend in inflation.

Further, a well-known property of stochastic trends is that their changes are unpredictable, so that our inflation trend evolves according to

$$\bar{\pi}_t = \bar{\pi}_{t-1} + \varepsilon_t, \tag{16}$$

with ε_t being a random shock—to be determined later—with the property that $E_{t-1}\varepsilon_t = 0$. In terms of the model characteristics that we stressed earlier, we note that the absence of a long-run trade-off means that a zero output gap is consistent with stochastically evolving trend inflation. Of course, zero trend inflation, or any other constant inflation trend, would imply a zero output gap. This would be the special case in which ε_t was always zero.

3.4.2 Innovations to the Inflation Trend

According to the previous derivation, output gap stabilization makes trend inflation variability possible. The variability of innovations to trend inflation, however, is governed by the other half of "business as usual," the degree of interest rate continuity. To see why, define the central bank's "interest rate continuity" parameter ϕ, where $0 < \phi < 1$ so that the degree of continuity increases with ϕ. Full stabilization of the output gap implies that $r_t = r_t^* = \sigma\rho\Delta y_t^* + r$ according to (8). We can write the consequences for the one-period-ahead forecast error for the nominal interest rate in terms of the forecast error in the natural rate of interest as

$$R_t = E_{t-1}R_t + (1 - \phi)(r_t^* - E_{t-1}r_t^*). \tag{17}$$

The Fisher equation (5) then implies that

$$E_t\pi_{t+1} - E_{t-1}\pi_{t+1} = -\phi(r_t^* - E_{t-1}r_t^*). \tag{18}$$

Hence, the innovation ε_t in the stochastic inflation trend evolves as

$$\varepsilon_t = \phi\sigma\rho\nu_t, \tag{19}$$

where $\sigma\rho\nu_t$ is the forecast error in the natural rate of interest, and ϕ controls the influence of shocks to capacity output ν_t on trend inflation. In this basic model, ε_t is also the innovation to the inflation rate itself, although that need not be the case. (See the appendix.) Without any interest rate continuity ($\phi = 0$), there are no innovations to trend inflation and nominal interest rate forecast errors fully reflect forecast errors in the natural rate of interest. In this case trend inflation is constant over time at a level determined by historical conditions. With full interest rate continuity ($\phi = 1$), one-period-ahead nominal interest rate forecast errors are eliminated completely, since the ε_t

innovation to expected inflation is the negative of the $\sigma\rho\nu_t$ innovation to the natural interest rate.

As long as "business as usual" pursues some degree of interest rate continuity, trend inflation should rise in periods when the natural interest rate is surprisingly low. For example, surprisingly low productivity growth typically lowers real interest rates in real business cycle models, as it does here according to equations (4) and (8). In a richer dynamic model, many different kinds of shocks would produce innovations in the natural interest rate working through saving and investment: according to our theory, such shocks would also contribute to the variability of trend inflation.

In ways that are reminiscent of Goodfriend (1987) and Broadbent and Barro (1997), the central bank's concern for smoothing the nominal interest rate produces nonstationarity in a nominal variable. However, in our context this nominal variable is the inflation rate rather than the price level. With output always at capacity and short-term nominal interest rate forecast errors at least somewhat attenuated, the central bank gives up control of long-run inflation, allowing trend inflation to evolve through time as a random walk.

3.4.3 Comovement of Short-Term Interest and Inflation

Under the inflation process derived earlier, the effect of a real interest rate innovation on the path of the nominal interest rate is given by

$$\begin{aligned}(20)\qquad & E_tR_{t+j} - E_{t-1}R_{t+j} \\ & = [E_tr^*_{t+j} - E_{t-1}r^*_{t+j}] + [E_t\pi_{t+j} - E_{t-1}\pi_{t+j}] \\ & = [\rho^j - \phi]\rho\sigma\nu_t\end{aligned}$$

for $j = 0,1,2,3, \ldots$ and $0 < \rho < 1$, with the coefficient $[\rho^j - \phi]\rho\sigma$ combining both real rate and expected inflation effects.

With full interest rate continuity ($\phi = 1$) a surprise increase in the current real interest rate is matched by an offsetting decrease in trend inflation, which leaves the current nominal short-term interest rate unchanged. Future nominal short rates then move gradually lower as the real natural interest rate returns asymptotically to its steady state r and the nominal interest rate moves permanently lower by $\rho\sigma\nu_t$. With partial interest rate continuity ($0 < \phi < 1$), a rise in the real rate can lead nearby nominal rates to rise while far away nominal rates fall.[8]

8. Gurkaynak, Sack, and Swanson (2005) find empirical support for this possibility with regard to US monetary policy in the period from 1990 to 2002. They report that forward rates at the short end of the yield curve increase following a surprise tightening of the federal funds rate (and decrease following a surprise easing). At longer horizons, however, they report that forward rates actually move in the direction opposite to that of the policy surprise; that is, a surprise policy tightening actually causes long-term forward rates to fall.

3.4.4 Term Structure Implications

The nominal long-bond rate would reflect the inflation effects more promptly than the short-bond rate. According to (10), the response of the L period long rate is

$$R_{Lt} - E_{t-1}R_{Lt} = \frac{1}{L}\sum_{j=0}^{L-1}[E_tR_{t+j} - E_{t-1}R_{t+j}] \tag{21}$$

$$= \frac{1}{L}\sum_{j=0}^{L-1}\{[E_tr^*_{t+j} - E_{t-1}r^*_{t+j}] + [E_t\pi_{t+j} - E_{t-1}\pi_{t+j}]\} \tag{22}$$

$$= \frac{1}{L}\sum_{j=0}^{L-1}[\rho^j - \phi]\rho\sigma\nu_t = \left[\frac{1}{L}\frac{1-\rho^L}{1-\rho} - \phi\right]\rho\sigma\nu_t.$$

The long-term interest rate would be a better indicator of movements in trend inflation than the short-term interest rate, with $R_{Lt} - E_{t-1}R_{Lt}$ approximately $-\phi\rho\sigma\nu_t = \bar{\pi}_t - \bar{\pi}_{t-1}$ for very long-term instruments.

3.5 Implementing "Business as Usual"

The consequences for inflation, output, and interest rates of "business as usual" were characterized in section 3.4 without saying anything about how the central bank's priorities for output gap stabilization and interest rate continuity could be implemented. We have four objectives in this section. First, we want to understand how business-as-usual priorities might be implemented with an interest rate rule. Second, we want to understand implementation in terms of a money growth rule. Third, we want to explain how a central bank, unaware of the effect of its business-as-usual priorities on trend inflation, could produce inadvertently the rational expectations equilibrium characterized in section 3.4. Fourth, we want to indicate how business-as-usual practices are susceptible to sudden, severe inflation surges capable of subordinating output gap stability and interest rate continuity to a priority for stabilizing inflation.

3.5.1 Implementation with an Interest Rate Rule

The interest rate rule

$$R_t = \bar{\pi}_t + r^*_t + \Omega(\pi_t - \bar{\pi}_t) \tag{23}$$

can deliver business-as-usual outcomes under the "Taylor principle" condition $\Omega > 0$, as follows. The rule says that the central bank adjusts its nominal interest rate policy instrument R_t so that the real interest rate $R_t - \bar{\pi}_t$ responds to the gap between actual inflation and what is, in effect, a time-varying inflation target $\bar{\pi}_t$. In addition, the central bank adjusts $R_t - \bar{\pi}_t$ one-for-one with fluctuations in the natural real rate of interest r^*_t.

We start by describing how this rule might work practically in response to a change in economic conditions. Suppose a negative shock to capacity output $\nu_t < 0$ in equation (4) causes r_t^* to fall in equation (8). In order to implement interest rate continuity and attenuate the incipient fall in R_t, the central bank must increase $\bar{\pi}_t$ somewhat. The required increase in $\bar{\pi}_t$ will vary from $\sigma\rho\nu_t$ to zero as the central bank's interest-rate-continuity parameter ϕ varies from unity to zero. The increase in $\bar{\pi}_t$ makes the inflation gap negative at the initial π_t. If the response coefficient Ω is sufficiently large, so that $R_t - \bar{\pi}_t$ is very sensitive to the inflation gap, then equilibrium interest rate policy will push π_t arbitrarily close to $\bar{\pi}_t$. In fact, in this case the central bank responds to deviations of inflation from its time-varying inflation target sufficiently aggressively that these never take place. Instead, equilibrium inflation π_t jumps immediately and permanently by $\bar{\pi}_t - E_{t-1}\bar{\pi}_t = -\phi\sigma\rho\nu_t$. It follows from (23) that $R_t - \bar{\pi}_t = r_t^*$. Since inflation is a random walk in this case, $E_t\pi_{t+1} = \bar{\pi}_t$, we have that $R_t - E_t\pi_{t+1} = r_t^*$ and the real interest rate shadows perfectly the underlying natural real rate of interest so that $y_t = y_t^*$ and the output gap is stabilized fully.

Interest rate rule (23) is consistent with a unique, stable rational expectations equilibrium that we described earlier. Formally, combining interest rate rule (23) and Fisher equation (5), using the fact that $\bar{\pi}_t = E_t\bar{\pi}_{t+1}$, we find that $E_t\pi_{t+1} - E_t\bar{\pi}_{t+1} = \Omega(\pi_t - \bar{\pi}_t)$. Then, the stable forward-looking solution is $\pi_t = \bar{\pi}_t$, the business-as-usual equilibrium we derived in section 3.4.

3.5.2 Implementation with a Money Growth Rule

The money growth rule

$$\Delta m_t^S = (\alpha - \phi\sigma\rho)\nu_t + \alpha\rho\Delta y_{t-1}^* + \pi_{t-1} \tag{24}$$

delivers business-as-usual objectives in a model that includes equations (2) through (7) augmented to include money demand function $\Delta m_t^D = \alpha\Delta y_t + \pi_t$, money growth rule (24), and a money market equilibrium condition $\Delta m_t^D = \Delta m_t^S$.

Suppose initially that the central bank wishes only to stabilize the output gap and sets $\phi = 0$. To do so, the central bank would move the current money stock with $\alpha\nu_t$ so that money market clearing makes current aggregate demand y_t conform to movements in capacity output y_t^* at the going inflation rate. To stabilize the output gap in the future, the central bank must make future money growth conform to future movements in money demand at capacity output and initial trend inflation. The required future money growth is reflected in the $\alpha\rho\Delta y_{t-1}^*$ term in (24). Future money growth would mirror the return of capacity output to its long-run growth path scaled by the income elasticity of money demand, α. In this case, the nominal interest rate would shadow the real natural rate associated with the shock ν_t. Monetary policy would stabilize the output gap fully and perpetuate the initial inflation trend.

If the central bank also seeks to implement interest rate continuity with

$0 < \phi < 1$, it must attenuate one-period-ahead forecast errors in the nominal interest rate by making expected inflation covary negatively with the shock to capacity output ν_t. The central bank can do this by promising to make future money growth covary negatively with ν_t. Consider a negative shock to ν_t. Seeing higher money growth coming, firms expect inflation to rise, and higher expected inflation stabilizes the short nominal rate against the negative shock to the real rate. Let the money growth rule continue to make y_t conform to y_t^* as discussed earlier. In this equilibrium, firms pass higher expected inflation through one-for-one to current inflation. The pass-through shows up as the $-\phi\sigma\rho\nu_t$ term in (24), which reflects the natural real interest rate innovation, $\sigma\rho\nu_t$, multiplied by the central bank's interest-rate-continuity parameter ϕ. This term reflects the effect of higher π_t on current money demand that the central bank must accommodate to continue to stabilize y_t at y_t^*. The lagged π_{t-1} term present in the money growth rule is there so that money growth in period $t + 1$ and thereafter perpetuates the elevated period t inflation trend required to stabilize the output gap.

3.5.3 How "Business as Usual" Creates Inflation Drift

Is it possible that a central bank in pursuit of output gap stabilization and interest rate continuity could push an economy unknowingly into the equilibrium with stochastic trend inflation characterized in section 3.4? This is an important question to ask because there is little evidence that central banks, during the Great Inflation, thought of themselves as managing inflation expectations deliberately with either an interest rate rule or a money growth rule to implement business-as-usual objectives. We answer the question in the affirmative below, showing how the public's rational expectations drive the stochastic trend in inflation, which the central bank happily accommodates in the pursuit of its business-as-usual priorities.

To understand how business-as-usual monetary policy inadvertently puts a stochastic trend in the inflation rate, imagine that initially the inflation rate is low and stable and is expected to remain so at $E\hat{\pi}$. Imagine also that the economy is subject to shocks to capacity output. Initially, suppose that the sole objective of monetary policy is to stabilize the output gap; that is, $\phi = 0$. In this case, the central bank would not distinguish between nominal and real interest rates; it would regard its management of the short-term *nominal* rate as equivalent to management of the short-term *real* interest rate. With no continuity restrictions, the central bank would move R_t so that $R_t - E\hat{\pi} = r_t^*$ at all times. For instance, the central bank would respond to a negative ν_t shock to capacity output by matching the initial fall in the real natural rate r_t^* with its nominal interest rate policy instrument R_t, and shadowing the real natural rate as it moved back gradually to its steady state level r, according to equations (4) and (8). If the central bank focused exclusively on stabilizing the output gap, there would be no reason for inflation to be destabilized. Inflation, inflation expectations, and trend inflation all would remain firmly anchored at $E\hat{\pi}$. The long-term interest rate would remain firmly anchored as well.

However, matters change if the central bank pursues a degree of interest-rate continuity, $0 < \phi < 1$, in addition to stabilizing the output gap. Now the central bank would attenuate somewhat the initial response of R_t to v_t. For instance, the central bank would respond to a negative v_t shock with an attenuated cut in R_t so that $R_t - E\hat{\pi} > r_t^*$. Interest continuity thereby would push current aggregate demand below current capacity output. To stabilize the output gap, the central bank would compensate for the insufficient contemporaneous interest rate cut by steering the interest rate somewhat *below* real natural interest rates in the future. Doing that, however, would push future aggregate demand *above* the path of future capacity output.

All this presumes that inflation, expected inflation, and trend inflation remain anchored at $E\hat{\pi}$. But there is a problem: steering future real interest rates below real natural rates pushes future aggregate demand above capacity output. New Keynesian pricing implies that the prospect of negative expected future output gaps would elevate future inflation. Hence, we would no longer have a rational expectations equilibrium. The public would catch on to the fact that a negative shock to capacity output would be followed by higher inflation. Rationally expected future inflation would rise with negative shocks to capacity output.

But this is not the end of the story. Elevated expected inflation $E_t\pi_{t+1}$ in response to $v_t < 0$ would deepen the contemporaneous real interest rate cut $r_t = R_t - E_t\pi_{t+1} < R_t - E\hat{\pi}$, for any given degree of interest-rate continuity ϕ. A deeper real rate cut, in turn, would allow the central bank to steer interest-rate policy closer to real natural rates in the future. In the limit, the economy converges to a rational expectations equilibrium response in which expected inflation would rise enough to push the current real interest rate all the way down to the current real natural interest rate. At this point, the central bank would stabilize the output gap fully because its nominal interest rate instrument (adjusted for elevated expected inflation) would perfectly shadow the natural real interest rate. Moreover, with the output gap stabilized fully, actual and expected rates of inflation would rise initially, identically, and permanently in response to a shock to capacity output. So, we see how the central bank's commitment to business-as-usual priorities and the public's incentive to form expectations of inflation rationally push the economy into the equilibrium with stochastic trend inflation characterized in section 3.4.

3.6 Empirical Implications of "Business as Usual"

Our model of business-as-usual monetary policy has the following empirical implications that we put to work in section 3.7 to help understand the Great Inflation:

1. Inflation is a random walk with a transitory component.
2. The random walk in inflation is driven by innovations to the natural interest rate, which are produced by shocks to the growth of capacity output in our model.
3. The variance of the permanent shock to inflation is directly related to the degree of interest-rate continuity pursued by the central bank and the variance and autocorrelation of shocks to the natural interest rate; it is inversely related to the intertemporal elasticity of substitution in consumption.
4. Short-term interest-rate continuity puts a random walk component in the long-term interest rate.
5. Real interest rate and inflation rate innovations are negatively correlated due to interest-rate smoothing.
6. Long-term interest rates lead short-term interest rates.
7. The powerful incentive for a central bank to pursue business-as-usual priorities when inflation is well behaved means that *low* inflation should inherit a stochastic trend from shocks to capacity output, though the variance of the stochastic trend may be small.

We also see the Great Inflation as overlain with "inflation fighting episodes" in which the Federal Reserve sought to restrain inflation by reducing real output. We do not specify a model that determines when the Fed sought to contain inflation, but our theory of trend inflation nevertheless makes predictions about the connections between business-as-usual monetary policy and episodes of inflation fighting. The connections that we see are:

8. A prolonged series of particularly severe, cumulative negative shocks to the growth of capacity output should be associated with (a) sharply rising inflation, (b) rising long-term interest rates, and (c) rising short-term interest rates that lag the rise in long-term rates. The rise in trend inflation could trigger a shift of priorities from "business as usual" to "inflation fighting."
9. "Inflation fighting" that makes progress against inflation should precipitate a recession if there is imperfect credibility. However, a return to "business as usual" would reverse the gains against inflation quickly in the presence of ongoing negative shocks to capacity output. Episodes of "inflation fighting" would thereby contribute to the variability of the stochastic inflation trend.
10. The marginal predictive content of the output gap for inflation should deteriorate in a period of low and stable inflation relative to a period of high and variable inflation because "business as usual" predominates in the former period and the latter period is apt to contain episodes of "inflation fighting."

3.7 Understanding the Great Inflation

We draw on a variety of evidence to understand the Great Inflation in terms of our business-as-usual model of monetary policy. First, we show that the statistical time-series model of US inflation identified and estimated by Stock and Watson (2007) is predicted by our model. Second, we use a measure of aggregate technology change for the United States constructed by Basu, Fernald, and Kimball (2006), together with Romer and Romer (1989) inflation-fighting dates, and time series for inflation and the term structure of interest rates, to show that these data behave as predicted by our model preceding periods when the Federal Reserve made "inflation fighting" a priority. Third, we emphasize that the attachment to "business as usual" predicts the "stop and go" character of monetary policy during the Great Inflation documented and studied by Shapiro (1994), in which the gains against inflation achieved during periods of fighting inflation were short-lived. Fourth, we explain why our model of monetary policy predicts the post-Great Inflation deterioration of predictive content of the output gap for inflation found by Atkeson and Ohanian (2001) and confirmed by Stock and Watson (2007).

3.7.1 A Statistical Time-Series Model of US Inflation

In their 2007 study of the statistical behavior of US inflation from the 1950s to 2004, Stock and Watson find that a "univariate inflation process is well described by an unobserved component trend-cycle model with stochastic volatility or, equivalently, an integrated moving average [IMA] process with time-varying parameters."[9] They report that the model explains a variety of recent forecasting puzzles and begins to explain some multivariate inflation forecasting puzzles as well. Their statistical model is implied by our business-as-usual model of monetary policy as follows.

In section 3.4, we utilized the New Keynesian pricing equation (2) without a shock term to highlight the random walk implication of our model: $\pi_t = \bar{\pi}_t$ and $\bar{\pi}_t = \bar{\pi}_{t-1} + \varepsilon_t$. However, standard practice is to add a white noise shock to the inflation equation, say η_t. Then, since η_t is unforecastable, the inflation solution becomes $\pi_t = \bar{\pi}_t + \eta_t$, where $\bar{\pi}_t = \bar{\pi}_{t-1} + \varepsilon_t$ under business-as-usual assumptions of output at capacity and interest-rate continuity.

In purely statistical terms, the Stock and Watson findings of a unit root in π_t, with negative first-order autocorrelations, and generally small higher-order autocorrelations of $\Delta\pi_t$, suggest that the inflation process is well described by the IMA (1, 1) process

$$\Delta\pi_t = (1 - \Lambda B)a_t, \tag{25}$$

9. Stock and Watson (2007, 3).

where Λ is positive, a_t is serially uncorrelated with mean zero and variance σ_a^2, and B is a backshift operator.

Stock and Watson point out that the IMA(1, 1) statistical model is observationally equivalent to an unobserved components model in which π_t has a stochastic trend τ_t and a serially uncorrelated disturbance η_t:

$$\pi_t = \tau_t + \eta_t, \quad \eta_t \text{ serially uncorrelated } (0, \sigma_\eta^2) \tag{26}$$

$$\tau_t = \tau_{t-1} + \varepsilon_t, \quad \varepsilon_t \text{ serially uncorrelated } (0, \sigma_\varepsilon^2), \tag{27}$$

where cov $(\eta_t, \varepsilon_j) = 0$ for all j.

Thus, our theoretical model implies the statistical model of inflation developed by Stock and Watson, and we can interpret aspects of their statistical analysis from the perspective of our model.

Stock and Watson report IMA(1, 1) parameters and the implied unobservable components parameters, as well as a variety of other statistics estimated using quarterly US inflation data from the 1950s to 2004 for a variety of inflation indexes. Broadly speaking, the findings are similar for all the indexes. For our purposes, the main findings are these: (a) inflation is driven by a random walk component τ_t plus a transitory component η_t; (b) a time-varying estimate of the standard deviation of the permanent innovation $\sigma_{\varepsilon,t}$ is 0.5 (percentage points at an annual rate) in the 1950s through the mid-1960s, rises sharply to a peak of 1.4 in the mid-1970s, falls gradually back below 0.5 by the mid-1980s, and settles below 0.2 after the mid-1990s; (c) a time-varying estimate of the standard deviation of the transitory innovation $\sigma_{\eta,t}$ is around 0.5 from the 1950s to 2004.

From this statistical perspective, the Great Inflation is a story about the "Great Inflation Drift" in the sense that the elevated variance of inflation during the great inflation period is entirely due to large increases in the variance of the innovation of the stochastic trend component driving inflation. Importantly, Stock and Watson point out that although the estimated variance of the permanent innovation in inflation diminished in statistical and economic importance since the mid-1980s, the confidence intervals for the largest AR root continue to include one, so that there is evidence of continuing trend variability for inflation.

Stock and Watson's statistical model of the inflation process supports three empirical predictions of our model listed in section 3.6. First, US inflation is characterized parsimoniously, and consistently, as a random walk with a transitory component. This is in keeping with our view that "business as usual" has been the predominant mode of monetary policy behavior, and that it induces a stochastic trend in inflation in the presence of shocks to capacity output. Second, the increased variability of inflation during the Great Inflation shows up as an increase in the variability of the innovation in the stochastic trend component, as our model of monetary policy predicts.

Third, inflation through 2004 still contains a small stochastic trend, which our model predicts should reflect the Federal Reserve's inclination to pursue business-as-usual priorities for output gap stabilization and continuity of the short rate when inflation is low.

3.7.2 From "Business as Usual" to "Fighting Inflation"

Our model suggests that business-as-usual monetary policy can be sustained indefinitely with low and reasonably stable inflation if the shocks to capacity output are small, especially if the central bank implements relatively little interest rate continuity so that ϕ is not too large. Nevertheless, business as usual exposes inflation to considerable variability if shocks to capacity output become large and happen to cumulate in one direction or another for a period of time. The public can tolerate a considerable range of inflation drift as long as it is relatively gradual and "orderly." As an operational matter, the central bank can continue to pursue business-as-usual objectives effectively as long as trend inflation does not drift too violently. However, a particularly severe series of cumulative negative shocks to capacity output has the potential to drive inflation, expected inflation, trend inflation, and the long-term interest rate all suddenly and sharply higher, even if all had been well-behaved for years. If inflation drifts upward too far, too fast in a "disorderly" manner, then business as usual may become unsustainable. The public may demand that inflation be contained and the central bank may be unable to execute stabilization policy effectively in the absence of a nominal anchor.

When such developments cause output gap stability and interest-rate continuity to be subordinated to containing inflation, the central bank is forced to switch from business as usual to fighting inflation. The central bank fights inflation by raising its nominal interest rate policy instrument above expected inflation in order to elevate longer-term real interest rates according to (9) to depress aggregate demand below capacity. According to New Keynesian pricing, given the expected rate of inflation, the central bank must sustain an output gap in order to make progress against inflation.[10] Once inflation is stabilized, even without much (if any) reduction, pressure builds quickly for the central bank to revert to business as usual in order to close the output gap and stabilize interest rates again. Thus, our business-as-usual model of monetary policy predicts that a period of large, cumulative negative shocks to capacity output is likely to precipitate a cycling of monetary policy priorities with upward inflation drift interrupted periodically but temporarily by deliberately contractionary monetary policy. We explore this idea next, although it goes beyond the implications of our theory.

10. Goodfriend and King (2005) analyze the mechanics of fighting inflation in a closely related model.

3.7.3 Factors Precipitating Inflation Fighting

Romer and Romer (1989) document that the Federal Reserve tightened monetary policy decisively to fight inflation on six occasions since World War II. These episodes began respectively in October 1947, September 1955, December 1968, April 1974, August 1978, and October 1979. Only two significant increases in unemployment were not preceded by Fed action to fight inflation. One occurred in 1954 after the Korean War and the second occurred in 1961, after the Fed tightened monetary policy to improve the international balance of payments. The two earliest Romer dates were part of a series of Fed policy actions through the mid-1960s that kept inflation relatively low on average. We are interested in the remaining four Romer dates, those that occurred during the Great Inflation.

We interpret Romer dates as instances when the Federal Reserve switched from business as usual to fighting inflation. Our model predicts that periods of business as usual preceding Romer dates should exhibit (a) sharply rising inflation, (b) a sequence of severe cumulative negative shocks to the growth of capacity output, (c) rising long-term interest rates, and (d) rising short-term interest rates lagging long rates. To check whether the Romer dates are precipitated as predicted, we employ an annual time-series measure of technological progress in the United States constructed by Basu, Fernald, and Kimball (2006, BFK series) that controls for aggregation effects, varying utilization of capital and labor, nonconstant returns, and imperfect competition. We utilize the BFK series in conjunction with data on inflation and the term structure of interest rates, all shown in figures 3.1 through 3.5 at the end of the chapter, to check whether the evidence supports the predictions of our model for each of the Romer dates in the Great Inflation. As discussed later, the evidence is broadly consistent with the predictions of our model.

December 1968

Inflation averaged about 1.5 percent at an annual rate in the first half of the 1960s, and surged at the start of the Great Inflation in 1965 to around 3 percent in 1966. Inflation stabilized briefly in the first half of 1967 after the Federal Reserve tightened monetary policy briefly, but surged again to around 4.5 percent by the first Romer date of the Great Inflation in December 1968. A number of explanations have been offered to explain the start of the Great Inflation: for example, excessive Federal spending to finance the Vietnam buildup, insufficient Federal Reserve independence, and a willingness to tolerate higher inflation in the belief that it might bring unemployment down according to the Phillips curve.[11] Our interest, however, is to check whether the December 1968 switch to fighting inflation is preceded, in addition to the sharp rise in inflation, by the three other factors

11. For instance, see Meltzer (2005) and references contained therein.

identified by our business-as-usual model of monetary policy. As predicted, BFK technology growth slows sharply from 1964 to 1969. The ten-year government bond rate moved up from 4 percent in 1966 to nearly 6 percent in 1968, indicating that 2 percentage points of the inflation surge prior to December 1968 was regarded as permanent. Finally, starting at 4 percent at the end of 1966, the federal funds rate clearly lagged the ten-year rate rise prior to December 1968.

April 1974

Inflation rose sharply from around 3 percent in mid-1973 to nearly 10 percent by the April 1974 Romer date, exacerbated by the first oil shock and the relaxation of price controls. Again, BFK technology growth slows sharply in the period preceding the 1974 Romer date. The ten-year bond rate moved up from about 6 percent in late 1972 to around 7.5 percent in April 1974, reversing the decline achieved during the previous period of inflation fighting beginning in December 1968, indicating that only 2 percentage points of the surge in inflation was then regarded as permanent. Finally, starting from around 4 percent in late 1972, the federal funds rate briefly lagged the ten-year rate on the way up, but passed the bond rate in 1973 and reached around 10 percent by April 1974.

August 1978

In early 1977, inflation settled at around 6 percent as a result of the inflation fighting begun in April 1974. Inflation began to move up once more in 1978, however, rising to around 7 percent by the August 1978 Romer date. Once more, BFK technology growth slows sharply in the period preceding the Romer date. The ten-year bond rate fell back to around 7.5 percent in mid-1977 as a result of the inflation fighting begun in April 1974. The ten-year rate then rose sharply by around 1 percentage point to around 8.5 percent by the 1978 Romer date, indicating that 1 percentage point of the upward inflation drift was regarded as permanent. Finally, starting from around 5 percent in mid-1977, the federal funds rate lagged the rising long rate, but again caught up around the Romer date.

October 1979

The period from August 1978 to the Romer date of October 1979 saw inflation surge from 7 percent to around 9.5 percent. And again, as predicted by our model, BFK technology growth in 1979 was surprisingly weak, lengthening the period of surprisingly slow growth of technology that preceded the August 1978 Romer date. The ten-year rate moved up by another 1 percentage point to October 1979, indicating that 1 percentage point of the inflation surge was regarded as permanent. In this case, however, starting roughly in line with the ten-year rate in August 1979, the federal funds rate actually led the long rate up as part of the inflation-fighting policy actions undertaken in the wake of the August 1978 Romer date. Then, on the October 1979 Romer date the Fed moved the federal funds rate sharply higher than the long-term interest rate to 13.5 percent.

3.7.4 Stop-and-Go Monetary Policy

Looking at the record before and after Romer dates, there is a recurrent pattern highlighted previously by Shapiro (1994). It is clear that the Romer dates initiate periods of inflation fighting in that they are all preceded by sharply higher inflation and followed by sharply higher short-term interest rates engineered by the Fed relative to long-term interest rates. Nevertheless, within two or three years inflation is no lower than when the period of "inflation fighting" began, indicating that these inflation-fighting episodes were meant only to contain inflation temporarily or that they were aborted attempts at reducing the inflation rate. For instance, the pattern is evident with respect to the inflation-fighting periods initiated by the December 1968 and April 1974 Romer dates. The Fed initiated recessions in 1970 and 1973 to 1975 as part of its inflation-fighting actions. And these recessions brought down inflation, trend inflation, and long bond rates. However, these gains were reversed within a few years.

Our model of monetary policy predicts that stop-and-go policy should be an integral part of a period of protracted inflation driven by recurring cumulative negative shocks to technology such as we saw during the Great Inflation. According to the model, business-as-usual priorities exposed the US economy to upward inflation drift due to unexpectedly slow growth of technology during the Great Inflation years. On a few occasions, a series of especially large negative shocks to technology growth pushed inflation, expected inflation, and long-term interest rates up sharply and precipitated a period of inflation fighting. The model predicts that inflation, inflation expectations, and long-term interest rates could be brought down *only* by creating a protracted recession; that is, by creating an output gap of enough size and duration to induce a disinflation in line with New Keynesian pricing. Thus, the model predicts that the stabilization of inflation would create pressure for monetary policy to end the accompanying recession and return to business as usual. The return to business as usual would expose the economy once more to upward inflation drift in the presence of unexpectedly slow growth of technology. Our view, then, is that the Fed's attachment to business-as-usual priorities, in conjunction with negative productivity growth shocks, is central to understanding the tremendous output and employment volatility during the Great Inflation.

3.7.5 Predictive Content of the Output Gap for Inflation

A striking statistical finding emphasized by Atkeson and Ohanian (2001) and confirmed by Stock and Watson (2007) is that the marginal predictive content of output-gap variables for inflation has deteriorated dramatically since 1984. Specifically, Atkeson and Ohanian compare the accuracy of inflation forecasts augmented with three different output-gap variables to a naive forecast that at any date inflation will be the same over the next year as it has been over the last year. They find that none of the forecasts is more accurate than the naive forecast, which is essentially a random walk forecast of inflation. Stock and Watson (2007) investigate the marginal predictive content of output-gap variables for inflation in more detail by augmenting a benchmark univariate forecasting model with a variety of measures and specifications of gap variables, and by comparing the marginal predictive content of the gap variables for two sample periods—a Great Inflation sample period from 1970 to 1983, and a Great Moderation sample period from 1984 to 2004.

Stock and Watson report that the relative performance of gap forecasts deteriorated substantially from the first period to the second. For example, during the 1970 to 1983 period at the four-quarter horizon, an inflation forecast augmented with an unemployment rate gap outperformed a univariate inflation autoregression benchmark with a relative mean square forecast error of 0.88. But during the 1984 to 2004 period it performed worse than the benchmark, with a relative mean squared forecast error (MSFE) of 1.48. Stock and Watson report that the change in relative performance is even larger at the eight-quarter horizon. The deterioration of output-gap forecasts is found for all activity predictors examined. The poor performance of gap variables is not simply a consequence of failing to allow for a time-varying nonaccelerating inflation rate of unemployment (NAIRU) or time-varying potential GDP. Finally, Stock and Watson report that the Atkeson and Ohanian naive (random walk) forecast substantially improves upon the abovementioned forecasts at the four- and eight-quarter horizons in the 1984 to 2004 period, but not at shorter horizons and not in the first period.

We regard the changing informativeness of the output gap for future inflation as important evidence in support of our business-as-usual model of monetary policy. Given the central bank's incentive to pursue business-as-usual priorities when inflation is low and stable, and to allow inflation to drift around, we would have expected the output gap to have much less predictive content for inflation during the Great Moderation than during the Great Inflation. Even though business as usual was also the predominant mode of Federal Reserve behavior during the Great Inflation, the Fed was then forced into fighting inflation on four Romer-date occasions. The output gap had great predictive content for inflation during the inflation fighting episodes because the Fed then deliberately created output gaps to contain inflation and bring it down. Thus, on the basis of our theoretical model one would not be surprised to learn that the Great Inflation sample period displays predictive content of output gaps for inflation far in excess of that evident during the Great Moderation.

3.8 Conclusion

The Great Inflation in the United States can be characterized statistically as a period in which a highly-volatile stochastic inflation trend exhibited fifteen years of predominantly positive innovations. We showed that a simple textbook macroeconomic model implies that a stochastic inflation trend arises if the central bank seeks to maintain output at a capacity level that varies through time, and also places weight on continuity of the short-term interest rate. Both of these features were, we believe, important components of Federal Reserve behavior. In our model, rising inflation results from a combination of bad policy and bad luck. The presence of stochastic trend inflation results from bad policy, which perpetuates inflation shocks. Our model identifies the relevant shocks as those that reduce the growth of capacity output and the natural real interest rate. We emphasized the effect of shocks to productivity growth on capacity output, but other real factors are relevant for the evolution of capacity output, including shifts in distortionary taxes and regulations. We found evidence of bad luck in that productivity growth was indeed surprisingly and especially slow during episodes of sharply rising inflation during the period.[12]

One reason for studying the Great Inflation is to prevent its recurrence. Our interpretation of the period suggests that a preoccupation with short-term interest rates and with maintaining output at capacity would, in the presence of adverse shocks to the growth of capacity output, combine to produce another period of inflation drift with similarly adverse consequences for employment and output.

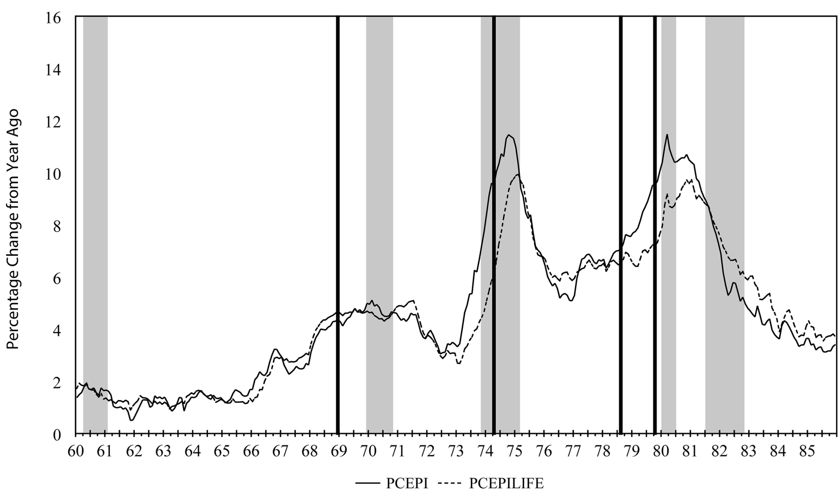

Fig. 3.1 Personal consumption expenditures chain-type price index (PCEPI) and consumption expenditures chain-type price index less food and energy (PCEPILIFE)

Notes: Vertical lines indicate "Romer dates." Shaded areas indicate NBER recessions. Dates are under First Month of Year; tick marks are every three months.

12. Other theories of the origin and nature of the Great Inflation would also suggest a link between real slowdowns and rising trend inflation (see, e.g., Orphanides 2003). An important task of future research is to distinguish empirically between competing theories.

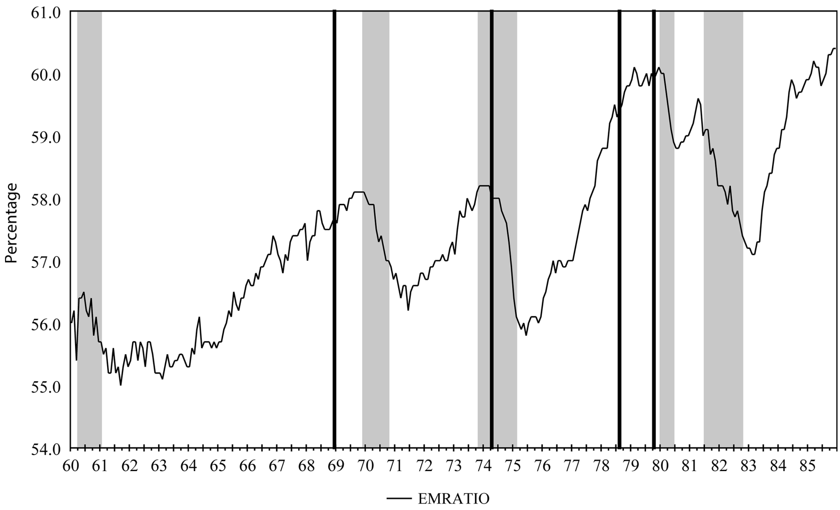

Fig. 3.2 Civilian employment-population ratio (EMRATIO)

Notes: Vertical lines indicate "Romer dates." Shaded areas indicate NBER recessions. Dates are under First Month of Year; tick marks are every three months.

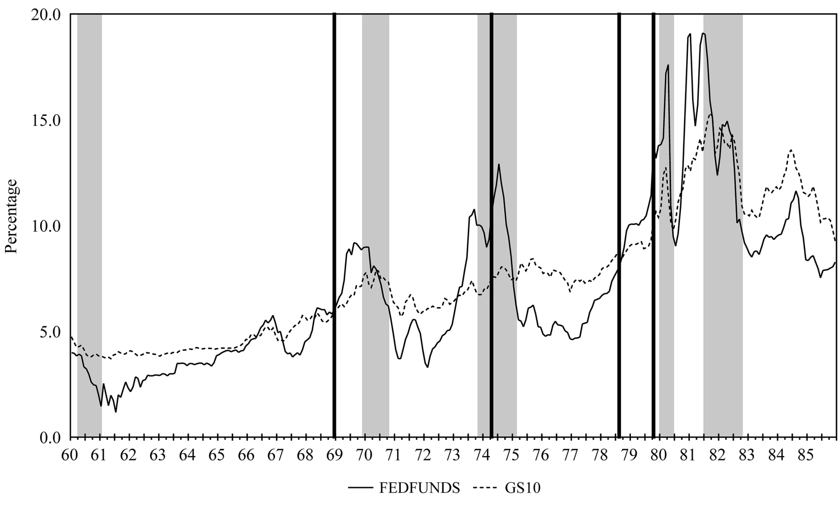

Fig. 3.3 Effective Federal funds rate (FEDFUNDS) and Ten-year Treasury constant maturity rate (GS10)

Notes: Vertical lines indicate "Romer dates." Shaded areas indicate NBER recessions. Dates are under First Month of Year; tick marks are every three months.

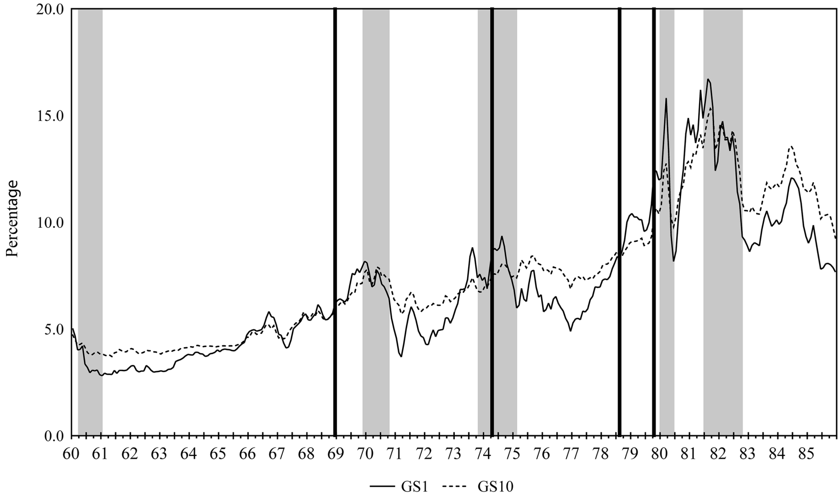

Fig. 3.4 One-year Treasury constant maturity rate (GS1) and Ten-year Treasury constant maturity rate (GS10)

Notes: Vertical lines indicate "Romer dates." Shaded areas indicate NBER recessions. Dates are under First Month of Year; tick marks are every three months.

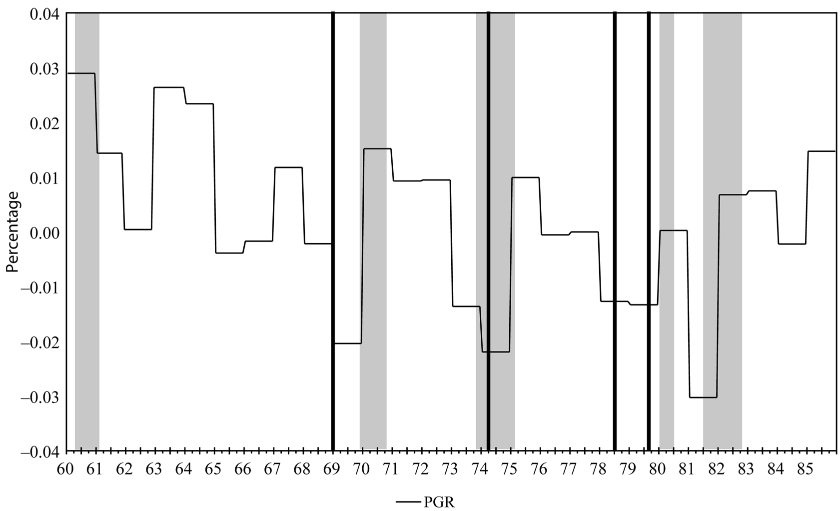

Fig. 3.5 Productivity growth rate (PGR)

Notes: Vertical lines indicate "Romer dates." Shaded areas indicate NBER recessions. Dates are under First Month of Year; tick marks are every three months.

Appendix

Alternative Specifications of the Phillips Curve

Consider modifying the New Keynesian Phillips curve to

$$\pi_t = (1-\theta)\, E_t\pi_{t+1} + \theta\pi_{t-1} + h(y_t - y_t^*).$$

This formulation nests two popular Phillips curve specifications that display no long-run trade-off between inflation and output relative to capacity. First, with $\theta = 0$, there is a Phillips curve implied by Calvo (1983) with no discounting. Second, with $0 < \theta < 1$, there is a Phillips curve with structural inflation persistence of the sort developed by Fuhrer and Moore (1995). Under the assumption that there is no output gap, we can rewrite the previous equation as

$$\pi_{t+1} = \frac{1}{1-\theta}\pi_t - \frac{1}{1-\theta}\pi_{t-1} + \xi_{t+1},$$

where ξ_{t+1} is a random shock with the property that $E_t\xi_{t+1} = 0$. Subtracting π_t from both sides and lagging the result by a period implies the following first-difference, first-order autoregressive process for the evolution of inflation

$$\pi_t - \pi_{t-1} = \frac{\theta}{1-\theta}(\pi_{t-1} - \pi_{t-2}) + \xi_t,$$

which has a stable rational expectations solution if $\theta < 1/2$. The forecast revisions for changes in inflation are given by

$$E_t\Delta\pi_{t+j} - E_{t-1}\Delta\pi_{t+j} = \left(\frac{\theta}{1-\theta}\right)^j \xi_t,$$

and those for the levels of inflation are

$$\begin{aligned} E_t\pi_{t+j} - E_{t-1}\pi_{t+j} &= \left[\sum_{h=0}^{j}\left(\frac{\theta}{1-\theta}\right)^h\right]\xi_t \\ &= \frac{1-\theta}{1-2\theta}\left[1-\left(\frac{\theta}{1-\theta}\right)^{j+1}\right]\xi_t. \end{aligned}$$

Thus, the inflation trend evolves as

$$\begin{aligned} \bar{\pi}_t &= \bar{\pi}_{t-1} + \lim_{j\to\infty}\{E_t\pi_{t+j} - E_{t-1}\pi_{t+j}\} \\ &= \bar{\pi}_{t-1} - \frac{1-\theta}{1-2\theta}\xi_t. \end{aligned}$$

We continue to assume there is no output gap so that the actual real interest rate evolves as the natural interest rate according to equation (8) in the text. Then, we use the Fisher equation (5) to decompose the one-period-ahead forecast error in the short-term nominal interest rate as

$$R_t - E_{t-1}R_t = (r_t^* - E_{t-1}r_t^*) + (E_t\pi_{t+1} - E_{t-1}\pi_{t+1}).$$

Using the "continuity of the short rate" policy rule (17),

$$R_t - E_{t-1}R_t = (1 - \phi)(r_t^* - E_{t-1}r_t^*),$$

and the Phillips curve formulation with no output gap given at the start of the appendix, we write

$$\xi_t = -\phi(1 - \theta)(r_t^* - E_{t-1}r_t^*).$$

Finally, we use equations (4) and (8) to express the inflation innovation in terms of the shock to capacity output growth

$$\xi_t = -\phi(1 - \theta)\sigma\rho\nu_t.$$

There are two points to be made about the formulation of the Phillips curve given in this appendix. First, it allows for a time-varying inflation trend when $\theta = 0$ even though a trend does not enter directly into the specification of the Phillips curve. Inflation is only the stochastic trend in this case, as in the model studied in the body of the chapter. Second, with structural inflation persistence ($0 < \theta < 1/2$), there is potentially much greater variability of trend inflation in response to natural interest rate shocks than implied by the specification of the Phillips curve given in section 3.2. However, in this case the inflation rate converges gradually over time to the new inflation trend after a shock because inflation evolves thoeretically as a first-difference, first-order autoregressive process. It is worth noting that this latter theory of inflation is inconsistent with Stock and Watson's (2007) finding that actual inflation is best modeled statistically as a first-difference, first-order moving average process. Of course, actual inflation time series may contain a first-difference autoregressive component that is hard to identify statistically in the data.

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Comment Lars E. O. Svensson

Introduction

Goodfriend and King's chapter provides an interesting explanation of the Great Inflation. It starts with the assumption that the Fed objectives were to stabilize the output gap and maintain "continuity of the interest rate" and then presents a model where inflation becomes a stochastic trend. In particular, inflation increases with negative innovations in potential-output growth. Fed monetary policy is seen as switching between business as usual and inflation fighting.

Model

There is a New Keynesian Phillips curve,

$$\pi_t - \bar{\pi}_t = \beta \mathrm{E}_t(\pi_{t+1} - \bar{\pi}_{t+1}) + h(y_t - y_t^*),$$

where $\bar{\pi}_t$ denotes an inflation trend that is assumed to follow a random walk (martingale),

$$\bar{\pi}_t = \mathrm{E}_t \bar{\pi}_{t+1}.$$

There is an aggregate-demand relation that relates the output gap between output, y_t, and potential output, y_t^*, to the real interest-rate gap between the real interest rate, r_t, and the natural interest rate, r_t^*,

$$y_t - y_t^* = \mathrm{E}_t(y_{t+1} - y_{t+1}^*) - \frac{1}{\sigma}(r_t - r_t^*),$$

where σ is the reciprocal of the intertemporal elasticity of substitution. Potential-output growth follows an AR(1) process,

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A first version of this comment was presented at the Great Inflation Conference sponsored by the NBER in Woodstock, Vermont, September 25–27, 2008. I thank Mathias Trabant for help with this comment. For acknowledgments, sources of research support, and disclosure of the author's material financial relationships, if any, please see http://www.nber.org/chapters/c9169.ack.