Inflation Targeting under Commitment and Discretion*

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Inflation targeting has been adopted by many central banks, but not by the U.S. Federal Reserve. Using an estimated New Keynesian business cycle model, I perform counterfactual simulations to consider how history might have unfolded if the Federal Reserve had adopted a form of flexible inflation targeting in the year Paul Volcker was appointed chairman. The first simulation assumes that the Federal Reserve could have tied its hands and committed once and for all; the second assumes that the Federal Reserve would have set policy with discretion. While the broad contours of historical outcomes remain under inflation targeting, there are times over the past 25 years when inflation targeting would have led to materially different outcomes.

1. Introduction

The first central bank to adopt inflation targeting was the Reserve Bank of New Zealand in 1990, followed soon after by the Bank of Canada. Since then, inflation targeting has grown in popularity and the list of central banks that have adopted it is now quite extensive. Both the Bank of England and the European Central Bank have explicit numerical inflation targets, as do many countries in Latin America. Some key characteristics of inflation targeting are that there is an announced target, or target range, for some measure of inflation, that there is explicit recognition that low and stable inflation should be the ultimate goal of monetary policy, and that the policy process is transparent to the extent that forecasts of inflation and other macroeconomic variables are often published (Bernanke and Mishkin 1997). Inflation targeting central banks also have some instrument independence, that is, the ability to set their instrument—typically a short-term nominal interest rate—without political interference (Debelle and Fischer 1994).

While the Federal Reserve is charged with the responsibility of promoting price stability and full employment, it does not possess many of the characteristics typically associated with inflation targeting, such as an announced inflation target and timely published forecasts.[1] Nevertheless, over the past 25 years, inflation in the United States has declined considerably, in much the same way it has in countries with inflation targets. In fact, there is little doubt that the last 25 years has been a period of relative stability and prosperity in the United States, and it is not unreasonable to think that some of this can be attributed to good monetary policy.

Inflation declined dramatically following Paul Volcker's appointment as chairman of the Federal Reserve in August 1979. Inflation in the price index for personal consumption expenditures (PCE) averaged about 7 percent over the second half of the 1970s, about 6 percent over the first half of the 1980s, and only 3½ percent over the second half of the 1980s. Not only has inflation fallen markedly since the early 1980s, but recessions also have become less frequent and less severe. The Business Cycle Dating Committee at the National Bureau of Economic Research records seven recessions during the period 1945–1979, a span of 35 years, but only four recessions during the period 1980–2004, a span of 25 years. Consistent with fewer recessions, McConnell and Perez-Quiros (2000) show that output growth has become less volatile since 1984, although whether this decline in volatility has been due to monetary policy remains an open question (Stock and Watson 2003, Sims and Zha 2004).

Although the Federal Reserve does not have all the characteristics associated with inflation targeting, it has been suggested that the Federal Reserve behaves much like an inflation targeting central bank. Bernanke and Mishkin (1997), for instance, argue that "a major reason for the success of the Volcker-Greenspan Fed is that it has employed a policymaking philosophy, or framework, which is de facto

*I would like to thank Glenn Rudebusch, Carl Walsh, and John Williams for comments and Stephanie Wang for outstanding research assistance.

1. The Federal Reserve does publish forecasts in its Greenbook, but these forecasts are not made public until five years following the FOMC meeting to which they relate. The Federal Reserve also publishes forecasts in its semiannual Monetary Policy Report to the Congress.

very similar to inflation targeting. In particular, the Fed has expressed a strong policy preference for low, steady inflation, and debates about short-run stabilization policies have prominently featured consideration of the long-term inflation implications of current Fed actions" (p. 113). If Bernanke and Mishkin (1997) are correct, then the decline in inflation and the relative prosperity of the last 25 years might be due partly to a form of implicit inflation targeting (see also Goodfriend 2003).

In this article, I investigate whether economic outcomes would have been materially different if the Federal Reserve had adopted a flexible inflation targeting regime when Volcker was appointed chairman in 1979. Following Svensson (1997), I model inflation targeting as the solution to a constrained optimization problem in which stabilizing inflation around an explicit inflation target features prominently. Using a small-scale dynamic New Keynesian model of the business cycle, which is estimated over the Volcker-Greenspan period, I rerun history to see how the economy might have unfolded had such a policy been in place. These counterfactual simulations touch on the issues raised in Bernanke and Mishkin (1997) because I look at whether outcomes with inflation targeting would have been broadly similar to actual outcomes. The estimated model provides the constraints in the optimization problem and it also supplies estimates of the demand and supply shocks.[2] A complicating factor is that the model is one in which households and firms are forward-looking, which introduces issues of time inconsistency. I address these issues, not by taking a stand on whether the Federal Reserve would have been able to commit to future policy actions—something that could never be known—but by considering inflation targeting with both commitment and discretion. With commitment, the Federal Reserve is assumed to be able to tie its hands to a policy strategy, whereas with discretion, the Federal Reserve is assumed to reassess its policy strategy decision by decision. Because I consider both possibilities, I am able to determine the effect time inconsistency can have on actual economic outcomes, and I am able to identify situations where there would have been large incentives at the margin for policymakers to renege on the promises that are inherent to the commitment policy.

The counterfactual simulations I perform are fully dynamic and, as such, they indicate how the economy might have evolved had the Federal Reserve adopted inflation targeting, given the shocks that occurred, according to the model. I find that monetary factors appear to have had little role in determining consumption outcomes but have been more influential for inflation. I also find that time inconsistency would have had nontrivial implications for inflation had inflation targeting been adopted.[3] If inflation targeting had been in place, then inflation could have been lowered much more quickly in the early 1980s with commitment than with discretion, but incentives to renege on the commitment policy would have intensified after low inflation had been achieved.

The exercise I perform relates to the work of Stuart (1996), who considered how interest rates in the United Kingdom would have differed from their historical path if policy had been set according to a Taylor rule (Taylor 1993) or a money growth rule (McCallum 1988). Unlike Stuart (1996), however, who looks at what these rules would have implied for interest rates *given the prevailing state of the economy* (see also McCallum 2000), my simulations illustrate how the economy's path—including interest rates—would have differed from its historical path had inflation targeting been adopted. This exercise also relates to the analyses in Judd and Rudebusch (1998), Stock and Watson (2003), and Orphanides and Williams (2005). However, whereas those papers focus on counterfactuals constructed using estimated Taylor rules (Taylor 1993), I focus on optimal policy rules and on the economic implications of time inconsistency.

The remainder of the article is structured as follows. A small-scale New Keynesian business cycle model is introduced and discussed in Section 2. This model is estimated in Section 3 and the results are compared to other studies in the literature. Section 4 describes the policy objective function that I use to summarize inflation targeting and shows how the inflation targeting policy depends on whether monetary policy is formulated with commitment or discretion. Section 5 presents counterfactual simulations showing how the economy might have played out if inflation targeting had been adopted when Volcker was appointed. These simulations also reveal important differences between the inflation targeting policies with commitment and with discretion. Section 6 concludes.

2. A Simple Macroeconomic Model

I study a relatively standard sticky-price New Keynesian model whose structure describes the aggregate behavior of

2. By construction, the policies that I consider are those that would best achieve the goals and objectives of an inflation targeting central bank, given the policy parameters that I specify. Different policy goals would lead to different inflation targeting policies and to different economic outcomes.

3. This result is in line with Dennis and Söderström (2005), who find that the effects of time inconsistency can be important in hybrid New Keynesian models of the type analyzed here.

households, firms, and the monetary authority. The economy is one in which firms are monopolistically competitive and prices and inflation are "sticky"—that is, they are unable to adjust quickly to clear goods markets. To model this price rigidity, I follow the literature on Calvo-pricing (Calvo 1983) and assume that in each period a fixed proportion of firms, $1-\xi \ (0 \leq \xi \leq 1)$, is able to reoptimize the price charged for their goods. When $\xi = 0$, all firms are able to reoptimize their price each period; when $\xi = 1$, no firms are able to reoptimize their price. The proportion ξ is constant over time, but whether any particular firm can adjust its price in a given period is determined by chance, independent of that firm's history of past price changes. Firms that can reoptimize their price charge the price that maximizes the firm's value, the discounted value of expected future profits. The remaining firms are assumed to index their price change mechanically to last period's aggregate inflation rate (Christiano et al. 2004).

To produce goods, firms hire workers in a perfectly competitive labor market. The economy's production technology transforms labor into goods that can be consumed, with the number of goods produced per worker in a given period shifted by an aggregate technology shock. Christiano et al. (2004) show that the log-linearized first-order condition for optimal price setting can be expressed as a Phillips curve equation in which aggregate inflation, π_t, evolves according to

$$\pi_t = \frac{1}{1+\beta}\pi_{t-1} + \frac{\beta}{1+\beta}E_t\pi_{t+1} + \frac{(1-\beta\xi)(1-\xi)}{(1+\beta)\xi}\widehat{mc}_t, \qquad (1)$$

in which $\widehat{mc}_t$ denotes real marginal costs, $\beta \ (0 < \beta < 1)$ is the subjective discount factor, and E_t is the mathematical expectations operator conditional upon period t information. Because physical capital does not enter into the production technology, real marginal costs equal real unit labor costs, the real wage divided by the marginal product of labor. When estimating equation (1) below, I will employ the approximation $\widehat{mc}_t = \widehat{c}_t + \widehat{u}_t$, where $\widehat{c}_t$ is the consumption gap (defined below) and $\widehat{u}_t$ is a supply shock. Any profits that firms earn are returned to shareholders (households) in the form of a lump-sum dividend payment. One important feature of this Phillips curve is that the price indexing by the non-optimizing firms introduces a lag of inflation into the specification.

On the demand side, households are assumed to be infinitely lived and to have identical preferences over consumption (relative to habit consumption), leisure, and real money balances. The representative household's expected lifetime utility is given by

$$U = E_t\sum_{i=0}^{\infty}\beta^i u\left(C_{t+i}, H_{t+i}, L_{t+i}, \frac{M_{t+i}}{P_{t+i}}\right), \qquad (2)$$

where C_t represents consumption, H_t represents habit consumption, L_t represents labor supply, and $\frac{M_t}{P_t}$, the ratio of nominal money balances to the aggregate price level, represents real money balances.

The household budget constraint is

$$C_t + \frac{M_t}{P_t} + \frac{B_t}{P_t} = \frac{W_t}{P_t}L_t + \frac{(1+R_{t-1})}{P_t}B_{t-1} + \frac{M_{t-1}}{P_t} + \frac{\Pi_t}{P_t},$$

where M_{t-1} and B_{t-1} denote the stocks of money and nominal bond holdings brought into period t, R_t is the nominal interest rate that prevails during period t, W_t is the nominal wage rate, and Π_t combines the lump-sum dividend payment that households receive from firms with transfers from the government that arise from seigniorage revenue.

The utility function (2) is specified to accommodate the possibility that external habit formation may affect a household's consumption decision. With external habits, a household's decisions about how much to consume are shaped by the behavior of other households. Specifically, the representative household's marginal utility of consumption is lowered when other households consume more. In other words, with external habits, households feel worse off when their consumption is low relative to other households, spurring efforts to "catch up with the Joneses."

To model the habit formation I assume that habit consumption, H_t, evolves according to

$$H_t = \gamma C_{t-1},$$

where $0 \leq \gamma < 1$, and that the instantaneous utility function takes the form

$$u\left(C_t, H_t, L_t, \frac{M_t}{P_t}\right) = \frac{e^{\widehat{g}_t}(C_t - H_t)^{1-\sigma}}{1-\sigma} + \frac{\left(\frac{M_t}{P_t}\right)^{1-\alpha}}{1-\alpha} - \frac{L_t^{1+\theta}}{1+\theta},$$

where $\widehat{g}_t$ is an aggregate shock to consumer preferences; σ, α, and θ are curvature parameters that are required to be positive. Larger values of γ increase the importance of habit formation. Utility maximization leads to the following log-linear Euler equation for aggregate consumption:

(3) $$\widehat{c}_t = \frac{\gamma}{1+\gamma}\widehat{c}_{t-1} + \frac{1}{1+\gamma}E_t\widehat{c}_{t+1} - \frac{(1-\gamma)}{\sigma(1+\gamma)}(R_t - E_t\pi_{t+1} - \rho) + g_t,$$

where $\widehat{c}_t$ represents the percent deviation of aggregate consumption from its nonstochastic steady state and the rate of time preference, ρ, is defined according to $\rho = -\ln(\beta)$.

3. Model Estimates

To estimate the parameters in equations (1) and (3), an equation describing the nominal interest rate is needed. For estimation, then, I assume that R_t obeys

(4) $$R_t = (1-\phi_3)[\phi_0 + \phi_1 E_t\pi_{t+1} + \phi_2\widehat{c}_{t-1}] + \phi_3 R_{t-1} + \varepsilon_t,$$

which is in the form of a forward-looking Taylor-type rule (Taylor 1993). The parameters ϕ_1 and ϕ_2 summarize the long-run responses of the federal funds rate to movements in expected inflation and the consumption gap, respectively, while ϕ_3 captures policy inertia, or gradualism (Bernanke 2004). According to this policy rule, policymakers respond to movements in expected future inflation and the (lagged) gap, but these responses are tempered so as to avoid large interest rate changes (see Clarida et al. 1998).

The complete model consists of equations (1), (3), and (4), which are parameterized by ρ, γ, σ, ξ, ϕ_0, ϕ_1, ϕ_2, and ϕ_3. To estimate these parameters, I require data for R_t, $\widehat{c}_t$, and π_t. Because R_t serves as the policy instrument, I measure R_t using the quarterly average of the federal funds rate. To construct the gap, I exploit the fact that the economy's resource constraint equates consumption to output and measure $\widehat{c}_t$ by applying the Hodrick-Prescott filter to total consumption per member of the labor force. Then, because the gap is constructed from consumption data, I measure inflation, π_t, using the annualized quarterly percent change in the PCE price index. Using these data, equations (1), (3), and (4) are estimated using Full Information Maximum Likelihood over the period 1979:Q4, the first complete quarter following Volcker's appointment to chairman, to 2004:Q1.

One of the most interesting and important parameters in the model is the Calvo-pricing parameter, ξ. For this data set, and over this sample period, ξ is estimated to be 0.75, which, because the model is estimated on quarterly data, implies that one firm in four reoptimizes its price each quarter. Alternatively, viewed in terms of durations, $\xi =$ 0.75 implies that the representative firm reoptimizes its price about once per year. Although data, sample periods, and estimation methods differ among studies, this estimate of ξ is broadly in line with the literature. Galí and Gertler (1999), for example, estimate ξ to be between 0.83 and 0.92, while Sbordone (2002) finds 0.63 to 0.72 to be a reasonable range.

Another important behavioral parameter is the habit formation parameter, γ. I estimate γ to equal 0.79, which implies that a household's desire to keep its level of consumption on par or above that of other households imparts considerable inertia in consumption. By way of comparison, Dennis (2004) estimates γ to be between 0.84 and 0.87, while McCallum and Nelson (1999) calibrate γ to 0.80.

I estimate $\frac{1}{\sigma}$, which describes the curvature of utility with respect to consumption (relative to habit consumption), to be about 0.02, which together with the estimate of γ, implies an intertemporal elasticity of substitution of about 0.002. This low estimate of the intertemporal elasticity of substitution suggests that households are relatively unwilling to substitute consumption through time. While small, this estimate of the intertemporal elasticity of substitution is similar to Cho and Moreno (2004) and is consistent with the Campbell and Mankiw (1989) finding that estimates of the intertemporal elasticity of substitution tend to be numerically small and are often statistically insignificant.

The remaining parameters of interest are those in the policy reaction function. I estimate ϕ_1 to be equal to 1.71, ϕ_2 to be equal to 1.81, and ϕ_3 to be equal to 0.83. By way of comparison, over the period 1987:Q3–1997:Q4, Judd and Rudebusch (1998) obtain $\phi_1 = 1.54$, $\phi_2 = 0.99$, and $\phi_3 = 0.78$. The only substantive difference between my estimates and Judd and Rudebusch (1998) lies in the estimate of ϕ_2, largely because their specification uses output data whereas mine uses consumption data. My estimates are also similar to Sack (2000), who obtains $\phi_1 = 1.52$, $\phi_2 = 1.16$, and $\phi_3 = 0.65$, with the exception that I obtain a larger estimate of ϕ_3. Again, my use of consumption data in the reaction function leads to a larger estimate of ϕ_2 than Sack (2000).

Taking my parameter estimates and inserting them into equations (1), (3), and (4), the resulting Phillips curve, consumption Euler equation, and interest rate equation are

(5) $$\pi_t = 0.5018\pi_{t-1} + 0.4982E_t\pi_{t+1} + 0.0430\widehat{c}_t + \widetilde{u}_t,$$

(6) $$\widehat{c}_t = 0.4404\widehat{c}_{t-1} + 0.5596E_t\widehat{c}_{t+1} - 0.0023(R_t - E_t\pi_{t+1} - 2.8197) + \widetilde{g}_t, \text{ and}$$

(7) $$R_t = 0.1676(0.6052 + 1.7091E_t\pi_{t+1} + 1.8149\widehat{c}_{t-1}) + 0.8324R_{t-1} + \varepsilon_t,$$

where, σ_u, σ_g, and σ_ε are estimated to be 1.190, 0.510, and 1.001, respectively, and $\widetilde{u}_t$ and $\widetilde{g}_t$ are the estimated supply and demand shocks.

Equations (5) through (7) illustrate that, despite inertia being introduced through habit formation and through inflation indexing, households and firms remain forward-looking in their decisionmaking. In both the Phillips curve equation (5) and the consumption Euler equation (6), numerically large coefficients are assigned to expected future variables. Similarly, although a strong dose of gradualism is evident in the policy rule, the monetary authority is still forward-looking, responding in accordance with the Taylor principle to movements in expected future inflation.[4] A further point worth noting is that the direct effect of interest rate movements on consumption is small, which means that, to stabilize inflation, monetary policy must operate primarily through private sector expectations of future inflation.

4. Inflation Targeting...

Since I am interested in how history might have unfolded under inflation targeting, I need to define what I mean by this. As discussed in Section 1, by inflation targeting I mean that monetary policy is conducted according to a targeting rule that is derived as the solution to an optimization problem in which (among other things) expected deviations between inflation and an inflation target are penalized. To formalize this, in place of equation (7), I assume that monetary policy is determined so as to minimize

$$Loss = E_0 \sum_{t=0}^{\infty} \beta^t \Big[\left(\pi_t - \pi^*\right)^2 + \lambda \widehat{c}_t^{\,2} + \nu \left(R_t - R_{t-1}\right)^2 \Big], \tag{8}$$

subject to equations (5) and (6).

Equation (8) is widely used in the monetary policy literature to describe the goals and objectives of inflation targeting (Svensson 1997). The function allows for an inflation stabilization objective, a gap stabilization objective, and an interest rate smoothing objective. The inflation target is denoted by π^*, while the weights assigned to gap stabilization and to interest rate smoothing, relative to inflation stabilization, are denoted by λ and ν, respectively. In the terminology of the literature, if λ and ν both equal zero, then the central bank is a strict inflation targeter (or an inflation nutter), since its only concern is to stabilize inflation about π^*, whereas if λ is positive, then it is a flexible inflation targeter. The interest rate smoothing parameter, ν, is not integral to inflation targeting but is present to capture the gradualism, or inertia, that is widely recognized to characterize actual policy behavior. It is assumed that both the inflation target, π^*, and the relative weights, λ and ν, are publicly known.

It should be apparent that the assumption that π^* is known is entirely consistent with the principles of inflation targeting, which requires an announced target, or target range, for inflation. However, the assumption that λ and ν are publicly known goes beyond what inflation targeting central banks generally publicize. Rather, this assumption is made here because it allows the private sector to solve for the central bank's inflation forecasts, which inflation targeting central banks typically do publicize.

The solution to the central bank's optimization problem depends on whether the central bank is able to commit or whether it sets policy with discretion. I consider both possibilities in turn.

4.1. ...under Commitment...

Under commitment, the central bank determines its optimal policy at some specific date and ties its hands to implement that policy, come what may. The reason that the central bank must tie its hands is that when households and firms are forward-looking, policies that are determined to be optimal when viewed from today are not necessarily optimal when viewed from tomorrow. The mere passage of time can render an optimal policy suboptimal. Time inconsistency, as this is known, arises because the optimal policy contains promises about how future policy will be conducted that are designed to shape households' and firms' expectations. In many situations, however, the policy that is promised for the future is not necessarily the one that the central bank would choose to implement when that future date arises.

The assumption that the central bank commits, or ties its hands, boils down to assuming that the central bank does not renege on its announced policies—even if, with the passage of time, it faces incentives to do so. In essence, the central bank designs its optimal policy on a single occasion, taking into account how that policy affects the expectations of households and firms. For their part, households and firms are assumed to understand that the central bank has tied its hands and they allow for this when forming expectations.

Under commitment it can be shown that the economy evolves through time according to

4. According to the Taylor principle, the monetary authority should raise the nominal interest rate more than one-for-one with expected inflation. Following this principle ensures that the ex ante real interest rate rises when expected inflation increases, which serves to help stabilize the economy.

Box 1
MODELING THE COMMITMENT POLICY

To solve for the optimal commitment policy I construct the Lagrangian

$$L = E_0 \sum_{t=0}^{\infty} \beta^t \Big[\left(\pi_t - \pi^*\right)^2 + \lambda \widehat{c}_t^{\,2} + \nu \left(R_t - R_{t-1}\right)^2 + 2\mu_{1t} s_{1t} + 2\mu_{2t} s_{2t} \Big],$$

where

$$(10) \qquad s_{1t} = \varphi_\pi \pi_{t-1} + (1-\varphi_\pi) E_t \pi_{t+1} + \alpha \widehat{c}_t + u_t - \pi_t = 0$$

$$(11) \qquad s_{2t} = \varphi_c \widehat{c}_{t-1} + (1-\varphi_c) E_t \widehat{c}_{t+1} - \phi \left(R_t - E_t \pi_{t+1} - \rho\right) + g_t - \widehat{c}_t = 0 .$$

Differentiating this Lagrangian with respect to π_t, $\widehat{c}_t$, R_t, μ_{1t}, and μ_{2t} yields equations (10) and (11) and

$$(12) \qquad \pi_t + \mu_{1t} - \beta^{-1} \varphi_\pi \mu_{1t-1} - \beta (1-\varphi_\pi) E_t \mu_{1t+1} - \phi \beta^{-1} \mu_{2t-1} = 0 \quad t > 0$$

$$(13) \qquad \lambda c_t - \alpha \mu_{1t} + \mu_{2t} - \varphi_c \beta^{-1} \mu_{2t-1} - (1-\varphi_\pi) \beta E_t \mu_{2t+1} = 0 \quad t > 0$$

$$(14) \qquad \nu \left(R_t - R_{t-1}\right) - \nu E_t \left(R_{t+1} - R_t\right) - \phi \mu_{2t} = 0 \quad t \geq 0 .$$

Because the optimization takes place at a particular point in time, here when $t = 0$, two further necessary conditions for an optimum are $\mu_{10} = 0$, and $\mu_{20} = 0$, which, together with $\pi_0 = \overline{\pi}_0$, $\widehat{c}_0 = \overline{\widehat{c}}_0$, and $R_0 = \overline{R}_0$, tie down the initial state of the economy.

$$(9) \qquad z_t^c = h_0^c + H_1^c z_{t-1}^c + H_2^c v_t ,$$

where $z_t^c = [\ \pi_t \ \ \widehat{c}_t \ \ R_t \ \ \mu_{1t} \ \ \mu_{2t}\ ]'$, $v_t = [\ u_t \ \ g_t\ ]'$, and h_0^c, H_1^c, and H_2^c are coefficient matrices conformable with z_t^c and v_t. A notable feature of the commitment equilibrium is that equation (9) depends not only on π_{t-1}, $\widehat{c}_{t-1}$, and R_{t-1}, but also on two additional variables, μ_{1t-1} and μ_{2t-1}. These additional variables, μ_{1t} and μ_{2t}, are Lagrange, or commitment, multipliers that measure the marginal increase in loss (equation (8)) that would arise from a marginal relaxation of equation (1) and equation (3), respectively. Box 1 shows why these lagged Lagrange multipliers affect the behavior of the economy. The fact that the commitment solution depends on these Lagrange multipliers was first noted by Kydland and Prescott (1980) and lies at the heart of the time-inconsistency problem. Suitably transformed, these commitment multipliers can be interpreted as shadow prices that measure the marginal cost (in terms of loss) of having higher inflation or a higher gap as a result of reneging on policy promises. When μ_{1t} and μ_{2t} are large (in magnitude), so too is the instant gratification the central bank receives by reneging on its policy promises.

4.2. ...and under Discretion

When policy is set with discretion, the central bank does not tie its hands but rather reoptimizes each time a policy decision has to be made. Because the central bank reoptimizes its policy each period, any announcements the bank makes about future policy are not credible to the private sector and are not believed. Consequently, the central bank loses some of the influence over private sector expectations that it would have had if it could commit. Of course, it needs to be borne in mind that although the central bank reoptimizes each period it is not myopic. When choosing its policy, the central bank takes into account the full impact its policies are expected to have on the economy, whether now or in the future.

Without going into detail, it can be shown that when policy is set with discretion the equilibrium takes the form[5]

$$(15) \qquad z_t^d = h_0^d + H_1^d z_{t-1}^d + H_2^d v_t ,$$

where $z_t^d = [\ \pi_t \ \ \widehat{c}_t \ \ R_t\ ]'$, and h_0^d, H_1^d, and H_2^d are coefficient matrices conformable with z_t^d and v_t.

5. Inflation Targeting as a Counterfactual to History

The previous section discussed inflation targeting and showed how to think about inflation targeting policies under commitment and discretion. Section 3 presented estimates of a simple dynamic model of the U.S. economy. In this section I combine the estimated model with inflation targeting and generate counterfactual data in a model sim-

5. See Dennis (2001) and the references therein.

ulation that can be compared to what actually occurred. This exercise is interesting for several reasons. First, it speaks to the issue of whether inflation's decline in the early 1980s was plausibly due to monetary policy or whether it was likely due to luck. Second, the counterfactual simulations illustrate how policymakers might have behaved differently had they pursued flexible inflation targeting. Third, the differences between the commitment counterfactual and the discretion counterfactual highlight the effect time inconsistency can have on actual outcomes. Finally, by tracking the commitment multipliers as the state of the economy changes I can identify times during the past 25 years when, if they had been able to commit, policymakers would have faced strong incentives to renege on their policy promises.

To determine how the economy might have evolved under inflation targeting, the optimization constraints, equations (10) and (11), are parameterized according to their empirical counterparts, equations (5) and (6). By design, the parameters in these optimization constraints are structural, relating to preferences and technology, and should be invariant to the Federal Reserve's policy rule.[6] Given the estimated constraints, the economy evolves according to equation (9) under commitment and equation (15) under discretion. Because the estimated demand and supply shocks enter equations (5) and (6), the data generated by these counterfactual simulations indicate how the economy would have evolved under inflation targeting, *given the shocks that are estimated to have occurred.*[7] Of course, to obtain equations (9) and (15), which are essential for the simulations, I must supply values for λ and ν.[8] I use a standard parameterization, setting λ equal to 1.0, which implies that the weight on consumption stabilization is equal to that on inflation stabilization, and setting ν equal to 0.5, giving a modest role for policy gradualism (Rudebusch and Svensson 1999).

5.1. A Commitment Counterfactual

Assume that the Federal Reserve had adopted an inflation target when Volcker was appointed chairman and that the Federal Reserve had been able to tie its hands and implement a commitment policy. In other words, assume that in 1979:Q4 the Federal Reserve solved for the optimal commitment policy, given the state of the economy in 1979:Q3, and that the policy chosen at that time is the one that has been applied ever since.

Given the estimated model, the estimated demand and supply shocks, and the assumed policy objective function, Figure 1 traces out how the economy would have evolved from its position in 1979:Q3 until 2004:Q1, if the Federal Reserve had pursued inflation targeting and had set policy with commitment.

Panel C shows the path for the federal funds rate with the inflation targeting policy (dashed line) alongside the path that the federal funds rate actually followed (solid line). Relative to the actual path, there are three periods when inflation targeting would have led to tighter policy and two main periods when it would have led to looser policy. In the early 1980s, soon after Volcker was appointed and when inflation was high, an inflation targeting policy would have raised interest rates much more than the historical policy. With higher interest rates, the inflation targeting policy would have lowered the consumption gap (panel B) and tempered expectations of future inflation, both of which would have exerted downward pressure on inflation (panel A). In fact, if the inflation targeting policy had been implemented, then inflation would have declined to around target by early 1982. Of course interest rates would have remained high somewhat beyond 1982, the consequence of a policy promise that must be honored to keep interest rates high for a sustained period, which helped to secure the quick reduction in inflation. It is worth noting that the differences between the actual policy and the inflation targeting policy around this time are not trivial. With inflation targeting, the nominal federal funds rate would not have been cut in 1980:Q2 and it would have been raised by as much as 7.8 percentage points higher than the policy actually followed.

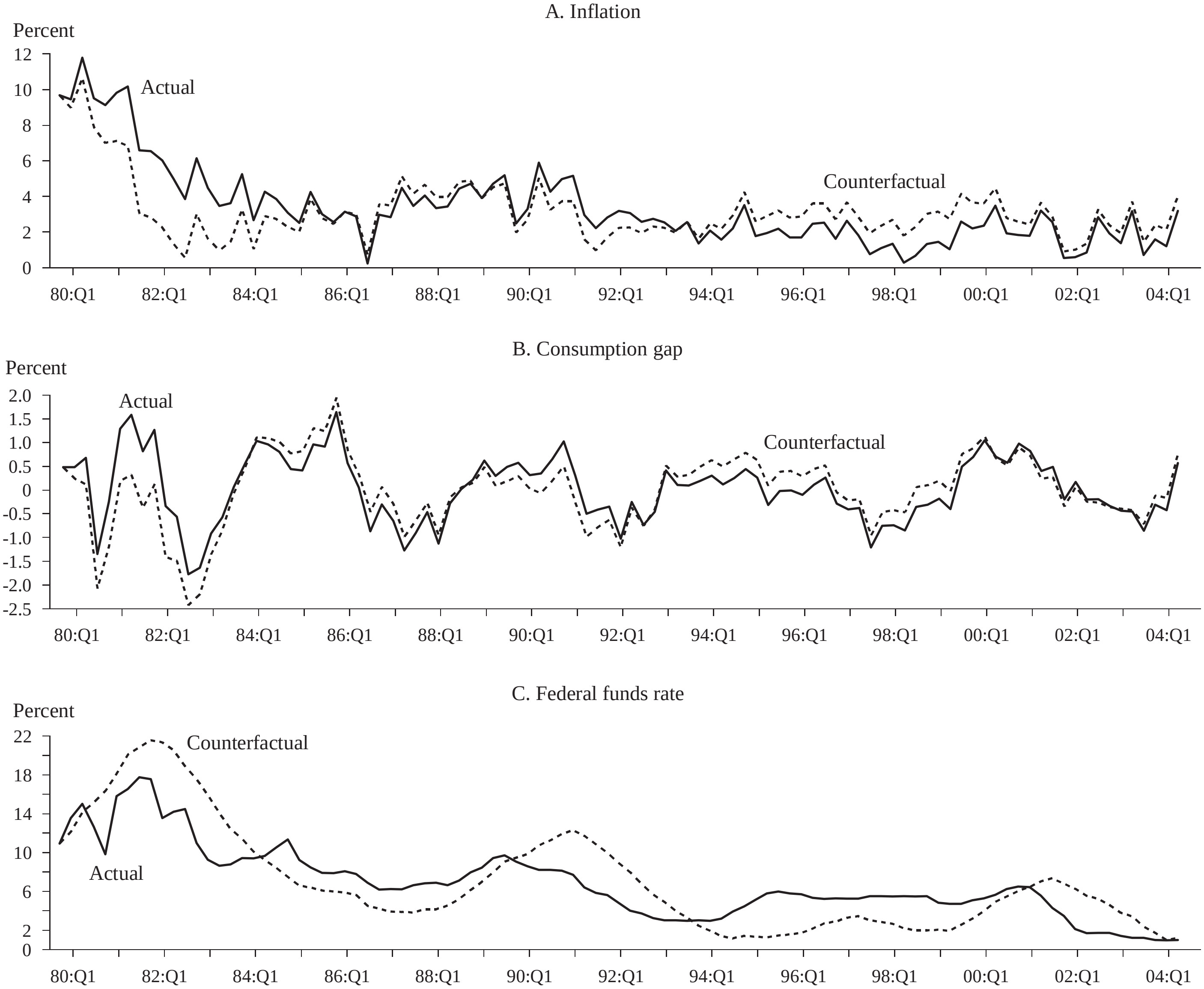
During the mid- to late 1980s, interest rates would have been lower with inflation targeting than their historical level. By this time, inflation would have been lowered to near target, and with the expectation that inflation would remain low in place, a looser policy than that actually implemented would have been possible and would have raised consumption. By the late 1980s, however, rising demand brought about by low interest rates would have allowed inflationary pressures to build up. To keep inflation in check, the inflation targeting policy would have recommended that interest rates be higher than they were at that time, but this would have been followed by a sustained period of lower interest rates that would have ended only when inflation began to pick up in 2000. Interestingly, although inflation targeting would have lowered interest

6. Because these behavioral parameters do not depend on the policy rule, these counterfactual simulations should be immune to the Lucas (1976) critique.

7. It is worth noting that, although these simulations are fully dynamic, the underlying model is estimated only once. It would be interesting, although difficult, to augment the analysis with real-time estimation supported by real-time data.

8. For the inflation target, π^*, I extract and use the estimate implied by equations (5) and (6).

FIGURE 1
ECONOMIC OUTCOMES UNDER COMMITMENT, ACTUAL AND COUNTERFACTUAL



rates relatively slowly during the most recent downturn, by 2004:Q1 the inflation targeting policy would be pretty similar to the actual policy.

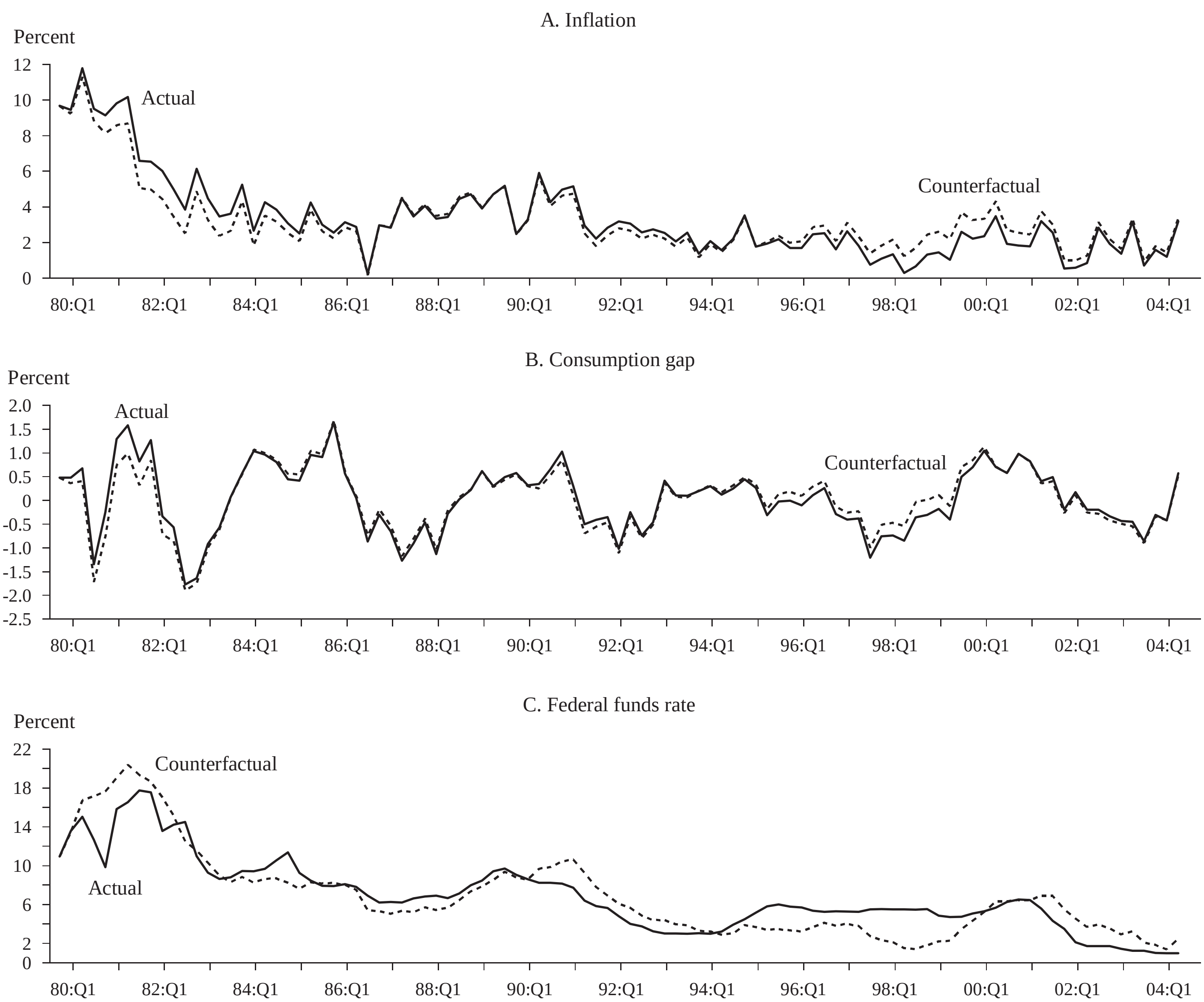
Looking at the consumption gap, the greatest differences between the actual policy and the inflation targeting policy occur during the 1990s and in the early 1980s. In the 1990s, higher consumption would have been possible with inflation targeting, with positive supply shocks and an absence of positive demand shocks allowing interest rates to remain low. But in the early 1980s, the inflation targeting policy would have led to lower consumption as part of the effort to subdue inflation.

Overall, the key differences between the two policies are that the inflation targeting policy would have lowered inflation more quickly in the early 1980s and that it would have allowed inflation to pick up more in the late 1990s. The fact that the inflation targeting policy is formulated with commitment, with the implication that policy promises must be honored, leads to periods when policy is systematically and enduringly tighter or looser than the policy actually pursued. Despite these apparent differences, since the counterfactual inflation targeting policy is determined using dynamic simulation, it is actually striking that the differences between the two consumption paths and the two inflation paths are not more pronounced, a result that touches on the arguments in Stock and Watson (2003) and Sims and Zha (2004), which is that good luck has been important for the success of the 1980s and 1990s.

5.2. A Discretionary Counterfactual

Having seen how history might have unfolded with inflation targeting under commitment, here I consider what might have happened if inflation targeting had been adopted and policy had been set with discretion. As noted earlier, with discretion the desired policy is reevaluated each period rather than determined once and for all at some specific date. Because the policy is reevaluated at each point in time, announcements about future policies are not credible and policymakers have less control over expected inflation. For the same model, the same shocks, and the same policy regime parameters ($\lambda = 1.0$ and $\nu = 0.5$), Figure 2 shows how the economy might have evolved between 1979:Q4 and 2004:Q1, given its position in 1979:Q3, if inflation targeting had been adopted and policy had been set with discretion. As earlier, the solid lines relate to actual outcomes while the dashed lines relate to the inflation targeting counterfactual; panels A through C show the paths for inflation, the consumption gap, and the federal funds rate, respectively.

FIGURE 2
ECONOMIC OUTCOMES UNDER DISCRETION, ACTUAL AND COUNTERFACTUAL



The first thing to note about Figure 2 is that the counterfactual data are quite similar to the actual data, particularly the consumption gap and especially since 2000. Of course, because the simulated data are sensitive to the policy regime parameters, λ and ν, this need not have been the case. However, for the standard parameterization of the policy objective function used here, the actual data can be more easily reconciled with inflation targeting if monetary policy is set with discretion rather than with commitment.

Turning to the details, in the early 1980s the inflation targeting policy would have raised the federal funds rate by more than the actual policy, and this would have lowered inflation more quickly. Unlike the commitment policy, however, with discretion the federal funds rate declines rapidly after inflation is lowered. Because the inflation targeting policy is effective at bringing inflation down and keeping it stable, interest rates over the middle part of the 1980s would have been lower than was historically the case and would only have risen above the historical path in 1990. During the second half of the 1990s the inflation targeting policy would have kept interest rates low, allowing inflation to rise by more than it did at that time. While inflation would have been higher, the benefit would have come in the form of higher consumption. Interestingly, with inflation targeting, outcomes for inflation and the consumption gap after 2000 would have been similar to their historical outcomes, but the federal funds rate would have declined more gradually. With both the consumption gap and the inflation rate picking up in 2004, the inflation targeting policy would have suggested a small policy tightening in 2004:Q1.

One implication of Figure 2 is that, for this benchmark policy regime at least, if policy had been set with discretion, then inflation targeting would have led to paths for consumption and inflation that are very similar to those that actually occurred. This, of course, does not mean that the Federal Reserve has pursued inflation targeting and set policy with discretion (the greatest differences between the simulation and reality occur for the federal funds rate), but it is consistent with the Bernanke and Mishkin (1997) argument that the Federal Reserve's policy framework is similar to inflation targeting.

5.3. *The Marginal Value of Promises Broken*

In this subsection, I set aside the economy's actual path and compare the two inflation targeting policies. Theory already shows something about the characteristics of the two policies, for instance, that the commitment policy will reflect an optimal degree of interest rate inertia, inertia that emerges (even when $\nu = 0$) because policymakers must respond to changes in economic circumstances while honoring promises made in the past (Woodford 1999). Theory also shows that the discretionary policy will lead to a stabilization bias, that is, a tendency for consumption to be overstabilized and for inflation to be understabilized (Dennis and Söderström 2005). Putting theory aside, I look at the differences between the commitment and discretionary policies in terms of actual economic outcomes. I also look at how the instant gratification policymakers receive by reneging on policy promises varies with the state of the economy.

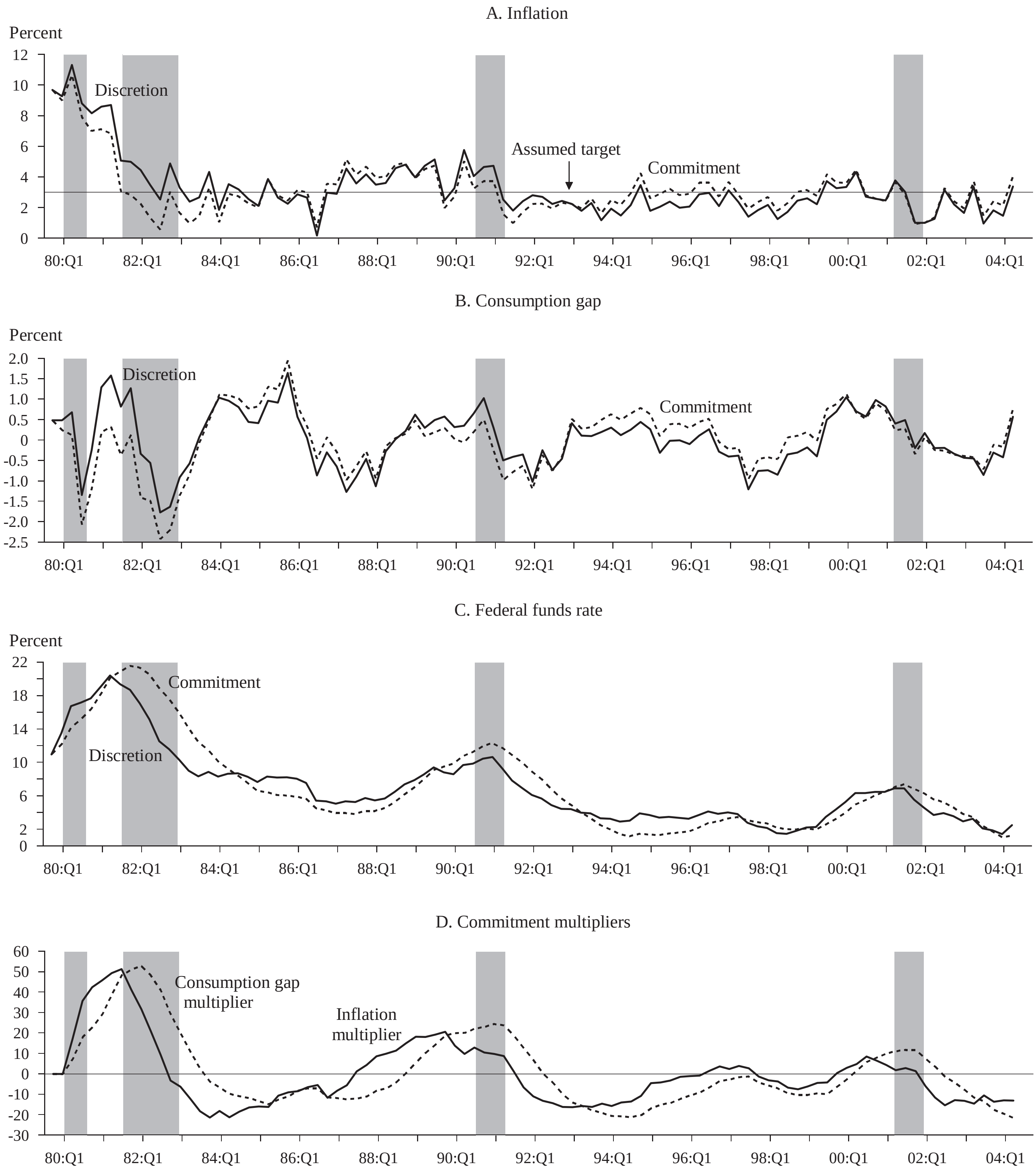
Figure 3 combines the data on inflation, the consumption gap, and the federal funds rate from the two counterfactual policies and displays them in panels A through C, respectively. Panel D shows the values for μ_{1t} and μ_{2t} that correspond to inflation targeting under commitment.[9] To interpret these multipliers, note that there is the incentive to renege on announced policies whenever they do not equal zero. When μ_{1t} and μ_{2t} are positive, then the policymaker benefits at the margin by reneging on promises so as to lower inflation and the gap, respectively.

Looking at panel B, it is clear that, in terms of broad contours, the consumption gap that might have been observed had inflation targeting been adopted in 1979:Q4 is relatively unaffected by whether the Federal Reserve could have tied its hands. If the Federal Reserve could have committed, then consumption would have been a bit lower in the early parts of the 1980s and 1990s and a bit higher in the mid-1980s and mid-1990s. Since about 1996, however, the consumption gap would have followed pretty much the same path. Turning to panel C, the interest rate inertia that is known to characterize commitment policies is readily apparent. The rise in interest rates associated with bringing inflation down in the early 1980s is both larger and more enduring with commitment than with discretion; similar behavior can be observed when inflation begins to rise in the early 1990s.

Of course, what really stands out when panels B and C are compared is how little the consumption gap paths differ given how different the interest rate paths are, which indicates that consumption outcomes are relatively invariant to monetary policy factors. The main reason why monetary policy has little effect on consumption is the small estimate of the intertemporal elasticity of substitution in the consumption equation (6). Because the direct effect of interest rates on consumption is small, the expectations channel, by

9. In fact, the Lagrange multipliers shown in panel D are a transform of the μ_{1t} and μ_{2t} discussed in Section 4.1. The transformed Lagrange multipliers measure the instantaneous increase in the loss function that would occur by reneging on a promise and allowing marginal increases in inflation or the consumption gap. These multipliers are equivalent to those that would be obtained if the optimization constraints (equations (1) and (3)) had been expressed in state-space form.

Figure 3
Incentives to Renege on Policy Promises: Outcomes under Discretion and Commitment



Note: Gray bars indicate NBER recessions.

which expected inflation influences actual inflation, is crucial for stabilizing inflation. The large differences between the paths for the federal funds rate emerge, then, as the commitment policy employs promises of sustained policy interventions to gain leverage over inflation expectations. The impact these policy promises would have on inflation is evident in panel A, which shows the counterfactual paths for inflation and the estimated inflation target. Particularly in the early 1980s when inflation was above target, by sticking to its promise to keep the federal funds rate high, monetary policy is able to orchestrate a rapid disinflation.

Finally, I turn to the time paths for the commitment multipliers shown in panel D. Because the commitment policy has the Federal Reserve reneging on any policy promises made prior to 1979:Q4 both multipliers equal zero at that date. After 1979:Q4, however, the inflation multiplier and the consumption multiplier both turn sharply positive and remain positive until 1982:Q3 and 1983:Q3, respectively. One thing that panel D makes clear is that the two multipliers are positively correlated, which is to be expected because the model implies that (all else constant) a higher consumption gap will raise inflation. In other words, reneging on a policy promise with the intention of raising consumption, which then boosts inflation, is broadly equivalent to reneging on a policy promise with the intention of raising inflation.

According to the model, both commitment multipliers would turn sharply positive in the early 1980s. With inflation already above target, the central bank would find it very costly to renege on a policy promise if reneging led to even higher inflation, but it would benefit if reneging led to lower inflation. With this intuition, it is reasonably clear that the inflation multiplier is generally negative when inflation is below target and generally positive when inflation is above target. Interestingly then, having used promises that interest rates would remain high to bring inflation down in the early 1980s, once inflation has been lowered the central bank would face incentives to renege on the promised tight policy and allow higher inflation. Two other occasions when the central bank would like to renege on promises in order to raise inflation are the early 1990s and the period after 2001. Notably, all three of these occasions are immediately preceded by recessions. Because inflation tends to decline during recessions, it is intuitive that incentives not to follow through on a high interest rate policy will emerge after recessions. On other occasions the policymaker would have faced incentives to renege on promises for the purpose of lowering inflation or the consumption gap.

6. Conclusions and Caveats

This article has looked at how the economy might have evolved differently had the Federal Reserve adopted inflation targeting at the time Volcker was appointed chairman. Using an estimated New Keynesian business cycle model I recreate how history might have unfolded with an inflation targeting policy, conditional on the demand and supply shocks that are estimated to have occurred. Because households and firms are forward-looking, time inconsistency is an issue that I address by considering both inflation targeting with commitment and inflation targeting with discretion.

Employing a standard loss function used in the literature to describe inflation targeting, I find that inflation targeting policies would have lowered inflation more quickly in the early 1980s than the policy pursued at the time. This is particularly the case for inflation targeting with commitment, which would have used the promise that interest rates would remain high for a sustained period to gain leverage over private sector inflation expectations. Interestingly, the simulations indicate that inflation targeting would have produced paths for consumption that are broadly similar to historical outcomes, regardless of whether policy is set with commitment or discretion, suggesting that monetary policy factors have not been especially pivotal for consumption outcomes. For inflation, however, whether policy is set with commitment or discretion is important. With commitment, the inflation targeting policy in the early 1980s would have raised the federal funds rate by more, and for longer, than the discretionary policy and would have brought inflation down more quickly. Whether policy is set with commitment or discretion also matters during the 1990s. In the early 1990s the discretionary policy would have allowed inflation to rise more in response to shocks, but the opposite is the case in the mid- to late 1990s. Looking at the commitment multipliers, I find that the central bank would want to renege on its policy promises in order to raise inflation when inflation is below target, which historically has tended to be the case after recessions. This makes sense because it implies that, following recessions, policymakers would want to renege on promises to keep interest rates high.

Although the simulations suggest that inflation targeting with discretion would have produced paths for inflation and consumption that are very similar to those actually experienced, consistent with Bernanke and Mishkin (1997), this result hinges on several important assumptions. The counterfactual simulations assume that monetary policy is formulated and implemented quarterly, which is obviously a simplification since the Federal Reserve's Open Market Committee meets formally eight times per year, and intermeeting interventions are not only possible, but do occur. The simulations also assume that households and firms fully understand that a switch to inflation targeting has occurred with Volcker's appointment and that they do not have to infer the regime change from observed outcomes and policy behavior. Furthermore, although the counterfactual simulations were conducted using standard weights on the target variables, how the economy responds to shocks depends on these parameters. Even more importantly, the simulations rely on the estimated model, which may or may not have the correct structure. Because this model shapes the counterfactual simulations, if it is incorrectly specified, then the simulations themselves may be misleading.

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