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Opportunistic and Deliberate Disinflation under Imperfect Credibility

One strategy for disinflation prescribes a deliberate path toward low inflation. A contrasting opportunistic approach eschews deliberate action and instead waits for unforeseen shocks to reduce inflation. This paper compares the ability of these two approaches to achieve disinflation—and at what cost. We analyze these issues using the Federal Reserve's FRB/US model, which allows alternative assumptions to be made about expectations held by agents in the economy; hence, the credibility of the central bank can be considered in assessing the cost of deliberate and opportunistic disinflations.

CENTRAL BANKS IN DIFFERENT COUNTRIES have adopted different strategies for achieving price stability. One approach is to take a *deliberate* path to an ultimate goal of low inflation. In the past decade, this approach has often been followed using explicit inflation targets [as described in Leiderman and Svensson (1995) and Haldane (1995)]. For example, in early 1990, New Zealand's central bank announced interim inflation target ranges of 3 to 5 percent by the end of 1990 and 1.5 to 3.5 percent by the end of 1991, as well as an ultimate inflation target range of 0 to 2 percent by the end of 1992. Similarly, in February 1991, with Canadian core inflation of about 4 percent, the Bank of Canada (1991) announced a deliberate disinflation with a target of 3 percent by the end of 1992 and an ultimate target of 2 percent by the end of 1995.

In contrast to a deliberate approach, an *opportunistic* strategy for disinflation has recently gathered attention.[1] An opportunistic disinflation policy also assumes an ultimate target of low inflation; however, except when inflation is too high, the oppor-

Helpful comments were provided by two anonymous referees, by seminar participants at the 1997 NBER Summer Institute, the 1998 Cambridge, United Kingdom, conference of the Society for Computational Economics, the IIES at Stockholm University, and the Swedish Riksbank, as well as by the authors' colleagues in the Federal Reserve System. They thank Steve Sumner for excellent research assistance. The opinions expressed in this paper are not necessarily shared by anyone else in the Federal Reserve System.

1. For example, see Orphanides and Wilcox (1996), Rudebusch (1996), Meyer (1997), and Orphanides et al. (1997). Like our paper, the last of these studies also investigates opportunism with simulations of an econometric model with explicit expectations. However, the authors do not consider credibility and use a definition of opportunism that is akin to "inflation zone targeting."

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Journal of Money, Credit, and Banking, Vol. 32, No. 4 (November 2000, Part 1)

tunistic policymaker's interim inflation target is simply the current rate of inflation. Thus, the opportunistic strategy typically eschews deliberate action to reduce inflation, and instead waits for unforeseen shocks to reduce inflation. An opportunistic strategy for disinflation was described by a participant at the FOMC meeting in December 1989: "Now, sooner or later, we will have a recession. I don't think anybody around the table wants a recession or is seeking one, but sooner or later we will have one. If in that recession we took advantage of the anti-inflation [impetus] and we got inflation down from 4-1/2 percent to 3 percent, and then in the next expansion we were able to keep inflation from accelerating, sooner or later there will be another recession out there. And so, . . . we could bring inflation down from cycle to cycle . . . ." Indeed, the gradual ratcheting down of inflation over time is the hallmark of the opportunistic approach. As long as inflation is not too high, the opportunistic policymaker takes no deliberate action to reduce inflation further, but waits to exploit recessions and favorable supply shocks to lower inflation. When inflation gets pushed down by a shock, the interim inflation target is reset to equal the new prevailing lower rate, and, in this fashion, price stability is eventually achieved.

How should a policymaker choose, on *economic* terms, between deliberate and opportunistic strategies for disinflation? Two key concerns are the timing and the cost of the disinflation. An opportunistic approach, which waits for shocks, will almost certainly take longer to reach price stability than a deliberate approach. However, an opportunistic strategy may be able to achieve disinflation at a lower cost, for example, by taking advantage of unforeseen negative price shocks rather than having to create excess slack in the economy. The answer to the choice between these two approaches to disinflation depends, in part, on the nature and the frequency of the shocks that affect the economy.

The costs of a disinflation are also commonly believed to depend on the credibility of the central bank's commitment to the new lower inflation target. Indeed, a major impetus behind the historical adoption of deliberate disinflation policies with explicit inflation targets was the view that by clearly communicating a low inflation goal to the public and by taking transparent actions to achieve that goal, the costs of disinflation could be lowered. As noted in the press release by the Bank of Canada (1991) at the initial announcement of its inflation targets: "The intention in setting out explicit targets . . . is to encourage Canadians to base their economic decisions on this downward path for inflation so that the lower inflation will be more readily achieved. . . ." That is, if people believe that inflation will indeed fall, then inflation may be reduced with a smaller cost in terms of lost output and employment. In contrast, during an opportunistic disinflation, a lack of credibility may be a concern. The continued use of the current inflation rate as an interim target may foster questions about the importance of the professed ultimate target of low inflation. Also, the future path of the interim inflation target depends to a very large extent on the size and distribution of future shocks to the economy. Thus, the absence of transparent announcements and decisive action under opportunism could well reduce credibility and undermine disinflationary expectations.

In this paper, we shall explore these issues. In the next section, we describe two simple policy rules that capture the essence of the deliberate and opportunistic approaches to disinflation. In section 2, we define credibility and describe how credibility can be gained and lost over time. Section 3 outlines the empirical macroeconomic model of the U.S. economy that we use—the Federal Reserve's FRB/US model. Our discussion of this model focuses on its expectational structure and on the costs of disinflation. Section 4 presents our simulation results, and section 5 concludes.

1. ALTERNATIVE APPROACHES TO DISINFLATION

This section defines deliberate and opportunistic approaches to disinflation. For both approaches, the impetus for the disinflation comes from a reduction in the ultimate inflation target, π_t^{**}. After adoption of a new lower ultimate inflation target, the deliberate policymaker immediately begins to take consistent actions to reach that goal. We model this behavior by assuming that the deliberate policymaker follows a simple variant of the Taylor (1993) rule:

$$i_t = r^* + \bar{\pi}_{t-1} + \beta_1(\bar{\pi}_{t-1} - \pi_t^{**}) + \beta_2 y_{t-1} \quad (1)$$

where i_t is the nominal short-term policy interest rate (the federal funds rate), r^* is the equilibrium real short-term rate (which is assumed to be known), $\bar{\pi}_t$ is the four-quarter inflation rate, and y_t is the real output gap. In this rule, the policymaker does not have access to current-quarter data, but must conduct policy with a one-quarter data lag (McCallum 1999).[2] That is, the deliberate policymaker consistently strives to eliminate inflation deviations from the ultimate target.

The opportunistic policymaker behaves somewhat differently. We assume that the opportunistic policymaker announces an *interim* inflation target, π_t^*, and an ultimate inflation target, π_t^{**}, and sets the short-term interest rate according to

$$i_t = r^* + \bar{\pi}_{t-1} + \beta_1(\bar{\pi}_{t-1} - \pi_t^*) + \beta_2 y_{t-1}\,. \quad (2)$$

Equation (2) is identical to (1) in all respects, except that the opportunistic policymaker sets the short rate according to the gap between lagged inflation and the *interim* inflation target. To capture the essence of the opportunistic approach to disinflation, we assume that the interim target evolves according to

$$\pi_t^* = \min(\pi_{t-1}^*, \bar{\pi}_{t-1}) \quad (3)$$

2. Of course, there are many possible rules that could be consistent with a deliberate approach to disinflation, see, for example, Rudebusch and Svensson (1999). The use of a one-quarter data lag is, of course, merely a rough approximation to the problem of real-time data uncertainty(see Rudebusch 1999, 2000).

with π_t^* bounded from below by π_t^{**}.

Equations (2) and (3) imply that as long as inflation is stable ($\bar{\pi}_t = \bar{\pi}_{t-1}$), the opportunistic policymaker takes no action to reduce it. However, the opportunistic policymaker will attempt to prevent prices from accelerating further. Also, if actual inflation happens to fall below the interim target—because of an unanticipated recession or favorable supply shock—then the opportunistic policymaker resets the interim target to the newly achieved lower inflation. This process continues until the disinflation is achieved and the interim and ultimate targets are equal.

2. MONETARY POLICY CREDIBILITY

In the previous section, we introduced the interim and ultimate inflation targets in the rules for monetary policy. Here, we define monetary policy credibility through the relationship between these inflation targets and inflation expectations. We also consider the achievement and the maintenance of credibility.

Our definition of central bank credibility is straightforward. At the beginning of each period, a deliberate central bank announces an ultimate inflation target, while an opportunistic central bank announces both interim and ultimate targets. The private sector must evaluate the future reliability of these targets. Agents must judge the central bank's credibility of intent—that is, whether the target represents the true goal of the central bank—and its credibility of action—that is, whether the central bank has the ability to meet the target even if it wants to (say, in the face of fiscal constraints). We measure overall credibility by the extent to which the pronouncement of a target is believed by the private sector in the formation of their inflation expectations.[3]

Specifically, we assume that period-t expectations of ultimate inflation target at time t, denoted $\pi_{t|t}^{**}$, are a weighted average of the current target and last period's (four-quarter) inflation rate:

$$\pi_{t|t}^{**} = \lambda_t^U \pi_t^{**} + (1 - \lambda_t^U)\bar{\pi}_{t-1} \,. \tag{4}$$

The parameter λ_t^U (with $1 \geq \lambda_t^U \geq 0$) indexes the ultimate target credibility of the central bank. If $\lambda_t^U = 1$, there is perfect credibility, and private sector's long-run inflation expectations will be equal to the announced long-run goal of the policymaker. If $\lambda_t^U = 0$, there is no credibility, and the inflation target is ignored in the formation of expectations. Intermediate values of λ_t^U represent the partial credibility of the an-

3. This definition of credibility differs from much of the theoretical literature, which stresses incentive compatibility in a game-theoretic setting. In an empirical context, we focus on the outcome of such compatibility as the alignment of expectations and targets. Our measure of credibility is precisely the one employed by King (1995) who analyzes the difference between long-run inflation expectations (derived from nominal and real yield curves) and inflation targets. It is also close to the expectational definitions in Johnson (1997a, 1997b) and Croushore and Koot (1994), who employ short-run inflation expectations from surveys.

nounced ultimate inflation target. With representative agents, λ_t^U may represent the subjective probability that an agent attaches to the future achievement of the target. With heterogeneous agents, λ_t^U could be considered the fraction of the population that believes the target will be achieved.

Similarly, for the opportunistic policymaker's interim inflation target, we assume that target expectations at time t, denoted $\pi^*_{t|t}$, are a weighted average of the just-announced target and last period's (four-quarter) inflation rate:

$$\pi^*_{t|t} = \lambda_t^I \pi_t^* + (1 - \lambda_t^I)\bar{\pi}_{t-1} \,. \tag{5}$$

The parameter λ_t^I (with $1 \geq \lambda_t^I \geq 0$) indexes the credibility of the central bank's interim inflation target.

Credibility as indexed by λ_t^U or λ_t^I is unlikely to be exogenous. The weight that agents place on the announced target plausibly reacts to developments in the economy. For example, targets that are egregiously missed on a consistent basis are likely to be down-weighted in the formation of expectations. There are many possible channels through which economic developments could affect the evolution of credibility. We consider three different mechanisms for endogenous credibility.

In our first mechanism, credibility is established by *outcome*. If past inflation matches the inflation target, then the target is given more weight by the private sector in the formation of expectations of future inflation. In this formulation, credibility evolves according to

$$\lambda_t^U = 1 - \alpha|\bar{\pi}_{t-1} - \pi_t^{**}| \quad \text{and} \tag{6}$$

$$\lambda_t^I = 1 - \alpha|\bar{\pi}_{t-1} - \pi_t^*| \,. \tag{7}$$

That is, credibility is reduced in a linear fashion as (the absolute value of) the deviation of past inflation from the target increases (with the bound $\lambda_t^U \geq 0$ and $\lambda_t^I \geq 0$).

Our second mechanism allows credibility to be established by the *behavior* of the central bank. Here agents are more forward-looking than in the first formulation. Agents do not just consider inflation over the immediate past, but they assess the stance of monetary policy and forecast inflation one year ahead ($\pi_{t+4|t-1}$). As the near-term forecast for inflation is closer to the target, then, irrespective of past inflation, credibility is higher. Specifically, our formulation is

$$\lambda_t^U = 1 - \alpha|\pi_{t+4|t-1} - \pi_t^{**}| \quad \text{and} \tag{8}$$

$$\lambda_t^I = 1 - \alpha|\pi_{t+4|t-1} - \pi_t^*| \,. \tag{9}$$

Thus, if the central bank can take actions that can focus near-term inflation expectations on its goal, its target credibility will increase even though past inflation has not matched the target.

It should be noted that these mechanisms for the establishment of credibility by outcome and by behavior are broadly similar to those used in the theoretical literature on acquiring credibility (or reputation) in repeated games [as surveyed in Rogoff (1989) and Blackburn and Christensen (1989)]. However, that literature has typically employed "trigger" mechanisms that assumed a quick and complete collapse of credibility after even a minor failure by the policymaker to meet the target. Equations (6) and (8), while in the same spirit, can display more plausible macrodynamics because variation in α allows more flexibility in modeling how much and how quickly agents revise their inflation expectations in response to missed targets.[4]

Finally, in our third channel, credibility may be enhanced merely by the *announcement* of transparent goals for inflation. In forming long-run inflation expectations, the public may place a higher weight on inflation targets that are clearly and unambiguously stated. Indeed, as noted in the introduction, the recent adoption of deliberate disinflation paths with explicit inflation targets by various central banks was motivated in part by the belief that some credibility could be established by announcement. Such a perspective is not that surprising at central banks where policymakers who are less than circumspect often find that their off-the-cuff comments can move financial markets (and sometimes there is intended "jaw-boning" as well). Still, there is much skepticism about credibility by announcement. Presumably, agents do not just listen to policymakers' words but also judge their underlying preferences and incentives. Targets are easy to announce but may be hard to deliver. The empirical evidence on credibility by announcement is decidedly mixed, but there is some evidence that past policy announcements of deliberate disinflations had some small effect on inflation expectations (for example, Johnson 1997a, 1997b; Amano et al. 1997; Spiegel 1998). We shall consider this possibility in some of our simulations by boosting credibility immediately after the announcement of a deliberate disinflation slightly above what the forward-looking specification (8) would suggest.

3. THE MODEL

The FRB/US model that we employ in our analysis is a large-scale macroeconometric model of the U.S. economy with an explicit expectational structure and was developed at the Federal Reserve Board for analysis and forecasting. Its long-run structure is akin to a neoclassical growth model: Economic growth is solely a function of population and technology growth, and inflation is determined by the ultimate inflation target implicit in the specification of monetary policy. In the short run, however, because of adjustment costs and other dynamic frictions, households and firms are often away from their long-run equilibrium paths, and monetary policy can have significant short-run effects on real activity. Below, we highlight two aspects of

4. While we view our mechanisms for endogenous credibility as plausible, there are other candidates in the empirical literature. For example, Fuhrer and Hooker (1993) and Huh and Lansing (2000) consider learning mechanisms that are perhaps more rigorous in formulation, but would be difficult to implement with our nonlinear policy rule.

the specification that are most relevant for our analysis: the costs of adjustment and the formation of expectations.[5]

3.1 Evolution of Key Macro Variables

Two distinct modeling approaches were used in the construction of FRB/US. Nonfinancial variables are assumed to evolve according to a generalized adjustment cost framework. Financial markets are governed by standard arbitrage equilibrium conditions.

Nonfinancial Markets. Firms set prices and make factor allocation decisions under imperfect competition. Households make consumption decisions in the context of a life-cycle framework. We shall use the firms' price-setting problem to illustrate the general modeling approach used in all key nonfinancial equations of FRB/US.[6] In doing so we shall pay special attention to the role played by expectations in the model's dynamics.

Nonfinancial variables are modeled according to two basic tenets. First, all economic agents are assumed to be forward looking, with their expectations of future conditions explicitly modeled in all key behavioral equations. Second, decision making in all nonfinancial markets is subject to nontrivial adjustment costs or frictions that prevent agents from instantaneous reaching their long-run or "target" factor allocations and prices. In practice, this approach is implemented by assuming that agents follow a two-state decision-making process. In the first stage, target values for all decision variables are determined; these are the values that would prevail in the absence of adjustment costs. For instance, given imperfect competition and a Cobb-Douglas production function, target prices (p_t^*) are a function of marginal costs of production (c_t) and a cyclical mark-up. In the second stage of the decision-making process, agents seek to close the gap between actual and target values of their decision variables subject to adjustment costs. Again using price setting as an illustration, the second-stage decision problem reduces to solving the cost minimization problem:

$$\min C_t = E_{t-1} \sum_{i=0}^{\infty} \beta^i \left[b_0 (p_{t+i} - p_{t+i}^*)^2 + \sum_{k=1}^{m} b_k (p_{t+i} - p_{t+i-k})^2 \right] \tag{10}$$

where p_t denotes the actual price level and p_t^* its target value. Equation (10) generalizes the adjustment cost assumption to go beyond the level-adjustment cost specification commonly used in standard linear quadratic models (for example, Sargent 1978 and Rotemberg 1982). For instance, for $m = 2$, equation (10) says that it is costly not just to change the price level, but also its rate of change.[7] The solution to the above minimization problem leads to the following decision rule for inflation:

5. See Bomfim et al. (1997), Brayton and Tinsley (1996), and Brayton et al. (1997) for more detailed descriptions of the FRB/US model.

6. The details of the modeling approach are described by Tinsley (1993).

7. Thus, though the model does not explicitly specify the structure of the dynamic frictions preventing fully flexible prices, the above specification captures the notion that changing the inflation rate is costly (for example, Fuhrer and Moore (1995).

$$\Delta p_t = a_0 + a_1(p_{t-1} - p^*_{t-1}) + \sum_{j=1}^{2} \rho_j \Delta p_{t-j} + \sum_{j=0}^{\infty} \gamma_{c,j} \Delta c_{t+j} + \sum_{j=0}^{\infty} \gamma_{u,j} u_{t+j} + e_{p,t} \quad (11)$$

where the cyclicality of the markup is captured by the term involving the unemployment rate (u_t), and $e_{p,t}$ is a price shock.

In the context of the model's price-setting behavior, equation (11) has a straightforward economic interpretation: It can be thought of as a forward-looking Phillips curve where today's inflation depends not only on past and expected inflationary developments, but also on anticipated conditions in the labor market.[8] In a broader context, (11) allows for the explicit decomposition of macroeconomic dynamics into "adjustment costs" and expectational factors. In particular, the lagged dependent variable appears on the right-hand side of (11) solely to reflect the nature of the generalized adjustment costs. Thus, if we only had level-adjustment costs—that is, producers can adjust the rate at which they change their prices costlessly—then it can be shown that $\rho_j = 0$ for all j. In contrast to this explicit attempt to decompose dynamics between expectations and adjustment costs, traditional specifications of the Phillips curve use lagged values of inflation to capture both ``inflation inertia" and the usefulness of past inflation in predicting its future values.

Equations like (11) permeate all aspects of key nonfinancial sectors of the model. For households, the two-stage decision problem of consumers involves, first, specifying "target" consumption as a function of lifetime income, and, second, solving an optimization problem similar to (10). Again, the result is a decision rule where consumption growth is a function not only of the gap between actual and target consumption, but also of past values of consumption growth and expected changes in consumption fundamentals. Firms' factor allocation and inventory accumulation decisions are also derived within this framework.[9]

Financial Markets. The main financial equations involve three long-term interest rates—for the five- and ten-year government bonds and the thirty-year corporate bond—and the stock market. Adjustment costs are assumed to be small enough to be negligible so that there is no distinction between target and actual values of financial variables.

Long-term interest rates are determined according to the expectations theory of the term structure. Following Shiller (1979), the yield on a long-term bond of maturity m is given by the expected future path of short-term interest rates (i_t) plus a term premium ($\phi_{m,t}$):

8. The estimated coefficients are such that expectations of high unemployment lead to a slowing in price increases.

9. Brayton and Tinsley (1996) provide details of individual equations.

$$i_{m,t} = \sum_{j=0}^{m-1} \tau_j i_{t+j|t} + \phi_{m,t} \,. \tag{12}$$

The model's equation for the stock market also follows standard specifications. It is based on the familiar notion that stock prices reflect the present discounted value of expected dividends.

3.2 Expectation Formation

As discussed above, expectations play a potentially important role in the evolution of both financial and nonfinancial variables in FRB/US. The version of the model used for the experiments described in this paper assumes that agents base their expectations on a simplified reduced-form representation of the economy. Thus, rather than explicitly using all 300+ equations and identities that make up the model, agents rely on small-scale vector-autoregressions to form their expectations. Such expectations are within the spirit of our disinflation exercise. As stressed by Taylor (1993), fully rational expectations may be unrealistic during the transition period after a new policy has been put in place. Certainly, the assumption that agents may be not fully certain about the ultimate inflation goal of the policymaker motivates our analysis of credibility.

The VAR forecasting systems vary from sector to sector—for example, while the price-setting decision leads firms to forecast the unemployment rate, households are required to generate explicit income forecasts when deciding how much to consume. Nevertheless, all small-scale forecasting models include a restricted VAR in three core macroeconomic variables: inflation (π_t), the short-term interest rate (i_t), and an output gap (y_t).[10] For the short rate, agents form expectations that are consistent with the policy rule adopted by the policymaker, except for the uncertainty surrounding the inflation goals.

Thus, under the deliberate policymaker, the private sector's forecasting equation for i_t is

$$i_t = r^* + \overline{\pi}_{t-1} + \beta_1(\overline{\pi}_{t-1} - \pi^{**}_{t|t}) + \beta_2 y_{t-1} \,, \tag{13}$$

which simply replaces the actual target with the perceived target in the policy rule. The other equations in the core VAR forecasting system are given by

$$\Delta\pi_t = \theta_4(\pi_{t-1} - \pi^{**}_{t|t}) + \theta_5(i_{t-1} - i^{**}_{t|t}) + \theta_6 y_{t-1} + A_2(L)x_{t-1} \tag{14}$$

$$\Delta y_t = \theta_7(\pi_{t-1} - \pi^{**}_{t|t}) + \theta_8(i_{t-1} - i^{**}_{t|t}) + \theta_9 y_{t-1} + A_3(L)x_{t-1} \tag{15}$$

10. Effectively, the inclusion of these three variables endows all agents in the economy with knowledge of its three essential macroeconomic relationships: a Phillips curve, a monetary policy rule, and an IS curve.

where $A_i(L)$ are polynomials in the lag operator L, $x_t \equiv [\Delta i_t, \Delta \pi_t, \Delta y_t]'$, and $i^{**}_{t|t}$ is defined as $r^* + \pi^{**}_{t|t}$.[11] The VAR restrictions imply that the forecasting system "error corrects" in the long run so that

$$\lim_{j \to \infty} \pi_{t+j|t} = \pi^{**}_{t|t} \tag{16}$$

$$\lim_{j \to \infty} y_{t+j|t} = 0\,. \tag{17}$$

For the opportunistic policymaker, agents must incorporate their beliefs about both the interim and ultimate inflation targets into their expectations. In this case, agents follow equations (13), (14), and (15) in forming long-run expectations (those over one year) but use (13), (14), and (15) with $\pi^*_{t|t}$ in place of $\pi^{**}_{t|t}$ for short-run expectations.

Expectation variables play an important role in the behavioral equations described above. Take, for example, the model's modified Phillips curve—equation (11): To forecast future values of the unemployment rate, firms rely on an expectational model composed of the three-equation core VAR system and an additional equation relating the unemployment rate to its own lags, and lagged values of inflation, short-term interest rates, and the output gap. Thus, as they look further and further into the future, their unemployment rate forecast becomes increasingly more affected by, say, their long-run inflation rate forecast. More important for the purposes of this paper, long-run inflation expectations play an important role in the workings of a policy to achieve disinflation. For instance, if the ultimate target of policy is fully credible, then $\pi^{**}_{t|t}$ coincides with the long-run inflation target implicit in the disinflation effort. In contrast, if $\pi^{**}_{t|t}$ is persistently above the monetary authority's long-run inflation target, then the private sector underestimates future unemployment rates and overestimates increases in production costs. According to (11), these misperceptions would lead to higher increases in output prices than otherwise and, consequently, a tighter monetary policy stance than in the case of full credibility.

4. MODEL SIMULATION RESULTS

Our goal is to compare the performances of the opportunistic and deliberate approaches to disinflation. We do this by conducting stochastic simulations of the FRB/US model. All of the simulations start from a steady-state baseline with the inflation target and actual inflation both at 5 percent. The stochastic simulations begin with the announcement of a 3 percent inflation target. The deliberate policymaker strives for this new target by following the Taylor-type rule in equation (1) with π^{**}_t

11. When estimating the model, long-run expectations for inflation are taken from survey data, and those for the federal funds rate from the forward interest rates implicit in the term structure of interest rates. In the terminology of Kozicki and Tinsley (1998), these expectational variables represent "moving endpoints" for inflation and interest rate forecasts.

equal to 3. The opportunistic policymaker employs the strategy described by equations (2) and (3).[12]

The stochastic simulations use a bootstrap procedure based on the errors made by key model equations (about fifty in number) over the 1966–1995 period. We ran one thousand simulations each under opportunistic and deliberate monetary policy. These simulations were run in pairs (which consist of one with each type of policy) that were each characterized by a different sequence of randomly selected macroeconomic shocks over which the disinflation episode took place (which is the obvious variance reduction technique). For each simulation, we recorded the number of years that were required until the disinflation was complete and the ultimate inflation target was achieved.[13] We also recorded how much the unemployment rate deviated from its steady-state value during each disinflation episode in order to compute the costs associated with each monetary policy strategy.[14] While the sacrifice ratio and disinflation duration are common metrics for disinflation, we also consider a more traditional discounted quadratic loss function of the type:

$$Loss = \sum_{j=1}^{80} \delta^j \left((\pi_{t+j} - \pi^{**}_{t+j})^2 + y^2_{t+j} \right). \tag{18}$$

This loss function sums the (discounted) squared deviations of inflation from its target and output from potential during the first twenty years after the disinflation begins.[15] Thus, for each stochastic simulation, we generated three pairs of observations: namely, the duration of the disinflation, the sacrifice ratio, and the quadratic loss for each policymaker.

Armed with one thousand observations on sacrifice ratios, losses, and durations of disinflation for each policymaker, we then proceeded to address the main question asked in this paper: Given the stochastic characteristics of the U.S. economy over the past three decades—as measured by the FRB/US model—how well can the opportunistic and deliberate policymakers deliver on their announced inflation targets? To address this question, we compared the average values of the variables mentioned above for each policymaker. We also used paired-sample *t*-tests to gauge the statistical significance of the reported differences between the opportunistic and deliberate policymakers.

12. For the policy rule parameters, we use Rudebusch's (1998) estimates for the Greenspan period—$\beta_1 = 0.78$ and $\beta_2 = 0.68$. Our results are robust to variation in these parameters.

13. The disinflation is considered complete in a quarter when the four-quarter inflation rate is at or below the ultimate target and remains there for the next three quarters.

14. We measure the cost of disinflation—the sacrifice ratio—as the cumulative annual deviation of the unemployment rate from the natural rate divided by the two-percentage-point decrease in the inflation rate. Therefore, if the disinflation policy started at quarter $t = 1$ and took N quarters to reach its goal, we compute the sacrifice ratio as as $(1/8)\Sigma_1^N(Udev_t)$ where $Udev_t$ are the unemployment rate deviations from the steady state.

15. The value of δ used is 0.98, and the output gap is defined as twice the unemployment gap in accord with Okun's Law.

Table 1 provides a summary of our results under various assumptions about credibility. The top half of the table considers three cases of exogenous credibility. The cases correspond to $\lambda_t^U = \lambda_t^I = 0$ (no credibility), $\lambda_t^U = \lambda_t^I = .5$, and $\lambda_t^U = \lambda_t^I = 1$ (perfect credibility). Consider the intermediate case first. With $\lambda_t^U = \lambda_t^I = .5$, the mean sacrifice ratio faced by the deliberate policymaker is 1.46; therefore, the cumulative deviation of the unemployment rate from the steady state during the two-percentage-point disinflation is about three percentage-point-years. This trade-off is less favorable than the 1.3 ratio faced by the opportunistic policymaker.[16] Furthermore, given the p-value of zero, these differences are statistically significant. Thus, it appears that the opportunistic policymaker, by waiting for the appropriate shocks, is able to reduce inflation with less cumulative unemployment that the deliberate policymaker. Of course, waiting for shocks increases the duration of the disinflation, which averages just over 4 years for the opportunistic policymaker and only 3.5 years for the deliberate one. Still, as measured by simple quadratic loss with equal weights on inflation and output deviations, the opportunistic policymaker does suffer a smaller loss.

Similar qualitative results are obtained for the case of perfect credibility, although both the sacrifice ratios and the disinflation durations are quantitatively smaller. In the case of no credibility, however, the results are less sharp in that the differences in sacrifice ratios between policymakers are not statistically significant.

Of course, as argued above, credibility is likely to respond endogenously to the performance of the policymaker, and results with endogenous credibility are given in the lower half of Table 1. In particular, as actual or anticipated progress is made toward the inflation target, the credibility of that target is likely to rise. The mecha-

TABLE 1
SIMULATION RESULTS

	Sacrifice Ratio			Duration of Disinflation		Discounted Loss Function	
	Opp.	Del.	p-value	Opp.	Del.	Opp.	Del.
Exogenous Credibility:							
$\lambda^U = \lambda^I = 0.0$	3.14	3.01	0.10	11.04	7.74	428.7	414.7
$\lambda^U = \lambda^I = 0.5$	1.30	1.46	0.00	4.08	3.50	283.6	300.4
$\lambda^U = \lambda^I = 1.0$	1.23	1.27	0.00	2.84	2.54	307.3	321.2
Endogenous Credibility:							
By Outcome	2.73	2.63	0.14	9.52	6.68	412.9	400.5
By Behavior	2.35	2.20	0.02	8.28	5.38	383.5	364.5
With Announcement	2.35	1.59	0.00	8.28	4.03	383.5	321.3

NOTES: Results under the opportunistic (opp.) and deliberate (del.) policy strategies are given for the sacrifice ratio (in percentage point years of unemployment rate deviations per percentage point of disinflation), the duration of disinflation (in years), and a loss function described in the text. The p-values test the equality of the opportunistic and deliberate mean sacrifice ratios.

16. These sacrifice ratios are very close to the one calculated by Ball (1994). Using a simple back-of-the-envelope calculation with quarterly U.S. data, he calculates a ratio of about 1.2 percentage points of unemployment per percentage point disinflation.

nisms for determining credibility are described in equations (6) through (9). In our simulations, we set $\alpha = .67$, which translates into a three-percentage-point range of credibility around the target.[17] Under the backward-looking mechanism depicted in (4)—credibility by outcome—if actual inflation is outside of this range, then the target has no credibility. Credibility is gained incrementally as the target is approached. In this case, as shown in Table 1, the deliberate policymaker actually has a *lower* sacrifice ratio and a smaller quadratic loss than the opportunistic one. The superior performance of the deliberate policymaker is especially significant for the forward-looking specification of credibility (credibility by behavior) and for the credibility-by-announcement mechanism (where the credibility of the deliberate policymaker is bounded below by .2 after the announcement of the new policy). To sum up, because the deliberate policymaker makes faster progress toward the goal of low inflation, he enjoys a faster rise in credibility and a lower sacrifice ratio and loss.

5. CONCLUDING REMARKS

There is a long history of exploring the performance of various policy rules in economic models. Almost all of this research has been conducted in the context of linear models and rules with a fixed expectations mechanism—either rational or adaptive expectations. Such a framework is not well suited for our investigation along two dimensions. First, our opportunistic policy rule is inherently nonlinear. While such a rule is very difficult to motivate with a symmetric loss function and linear constraints, as noted in the introduction, it does appear to hold considerable appeal for some policymakers. Second, our interest is in a period that is clearly transitional—the disinflation—again, mirroring the interests of policymakers. Such a transition will likely involve learning and credibility and changes over time in the expectations formation process.

Given the somewhat atypical, but clearly important, topic of our investigation, there are few clear answers in the literature to the many modeling choices required. What is the nature of learning during a policy transition? How are expectations formed? How will the success of an opportunistic policy be judged? Our results are, of course, dependent upon the modeling choices that we have made, but still we see them as useful, not for their precise quantitative answers, but for providing a cautionary tale. Namely, there seems to be a fundamental tension between credibility and opportunism. The public may well be skeptical about the importance of an ultimate inflation target when it is promulgated but not acted upon by an opportunistic central bank, and this skepticism may lead to a higher cost for a disinflation policy.

17. Our results are robust to some variation in α.

LITERATURE CITED

Amano, Robert, Paul Fenton, David Tessier, and Simon van Norden. "The Credibility of Monetary Policy: A Survey of the Literature with some Simple Applications to Canada." In *Exchange Rates and Monetary Policy*, pp. 1–64. Proceedings of a conference held by the Bank of Canada, October 1996. Ottawa: Bank of Canada, 1997.

Ball, Laurence. "What Determines the Sacrifice Ratio?" In *Monetary Policy*, edited by N. G. Mankiw, pp. 155–82. Chicago: University of Chicago Press, 1994.

Bank of Canada. "Press Release: Targets for Reducing Inflation." *Bank of Canada Review* (March 1991), 5–6.

Blackburn, Keith, and Michael Christensen. "Policy Credibility: Theories and Evidence." *Journal of Economic Literature* (1989), 1–45.

Bomfim, Antulio, Robert Tetlow, Peter von zur Muehlen, and John Williams. "Expectations, Learning, and the Costs of Disinflation: Experiments Using the FRB/US Model." *Bank of International Settlements Conference Papers* (1997).

Brayton, Flint, Eileen Mauskopf, David Reifschneider, Peter Tinsley, and John Williams. "The Role of Expectations in the FRB/US Macroeconomic Model." *Federal Reserve Bulletin* (April 1997), 227–45.

Brayton, Flint, and Peter Tinsley, eds. "A Guide to FRBUS: A Macroeconomic Model of the United States." Finance and Economics Discussion Paper 1996–42, Federal Reserve Board, 1996.

Croushore, Dean, and Ronald S. Koot. "A Measure of Federal Reserve Credibility." *Journal of Policy Modeling* (1994), 215–31.

Fuhrer, Jeffrey, and Mark A. Hooker. "Learning about Monetary Regime Shifts in an Overlapping Wage Contract Model." *Journal of Economic Dynamics and Control* 17 (1993), 531–53.

Fuhrer, Jeffrey, and George Moore. "Inflation Persistence." *Quarterly Journal of Economics* 110 (1995), 127–59.

Haldane, Andrew G., ed. *Targeting Inflation*. Bank of England, 1995.

Hall, Stephen, and Anthony Garratt. "Model Consistent Learning and Regime Switching in the London Business School Model." *Economic Modelling* 12 (1995), 87–95.

Huh, Chan G., and Kevin J. Lansing. "Expectations, Credibility, and Disinflation in a Small Macroeconomic Model." *Journal of Economics and Business*, 51 (2000), 51–86.

Johnson, David. "On the Credibility of Monetary Policy: International Evidence Based on Surveys of Expected Inflation." Manuscript, Wilfrid Laurier University, 1997a.

_____ . "Expected Inflation in Canada 1988–1995: An Evaluation of Bank of Canada Credibility and the Effect of Inflation Targets." In *Canadian Public Policy*, 1997b.

King, Mervyn. "Credibility and Monetary Policy: Theory and Evidence." *Bank of England Quarterly Bulletin* (February 1995).

Kozicki, Sharon, and Peter Tinsley. "Moving Endpoints and the Internal Consistency of Agents' Ex Ante Forecasts." Computational Economics 11 (1998), 21–40.

Leiderman, Leonardo, and Lars E.O. Svensson, eds. *Inflation Targets*. Center for Economic Policy Research, 1995.

McCallum, Bennett T. "Issues in the Design of Monetary Policy Rules." In *Handbook of Macroeconomics*, edited by J. B. Taylor and M. Woodford, pp. 1483–1530. New York: Elsevier, 1999.

Meyer, Laurence. "Monetary Policy Objectives and Strategy." *Business Economics* (January 1997), 17–20.

Orphanides, Athanasios, and David Wilcox. "The Opportunistic Approach to Disinflation." Finance and Economics Discussion Paper 1996–24, 1996.

Orphanides, Athanasios, David H. Small, Volker Wieland, and David Wilcox. "A Quantitative Exploration of the Opportunistic Approach to Disinflation." Finance and Economics Discussion Paper 1997–36, 1997.

Rogoff, Kenneth. "Reputation, Coordination, and Monetary Policy." In *Modern Business Cycle Theory*, edited by R. Barro, pp. 236–64. Harvard University Press, 1989.

Rotemberg, Julio. "Sticky Prices in the United States." *Journal of Political Economy* 90 (1982), 1187–1211.

Rudebusch, Glenn D. "Is Opportunistic Monetary Policy Credible?" *Federal Reserve Bank of San Francisco Economic Letter*, October 4, 1996.

_____ . "Is the Fed Too Timid? Monetary Policy in an Uncertain World." Manuscript, Federal Reserve Bank of San Francisco, 2000, forthcoming in the *Review of Economics and Statistics*.

_____ . "Do Measures of Monetary Policy in a VAR Make Sense?" *International Economic Review* 39:4 (1998), 907–931.

_____ . "Assessing Nominal Income Rules for Monetary Policy with Model and Data Uncertainty." Manuscript, Federal Reserve Bank of San Francisco, 1999.

Rudebusch, Glenn D., and Lars E.O. Svensson. "Policy Rules for Inflation Targeting." In *Monetary Policy Rules*, edited by John B. Taylor, pp. 203–46. University of Chicago Press for National Bureau of Economic Research, 1999.

Sargent, Thomas. "Estimation of Dynamic Labor Demand Schedules under Rational Expectations." *Journal of Political Economy* 86 (1978), 513–42.

Shiller, Robert. "The Volatility of Long-Term Interest Rates and Expectations Models of the Term Structure." *Journal of Political Economy* 87 (1979), 1190–1219.

Spiegel, Mark. "Central Bank Independence and Inflation Expectations: Evidence from British Index-Linked Gilts." Federal Reserve Bank of San Francisco, *Economic Review* 1 (1998), 3–14.

Taylor, John. "Discretion versus Policy Rules in Practice." *Carnegie-Rochester Conference Series on Public Policy* 39 (1993), 195–214.

Tinsley, Peter A. "Fitting Both Data and Theories: Polynomial Adjustment Costs and Error Correction Decision Rules." Finance and Economics Discussion Paper 1993–21, 1993.