

Central Bank Behavior and Credibility: Some Recent Theoretical Developments

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ONE of the most widely accepted tenets of monetary theory is that persistent inflation is a monetary phenomenon. A deeper understanding of persistent inflation, therefore, must uncover the reasons for persistent increases in the money stock. This leads naturally to an investigation of the motives and constraints facing central bankers who decide the course of monetary policy.

Recent theoretical literature on the behavior of monetary policymakers may be divided into two broad categories — positive and normative. The *positive* literature formulates hypotheses about the objectives and constraints facing central bankers and derives implications for the behavior of both observable variables (e.g., the rate of monetary growth and the rate of inflation) and unobservable variables (e.g., policy credibility). The *normative* literature focuses on the issue of how, given the behavior of central bankers, monetary institutions can be redesigned to improve social welfare. Both approaches use the same general analytic framework to model central bank behavior.

This paper, the first in a two-part survey, focuses on the positive aspects of central bank behavior, with particular emphasis on the characterization and the determinants of policy credibility.

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POSITIVE APPROACHES TO CENTRAL BANK BEHAVIOR AND THE IMPORTANCE OF CREDIBILITY: AN OVERVIEW

Positive (and normative) theories of central bank behavior rely heavily on the notion that unanticipated money growth has temporary, positive effects on output and employment as a result either of the Lucas (1973) effect¹ or the existence of long-term contracts in conjunction with ex post determination of employment by labor demand.² They also rely on the view that central bankers have a well-defined objective function (preferences) for economic stimulation and inflation within each period as well as intertemporal preferences over combinations of those variables in the present and in the future.

The notion of policy credibility is a fundamental one because the ability of monetary policymakers to achieve their future objectives depends on the inflationary expectations of the public. These inflationary expectations depend, in turn, on the public's evaluation of the credibility of the monetary policymakers. For example, Fellner (1976) and Haberler (1980), who coined the term "Credibility Hypothesis," have stressed that the less credible disinflationary policies are, the longer and the more severe their interim adverse economic effects will be.

¹A recent exposition appears in chapter 3 of Cukierman (1984).

²Fischer (1977), Taylor (1980).

The theoretical literature defines credibility as the extent to which the public believes that a shift in policy has taken place when, indeed, such a shift has actually occurred.³ More important, to be credible, a policy must be consistent, at each stage, with the public's information about the objectives and constraints facing the central bank. The public will not believe an announced policy if it knows the policy is incompatible with the current objectives of policymakers.

Part of the theoretical literature interprets the central bank's objective function as a social welfare function. In this approach, the policymaker is cast as a benevolent planner whose sole concern is to maximize a well-defined social welfare function. Another part of the literature interprets the objective function of the policymaker in terms of political objectives. In this approach, the importance assigned to preventing inflation relative to stimulating the economy depends on the relative influence on the central bank of the pro-stimulation and anti-inflation advocates within government and the private sector. Formal models based on the social welfare and political approaches are similar at times; however, interpretations of their results are quite different depending on which approach is used. Therefore, the two approaches are discussed separately.

THE SOCIAL WELFARE APPROACH AS A POSITIVE THEORY OF CENTRAL BANK BEHAVIOR

The social welfare approach is based on three key relationships. First, the economy is one in which deviations of employment from its natural level are positively related to unanticipated inflation; this can result from either the existence of a Lucas (1973)-type short-run Phillips curve or a Fischer (1977)-Taylor (1980) contract framework. Second, the monetary authority has a social welfare function that gives a negative weight to inflation and a positive weight to employment even beyond the natural rate.⁴ It chooses the rate of money growth and, hence, inflation, over which it has perfect control, that maximizes the social

³Under this definition, a new policy is credible if it is promptly believed, whether or not the new policy is more or less inflationary than the old one. This point is made in a related survey by McCallum (1984).

⁴The natural rate is the level of employment that would be obtained in the absence of monetary disturbances. Employment or output beyond this level contributes to social welfare if distortionary taxes or other constraints hold employment below its optimal level. An elaboration appears at the end of this section.

Table 1
The Monetary Policy Game: Basic Model

I. Output Relationship

$$(1) y = y_n + (m - m^e)$$

**II. Social Welfare Function =
Policymaker's Objective Function**

$$(2) W = -m^2 + 2(y - y_n)$$

III. Policymaker's Objective Function in terms of m

$$(3) W = -m^2 + 2(m - m^e)$$

IV. Public's Utility Function

$$(4) U = -(m - m^e)^2$$

welfare function.⁵ Finally, the public understands the central bank's behavior and forms its inflationary expectations accordingly. Since inflation is "bad," the best rate of monetary expansion must be zero. Therefore, social welfare is maximized when both the actual and expected inflation are zero and employment is at its natural level.

Yet, the relatively simple model just described is sufficient to generate an inflationary bias; as a result, social welfare is lower than it would have been had the monetary authority been credibly committed to a zero money growth (zero inflation) rule.⁶ In essence, the monetary authorities and the public are caught up in a kind of "prisoners' dilemma."

The Prisoners'-Dilemma Aspect of Monetary Policy

The dilemma is illustrated simply in the following model.⁷ The monetary authority and the public can be viewed as engaged in a game to determine what the level of output and the rate of inflation will be. The economy's output is determined by a Lucas-Sargent aggregate supply function as shown in equation 1 in table 1, where y is the actual level of output, y_n is its

⁵Short-run discrepancies between the rate of inflation and the rate of monetary growth are abstracted from, in this discussion, by assuming that those two rates are equal at all times.

⁶This scenario originated in a well-known example by Kydland and Prescott (1977) and was elaborated and formulated within an explicitly dynamic framework by Barro and Gordon (1983b).

⁷This model is based on a static reformulation by Backus and Driffill (1985a).

Table 2
Payoff Tables for Basic Monetary Policy Game

I. Policymaker's Payoff Table (from equation 3)

Policymaker chooses (m)	Public expects (m ^e)	
	0	1
0	0	-2
1	1	-1

II. Public's Payoff Table (from equation 4)

Policymaker chooses (m)	Public expects (m ^e)	
	0	1
0	0	-1
1	-1	0

natural level, and m and m^e are the actual and expected inflation rates, respectively.⁸ The policymaker's objective function (taken to be identical to the social welfare function) is shown in equation 2 (table 1).⁹

When equation 1 is substituted into 2, the policymaker's objective function now takes the form shown in equation 3 in table 1. Taking m^e as given, the value of m that maximizes social welfare is $m = 1$, resulting in a positive inflation rate. This outcome can easily be seen in the monetary policymaker's payoff matrix shown in table 2 (I). If the monetary authority chooses zero inflation, $m = 0$, its payoff is either 0 or -2, depending on whether m^e equals 0 or 1. If it chooses $m = 1$, however, its payoff is either 1 or -1, depending on whether m^e equals 0 or 1. Inflation is clearly the dominant strategy from the point of view of the monetary authority; the payoffs for $m = 1$ are higher *regardless of what inflation rate the public expects*.

So far the analysis has focused solely on the monetary policymaker's objective function. However, the public also has an objective function; it is assumed to resist being fooled by policymakers. The public is assumed to maximize a utility function similar to equation 4 in table 1, taking m as given. Because the public knows the monetary authority's incentive

structure, it expects the monetary authority to choose $m = 1$; consequently, it chooses $m^e = 1$.¹⁰ The resultant outcome is an inferior solution, with payoffs of -1 to the monetary authority and 0 to the public.

The inflationary bias occurs because the monetary authority has the incentive to inflate in order to increase employment once the public's inflationary expectations have been set. This incentive is present regardless of whether the public expects a zero or a positive rate of inflation. Because the public recognizes this incentive, it rationally expects a positive rate of inflation; this forces the monetary authority actually to inflate in order to maintain employment at its natural level. As a result, the economy ends up with the same employment level as under a zero money growth rule, but with excessive inflation and lower welfare.

Barro and Gordon (1983b) characterize this solution as "discretionary" because the monetary authority can choose whatever rate of monetary growth (and, hence, inflation) it desires. If the monetary authority had been credibly committed to zero money growth (by a constitutional amendment, for example), the superior solution, $m = m^e = 0$, could have been achieved. But, in the absence of credible commitments on the part of the policymaker, the (Nash) equilibrium to the policy game involves positive and suboptimal inflation.¹¹

A Dynamic Extension of the Model

As pointed out by Barro and Gordon (1983b), the prisoners'-dilemma aspect of the policy game carries over to the case in which the policymaker cares about social welfare in both the present and future periods. This can be illustrated by generalizing the objective function of the policymaker as shown in equation 5:

$$(5) W = \sum_{i=0}^{\infty} \beta^i [A(m_i - m_i^e) - \frac{m_i^2}{2}]$$

β is the discount factor applied to future welfare in the policymaker's social welfare function. The term in brackets is the level of social welfare attained in the i^{th} period.¹² The constant, A , is the marginal rate of substitution between economic stimulation and inflation prevention; the larger A is, the more the policy-

⁸Since output and employment are positively related, y can also be viewed as a proxy for employment.

⁹The various constants in equations 1 and 2 have been chosen for simplicity of exposition. The main qualitative point does not depend on the values of those constants.

¹⁰This is obtained by differentiating equation 4 with respect to m^e , equating to zero and solving for m^e .

¹¹A Nash equilibrium is defined as a situation in which each of two sides chooses his best strategy, taking as given the optimal response of the other side.

¹²This term is a slightly more general form of equation 3.

maker cares about employment relative to inflation prevention at the margin.

As before, the policymaker chooses m_t to maximize the social welfare function in equation 5, taking m_t^e as given. Since there is nothing that links the periods, maximization of equation 5 is equivalent to maximization of welfare within each period separately. More formally, the policymaker maximizes equation 6 for all t :

$$(6) W_t = A(m_t - m_t^e) - \frac{m_t^2}{2}$$

As shown in the monetary policymaker's pay-off matrix in table 3, the best choice is $m_t = A$ in all periods.¹³

As before, the public resists being fooled. Because it understands the structure of incentives facing the policymaker, it rationally sets $m_t^e = A$ in all periods. Again, the economy ends up with a positive rate of inflation. As before, the discretionary solution is not optimal; zero money growth yields a value of zero to the policymaker (if the public expects money growth to be zero), while the discretionary result yields a social welfare of $-A^2/2$.

It is tempting to argue that a sophisticated policymaker would eliminate this suboptimality by simply consistently setting $m_t = 0$, thus convincing the public that m_t^e should equal zero as well. The public, however, knows that, as soon as they expect inflation to be zero, the policymaker can increase welfare (to $A^2/2$) by reverting to the discretionary inflation solution. Because the policymaker will revert to discretion in this case, the public will rationally expect that inflation will equal A . As a result, the best solution, $m_t = m_t^e = 0$ is unstable, whereas the discretionary (Nash) solution $m_t = m_t^e = A$ is stable.¹⁴

The Impact of Asymmetric Information

To this point, the public and the policymaker were assumed to have the same information. Suppose, however, that this is not the case. Backus and Driffill (1985a, 1985b) consider a model in which the policymaker is one of two types: "weak" or "strong." If the policymaker is weak, his payoff matrix is the one shown in table 2(I) or 3(I); he, therefore, has an incentive to generate inflation. If the policymaker is strong, however, he always prefers zero inflation.

Table 3
Payoff Tables for a Typical Period in the Dynamic Monetary Policy Game

I. Policymaker's Payoff Table (from equation 6)

Policymaker chooses (m_t)	Public expects (m_t^e)	
	0	A
0	0	$-3A^2/2$
A	$A^2/2$	$-A^2/2$

II. Public's Payoff Table (from equation 4)

Policymaker chooses (m_t)	Public expects (m_t^e)	
	0	A
0	0	$-A^2$
A	$-A^2$	0

In the beginning, the public assigns some probability to the condition that the policymaker is strong and, therefore, will not inflate. Weak policymakers are tempted to inflate. However, since they maximize welfare over several periods, they have an incentive to appear strong, at least initially, to discourage inflationary expectations. The public watches the actions of the policymaker and adjusts its probability accordingly that the policymaker is strong. This probability is considered to be a measure of credibility.

As long as the policymaker does not inflate, the public assigns some positive probability to the event that the policymaker is strong. If the policymaker inflates *even one time*, however, he immediately reveals himself to be weak. Because strong policymakers never inflate, there is no way that a policymaker can reestablish his lost reputation. Consequently, once inflation starts, it continues forever.

Backus and Driffill formulate this problem as a dynamic, mixed-strategies Bayesian game using Kreps and Wilson's (1982a, 1982b) notion of sequential equilibrium.¹⁵ This formulation captures the incentive of the weak policymaker to act temporarily as if he were strong in order to maintain future inflationary expectations at a lower level. It also provides the public with a rationale for watching the actions of the policymaker, at least until it is known that he is weak. This analysis is restricted, however, by the fact that the policymaker can be one of only two unchanging types. As

¹³It is obtained from the first-order condition for the maximization of (6).

¹⁴The dynamic inconsistency of the first best solution was originally noted by Kydland and Prescott (1977).

¹⁵A similar analysis appears in Barro (1985).

a consequence, once a reputation is destroyed, it cannot be rebuilt. Those features of the analysis are inconsistent with the observed frequent reversals in the rate of monetary growth in the United States, England and other democracies.

Criticism of the Social Welfare Approach

Because equation 2, or its multi-period variant, equation 5, is used frequently as a social welfare function in the theoretical literature on central bank behavior, it is important to examine why it takes this specific form.¹⁶ The negative effect of inflation on social welfare results from the familiar loss of consumer surplus that inflation produces through the decrease in the public's real money balances. The positive association between deviations of employment from its natural level and social welfare can be explained by the existence of various labor market distortions (like taxes and unemployment benefits) that make the natural level of employment too low (Barro and Gordon, 1983b). Another explanation, offered by Canzoneri (1985), is that the presence of large unions keeps real wages too high and the natural employment level too low.

The view that the existence of distortionary taxes necessarily induces an inflationary bias on the part of a socially minded central bank raises several questions. First, this notion relies only on the distortionary effect of taxes on the allocation of time between labor and leisure, neglecting the utility from the public good that is financed by these taxes. Since individuals take the level of the public good provided by government as being independent from their individual labor-leisure decisions, while the central bank takes into consideration that this level depends on total tax collections — which depend in turn on total employment — there is also an externality. If the socially optimal level of the public good is higher than the amount that can be financed through the taxes collected in the absence of central bank intervention, the bank has an incentive to increase total tax collections. Whether this implies that it has an incentive to increase employment or decrease it depends on the tax structure and the elasticity of labor demand. In the latter case, the tax distortion and the public good externality have conflicting effects on the socially optimal level of employment in relation to its general equilibrium level in the absence of central bank intervention. Cukierman and

Drzen (1986) show within a nominal contracts framework of the Fischer (1977) type that, if the demand for labor is sufficiently inelastic, the last effect dominates, producing an incentive to decrease employment via unanticipated deflation. Furthermore, the range of cases in which the central bank turns out not to have an inflationary bias is by no means negligible.¹⁷ The upshot is that a socially minded policymaker facing distortionary labor taxes should not be automatically presumed to possess an inflationary bias.

Second, if the level of employment is too low because of distortionary taxes, a full analysis of the behavior of policymakers should be able to determine simultaneously both inflation and other taxes, taking into consideration the tax revenues from inflation. Such an extension is considered by Alesina and Tabellini (1985) within a framework in which fiscal and monetary policies are determined by two independent authorities. An important implication of this framework is that the resulting equilibrium rate of inflation is not necessarily suboptimal. This will be discussed more fully in the second installment of this survey.

Finally, the social welfare function interpretation of the policymaker's objectives does not fit very well with the notion that there are two alternative types of policymakers. One possibility might be that there are two alternative welfare functions that characterize the economy. If that is the case, however, it seems peculiar that the relevant one is known only to the policymaker. Indeed, this possibility seems untenable. Another possibility is that, while the objective function of the weak policymaker is identical to the social welfare function, the strong policymaker's objective function is different from it. Once it is recognized that the objectives of the policymaker may differ from the social welfare function, however, there is no reason to restrict the analysis to only a single alternative formulation. Consideration of a variety of alternatives is handled by a political interpretation of the policymaker's objective function.

THE POLITICAL APPROACH AS A POSITIVE THEORY OF CENTRAL BANK BEHAVIOR

Recent work in both economics and political science suggests that monetary policy is not totally divorced from the general political process. For exam-

¹⁶For example, when there is too much of the public good in the no-intervention equilibrium, the central bank has a deflationary bias, provided labor demand is sufficiently elastic.

¹⁷In addition to the papers quoted above, those include Barro and Gordon (1983a), Backus and Driffill (1983b), Rogoff (1985) and, to some extent, Canzoneri (1985).

ple, in spite of the Federal Reserve's statutory independence from other branches of government, monetary policy is partly responsive to the desires of the President, Congress, the financial community and periodically some other less visible institutions or groups.¹⁸

Discretionary Policy, Changing Objectives and Asymmetric Information

The central bank knows both the extent of the political pressure focused on it to change monetary policy at any given moment and how likely it is to accommodate this pressure. Further, the formation of effective coalitions determined to change the course of monetary policy is subject to large stochastic elements. Cukierman and Meltzer (1986a) formalize this notion with an objective function similar to equation 5 in which the monetary authority's marginal prefer-

ence for economic stimulation vs. inflation prevention shifts randomly through time. In this formulation, the constant marginal rate of substitution A is replaced by a random variable x_i which reflects the current compromise that the central bank strikes between advocates of economic stimulation and advocates of price stability.¹⁹

The crucial element in this formulation is that x_i is in a continuous state of flux and is not known by the general public. However, the public can rationally and gradually detect *changes* in x_i by observing changes in the rate of growth of the money supply; this detection activity provides an explanation for "Fed watching." Since the public is unaware, at any given moment, of the precise value of the central bank's current x_i , the central bank is able to affect output through surprise money creation.

There are both similarities and differences between the social welfare and the political interpretation of the policymaker's objective function adopted in this section.²⁰ The political approach views the policymaker as choosing money growth to maximize the expected value of

$$(7) \sum_{i=0}^{\infty} \beta [x_i (m_i - m_i^e) - \frac{m_i^2}{2}]$$

where x_i is a stochastic variable with some persistence.²¹

Equation 7 is formally equivalent to equation 5 with the sole exception that A is replaced by x_i ; however, its interpretation is quite different. Equation 7 reflects the current political compromise between competing objectives preferred by the policymaker; it is not a social welfare function. Similarly, the discount factor β reflects the time preference of the policymaker as an

¹⁸The precise channels through which these responses are elicited are subtle and, at times, elude precise formulation because the President, Congress and the Federal Reserve all have a common interest in preserving an image of the Central Bank as an independent, apolitical institution.

Kane (1980, 1982) has argued that the Federal Reserve performs a scapegoat function for the President and Congress. In return, the Fed gets a fair degree of independence which is necessary in order to credibly perform the scapegoat function. A general discussion of the political approach in the context of monetary reform appears in Willet and McArthur (1985).

Weintraub (1978, p. 356) concludes after summarizing the history of the post accord monetary policy that much of this policy "... can be explained just by noting who the President was when the policy under review was in effect." In a study of Presidential influence on monetary policy, Beck (1982) concludes that presidential political demands are somehow transmitted to the Fed. Beck notes that the transmission mechanism requires further study but that it seems clear that presidential preferences are an important determinant of Fed policymaking (Beck, 1982, p. 443). Woolley (1984) holds a similar view. Hetzel (1985) argues that current institutional arrangements allow Congressmen to pass on political pressures of various constituent groups to the Fed while avoiding association with the consequences that adversely affect the welfare of other groups. This explains Congress' consistent preference (noted by Woolley, 1984, chapter 7) for attempting to influence monetary policy through a variety of threats to limit the Fed's institutional autonomy rather than through an explicit mandate to guide monetary policy (Hetzel, 1985, p. 7). Since the autonomy of the Fed depends on Congress, it must be at least somewhat sensitive to the wishes of Congress provided the Fed values autonomy.

Both Congress and the Presidency are institutions largely concerned with various redistributive considerations. As a consequence the Fed is, possibly to a lesser degree, also sensitive to redistributive considerations. In addition, the Fed is not indifferent to the interests of groups with which it deals on a daily basis, e.g., banks and the financial community in general (Woolley, chapter 4). Arthur Burns (1979) appears to share the view that the Fed is not a totally free agent. He believes that the Fed can work to achieve price stability only if the policy does not adversely affect production and employment and does not irritate Congress. In Burns' words, the role of the Fed is to continue "probing the limits of its freedom to undernourish ... inflation" (Burns 1979, p. 16).

¹⁹The motivation of either group of advocates may be mostly distributional. Some people are relatively more adversely affected by unemployment than by inflation. Changes in x_i reflect changes in (a) the relative sizes of those groups, (b) the degree to which they are adversely affected by inflation and unemployment and, (c) the perceptions of the central bank about those changes and the degree of urgency in accommodating them. In some long-run sense, the central bank may be responding to the desires of voters. However, the public does not know the extent to which the central bank currently responds to voters.

²⁰The following discussion draws heavily on Cukierman and Meltzer (1986a).

²¹The precise stochastic structure is:
 (a) $x_i = A + p_i$ $A > 0$
 (b) $p_i = \rho p_{i-1} + v_i$ $0 < \rho < 1$
 (c) $v_i \sim N(0, \sigma_v^2)$.

A is a positive, publicly known, constant and p_i a first-order Markoff process whose realization is known only to the policymaker.

institution with its own priorities rather than the social rate of discount.²²

The political interpretation avoids some of the criticisms directed toward the social welfare interpretation for the policymaker's objective function. Thus, while it is difficult to explain why the monetary authority should be better informed about the social welfare function than the public, it is easy to believe that the policymaker is better informed about x_i , which simply reflects the policymaker's currently preferred compromise between conflicting objectives.²³

The policymaker acts in a discretionary manner in planning the rate of money growth (and inflation), taking into account the tradeoffs he faces between current stimulation and the public's future inflationary expectations. In particular, the policymaker knows that current actions which raise future inflation expectations make it more costly (in terms of inflation) to further stimulate the economy in the future. The policymaker chooses both the current money growth and plans for future money growth to achieve a maximum for the expected value of the objective function in equation 7.

The Effects of Imperfect Control and Uncertain Future Objectives

The decision pattern just described is complicated by two additional conditions. First, the policymaker is assumed to have imperfect control of the money supply — actual money growth deviates randomly from the growth planned by the monetary authority as shown in equation 8,

$$(8) \quad m_i = m_i^p + \eta_i,$$

where m_i^p is the rate of monetary growth planned by the policymaker for period i and η_i is period i 's realization of a white noise process, the variance of which is determined by the precision of existing monetary control procedures.²⁴

²²This formulation is consistent with the views of long-time students of the Fed like Lombra and Moran (1980), Lombra (1984) and Kane (1982) concerning the Federal Reserve System. In particular, Kane (1982, p. 207) writes:

"Inherent in the utopian view of the Fed is the presumption that the Fed can somehow evaluate the public interest on its own. In the contemporary United States, it is hard to conceive of the public interest except as a delicate balance of conflicting private interests."

²³In addition, the political approach does not rely on the notion that distortionary taxes necessarily induce policies biased toward inflation.

²⁴The case in which the level of precision in monetary control is a choice variable is considered later in this paper.

Second, the policymaker is assumed to be uncertain about his own future objectives. He knows, however, their current values and uses their persistent structure (see footnote 21) to derive optimal predictors of future values of x_i . These predictions are necessary, even though no commitment to any particular future money growth is required, because he knows that the current rate of monetary growth will affect future inflationary expectations. If he expects to care more about employment in the future than he does now, he will increase his ability to create surprises at relatively low inflation in future periods by choosing a relatively low current monetary growth. If he expects to care less about employment in the future than he does at present, he will choose faster current monetary growth (and faster inflation).

The important point is that the policymaker must predict his own uncertain objectives in the future when choosing the current rate of money growth. This uncertainty arises because he does not currently know for certain what the future optimal (for him) balance will be between pressures exerted by various groups and institutions. The more stable the underlying socio-political environment, the smaller this uncertainty will be. The uncertainty can be measured by the variance of the policymaker's objectives; this is denoted as σ_i^2 (see footnote 21).

Cukierman and Meltzer (1986a) (CM hereafter) show that the solution to the policymaker's decision problem in equation 7 is

$$(9) \quad m_i^p = B_0 A + B p_i,$$

where B_0 and B are positive constants that depend on the parameters of the policymaker's objective function and the precision of monetary control, and where p_i is the random part of x_i (see footnote 21). When equation 9 is substituted into equation 8, actual money growth can be expressed as

$$(10) \quad m_i = B_0 A + B p_i + \eta_i.$$

This model assumes that the public does not know the current state of the policymaker's objectives — x_i or p_i is known only by the policymaker.²⁵ The public, however, knows the policymaker's decision rule in equation 10 and has observed m in each period up to and including the previous one. Since m_i has some degree of persistence, past values of money growth convey noisy, but meaningful, information about future money growth to the public. The noise is induced by the control error, η_i .

²⁵Since A is public information, knowledge of x_i is equivalent to knowledge of p_i .

The optimal predictor of future money growth adjusts slowly to actual changes in observed money growth; specifically,

$$(11) m_t^e = (\rho - \lambda) m_{t-1} + \lambda m_{t-1}^e + (1 - \rho) B_0 A.^{26}$$

The parameter λ is determined by the degree of persistence in the policymaker's objectives, the precision of monetary control and the degree of instability in the political environment of the policymaker as measured by σ_η^2 . Because λ is bounded between 0 and ρ , the value of $\rho - \lambda$ is positive.

Equation 11 specifies that expected money growth is a weighted average of last period's money growth, m_{t-1} , the last period's expectation, m_{t-1}^e , and $B_0 A$.²⁷ Inflationary expectations partially adjust to changes in actual and planned money growth because, as implied by equation 10, actual money growth is influenced both by persistent changes in the objectives of the policymaker and by transitory control errors. The public, therefore, rationally attributes only part of the fluctuations in m to persistent changes in the objectives of the policymaker.

When choosing the rate of money growth, the policymaker takes into consideration its effect on future inflation expectations (equation 11). In fact, the policymaker's decision rule (equation 9) is the solution to maximization of the expected value of his objective function (equation 7), given how the public's inflation expectations are formed (equation 11).

The equilibrium formed from these equations is self-fulfilling. Given the decision rule of the policymaker (equation 9) and the money growth equation (equation 10), the best predictor of future inflation is given by equation 11. Conversely, given this predictor, the best strategy for the policymaker is shown by equation 9, which induces the money growth shown by equation 10.

Monetary Surprises and Credibility

The self-fulfilling nature of equilibrium does not mean that there are no monetary surprises. In fact, monetary surprises occur frequently; their expected value, however, is zero. The reason for frequent monetary surprises is that the objectives of the policymaker

are continually changing; the public, however, becomes aware of those changes only gradually by observing past rates of inflation. Thus, when the policymaker becomes relatively less concerned about inflation prevention, the public recognizes this policy change only gradually. In the interim, actual inflation is higher than expected and employment is above its natural level. Conversely, when the policymaker becomes relatively more concerned about inflation prevention, inflation is lower than expected and output is below its natural level until the public recognizes this policy change.

The public monitors changes in monetary growth because these figures provide additional information about future inflation. This incentive to monitor money growth explains why resources are devoted to Fed watching (Bull, 1982; Hardouvelis, 1984). In the absence of asymmetric information, there would be no reason for this activity.

Recently Fischer (1984) has stressed the importance of the speed with which the public's expectations adjust for determining the costs of disinflation policy actions. The faster expectations adjust, the lower the output costs of disinflation will be. CM show that the speed with which expectations adjust is systematically related to the precision of monetary control. In particular, the less precise monetary control is, the larger is λ in equation 11 and the longer it takes for the public to recognize that the policymaker's objectives have changed.²⁸

CM conceive of credibility as the speed with which the public recognizes that a change in the policymaker's objectives has actually occurred. This concept of credibility seems appropriate when policy is discretionary and the policymaker's objectives (known only to him) are in constant flux. The parameter λ from equation 11 is a natural and convenient measure of credibility.²⁹ Using this measure, credibility is higher, the more precise monetary control is (the lower the variance of η).

It has been observed that short-run considerations often are given relatively large weight in the actual conduct of monetary policy.³⁰ In terms of the frame-

²⁶In statistical terms m_t^e is the expected value of m_t conditioned on m_{t-1}, m_{t-2}, \dots

²⁷Taking unconditional expected values on both sides of equation 10, $B_0 A$ can be recognized as the unconditional mean money growth.

²⁸With a higher λ , less weight is given to the last observed inflation, m_{t-1} , and more weight is given to the last inflation expectation, m_{t-1}^e .

²⁹As shown in equation (10b) of CM, λ is a known function of σ_η^2 and ρ as well so that credibility is also influenced by the instability of objectives and their persistence.

³⁰For example, see Brunner and Meltzer (1964), Kane (1977, 1980), Pierce (1980), and Mayer (1982).

work presented here, this observation means that the policymaker has a high time preference (β in equation 7 is low). CM show that the higher the policymaker's time preference, *ceteris paribus*, the higher the variability and the uncertainty in the rate of monetary growth.

The characterization of credibility differs somewhat among various models of monetary policy behavior. As explained above, in the CM formulation, credibility is a parameter. It measures the speed with which the public detects the actual changes in the policymaker's objectives. CM characterize credibility under discretion and asymmetric information. In models with two types of policymakers, credibility or reputation is a state variable.³¹ It is the current subjective probability assigned by the public to the event that the policymaker is strong.

Barro and Gordon (1983b), on the other hand, focus on the credibility of the first-best, non-inflationary policy and point out that this policy is "incredible" under discretion and symmetric information.

The Credibility of Publicly Announced Monetary Targets

Cukierman and Meltzer (1986b) extend the politically based model to the case in which the policymaker makes noisy (e.g., announcements of target ranges rather than a specific level) but unbiased announcements about his future plans.³² In this case, the public finds it optimal to use the information from past announcements in addition to past monetary growth to form its expectations. In comparison to the case in which no announcements are made, noisy announcements *never* increase (and usually decrease) the public's uncertainty about future monetary growth. In the case in which announcements are made, credibility is naturally defined as the deviation between the current announcement and the public's expectation. This deviation depends on the relative amounts of noise in both the control of the money supply and the announcements, as well as on the

³¹Backus and Driffill (1985a, 1985b); Barro (1985).

³²House Concurrent Resolution 133, and later the Humphrey-Hawkins Act, require the Federal Reserve to announce planned rates of growth for principal monetary aggregates. The purpose of this legislation is to provide the public and Congress with more precise information about the particular monetary actions contemplated by the monetary authority. Announcements are (or have been) made in Germany, Japan, U.K., France, Canada, Australia and Switzerland.

magnitude of recent changes in the policymaker's objectives.

THE ROLE OF AMBIGUITY AND SECRECY IN THE CONDUCT OF MONETARY POLICY

Various students of central bank behavior have suggested that the low credibility and ambiguity in the specification of objectives by central banks may be, to some extent, deliberate.³³ The political approach presented in the previous section provides an explanation for this inclination for policy ambiguity. Consider the case in which the level of noise in monetary control is a choice variable rather than a technological datum. The policymaker will choose, once and for all, the variance of the monetary control error that maximizes the unconditional expected value of his objective function, which, for this discussion, is equation 7.³⁴

For any given level of control precision, the planned and actual money growth are determined by equations 9 and 10, respectively, and the public's inflationary expectations are determined by equation 11. By choosing more noisy control procedures, the policymaker increases λ in equation 11; this, in turn, increases the length of time it takes the public to recognize a change in the policymaker's objectives.

Whether a longer recognition period is desirable, however, depends upon the change in policymaker objectives. It is advantageous when the policymaker becomes relatively more concerned about economic stimulation; in this case, he can produce positive surprises for a longer time period. When the policymaker becomes relatively more concerned about inflation, however, a higher λ is detrimental; it lengthens the period of recession and negative surprises necessary to decrease inflation. Thus, the policymaker would like to have lower credibility (in the CM sense)

³³In recent hearings before the Joint Economic Committee, Lombra argues that the observed incompleteness in the specification of quantitative goals for monetary policy is deliberate (Lombra, 1984 p. 113). Similar views are expressed in Brunner and Meltzer (1964) and Lombra and Moran (1980). The penchant of the Central Bank for secrecy has recently been revealed in the legal record of a case in which the Federal Open Market Committee (FOMC) was sued under the Freedom of Information Act of 1966. The suit required the FOMC to make public immediately after each FOMC meeting the policy directives and minutes for that meeting (Goodfriend, 1986). The Federal Reserve argued the case for secrecy on a number of different grounds. The important issue from the point of view of this section is that the Federal Reserve attempted to preserve its information advantage.

³⁴The following discussion is based on section VI of Cukierman and Meltzer (1986a).

when he becomes more interested in stimulating employment and higher credibility when he becomes more interested in preventing inflation.³⁵

Although positive and negative surprises cancel each other out on average, the policymaker may still find it advantageous to choose control procedures that slow down public recognition of changes in his objectives. Greater ambiguity provides the policymaker with greater control in timing monetary surprises. When there is more ambiguity about policy, he can create larger positive surprises when he cares more about stimulation and leave the inevitable negative surprises for periods in which he is relatively more concerned about inflation.

Thus the policymaker makes a once-and-for-all (politically) optimal choice of control procedures that also determines his public credibility. This choice is systematically related to the degree of time preference of the policymaker; in particular, policymakers with a stronger time preference will choose less precise control procedures.³⁶

Moreover, the higher the degree of uncertainty in the policymaker's objectives, the more likely he is to choose less precise control procedures and lower credibility. When the policymaker's objectives are relatively unstable, a rational public will give more weight to recent developments in forecasting the future rate of growth of money. Consequently, for a given precision in monetary control, it is more difficult to exploit the benefits of monetary surprises. By decreasing the precision of monetary control, a policymaker with relatively unstable objectives can partially offset this effect by increasing the length of time it takes the public to detect a given shift in its objectives.

ESTABLISHING CREDIBILITY BY DETERRENCE

Ever since Kydland and Prescott (1977) pointed out that the monetary authority and the public are caught

in a prisoners' dilemma resulting in excessive inflation, it has become natural to look for mechanisms that would eliminate or reduce this inefficient result. Obviously, a first-best solution would be to effectively commit the policymaker to a zero inflation policy.³⁷ If such commitments are impossible, second-best solutions may be sought.

One second-best solution that relies on deterrence within a symmetric information environment has been suggested in Barro and Gordon (1983a). It can be illustrated using the relationships previously described. The basic idea is that the public must determine its inflation expectation in a way that deters the policymaker from choosing its optimal discretionary rate of inflation, for example, A in equation 6. Suppose that the policymaker announces a rate of inflation, m^* , that is lower than A . The public then sets its inflationary expectation for the current period as follows: If actual inflation in the previous period accords with expectations, they expect that inflation will continue at m^* . If the previous period's inflation does not accord with expectations, they expect instead that the monetary authority will inflate at the higher discretionary rate, A . Thus, whenever the monetary authority inflates at rate A rather than at its announced rate m^* , the public "punishes" it for one period by believing that it will continue to do so in the next period as well.³⁸

The monetary authority maximizes its objective function (equation 5) subject to the public's behavior.³⁹ In considering whether to inflate at rate A today, it compares the difference between the current value of social welfare when it inflates at rate A rather than at rate m^* (given that the public expects m^*) with the discounted value of the loss in next period's welfare because the public's inflation expectations increase from m^* to A .⁴⁰ As long as the latter term (which acts as a deterrent) is larger than the former term (which

³⁵This may explain why public concern about lack of credibility is aroused mostly when disinflation is considered. Not much concern was expressed at the end of the '60s and the '70s complaining about the lack of credibility of the increased inflationary policies of those times.

³⁶Long-time students of the Fed like Brunner and Meltzer (1964), Kane (1977, 1980), Mayer (1982) and Pierce (1980) suggest that the Federal Reserve engages primarily in "fire fighting." In terms of the model, this would imply a high rate of time preference (low β in equation 7). In conjunction with the result obtained by CM, this implies that the Fed is likely to have a preference for incomplete control procedures and imperfect credibility.

³⁷Or to whatever the optimal rate of inflation happens to be.

³⁸In spite of its popularity, this term does not quite catch the function of this strategy. The idea is not to *punish* the monetary authority but rather to *deter* it from inflating at the discretionary rate A . This observation is due to Edward Green.

³⁹The example here is within the social welfare framework in which the policymaker's objectives are identical to the social welfare function.

⁴⁰The calculation of this loss is based on the understanding that the monetary authority chooses A also in the next period. The reason is that this choice yields a better value to its objective function than the choice m^* . Given that, in the next period, expectations are at A , inflation at A yields $-A^2/2$ to the policymaker whereas inflating at m^* yields $A(m^* - A) - (m^*)^2/2$ which is smaller for any $m^* < A$.

represents the temptation to inflate at rate A), the policymaker picks m^* , the lower inflation rate.

Formally (from equation 5), the condition for effective deterrence of the higher inflation A is

$$(12) \quad \frac{\beta}{2} [(A^2 - (m^*)^2)] > A(A - m^*) + \frac{(m^*)^2 - A^2}{2}$$

The left-hand term is the discounted value of the loss in next period's welfare due to the increase in expectations. The right-hand term is the gain in current welfare induced by higher current employment.⁴¹

The lowest credibly sustainable rate of inflation can be found by equating the two sides of equation 12 and solving for m^* .⁴² The solution is shown in equation 13:

$$(13) \quad m^* = \frac{1 - \beta}{1 + \beta} A.$$

This rate is higher than the first-best zero inflation, but lower than the rate of inflation, A , that would occur in the absence of deterrence. Equation 13 expresses the best enforceable rule as a function of the discount factor β . The higher the degree of time preference, the higher the minimum sustainable rate of inflation will be.⁴³ Once this mechanism is in place, it is self-fulfilling: the public believes that the policymaker will inflate at rate m^* and, indeed, the policymaker does so. In the absence of commitments, therefore, a second-best lower rate of inflation can be credibly sustained by an appropriate deterrence mechanism.

Criticism of the Deterrence Approach to Central Bank Credibility

The deterrence approach to enhancing central bank credibility has been interpreted by some (e.g., Barro and Gordon, 1983a) as a positive theory of inflation.⁴⁴ Taylor (1983), however, raises doubts about its usefulness as a positive theory of inflation on the grounds

⁴¹Note that the ideal inflation expectation, $m^* = 0$, cannot be sustained if there is positive time preference. It would require the inequality

$$\beta \frac{A^2}{2} > \frac{A^2}{2}$$

to hold; however, this condition cannot be satisfied when $\beta < 1$. A somewhat higher rate of inflation can be sustained by this mechanism even for $\beta < 1$.

⁴²Since this is a quadratic equation there are two roots, the smallest of which corresponds to the minimum credibly sustainable inflation.

⁴³Obviously other deterrence mechanisms will yield different sustainable ranges for the rate of inflation.

⁴⁴It also can be considered from a normative point of view, in which it represents a mechanism that improves welfare in comparison to a situation in which this mechanism is absent.

that, in other similar dynamic inconsistency situations, society has found ways to circumvent the problem. He cites patents as a device for eliminating the dynamic inconsistency problems faced by inventors as an example.

In addition, the deterrence equilibrium implies that the rate of inflation remains constant (Canzoneri, 1985). This implication is clearly at odds with observations that both inflation and monetary growth fluctuate substantially over time. Further, the deterrence equilibrium depends critically on the punishment strategy assumed in the analysis. Consequently, the infinite-horizon monetary policy game has multiple Nash equilibria with no mechanism for choosing among them (Backus and Driffill, 1985a). Therefore, any specific link between the current actions of the policymaker and the future expectations of the public is strictly arbitrary.

Finally the deterrence strategy may be subject to a free rider problem.⁴⁵ Individuals may simply find that it is not worthwhile to achieve a lower rate of inflation via the deterrence mechanism if the private costs of monitoring the policymaker's actions are higher than the marginal private benefits. This problem, while of lesser importance in the context of oligopoly theory from which the formal structure of the deterrence equilibrium above has originated, may be serious if the public is composed of many individuals.⁴⁶ Each individual may rely on the others to deter the policymaker from acting in a discretionary manner, thus eliminating the deterrence mechanism that made the lower inflation policy credible in the first place.

CONCLUDING REMARKS

Traditional economic analysis generally has treated policymakers' behavior as determined exogenously. In contrast, recent literature on central bank behavior focuses explicitly on how the motives, constraints and information of policymakers and the public determine monetary policy outcomes.

Some analysts use a political explanation of the policymaker's objectives; others identify the policymaker's objectives with a social welfare function. Both approaches show how an inflationary bias is created by interactions between the policymaker and the

⁴⁵Suggested by Edward Green in conversation.

⁴⁶J. Friedman (1971, 1977) contains an early discussion of the deterrence strategy in the context of oligopoly.

public. Models utilizing the political approach, however, seem to be better able to explain two widely observed phenomena: the preference of monetary authorities for ambiguity in public policy pronouncements and the large swings in actual rates of money growth and inflation. Unfortunately, existing political models have not identified explicitly how various groups and political institutions combine to shape the objectives of the monetary authority.⁴⁷

More recently, models have appeared that combine explicitly some interaction between political behavior, institutions, and economic policymaking. Some of these models rely on the existence of long-term contracts to induce a tradeoff between lower inflation and stimulation. A central theme of this literature is the optimal design of monetary institutions. Those developments will be described in the second part of this survey.

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⁴⁷While there is a substantial amount of descriptive narration (e.g., Woolley, 1984; and Hetzel, 1985), there is very little analytical discussion of these issues.

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