How Should Central Banks Reduce Inflation?—Conceptual Issues

By Mervyn King

It is tempting to give a very short answer to the title of the session—raise interest rates and reduce monetary growth. But when and by how much? That raises two questions which are central to the design of monetary policy. First, starting from an inflationary episode, how quickly should inflation be reduced to its desired level? Second, should monetary policy react to shocks to output as well as to inflation? The two questions are closely related and are the subject of this paper.

Both questions were faced by the United Kingdom following departure from the exchange rate mechanism (ERM) in September 1992. At that time, the latest published inflation rate (retail price inflation excluding mortgage interest payments) was 4.2 percent, but that was following a recession during which output fell, relative to trend, by almost 10 percent, and the sterling effective exchange rate had just depreciated by 13 percent. The policy challenge was to prevent the depreciation having second-round effects on wages and prices, and to keep inflation falling during a recovery in output that had already started.

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The exchange rate link was replaced by a domestic monetary framework defined in terms of an inflation target. The objective was to achieve "price stability" in the long run, defined by the then Chancellor, as a measured inflation rate of 0 to 2 percent a year. But the aim was not to bring inflation down to below 2 percent by the next month, or even the next year. It was to approach price stability gradually. In October 1992 a wide band of 1 to 4 percent for the target range of inflation was announced, with the additional objective of reaching a level below 2.5 percent by the end of the Parliament, a date then some four to five years ahead. The implicit assumption was that it would take approximately five years to make the transition to price stability. In the event, inflation fell below 2.5 percent in March 1994, remained below that level for ten months, but then rose again to just over 3 percent. In August 1996 inflation was 2.8 percent.

In 1995 the target was modified. Monetary policy would aim consistently to achieve an inflation rate of 2.5 percent or less some two years ahead. Shocks would mean that inflation would sometimes be above and sometimes below that figure. But in the long run, if policy were successful in achieving the target, inflation would average 2.5 percent or less. The stated objective of monetary policy was permanently low inflation. There was no mention of output

Table 1

COUNTRIES WITH INFLATION TARGETS

Country	Price index	Date of introduction	Inflation rate at date of introduction	Inflation target
Australia	CPI	1993	1.8	Average of 2%-3%
Canada	CPI	February 1991	6.2	1%-3% from 1995
Finland	CPI	Early 1993	2.6	2% from 1995
Israel	CPI	December 1991	18.0	8%-11% for 1995
New Zealand	CPI	March 1990	7.0	0%-2%
Spain	CPI	November 1995	4.4	Below 3% by 1997
Sweden	CPI	Early 1993	4.8	2% ± 1% from 1995
United Kingdom	RPIX	October 1992	4.2	2.5% or less

as an explicit consideration in setting monetary policy.

Other countries have shown an equal reluctance to move quickly to price stability. Table 1 shows those countries which have in recent years adopted an explicit inflation target. Except for Australia, in all cases target inflation was below the existing rate of inflation. And in most cases, there was planned to be a gradual transition to price stability. A good example is that of Canada, which planned to bring inflation down from over 6 percent to a range of 1 to 3 percent over four years. New Zealand is a contrast in which the aim was to move quickly from an inflation rate of 7 percent to a range of 0 to 2 percent.

Table 2 shows average inflation rates in each decade since 1950 for the G-3 countries and the seven industrialized countries which adopted inflation targets. From a peak in the 1970s and 1980s, inflation declined steadily. But only in Germany, Japan, and New Zealand was there anything other than a slow adjustment to low inflation. Chart 1 compares the path of the inflation rate since 1950 for the G-3 countries and the inflation target countries as a group. Not surprisingly, on average the countries which subsequently adopted an inflation target experienced higher inflation than the G-3 over most of the period. It is interesting that following an inflation shock there were rather different speeds of adjustment. Japan, in particular, appears to have brought inflation down more quickly than either the United States or the inflation target countries over the past 20 years.

Is it possible to explain the different responses of the two sets of countries? It is important to distinguish between two speeds of adjustment. The first is the speed at which the inflation target implicit in monetary policy converges to price

Table 2

INFLATION RATE BY DECADE IN SELECTED COUNTRIES

	Average of:				
Country	1950s	1960s	1970s	1980s	1990-95
Countries with inflation targets:					
Australia	6.5	2.4	9.8	8.4	3.3
Canada	2.4	2.5	7.4	6.5	2.7
Finland	6.2	5.1	10.4	7.3	2.7
New Zealand	5.1	3.3	11.5	11.9	2.7
Spain	6.2	5.8	14.4	10.3	5.3
Sweden	4.5	3.8	8.6	7.9	5.0
United Kingdom	4.3	3.5	12.7	6.9	4.6
G3 countries:					
Germany	1.1	2.4	4.9	2.9	3.2
Japan	2.9	5.3	8.9	2.5	1.6
United States	2.1	2.3	7.1	5.5	3.5

Note: Inflation is measured in terms of the Consumer Price Index, except in the United Kingdom, where RPIX is used, which excludes mortgage interest payments.

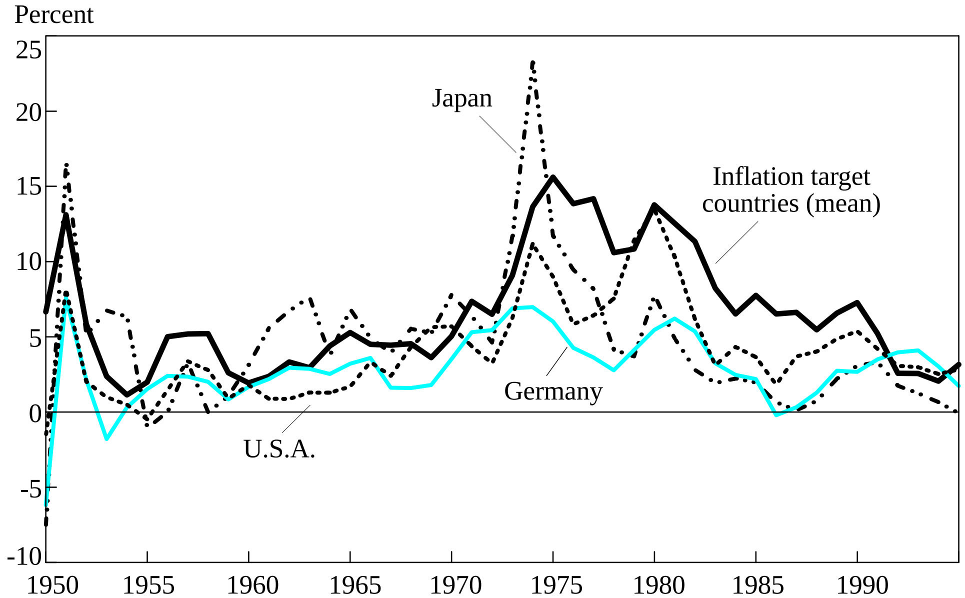
stability—the optimal speed of disinflation. The second is the speed at which policy offsets a temporary shock to inflation—the flexibility of monetary policy. In countries with a credible commitment to price stability (or to a stable low inflation rate, as in the G-3) only the second speed of adjustment is relevant. But in countries attempting to change from a regime of moderate or high inflation to one of price stability, there is an additional issue of the optimal speed of disinflation. That depends on how rapidly private sector expectations of inflation adapt to the change in regime.

It has been argued that "the United States is only one recession away from price stability." In contrast, it has been suggested that the United Kingdom is only one expansion away from diverging from price stability. Too slow a convergence on price stability, and too great an accommodation of inflation shocks, have their dangers. The ultimate target becomes less credible. So what determines the optimal speed of disinflation and how flexible should monetary policy be in the face of shocks? Those questions are analyzed in the second and third sections, respectively. I shall assume that the long-term objective of monetary policy is price stability.[1]

I. THE OPTIMAL SPEED OF DISINFLATION

In this section I examine the speed of disinflation that would be chosen by a central bank in a world in which monetary policy affects real

Chart 1
CPI INFLATION IN THE G3 AND INFLATION TARGET COUNTRIES, 1950-95



Note: Inflation target countries are those shown in Table 1.

output and employment in the short run but not in the long run. I shall make two points. First, irrespective of the instruments used to implement it, monetary policy is a combination of an ex ante inflation target chosen each period and a discretionary response to certain shocks. Those shocks are ones to which the central banks can respond before the private sector is able to adjust nominal contracts. Second, in general, it is not optimal to move immediately to a regime of price stability unless that regime can be made fully credible by institutional or other changes.

Following a prolonged period of inflation, why should a central bank not move immediately to price stability? The answer is that there are costs of disinflation, and, moreover, those costs increase more than proportionally with the rate of disinflation. Such costs result from a change in the monetary policy regime—the target inflation rate—because private sector agents cannot easily tell whether the regime has changed or not. Learning takes time. And the longer the period during which inflation was high, the longer it is likely to be before the private sector is persuaded that policy has changed. An unanticipated disinflation will depress output because wages and prices take time to adjust to the new lower price level (relative to expectations). Disinflations in both the United States and the United Kingdom in the early 1980s proved costly in terms of lost output and employment.

The speed at which expectations adjust during that transition will influence the magnitude of the output loss. A central bank can lower those costs by reducing the gap between private sector inflation expectations and the inflation target implied by its own monetary policy. A target is credible when the gap is zero. Indeed, "rational expectations" are defined as those where expected inflation is equal to the inflation target. But the mere announcement of a commitment to price stability as the basis for monetary policy is unlikely to generate full credibility quickly. Indeed, in a deeper sense, expectations are likely to be influenced by the commitment to price stability among the public at large. Institutional changes such as central bank independence, may improve credibility; but when they do so, it is largely because they reflect a commitment among the public to the objective of price stability.

The optimal speed of disinflation depends, therefore, on the real output costs of changing expectations held by the private sector about the intentions of the central bank to reduce inflation. Those costs reflect the existence of a short-term tradeoff between inflation and output. Such a tradeoff reflects nominal stickiness in wages and prices, which results from the cost of processing information in order to determine the prices which it is optimal to charge, as well as incomplete adjustment of expectations to changes in the monetary policy regime. In a survey of 200 firms, Blinder (1994) found that "almost 80 percent of GDP is repriced quarterly or less frequently." Both nominal stickiness and slow adjustment of inflation expectations play a role in the analysis set out below. Nominal stickiness means that the central bank can affect output in the short run because monetary policy is able to respond to at least some of the shocks hitting the economy before wages and prices can be adjusted by private sector agents. I do not assume that the central bank has private information—except about its own preferences for price stability. There can be few decisions where the relevant information is more widely available to, and analyzed by, the public than monetary policy. But the central bank may be able to respond to a shock before all wages and prices have adjusted, and it is that speed of response which enables monetary policy to influence the extent to which shocks impact on output or inflation. Of course, there will be some shocks to which even the central bank will find it difficult to respond in time, and such shocks introduce a random element into the behavior of inflation despite the best efforts of central banks to control the price level.

The speed at which expectations adjust to changes in inflation was a key element in the expectations-augmented Phillips curve of Friedman and Phelps. In their model, expectations adjusted slowly to changes in actual inflation, and the central bank could raise output for a time by raising the inflation rate. At a constant inflation rate, expectations would be consistent with actual inflation, and unemployment would be at its natural rate. It was the assumption of rational expectations that enabled Lucas (1973) to undermine the theoretical plausibility of even a short-run trade-off. Monetary policy could not affect output because expectations adjusted immediately. Only when the private sector had incomplete information about monetary policy could changes in money affect output. That is because, in the Lucas model, agents are uncertain about how to interpret changes in nominal prices. Do they reflect changes in the aggregate money stock or are they changes in relative prices? Confusion can exist for awhile because neither the money supply nor the aggregate price level is perfectly observable. Such an assumption is not plausible empirically. The world is not short of statistics on money and inflation. But nominal stickiness—nominal contracts which last for several periods—mean that future inflation matters. And agents, although able to observe current money supply, may be uncertain about how the central bank will conduct monetary policy in the future. So differences between actual and anticipated monetary policy will affect output.

A change in the way monetary policy is conducted will alter private sector expectations. It is not sensible to ignore that aspect of a change in monetary policy, as was done in the more extreme Keynesian models. Equally, however, it is too extreme to suppose expectations adjust immediately to a new regime. Learning takes place in real time. As Brunner and Meltzer put it,

> Both positions are unacceptable. The Keynesians failed to recognize that people learn and are not locked into their beliefs and behavior. The new classical macroeconomists introduce learning but neglect costs of acquiring information. Neglect of these costs leads them to exaggerate the speeds of learning and response in the marketplace and the knowledge that people have about the future in a changing and uncertain world (1993, p.132).

Nevertheless, Sargent (1986) has argued that a sharp disinflation may be preferable to gradualism because expectations adjust quickly. There is no doubt that the "rational expectations" approach to understanding changes in monetary regimes has been very important. When governments change behavior, agents learn. But how do they learn and over what time span? Those are the key questions the answers to which determine the optimal speed of disinflation. In Sargent's view, "gradualism invites speculation about future reversals, or U-turns, in policy" (p.150). Excessive gradualism surely does so; but so does excessive radicalism. Sargent's strictures on gradualism relate primarily to paths toward price stability that are accompanied by large and persistent government budget deficits. On that I fully agree. Unless budget deficits are reduced to levels consistent with price stability, no commitment to price stability is credible. In what follows I shall assume that deficits are on a path consistent with price stability in the long run.

I shall examine the role of learning in a simple model of aggregate demand and supply.[2] For those who enjoy equations, a good many are given in the appendix. There are three equations for the three key variables: aggregate supply, aggregate demand, and the money stock. The model is standard—with one exception. In the recent literature on the "inflation bias" of discretionary monetary policy, it has become fashionable (despite the best efforts of McCallum 1995, 1996) to assume that the central bank aims for a rate of unemployment below the market-generated natural rate of unemployment. Put simply, the central bank uses monetary expansions to create jobs which do not exist in the long run. In contrast, I shall assume that the central bank does not use monetary policy as a substitute for microeconomic structural reforms. Because it is not trying systematically to push unemployment below the natural rate, there is no "time inconsistency" in monetary policy. By relating monetary policy to macroeconomic rather than microeconomic goals, there is no "inflation bias" and hence no obstacle to the achievement of price stability.

The model is simple. First, aggregate supply exceeds the "natural" rate of output when inflation is higher than was expected by agents when nominal contracts were set. Positive price surprises make it profitable for firms temporarily to increase output. Output is also subject to random shocks. These are of two types. The first (type 1 shocks) are shocks which can be observed by the central bank before monetary policy is determined, but which the private sector observes only after wages and prices have been set for that period. Monetary policy can respond to those shocks. The second (type 2 shocks) cannot be observed by the central bank until after policy has been set for that period. They may not be observable until data are published some months after the event. Type 2 shocks will introduce additional randomness into inflation and output, but are not central to the choice of monetary strategy.[3]

Aggregate demand is positively related to real money balances and to expected inflation. That is the reduced form of a system in which the demand for money is a function of nominal expenditure and nominal interest rates, the demand for goods is a function of real money balances and the real interest rate, and the real interest rate is equal to the nominal interest rate less the expected inflation rate.

The final relationship describes the process by which the central bank determines the growth of the money supply. In the technical jargon, monetary policy is a "reaction function" which determines policy as a function of changes in observable economic variables. Each period the money supply (or, equivalently, the short-term interest rate) is set by the central bank in full knowledge of the size of the shock to output, which it has been able to observe. The expectations of the private sector that influence demand and supply are, however, formed before agents can observe the shock. That reflects nominal stickiness in setting wages and prices. It is possible, therefore, to express the monetary policy reaction function as a choice by the central bank of two variables. The first is an inflation target for that period, defined as the value of the inflation rate which the central bank would like to achieve in the absence of any shock to output. The second term is the discretionary response by the central bank to the observed shock that leads it to choose values for interest rates or monetary growth that are an appropriate response to the shock. It is shown in the appendix that it is possible to compress the model into two equations—for inflation and output. These are:

$$\textit{inflation} = \textit{inflation target} + R_I(\textit{type 1 shock}) + \textit{type 2 shock}$$

$$\textit{output} = \textit{natural rate} + b(\textit{inflation target-expected inflation}) + R_O(\textit{type 1 shock}) + \textit{type 2 shock},$$

where R_I and R_O are coefficients which describe the effects of monetary responses to type 1 shocks on inflation and output, respectively, and b measures the impact of inflation surprises on output.

There are two points to note. First, *any* monetary policy can be described as a choice of (1) an *ex ante* inflation target and (2) an optimal response to observable shocks. An inflation target is not a particular form of setting monetary policy; rather, it is its generic form. That is why the difference between an inflation target regime for monetary policy and a regime based on a monetary target can easily be exaggerated. Choosing the inflation target, however, does not uniquely define monetary policy. There is the subsidiary question of how policy should respond to shocks. It is important to distinguish these two aspects of policy in order to avoid confusion between changes in trend inflation, which are monetary, and changes in price levels caused by real shocks.

Second, inflation can differ from the long-run desired level which corresponds to price stability, for three reasons. First, the inflation target itself may differ, at least temporarily, from zero. Second, it may be optimal to accommodate a temporary inflation shock. Third, there may be other shocks to inflation about which the central bank can do little in time to prevent their feeding through to the final price level. Since the shocks average to zero over a period, it is clear that a central bank can achieve price stability by setting its inflation target to zero (or whatever measured inflation rate corresponds to price stability).

The two equations determine inflation and output as a function of the choices made by the central bank (the inflation target and the discretionary response to a shock), the expected inflation rate, and the shock to output. For any given model of learning by the private sector about how the central bank will set its inflation target it is possible to solve for the actual paths of inflation and output (see the appendix).

Suppose that inflation has averaged some positive rate for a period, and that both expected inflation and the implicit inflation target are consistent with that rate. If the central bank now announces that it intends to pursue price stability in the future, what will happen to inflation and output? That depends on how quickly expectations adjust to the new monetary strategy. Three cases may be analyzed corresponding to different models of learning. These are rational expectations; exogenous learning, in which expectations adjust along a path that is independent of the inflation out-turn; and endogenous learning, in which the speed of learning depends on the policy choices made by the central bank.

A fully credible change in regime

A change to a regime of price stability that is fully credible means that private sector expectations are consistent with the adoption of a new inflation target corresponding to price stability. When expected inflation equals the actual inflation target chosen by the central bank, there is no systematic deviation of output from its natural rate. Policy can achieve price stability without any expected output loss. The optimal strategy is to move immediately to a zero inflation target. There is, however, one exception, even in the case of full credibility. In an open economy, nominal wage and price stickiness may mean that, after a change to a regime of price stability, the exchange rate rises to a level above its long-run equilibrium corresponding to the new monetary policy, causing a short-term rise in the real exchange rate. Such Dornbusch overshooting of the exchange rate depresses the demand for domestically produced output. In that case the time horizon for a move to price stability is determined by the duration of nominal stickiness.

Exogenous learning

In general, an announcement by the central bank that in the future the inflation target will be consistent with price stability does not command immediate credibility. It takes time for the private sector to be convinced that the target will be chosen to be consistent with price stability. The private sector will try to learn about the true preferences of the central bank. Their pronouncements will not necessarily be taken at face value. Modeling learning is difficult. As Sargent argues:

> The characteristics of the serial correlation of inflation are inherited from the random properties of the deep causes of inflation, such as monetary and fiscal policy variables (1986, p. 113).

There is no unique way to model rational learning. Nevertheless, it seems implausible to suppose that learning takes place immediately upon a switch to a new monetary regime. By moving rapidly to price stability, a central bank can hope to demonstrate that it is committed to price stability. Indeed, in a world in which there are only two kinds of central banks—“tough” and “weak”—it has been shown that a “tough” central bank will disinflate just fast enough to differentiate itself from a “weak” central bank that might otherwise be tempted to pass itself off as a true inflation-fighter. (Vickers 1986, Persson and Tabellini 1990). In practice, there is a spectrum of views on inflation that might be held by a monetary authority, and it becomes much more difficult to learn where on that spectrum a central bank lies. Successful regime shifts usually occur when public opinion is behind the need for a dramatic reform, and hence the sustainability of the reform is more credible. That support is less obvious for a shift from low and moderate inflation rates to price stability than when tackling a hyperinflation. To be credible, the change in regime must be widely understood and thought likely to persist. For that to be the case, it is insufficient for a central bank to make a public announcement; the change must also be thought acceptable to a wider public. Consider the following example of a clear regime shift suggested by Sargent,

> It is arguable that pegging to a foreign currency is a policy that is relatively easier to support and make credible by concrete actions, since it is possible to hook the domestic country's price expectations virtually instantaneously onto the presumably exogenous price expectations process in the foreign country (1986, p.121).

When Britain joined the ERM in 1990, inflation expectations did not jump to those in Germany or other "inner" core members of the ERM. Inflation expectations did fall modestly, and they rose again when Britain left the ERM in September 1992. But the process of learning about the government's commitment, both to the ERM and to price stability, did not stop upon entry to the ERM. That shows that a regime shift may be easier to identify in theory than in practice.

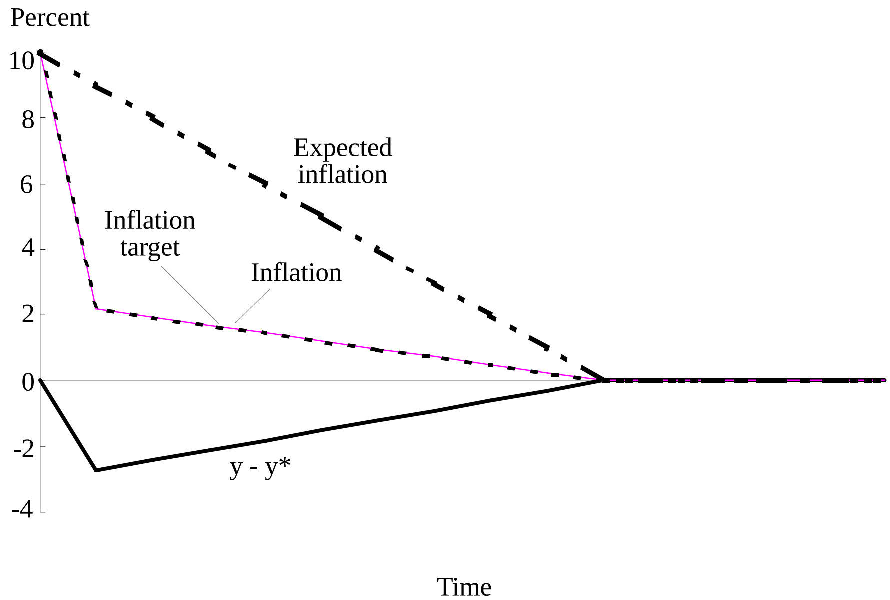
Much of the process of learning about central bank preferences is independent of the actual evolution of inflation itself. Central bank behavior reflects the degree of external support for its objectives. And since the ultimate basis for a central bank commitment to price stability is a wider public support for that objective, it is not easy to forecast how quickly a central bank will be able or willing to move toward price stability. In practice, learning is continuous. The idea that private agents are trying to learn about a fixed point—the long-run inflation target—misses some important aspects of behavior. Central banks are not static institutions. There is turnover among members of the governing board, and new ideas about monetary policy are continually injected into the policy debate. Since central banks' views change, private agents need to learn continuously about those views.[4] The significant reduction in inflation in the industrial countries over the past 20 years surely derives at least as much from the gradual acceptance that there is no long-run trade-off between inflation and unemployment as from changes in preferences about inflation itself. It is worth examining, therefore, the consequences of a learning process that is exogenous to the short-run path of inflation.

If expected inflation exceeds the inflation target, then there are systematic output losses during the transition to price stability. It would be costly to pursue price stability from the outset. It is possible to calculate the optimal transition path given the objective of minimizing deviations of inflation from the desired level of zero and of output from its natural rate. There is a trade-off between the two. Too slow a reduction in the inflation target implies inflation remains high for a long period; too rapid an approach to the long-run target means large output losses.

It is shown in the appendix that when expected inflation converges on price stability at an exogenous rate, then it is optimal to set the inflation target at a constant proportion of the exogenous expected inflation rate. That proportion depends upon (a) the weight attached to the importance of keeping inflation close to price stability relative to keeping output close to its natural rate, and (b) the impact of inflation surprises on output. The inflation target converges gradually to price stability but is always below expected inflation. Inflation itself also falls gradually.

The "gradualist" path to price stability is, in general, preferable to either a "cold turkey" strategy, in which the inflation target is set to zero from the outset, or an "accommodation" strategy in which the inflation target declines in line with expected inflation. The former involves greater output losses during the tran-

Figure 1a
INFLATION AND OUTPUT WITH EXOGENOUS LEARNING

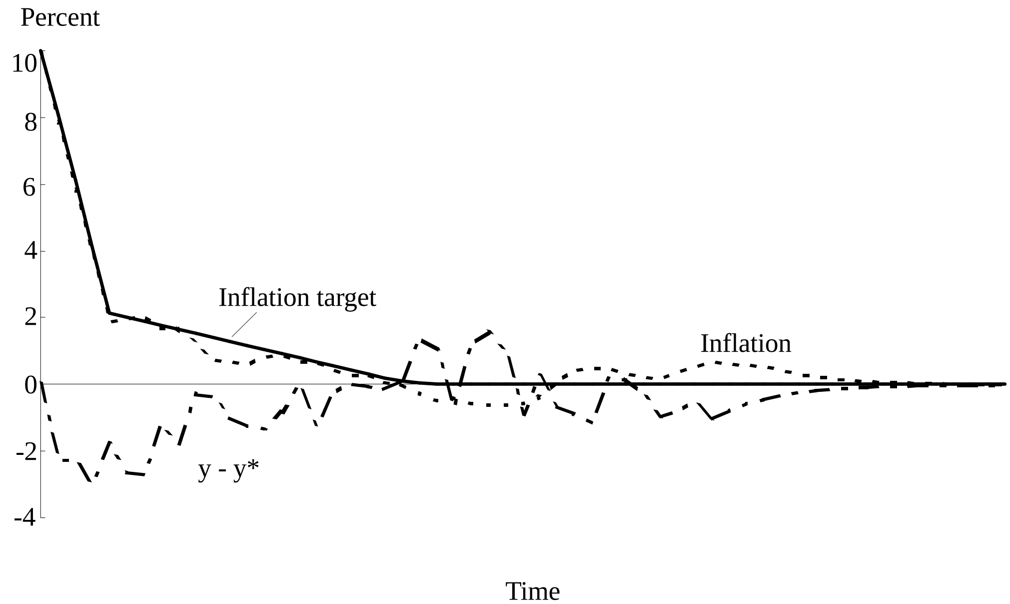


sition and the latter involves larger deviations of inflation from price stability.

Figure 1a shows an example in which expectations decline steadily, and linearly, over a fixed period of length *T*. Both output and inflation adjust to their long-run values gradually over time. If the relative importance which the central bank attaches to minimizing deviations of inflation from price stability relative to deviations of output from its natural rate is denoted by *a*, and *b* measures the impact on output of price surprises, then the cumulative output loss during the transition to price stability is $[\, ab/(a+b^2)\,]\,\pi_0\,(T/2)$, where π_0 is the initial inflation rate.[5] Plausible values are $a = 0.25$ and $b = 0.5$ for quarterly data. Hence the cumulative output loss along the optimal transition path from an initial inflation rate of 10 percent a year to price stability when learning is complete only after ten years is 12 percent of the initial level of annual output. That can be contrasted with the cumulative output loss under the "cold turkey" strategy of over 24 percent.

Random shocks to the economy make the path less smooth than that shown in Figure 1a. It is possible to simulate the shocks, and Figure 1b shows a path both during and after the transition to price stability for parameters of the random process generating shocks fitted to UK data. Figure 1b plots output each quarter and inflation over the previous 12 months since they are the usual

Figure 1b
INFLATION AND OUTPUT WITH EXOGENOUS LEARNING AND SHOCKS

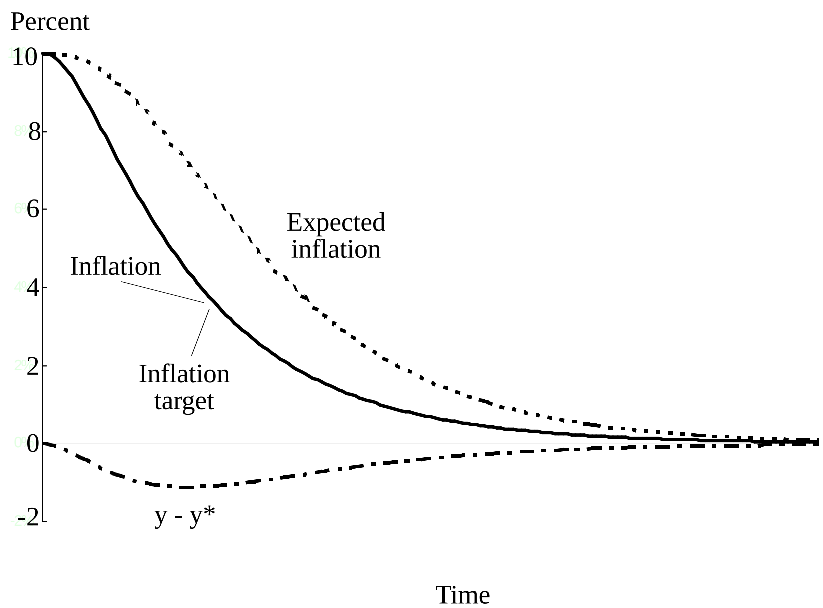


definitions of published statistics. Not surprisingly, the 12-month inflation rate changes more smoothly over time than does quarterly output. The path to price stability contains periods in which inflation rises before converging to zero.

Endogenous learning

In the previous section it was argued that there are good reasons to suppose that, in trying to learn about the future inflation target of the central bank, many of the relevant factors are exogenous to the path of inflation itself. But a central bank may try to convince the private sector of its commitment to price stability by choosing to reduce its inflation target toward zero quickly. One might call this "teaching by doing." The choice of a particular inflation target influences the speed at which expectations adjust to price stability. Each period the private sector can look back and infer from the shocks that occurred in the past the inflation target that was chosen in the previous period. It then updates its belief about the current inflation target according to how fast the actual inflation target itself adjusts to price stability. I call this a case of endogenous learning. The optimal speed at which the inflation target approaches zero is derived in the appendix for the special case of a constant updating parameter. As in the case of exogenous learning, price stability is reached gradually, and an example is shown in Figure 2.

Figure 2
INFLATION AND OUTPUT WITH ENDOGENOUS LEARNING

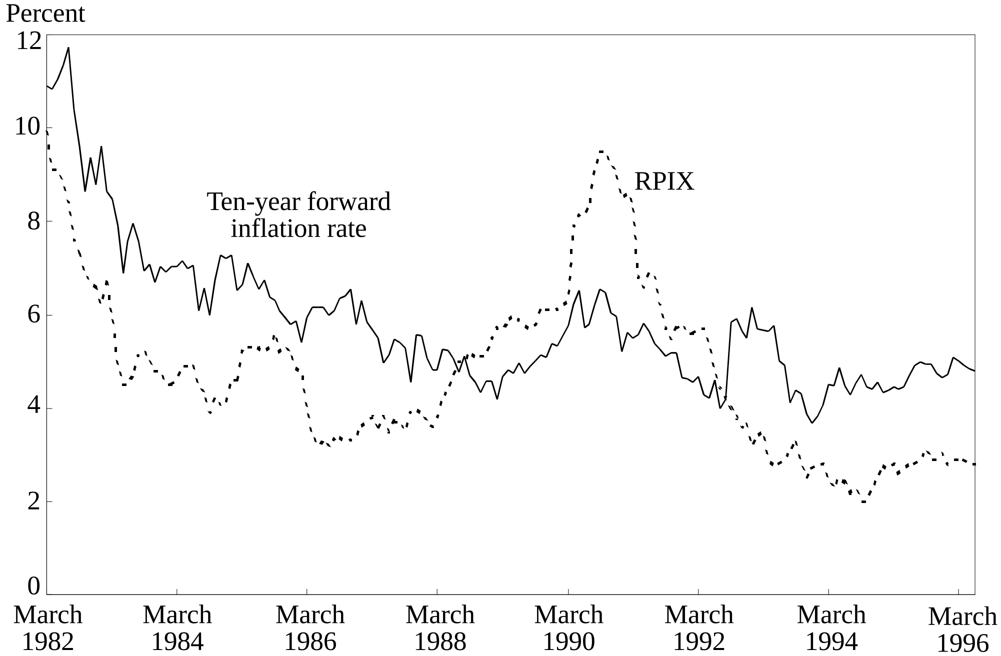


In general, the weight attached to past observations of the inflation target will depend upon the perceived uncertainty of the commitment to price stability. With a stable institutional arrangement for monetary policy, credibility is likely to grow over time. But any uncertainty over the continuation of the new regime, perhaps because of a lack of public support, slows down the acquisition of credibility.

The rationality attributed here to private agents—in which they can observe past shocks and so infer the previous period's inflation target—means that the optimal degree of flexibility in monetary policy is unaffected by whether learning is endogenous or exogenous. If, however, learning depends on the actual rate of inflation rather than the inferred inflation target, then it may be optimal not to accommodate temporary inflation shocks for fear that doing so might lead to higher inflation expectations in the future. In this case in the early stages of the transition to price stability it is optimal to pursue a much less flexible monetary policy than would be desirable once credibility had been attained.

The general prediction of the learning models is that the inflation target—and hence actual inflation—will fall faster in the earlier years of the transition and will always lie below expected inflation. That appears to have been the U.K. experience during the 1980s. Chart 2 shows expected inflation derived from a comparison between the yields on nominal and index-linked government bonds and the actual inflation rate. The predicted pattern holds with the exception

Chart 2
UNITED KINGDOM TEN-YEAR FORWARD INFLATION RATE AND ACTUAL INFLATION



of the period toward the end of the decade when the pursuit of price stability was temporarily suspended. The data are not ideal for the purpose of making comparisons with the model. Estimates of expected inflation are available only from 1982, some three years after the initial change in regime, and they refer to inflation expected some ten years ahead because of difficulties in estimating accurately the short end of the yield curve. But the general pattern is clear, and seems to have been repeated in the renewed attempt to reach price stability in the 1990s. It is evident that the United Kingdom has not achieved credibility in its stated inflation target. The data in Chart 2 can be used to estimate the learning model given by equation 22 in the appendix. From 171 observations, the estimated value of the updating parameter ρ is 0.921 with a standard error of 0.023. For the case considered above where $a = 0.25$ and $b = 0.5$, this estimate implies that it takes just over six years before the inflation target falls from 10 percent to 5 percent a year.

Table 3 and Chart 3 provide information on the two speeds of adjustment of inflation discussed above. The upper panel of Table 3 shows the change in inflation from a cyclical peak to the next trough in a number of industrialized countries. The speed at which inflation was brought down is shown together with the average inflation rate over the period 1965 to 1995. The data refer to completed cycles over that period. The average speed is a mixture of the speed of disinflation and the rate at which temporary shocks to inflation are allowed to die away.

Table 3

INFLATION CHANGES OVER THE CYCLE

Country	Change from peak to next trough (pp) (1) (b) (c)	Number of quarters (2)	Change in inflation per quarter (1)/(2)	Ranking (a)	*Average inflation 1965-1995*
Germany	-3.8	11	-.6	6	*3.6*
UK	-8.6	6	-1.5	13	*8.1*
United States	-5.2	10	-.5	5	*5.3*
Italy	-6.8	9	-1.1	11	*9.2*
Japan	-4.7	7	-.9	9	*5.0*
France	-3.9	12	-.3	1	*6.4*
Canada	-3.2	8	-.4	2	*5.6*
Belgium	-5.2	9	-.5	4	*5.0*
Netherlands	-4.1	7	-.7	7	*4.5*
Sweden	-6.2	8	-.9	10	*7.0*
Switzerland	-4.7	9	-.5	3	*3.9*
Australia	-6.5	9	-.7	8	*7.0*
New Zealand	-8.9	11	-1.2	12	*8.7*

Country	Change from trough to next peak (pp) (1)	Number of quarters (2)	Change in inflation per quarter (1)/(2)	Ranking (a)
Germany	4.0	11	.5	1
UK	8.6	8	1.1	11 =
United States	5.3	9	.6	5
Italy	7.2	7	1.1	13
Japan	4.3	7	.7	9
France	3.8	8	.5	2
Canada	3.1	5	.6	4
Belgium	4.4	9	.5	3
Netherlands	3.7	8	.7	7
Sweden	6.3	9	1.1	11 =
Switzerland	4.6	8	.7	8
Australia	6.3	11	.6	6
New Zealand	7.8	10	.9	10

(a) Ranking is from lowest to highest rate of change of inflation.
(b) For peak-to-trough or trough-to-peak half cycles started and completed between March 1965 and 1992.
(c) Inflation as measured by the three month moving average of the annual rate of change of the CPI.
Source: IFS.

Countries with a credible commitment to stable low inflation have inflation slopes—defined as the reduction in inflation per quarter—of around 0.5. Countries with worse inflation records, such as the United Kingdom, Italy, Sweden, and over much of the period New Zealand, show much steeper slopes with an absolute value around unity. There does seem to be evidence that the two speeds of adjustment are different. In the lower panel of Table 3, similar calculations are presented for the change in inflation from a cyclical trough to the next peak. A similar pattern emerges, reflecting the speed with which the lower credibility countries allowed inflation to rise in the 1960s and 1970s. Chart 3 plots the profile of inflation for selected G-10 countries over the period 1965 to 1995. The difference in the inflation slopes is evident.

There is one additional cost of a disinflation in which actual inflation falls faster than expected inflation. With government debt fixed in nominal terms, the burden of the debt rises when there is unanticipated disinflation. At last year's Jackson Hole conference I called this "unpleasant fiscal arithmetic" (King 1995). Too rapid a disinflation can, therefore, add to the fiscal burden. But there is a ready solution at hand—the use of index-linked debt.

II. THE OPTIMAL FLEXIBILITY OF MONETARY POLICY

The previous section discussed the optimal speed of adjustment from some initial inflation rate to price stability. Although the overriding objective of monetary policy is price stability, that does not uniquely define monetary policy. Inflation can differ from the target level because of either type 1 or type 2 shocks. Price stability is better defined as a situation in which the inflation target is equal to the expected rate of inflation and both in turn equal zero. That corresponds better with Alan Greenspan's definition of price stability in which inflation does not affect significantly decisions by economic agents, and leaves open the choice of the optimal response to type 1 shocks. In general, it is optimal to accommodate part of any such shock. The fraction that is accommodated depends upon the relative weight attached to deviations of inflation from price stability, on the one hand, and to deviations of output from its natural rate, on the other.[6] As John Crow has argued, a mandate of price stability does not absolve a central bank from taking countercyclical actions, but its purpose is "to ensure that such actions when taken do not build in an inflationary bias, not that they not be taken at all."[7]

In most cases the optimal degree of accommodation of temporary shocks is quite separate from the optimal speed of disinflation. But when learning depends on past inflation, matters are more complicated. Any accommodation of an upward shock to inflation, albeit temporary, affects future expectations of inflation. That in turn increases the output costs of any given inflation target. Hence, especially in the early stages of the transition to price stability, it pays not to accommodate as much of the inflation shock as would be optimal once expectations have adjusted to price stability. A central bank that is embarking on the road to price stability cannot afford to engage in as much flexibility in monetary policy as can a central bank which has established a track record for a commitment to price stability. There is a tradeoff between credibility and flexibility. But that tradeoff exists only during the transition to price stability. That may explain why there is little empirical evidence of a tradeoff between credibility and flexibility in cross-section data.

There is a further reason for caution in a transition to price stability. It is clear from the literature on time inconsistency of monetary policy that a central bank which tries to stabilize

Chart 3
INFLATION IN SELECTED G10 COUNTRIES

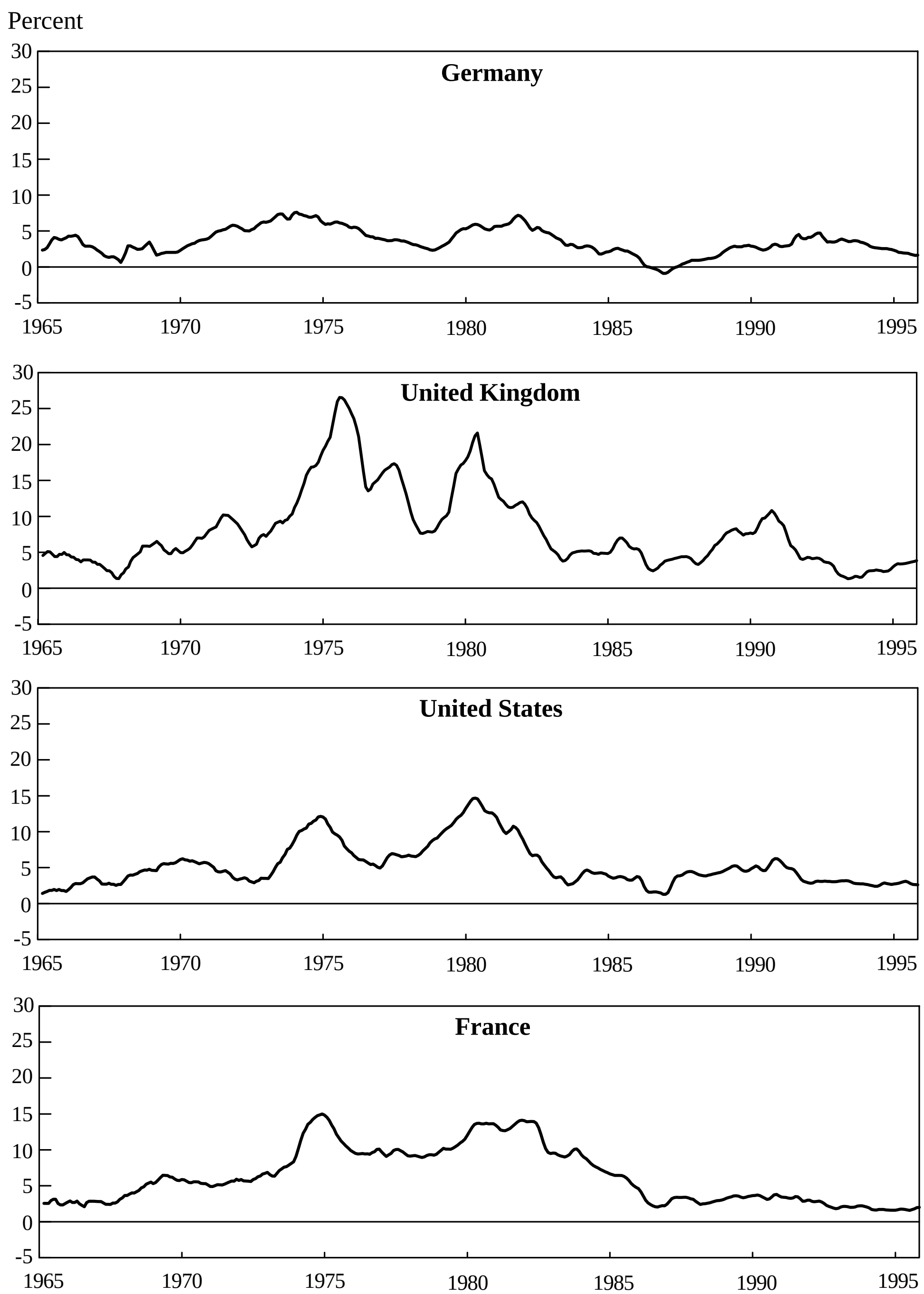
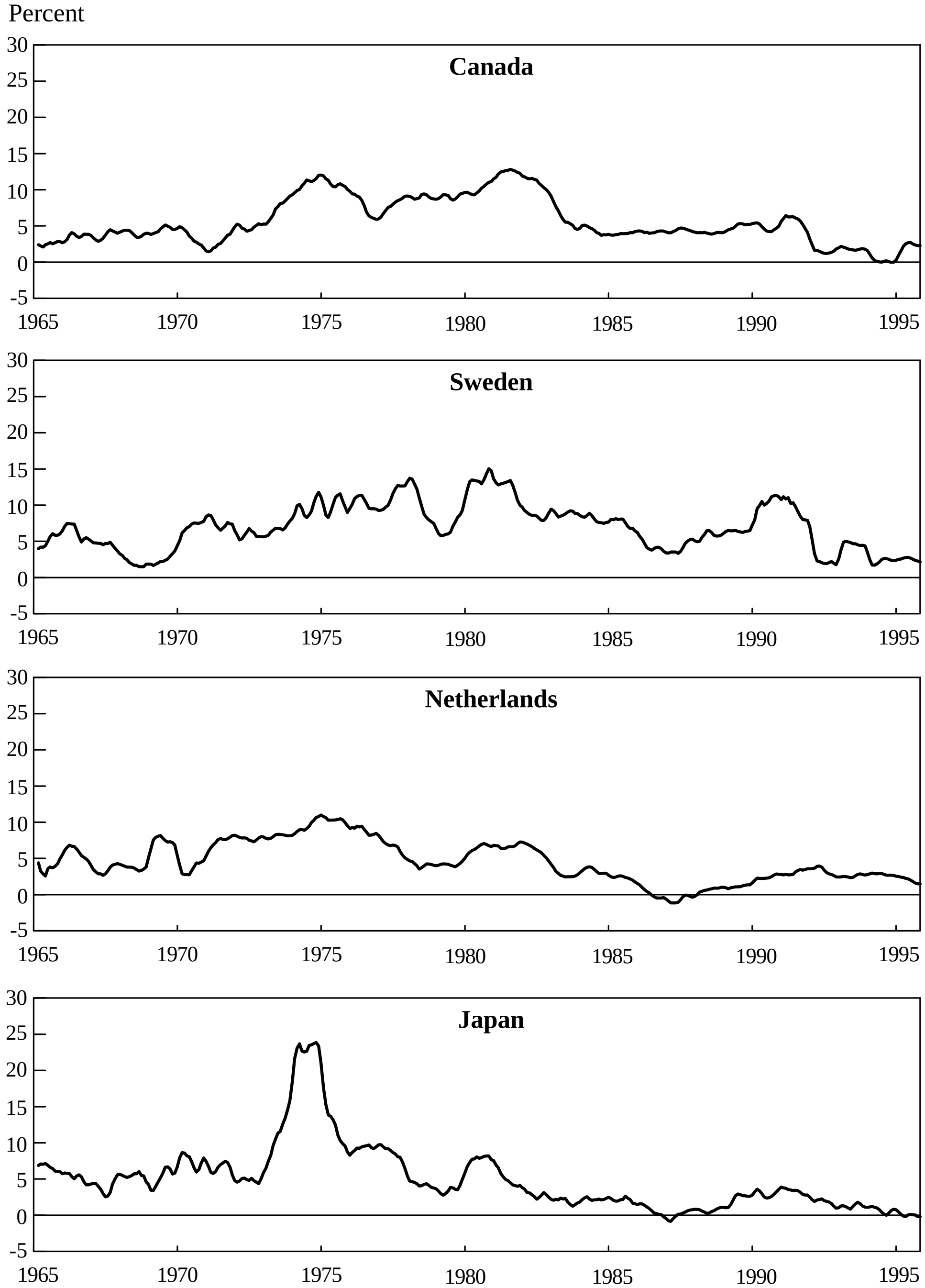


Chart 3 (continued)
INFLATION IN SELECTED G10 COUNTRIES



Source: ONS for United Kingdom, IFS for other G10 countries.
The UK inflation rate is for retail prices excluding mortgage interest payments (RPIX), headline CPI for all other countries.

output around a level in excess of the natural rate can create an inflationary bias. During the transition, it is important for the central bank to convince the market that it is not trying to use monetary policy to achieve a level of output in excess of the natural rate as a substitute for structural reforms. In the absence of a track record of price stability, it is quite possible that the market may be suspicious that a central bank is trying to do just that. This is quite distinct from the issue of the speed of learning. And it suggests why central banks are extremely cautious in their use of language to describe how output affects monetary policy. It is easy for economists to make a clear, logical distinction between two different models. But it is vital for a central bank to ensure that markets do not suspect it of behaving according to one model rather than the other. And that is not straightforward when the key variables—the natural rate of unemployment and the output gap—are not observable. Hence, even though it may be perfectly rational to accommodate temporary shocks to inflation, the need to ensure that markets do not suspect other motives implies the importance of caution in the language used by central banks about output stabilization. Words matter. Indeed, actions may be safer than words.

Another aspect of the link between the two elements of monetary policy—the inflation target and the response to shocks—has surfaced in the recent proposal for an "opportunistic" approach to disinflation, an idea associated with Alan Blinder.[8] An analysis of the opportunistic model has been provided by Orphanides and Wilcox (1996). The opportunistic approach implies that when inflation is either too high or too low the approach to price stability is as analyzed above. But when inflation is in an intermediate range, the inflation target is not reduced any further unless there is a negative inflation shock. When such a shock occurs no attempt is made to benefit from a temporary excess of output over trend—the shock is fully accommodated. The inflation target is then ratcheted down. There is an asymmetric approach to positive and negative shocks when inflation is in the intermediate range. Positive shocks are suppressed; negative shocks are accommodated. Why would a central bank behave in this way? Orphanides and Wilcox identify two conditions under which a central bank might pursue such a strategy. First, its attitude to current inflation must depend on the path of inflation in the recent past. To quote the example given by Orphanides and Wilcox,

> An opportunistic policymaker evaluates a 3 percent rate of inflation today less favorably if inflation yesterday was 2 percent than if inflation yesterday was 4 percent. In the former case, an opportunistic policymaker might well aim to drive output below potential, whereas in the latter case, she would aim simply to hold output at potential.

Second, the central bank pursues output stabilization when inflation is low, and price stability when inflation is high. An opportunistic central bank which starts with low inflation will focus on output stabilization even if inflation drifts upward for a time.

But that strategy may be observationally equivalent to that of a central bank which uses monetary policy to target a level of employment in excess of the natural rate—that is, to create jobs that are not there—and incurs the inflation bias of discretion. Equally, a central bank that waits for negative inflation shocks before reducing inflation may also appear similar to a central bank that is trying to achieve unemployment below the natural rate. The loss of credibility may then create output losses when inflation is reduced.

So far I have examined learning by economic agents. But central banks learn also. An optimal monetary strategy can be expressed in terms of a predetermined rule only if the procedure for updating the policy rule can itself be written as a rule. Since there is no unique optimal learning strategy, that is unlikely. But if discretion is inevitable, then why has it been suggested that several central banks have, in fact, followed rules, in particular the rule suggested by John Taylor?[9] The Taylor rule implies that nominal short-term official interest rates should be set such that the real interest rate differs from the real interest rate that would hold at the natural rate of output by an amount which is proportional to the excess of output over its natural rate and the excess of inflation over its target rate. It is vital to distinguish between two uses of the Taylor rule. The first is as a normative rule for policy. The second is as a positive description of the behavior of central banks in practice. The Taylor rule implies a correlation between real interest rates, output, and inflation. In the normative sense, causation runs from interest rates to output and inflation. But such a correlation exists in any economy that behaves according to the simple model presented in this paper. It is easy to show that, for *any* choice of inflation target and response to temporary shocks, the linear relationship between real rates, output, and inflation is identical to the Taylor rule (see appendix). Any set of observations can be rationalized as a Taylor rule for a suitable choice of inflation target. Hence it is impossible to distinguish between those central banks which are following a Taylor rule and those which are not. Differences show up in the time paths of inflation and output, not in the relationship between real interest rates, inflation, and output.

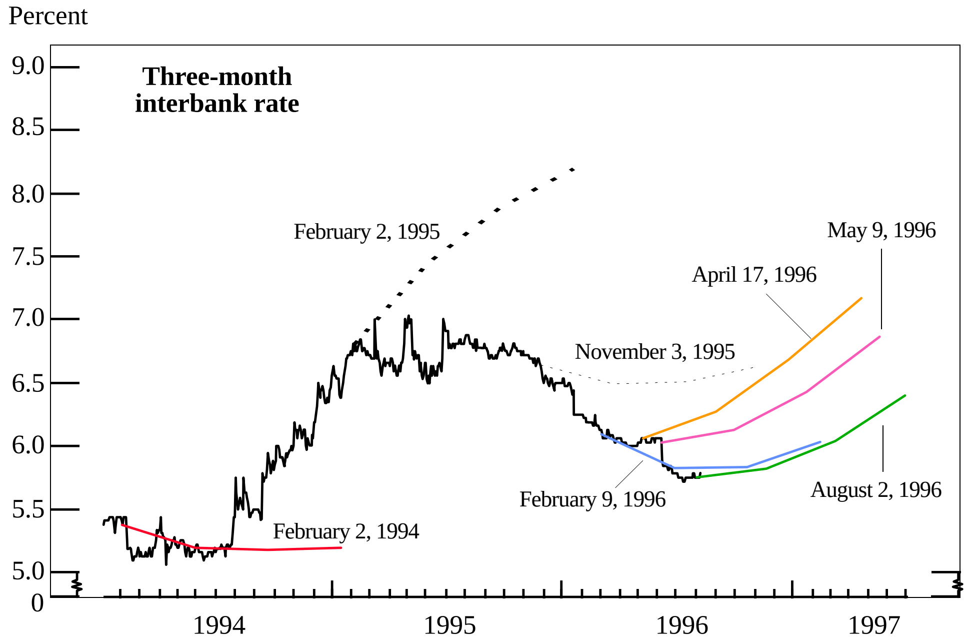
The main lesson from the discussion of rules is the importance of trying to ensure that private sector expectations are consistent with the monetary strategy pursued by the central bank. It is the predictability of policy rather than the fact that the policy can be expressed in terms of a rule that is crucial. If the exercise of discretion is inevitable, then predictability implies a significant degree of transparency in the setting of monetary policy. Explanations by the central bank of the rationale for policy help to increase predictability and reduce volatility. Monetary policy in both the United Kingdom and the United States in recent years has clearly not followed a simple rule. But it has been somewhat more predictable than at times in the past. One consequence is that quite small changes in official interest rates—or even a decision *not* to change rates—have led to significant movements in short-term market rates and hence to short-term real interest rates. Charts 4 and 5 show the short end of the yield curve in the United Kingdom and the United States, respectively, from January 1994. In both countries modest movements in official rates led to significant changes in expected three-month market interest rates over the following 12 to 24 months. Rates moved in anticipation of future policy changes, and the yield curve did a lot of the work in altering the stance of monetary policy.

III. CONCLUSIONS

The main point of this paper is simple. The design of monetary policy in the transition to price stability must take seriously learning by both economic agents and the central bank. No successful transition can be designed that ignores learning by private sector agents about the implicit inflation target of the monetary authority. Equally, pure rational expectations models are not a good basis on which to base policy because they ignore the process of learning. Models of learning under conditions of bounded rationality are few and far between. As Sargent puts it,

> We might have prejudices and anecdotes to guide our preferences among transition strategies but no empirically confirmed informed theories (1993, p.1).

Chart 4
UNITED KINGDOM THREE-MONTH INTEREST RATE EXPECTATIONS

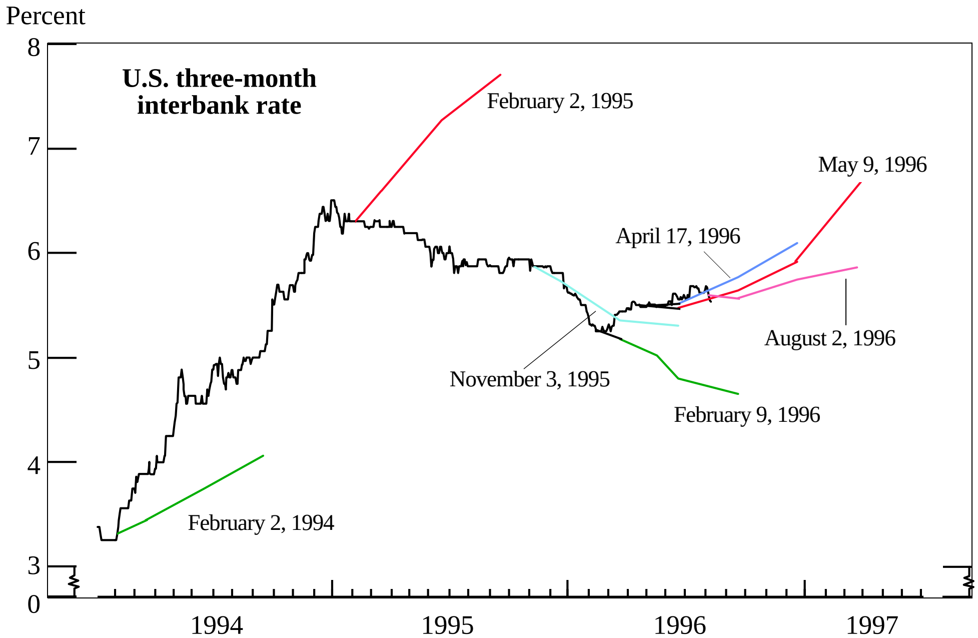


Note: Interest rate expectations are based on a combination of sterling interest rate futures contracts.
Sources: Bank of England and LIFFE.

The search for a simple policy rule to guide the transition is an illusion. But central banks can try to accelerate the learning process by "teaching by doing;" in other words, making clear their own preferences and explaining their own view of how the economy behaves. Like economic agents, central bankers do not have a fixed stock of knowledge. They learn—especially from conferences at Jackson Hole—and the product of this learning should be communicated to the public at large. That is one reason why transparency is important. A switch in monetary regime from hyperinflation to low and stable inflation is likely to be sufficiently dramatic that the behavior of inflation itself communicates the change to agents. But the transition from low or moderate inflation to price stability will be more difficult to detect. In those circumstances, transparency can help to speed up learning by both private agents and the central bank.

The overriding objective of monetary policy should be price stability. But two subsidiary questions arise. First, how fast should a central bank disinflate in order to reach price stability? Second, how flexible should policy be in accommodating temporary inflation shocks in order to avoid costly volatility in output? An optimal monetary strategy is a choice of an *ex ante* inflation target and a discretionary response to temporary shocks. In general, the optimal speed of disinflation is a gradual approach to price stability, but one in which the inflation target is always below expected inflation and falling.

Chart 5
US INTEREST RATE EXPECTATIONS



Note: Interest rate expectations are based on a combination of U.S. dollar interest rate futures contracts.

There should also be some accommodation of temporary shocks. Any response to such shocks should be more cautious in the early stages of a transition in order to speed up learning by the private sector of the central bank's commitment to reducing the inflation target. None of that is surprising. It is merely the best practice of successful central banks that combine a choice of an inflation target with some degree of flexibility in response to shocks. What successful central banks have in common is not a particular intermediate target to guide policy, but rather a common policy reaction function.

APPENDIX

Optimal disinflation

The propositions about the optimal speed of disinflation discussed in the main part of the paper can be demonstrated rigorously in a simple macroeconomic model which combines nominal wage and price stickiness and slow adjustment of expectations to a new monetary policy regime. The model has three key equations—for aggregate supply, aggregate demand, and money supply. This last equation is the central bank's policy reaction function.

Aggregate supply in period t, y_t, is given by a reduced form supply function (or short-run Phillips curve)

$$(1) \qquad y_t = y_t^* + b(\pi_t - \hat{\pi}_t) + \varepsilon_t,$$

where y_t^* is the "natural" rate of output, π_t is the inflation rate, $\hat{\pi}_t$ is the private sector's expectation of the central bank's target inflation rate in period t, and ε_t is an aggregate disturbance which is assumed to be white noise. All variables other than inflation and interest rates are measured in natural logarithms.

Aggregate demand is a function of real money balances and expected inflation.[10]

$$(2) \qquad y_t = c(m_t - p_t) + d\hat{\pi}_t,$$

$$(3) \qquad \pi_t = p_t - p_{t-l},$$

where m_t is the money stock.

Each period the money supply (or, equivalently, the short-term interest rate) is set by the central bank in full knowledge of the size of the shock to output (the realization of ε). The expectations of the private sector which influence demand and supply are, however, formed before ε is observed. That assumption reflects nominal rigidities in setting wages and prices, and other nominal contracts.

Given the linear structure of the model and the serially uncorrelated nature of the supply shock, the most general form of a monetary policy reaction function is

$$(4) \qquad m_t = \lambda_{1t} + \lambda_{2t}\,\varepsilon_t,$$

Note that the money supply process is allowed to vary on the transition path to price stability.

For any given policy reaction function, the model can be solved to give paths for output and inflation in each period as a function of private sector expectations, the aggregate shock, and the parameters of the model. Substituting equation 4 into equations 1 to 3 yields

$$(5) \qquad y_t = y_t^* + b\alpha_t + \left(\frac{b(d-c)}{b+c}\right)\hat{\pi}_t + \beta_t\,\varepsilon_t,$$

$$\pi_t = \alpha_t + \left(\frac{b+d}{b+c}\right)\hat{\pi}_t + \left(\frac{\beta_t - 1}{b}\right)\varepsilon_t, \qquad (6)$$

where

$$\alpha_t = \frac{c\,(\lambda_{1t} - p_{t-1}) - y_t^*}{b+c}$$

$$\beta_t = 1 + \frac{b(c\lambda_{2t} - 1)}{b+c}. \qquad (7)$$

I shall assume that the central bank has rational expectations in the sense that it understands that output and inflation are generated by equations 5 and 6. It is possible to rewrite the monetary policy reaction function in terms of the central bank's choice of an inflation target each period. The inflation target is defined as the rational expected value of inflation before ε is realized which is given by

$$\pi_t^* = E\pi_t = \alpha_t + \frac{b+d}{b+c}\hat{\pi}_t\,. \qquad (8)$$

Substituting into equations 5 and 6 yields

$$y_t = y_t^* + b(\pi_t^* - \hat{\pi}_t) + \beta_t\,\varepsilon_t$$

$$\pi_t = \pi_t^* + \left(\frac{\beta_t - 1}{b}\right)\varepsilon_t\,. \qquad (9)$$

Monetary policy is a choice of an *ex ante* inflation target, π_t^*, and a response to stochastic shocks described by the choice of β_t.

Consider a switch from a monetary policy regime in which inflation has averaged π_0 to a regime of price stability in which average inflation is zero. What is the optimal transition path? That will depend upon how quickly private sector expectations adjust to the new regime. It is useful to consider three cases: (1) a completely credible regime switch: private sector expectations adjust immediately to the new policy reaction function—this is the case of rational or model-consistent expectations; (2) exogenous learning: expectations adjust slowly along a path exogenous to the actual policy choices made in the new regime; (3) endogenous learning: the speed of learning depends on the policy decisions made in the new regime.

Case 1: Fully credible regime switch

With a completely credible regime change, private sector expectations are consistent with the new inflation target:

$$\hat{\pi}_t = \pi_t^*. \qquad (10)$$

Hence

$$y_t = y_t^* + \beta_t\varepsilon_t$$

$$\pi_t = \pi_t^* + \left(\frac{\beta_t - 1}{b}\right)\varepsilon_t\,. \qquad (11)$$

Since the level of output is independent of the inflation target, policy can aim at price stability without any expected output loss. The optimal policy is to move immediately to a zero inflation target.

Case 2: Exogenous learning

The central bank announces that it intends to move to a regime of price stability, defined as a regime in which the unconditional expectation of inflation each period is zero. But the private sector adjusts its beliefs about the inflation target only slowly, and at a rate that is exogenous to the monetary policy decisions taken in the transition. From equation 9, it follows that if expected inflation exceeds the inflation target then there are systematic output losses during the transition to full credibility. It may be costly to pursue price stability from the outset of the new regime. How should the central bank choose the inflation target during the transition? From case 1 it is clear that once credibility has been established, it is optimal to set the inflation target to zero. During the transition, optimal monetary policy is a sequence for the pair $\{\pi_t^*, \beta_t\}$. Let the loss function of the central bank be defined over the expected value of the squared deviations of inflation from its desired level of zero and of output around the natural rate.[11]

$$(12) \qquad L_t = aE\pi_t^2 + E(y_t - y_t^*)^2.$$

Denote the length of the transition to full credibility under exogenous learning by T. Assuming no discount factor, the loss during the transition is

$$(13) \qquad L = a\sum_{t=1}^{T} \left\{\pi_t^{*2} + \left(\frac{\beta_t - 1}{b}\right)^2 \sigma_{\varepsilon t}^2 \right\}$$

$$+ \sum_{t=1}^{T} \left\{b^2(\pi_t^* - \hat{\pi}_t)^2 + \beta_t^2 \sigma_{\varepsilon t}^2\right\}.$$

Differentiating w.r.t. π_t^* and β_1 gives the optimal monetary policy as

$$(14) \qquad \pi_t^* = \frac{b^2}{a+b^2}\hat{\pi}_t$$

$$\beta_1 = \frac{a}{a+b^2}.$$

Provided that learning is exogenous, the optimal transition to price stability is to allow inflation to fall gradually. The inflation target should start out at a fraction of the initial inflation rate and then decline as a constant proportion of the exogenous expected inflation rate. The expected cumulative output loss in the optimal transition is

$$(15) \qquad CYL \equiv \sum_{t=1}^{T} E(y_t - y_t^*) = b\sum_{t=1}^{T} (\pi_t^* - \hat{\pi}_t)$$

$$= -\frac{ab}{a+b^2}\sum_{t=1}^{T} \hat{\pi}_t.$$

The optimal path may be contrasted with the two extremes of pursuing price stability from the outset—a "cold turkey" strategy—and setting the inflation target to accommodate inflation expectations—an accommodation strategy. The "cold turkey" strategy is defined by

$$(16) \qquad \pi_t^* = 0 \ \forall\ t.$$

On average, price stability is achieved even during the transition period, but only at the cost of an expected cumulative output loss of

$$(17) \qquad CYL_{CT} = -b\sum_{t=1}^{T} \hat{\pi}_t \, .$$

A strategy of full accommodation is defined by

$$(18) \qquad \pi_t^* = \hat{\pi}_t .$$

It is clear from equation 9 that such a strategy eliminates any output loss, but at the cost of inflation falling only at the exogenous rate of decline of private sector inflation expectations.

In all of these cases it can be seen from equation 14 that the choice of β_t, the flexibility of monetary policy in the face of shocks, can be separated from the choice of the optimal inflation target during the transition.

A convenient representation of exogenous learning is that expectations adjust linearly over a fixed horizon of T years:

$$(19) \qquad \hat{\pi}_t = \left(\frac{T-t}{T}\right)\pi_0 \qquad 0 < t \le T$$
$$= 0 \qquad t > T.$$

With that specification, the cumulative output loss under the "cold turkey" strategy is

$$(20) \qquad CYL_{CT} = -b\left(\frac{T-ialic1}{2}\right)\pi_0 \, .$$

Along the optimal path the output loss is

$$(21) \qquad CYL_{OPT} = -\left(\frac{ab}{a+b^2}\right)\left(\frac{T-1}{2}\right)\pi_0 \, .$$

Case 3: Endogenous learning

The speed at which expectations adjust depends on actual inflation experience, and hence on policy choices made during the transition. A convenient representation of this learning process is

$$(22) \qquad \hat{\pi}_t = \rho\hat{\pi}_{t-1} + (1-\rho)\,\pi_{t-1}^* .$$

The smaller is ρ, the faster is the learning process. For a positive value of ρ, expected inflation converges asymptotically to the inflation target. Equation 22 is, however, problematic. For a well-defined change of regime it is likely that ρ will decline over time under rational learning as more weight is placed on the lagged inflation target in the optimal updating rule. But with, for example, Markov switching between regimes, ρ may not decline. Even with rational learning, it is unlikely that expected inflation will jump to the new inflation target.

The model of learning in equation 22 assumes that agents can infer last period's inflation target by adjusting *ex post* for the effect of the previous period's shock on monetary policy. That is more rational than assuming that agents look only at past inflation. But if learning does depend on the actual rate of inflation, as would be the case if agents could not observe the shock *ex post*, then the optimal flexibility of monetary policy interacts with the optimal speed of disinflation. Rewriting equation 22 using the lag operator L

$$(23) \qquad \hat{\pi}_t = \frac{(1-\rho)L}{(1-\rho L)} \pi^*_t .$$

Since learning occurs over an infinite horizon, the loss function may be defined as

$$(24) \quad L \equiv \sum_{t=1}^{\infty} (1+\theta)^{-t} \{ aE\pi^2_t + E(y_t - y^*_t)^2 \},$$

where θ is the time discount rate.

Substituting equations 9 and 23 into the loss function and differentiating w.r.t. π^*_t yields the following second-order difference equation for the optimal inflation target

$$(25) \quad \pi^*_t = \pi^*_{t-1} \left\{ \frac{2(a\rho+b^2)}{(a+b^2)} \right\} - \pi^*_{t-2} \left\{ \frac{a\rho^2+b^2}{a+b^2} \right\}$$

The optimal degree of flexibility in monetary policy, measured by β, is the same as in the case of exogenous learning.

When learning is defined over the actual rate of inflation, accommodating temporary shocks affects expected inflation in the future. The central bank can invest in credibility by refraining from such stabilization in the early stages of the transition.

Finally, the model generates data that look as though the Taylor rule had been followed. Under the Taylor rule, official nominal interest rates are set so that the short-term real interest rate equals the "natural" rate plus terms related to the deviation of output from trend and inflation from its target rate:

$$(26) \qquad r = r^* + \lambda_1(y-y^*) + \lambda_2(\pi-\pi^*).$$

For any monetary policy $\{\pi^*, \beta\}$ it is the case that the model leads to an equation of the form of equation 26 because all three variables (expressed as deviations from their natural or target rates) are proportional to the shock. Hence it is crucial to distinguish between a normative and a positive interpretation of equation 26.

ENDNOTES

1 The case for price stability was restated at this conference by Fischer (1996); recent estimates of the cost-benefit analysis of moving from moderate inflation to price stability were given by Feldstein (1996).

2 An early analysis of the problem can be found in Taylor (1975).

3 The formal analysis in the appendix ignores type 2 shocks which add only random noise to the paths of output and inflation, and do not alter the optimal speed of disinflation.

4 The importance of continuous learning was stressed by Balvers and Cosimano (1994).

5 A formal derivation of this result with discrete time periods is shown in the appendix.

6 Details are provided in the appendix.

7 Letter to the *Financial Times*, January 8, 1996.

8 Alan Blinder's views were set out in an opening statement at his confirmation hearing before the U.S. Senate Committee on Banking, Housing, and Urban Affairs in May 1994.

9 Taylor (1993), Clarida and Gertler (1996), Stuart (1996).

10 The aggregate demand function is the reduced form of the three-equation system:

(i) demand for money $m_t = p_t + y_t - \gamma\, i_t$, where i_t is the nominal interest rate;

(ii) demand for goods $y_t = \delta(m_t - p_t) - \theta r_1$

(iii) definition of the real interest rate $r_t = i_t - \hat{\pi}_t$.

Hence in equation 2, $c = (\theta + \gamma\delta) / (\theta + \gamma)$ and $d = \theta\gamma$.

11 Note that the loss function does not assume that the central bank is using monetary policy to target output in excess of the second-best natural rate as is assumed in those models which generate an inflationary bias of discretionary monetary policy.

REFERENCES

Balvers, R.J., and T.F. Cosimano. 1994. "Inflation Variability and Gradualist Monetary Policy," *Review of Economic Studies*, 61, pp. 721-38.

Blinder, A. 1994."On Sticky Prices: Academic Theories Meet the Real World," in N.G. Mankiw, ed., *Monetary Policy*. Chicago: University of Chicago Press.

Brunner, K., and A.H. Meltzer. 1993. *Money and the Economy: Issues in Monetary Analysis*, Cambridge: Cambridge University Press.

Clarida, R., and M. Gertler. "How the Bundesbank Conducts Monetary Policy," National Bureau of Economic Research Working Paper 5581, mimeo.

Feldstein, M.S. 1996. "The Costs and Benefits of Going from Low Inflation to Price Stability," paper presented at the NBER Conference on Monetary Policy and Inflation, January, mimeo.

Fischer, S. 1996. "Why are Central Banks Pursuing Long-Run Price Stability?" in *Achieving Price Stability*, proceedings of a symposium sponsored by the Federal Reserve Bank of Kansas City in Jackson Hole, Wyo., August 29-31.

King, M.A. 1995. "Monetary Policy Implications of Greater Fiscal Discipline," in *Budget Deficits and Debt: Issues and Options*, proceedings of a symposium sponsored by the Federal Reserve Bank of Kansas City in Jackson Hole, Wyo., August 31-September 2.

Lucas, R.E. 1973. "Some International Evidence on Output-Inflation Tradeoffs," *American Economic Review*, 63, pp. 326-34.

McCallum, B.T. 1996. "Crucial Issues Concerning Central Bank Independence," NBER Working Paper 5597, mimeo.

______.1995. "Two Fallacies Concerning Central Bank Independence," *American Economic Review Papers and Proceedings*, 85, pp. 207-11.

Orphanides, A., and D.W. Wilcox. 1996. "The Opportunistic Approach to Disinflation," Federal Reserve Board Discussion Paper 96-24, mimeo.

Persson, T., and G. Tabellini. 1990. *Macroeconomic Policy, Credibility and Politics*, London: Harwood Academic Publishers.

Sargent, T.J. 1993. *Bounded Rationality in Macroeconomics*, Oxford: Oxford University Press.

______. 1986. *Rational Expectations and Inflation*. New York: Harper and Row.

Stuart, A. 1996. "Simple Monetary Policy Rules," *Bank of England Quarterly Bulletin,* 36, pp. 281-87.

Taylor, J.B. 1993. "Discretion Versus Policy Rules in Practice," *Carnegie-Rochester Conference Series on Public Policy,* 39, pp. 195-214.

_____________. 1975. "Monetary Policy During a Transition to Rational Expectations," *Journal of Political Economy,* 83, pp. 1009-21.

Vickers, J. 1986. "Signaling in a Model of Monetary Policy with Incomplete Information," *Oxford Economic Papers,* 38, pp. 443-55.