KEYNES LECTURE IN ECONOMICS

Central Bankers and Uncertainty

C. A. E. GOODHART
London School of Economics and Political Science
Fellow of the Academy

FOR THE MAJORITY OF MY PROFESSIONAL LIFE, I have had the good fortune to be simultaneously involved both as a participant in, and as an academic observer of, central banks. Today, and as is suitable for this occasion and audience, I shall be primarily emphasising my academic observations. Nevertheless, my study of central bank behaviour is inevitably informed and coloured by my previous years as a Bank official, and current position as an external member of the Monetary Policy Committee (MPC), but my comments today are unauthorised, not necessarily representative of any of my colleagues or of other central bankers, independent and, I trust, reasonably objective—and where they are mistaken I have no one to blame but myself, except of course for the econometrics, where I have had help from the Bank staff.

Let me plunge into the central policy issue. The key decision that the monetary authorities take each month is whether, and by how much, to change the short-term interest rate. There was a time when a vocal segment of the academic community advocated a notably different operating mechanism, of monetary base control, but that debate has faded.

The question has, instead, become how central banks actually do, and how they should, vary interest rates in response to economic developments. The suggestion has now been made by a number of academics, notably by John Taylor, that most central bank reaction functions (except for those pegging their exchange rates and hence their

Read at the Academy 29 October 1998.

Proceedings of the British Academy, **101**, 229–271.

interest rates to some other country) can in practice be reasonably well described by a relatively simple function, often now termed the Taylor rule; and that this rule approximates quite closely to the social welfare optimum, when examined in the context of a variety of models established for a variety of countries (Taylor, 1998*a*, *b*, and *c*, and papers at the June 1998 Stockholm Conference). Under such a Taylor reaction function, the level of the nominal interest rate is determined by the current level of two variables, the rate of inflation and an (inherently somewhat uncertain) measure of the output gap, the deviation of actual output from potential, so:

$$i_t = a + b_1\pi_t + b_2\,(y - y^*)_t$$

where a is the equilibrium real interest rate (usually about 2% or 3%).[1]

My first point is that virtually all attempts to estimate the Taylor rule empirically require the addition of a lagged dependent variable, i.e. the interest rate in the previous period, in order to fit well. Moreover, with monthly, or quarterly data, the coefficient on the lagged dependent variable is usually close to, and in some estimated cases greater than, unity. This means that central banks have historically changed rates by only a small fraction of their ultimate cumulative reaction in response to an inflationary shock or to a deviation of output from potential. Thus, the equation actually fitted becomes:

$$i_t = a + (1 - \rho)\, b_1\pi_t + (1 - \rho)b_2\,(y - y^*)_t + \rho i_{t-1}$$

My main theme today is to enquire further into this phenomenon whereby virtually all central banks change interest rates, in response to shocks, by a series of small steps in the same direction, rather than attempting more aggressively to offset that shock quickly in order to return the economy to equilibrium.

Some academics studying this subject deal with this issue by positing that changes in interest rates enter the authorities' loss function. But why should that be so? One can easily understand the social loss arising from inflation and deviations of output from potential, but what exactly is the social loss arising from changes in interest rates themselves? We shall attempt to pursue this question further soon, but in the interim I

[1] Indeed, in some cases, notably Germany, evidence has been presented that such a reaction function fits the observed data better than the explanations given by the central bank of its own behaviour. Thus, Clarida and Gertler (1997) show that the addition of monetary variables to a Taylor-rule reaction function for Germany adds nothing to the explanatory power of the equation.

want to raise a few points about the use of such a reaction function and its application to the United Kingdom.

First, the generally quite good fit of an estimated Taylor rule is not to say that in some countries, over some time periods, one cannot improve the fit by adding other variables. In small open economies, especially those pegging their exchange rate, the interest rate in the home country will also respond significantly to interest rates in its larger neighbour (Peersman and Smets, 1998). Nor, of course, are the coefficients closely similar for all countries (and over all time periods) in such estimated reaction functions.

One of the curious lacunae in this literature has been the failure so far to integrate the Taylor reaction function literature with the literature on central bank independence.[2] I would expect the measure of independence to be positively associated with the size, and perhaps the speed, of the authorities' reaction to inflation shocks.[3] There is some partial and preliminary evidence that this conjecture is correct. For example, Stephen Wright at Cambridge (1997) tested such reaction functions for Germany, the United States, and the United Kingdom over the time period 1961 Q1–94 Q4, and found that over this time period the estimated cumulative responses of the monetary authorities in the United Kingdom to an inflationary shock, i.e. the size of the coefficient b_1, at 0.8, was both considerably less than that of the Federal Reserve and of the Bundesbank, and also below the value of unity required to guarantee price stability. But when I asked Wright to re-run his equation over the last decade, he obtained the much higher value of 1.6 for the b_1 coefficient in the United Kingdom, as large as that in Germany, and slightly larger than the standard value of 1.5 incorporated in the normative versions of the Taylor rule.

Similarly, a preliminary study of a number of separate, and quite short, monetary regimes in the United Kingdom, undertaken by the Bank by Ed Nelson (1998), has found the coefficients in the Taylor reaction function, especially the b_1 (inflation response) coefficient, to be strongly time-varying, as shown in Table A.

One of the most visible and widely remarked aspects of current central banking *mores* is that they, especially when independent, are

[2] This void is being rapidly filled now; see, for example, Murchison and Siklos (1998).
[3] Though there is evidence that the Bundesbank, and perhaps other more independent central banks, react as or more slowly than those that have been more subservient (see Goodhart (1997) and Fischer (1996)).

Table A. Taylor reaction function coefficients; United Kingdom, 1972–97

	b_2	b_2	ρ	
1972/76	0.00	0.69[a]	0.79[a]	Quarterly
1976/79	0.44[b]	0.58	0.70[a]	Monthly
1979/87	0.46[a,b]	0.08	0.75[a]	Monthly
1987/90	−ve	0.25[a]	0.66[a]	Monthly
1992/97	1.32[a,b]	0.24	0.40[a]	Quarterly

[a] Significant t > 2.
[b] Forward-looking: using instrumental variables.

supposed to give absolute primacy to the achievement of price stability. The level of output is not supposed to enter, for example, the objective function of the ECB or of the Bank of England. Yet, as described, the revealed preference of all monetary authorities appears to be to respond both to current inflation and to the current output gap. Actually, this seeming conundrum is very simply resolved. There are two ways to answer this question. The first is that these two variables, i.e. current inflation and the current output gap, are the critical variables needed to forecast future inflation. A regression of current inflation for the United Kingdom on the levels of inflation and a measure of the output gap one year previously, a measure that is as always somewhat arbitrary and uncertain, gives the following result:

$$\underset{}{\pi_t} = \underset{(0.011)}{0.010} + \underset{(0.113)}{0.840\,\pi_{t-1}} + \underset{(0.199)}{0.527\,(y - y^*)_{t-1}}$$

$R^2 = 0.739$, SEE $= 0.029$, (1974–97 annual data).

This is not to say that the vast efforts put in by the Bank staff and others to construct the inflation forecast do not add value to our estimates of future inflation, but it does suggest that knowledge of current inflation and where the country stands on the output gap, or equivalently using Okun's Law with respect to the natural rate of unemployment, can take one most of the way there. Given that lags in the transmission mechanism mean that the authorities can only reasonably target an inflation forecast (Svensson, 1997, *a* and *b*, and Svensson and Rudebusch, 1998), appearing to respond to current inflation and to the current outer gap may well appear superficially much the same as targeting a pure inflation forecast.

The second leg of the answer, which was discussed in greater depth by Mervyn King in his 1997 Financial Markets Group lecture, is that even if we knew exactly how our economies worked, subject only to additive stochastic shocks with mean zero, such shocks would still, from time to time, drive us away from our longer-term objectives of holding output close to productive potential with low, or zero, inflation. As is well known, the problem is particularly acute with supply shocks. That gives rise to the well understood complication that if one tries to restore inflation back very rapidly to its equilibrium, the lagged effects of monetary policy can lead both to large-scale, 'excessive', variations in output (around productive potential), and in many cases also to instrument instability (when the changes in interest rates needed to offset last time's disequilibrium, become explosively greater over time). On the other hand, enormous concern to prevent any large deviation of output from its equilibrium can lead to continuing and excessive deviations of inflation from target. This leads to a trade-off between output-variability and inflation-variability of the general form shown in Chart 1.

Fortunately for the MPC, the empirical evidence for the United Kingdom currently indicates that this is not a serious problem. The work of Haldane, Batini and Whitley at the Bank of England (1997) suggests that if one chooses an appropriate horizon for returning inflation to its target, one will achieve about as good an outcome for

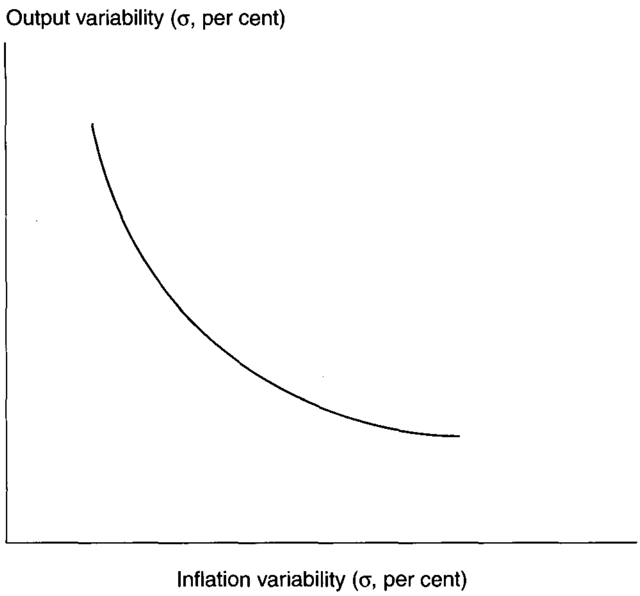

Chart 1. Output/inflation variability trade-off.

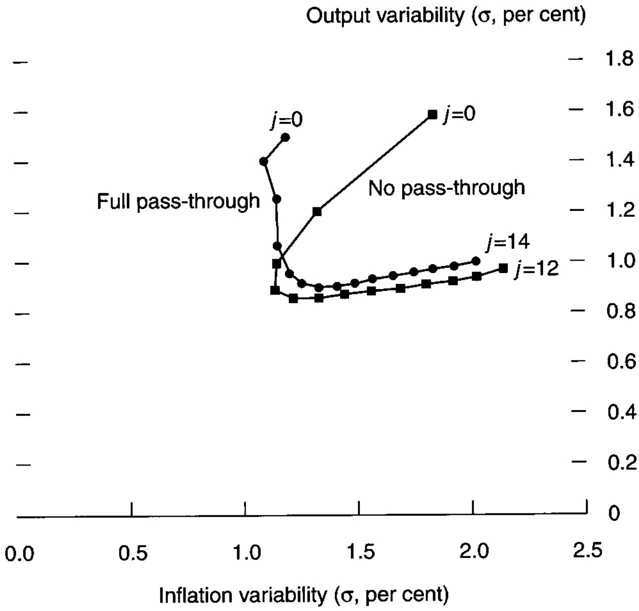

Chart 2. *j*-loci: full and no pass-through cases[a]

(a) Chart 2 plots the locus of output/inflation variability points as the horizon of the inflation forecast (j) is varied, one assuming full and immediate import-price pass-through (a shorter transmission lag), and the other, no immediate pass-through (a longer transmission lag).

both inflation and output variability together as is practicably possible. Thus, in Chart 2, there appears to be relatively little trade-off between minimising the variability of inflation and of output, if one chooses the appropriate lag length (j in the chart). Put another way, the loci are approximately, though not strictly, rectangular.

In another independent exercise, my discussant, Charlie Bean (1998), estimated such a policy frontier between the standard deviations of inflation and output (see Chart 3). He then wrote:

> The most striking thing about these frontiers is how sharply curved they are—indeed they are almost rectangular—and how closely together are the optimal points for relative weights in the range 1: 3 to 3: 1. This rectangular quality is also found in the work of Haldane and Batini (1998) . . . suggesting that it is not simply an artefact of the rather simple model structure employed here. This rectangularity has an important implication: a wide range of possible weights on output *vis-à-vis* inflation lead to the selection of rather similar points on the policy frontier. Hence little is lost by the government being able to write only an incomplete contract with the central bank, which does not explicitly prescribe the relative weight the central bank is supposed to place on output volatility versus inflation volatility; the central bank only

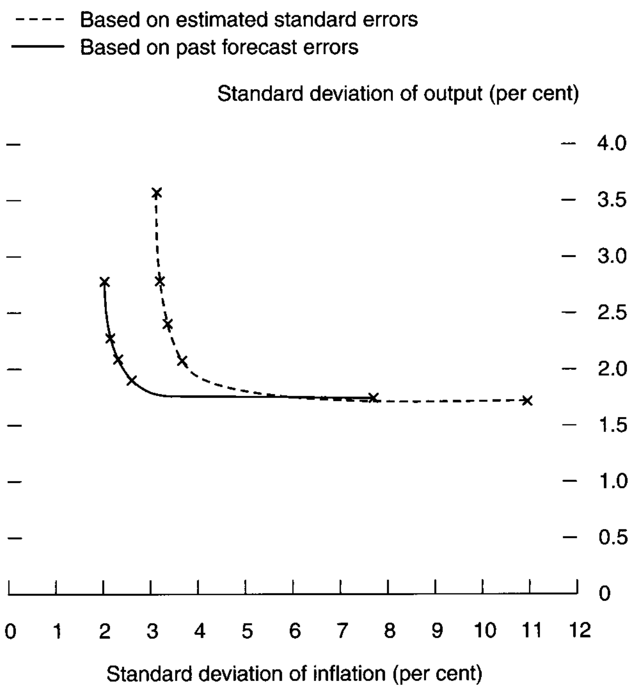

Chart 3. Policy frontiers.

needs to know that preferences are not extreme. Furthermore such an incomplete contract is likely to lead to a better outcome than a more completely specified contract that encourages the central bank to select a policy that is at the upper end of the policy frontier. One interpretation of the United Kindom inflation remit is that it is precisely such an incomplete contract.

So the evidence suggests that the short-term trade-off between the variance of inflation and output, over which so much blood has been spilt, is, in the United Kingdom at least, in practice not such a difficult and troublesome issue. The key point is that the MPC should choose an appropriate future horizon at which to aim to return to the inflation target set by the Chancellor. By doing so, they should come close to minimising the variance of both output and inflation. Given that horizon, how then should the monetary authorities operate, according to the principles that flow from our models of the economy, always remembering, and I really want to emphasise this, that in most of these models the only uncertainty in the system is additive and stochastic?

The answer to that conditional question is fairly clear. We should each month alter interest rates so that the expected value of our target, the forecast rate of inflation at the appropriate horizon about 18 months to two years hence, should exactly equal the desired rate of $2^1/_2$%. Lars Svensson has written several papers (e.g. 1997*a*, 1997*b*, 1998*a*) on the optimality of such a procedure. If we start from an initial position in which the predicted forecast value of inflation is already close to the objective, then as a first approximation we should expect interest rates to respond to the unanticipated element in the incoming news. Since this is by definition a martingale series, often somewhat loosely termed a 'random walk', then, on these assumptions, an optimally conducted interest rate path also ought to be nearly random walk. This is, broadly, what the generality of our economic models imply.

I shall shortly demonstrate how, and why, no central bank actually does behave in such a random walk fashion. But before I do so, I want to contrast the normative theory inherent in our basic models with the public perception that such random walk behaviour is not optimal in practice. Thus, in *The Times* on Thursday, 11 June, under the headline 'Anger grows at Bank's U-turn' (p. 29), Janet Bush and Anne Ashworth state that,

> Critics of the increase described the Bank's apparent shift in policy as 'almost laughable'. One said: 'It is like a drunk staggering from side to side down the street'.

You will appreciate that this latter is an almost perfect description of a random walk path. Similarly, the *Sunday Business* main leader of 7 June was entitled 'The fickleness of hawks today and doves tomorrow'; the unnamed writer commented,

> Where the committee lost credibility last week is in its inconsistency. . . . What is the outside world meant to make of members who can change their view so readily? It suggests a fickle committee, influenced by the latest anecdotal or statistical evidence, swaying its opinions one way or the other and back again.

One of the arguments used by Wim Duisenberg, the President of the ECB, in rejecting the publication not only of individual voting records but also of minutes for some long duration is apparently (and this passage is in direct quotes in Robert Chote's *Financial Times* article on 1 June (p. 10)) that:

> Publication of the minutes soon after decisions have been taken or meetings have taken place will—and this is only human—make it more difficult for individual participants in the discussion to change their minds and be convinced of the arguments of others.

Now this struck a particular chord with me; for example, yet another commentator, Jonathan Loynes, writing in *Greenwell Gilt Weekly* on 18 May, wrote,

> Of course, this does not mean that Professor Goodhart cannot switch *back* to the Hawks. If his change of heart was driven by recent softer earnings numbers then the latest pick-up could cause him to think again. But an immediate about-turn is most unlikely, if only for reasons of credibility.

Wim Duisenberg presumably now doubts my humanity, Jonathan Loynes my credibility. Yet let me reprise once again. If policy is roughly on course to deliver the desired objective, then policy should be finely balanced, and should react to incoming unanticipated news in an approximately random walk fashion. A committee, or an individual within that, who consistently votes the same way for month after month either has got the balance of policy seriously wrong, or individually must think that that balance is seriously wrong.

I previously qualified the term 'random walk behaviour' with the adverb 'approximately'. The first point to make is that the dynamic structure of the economy involves strong serial correlation and long lags in monetary policy effects. If we seek to optimise monetary policy in a model with such inherent lags, even if we still use a certainty-equivalent model (only involving additive stochastic uncertainty), then we could expect to find some degree of serial correlation in the path of interest rates. The dynamic structure of the economy itself can account for part of the observed persistence in the directional movement of interest rates. To repeat, interest rates should not follow a random walk even under certainty-equivalence. But the degree, the extent, of gradualism exhibited in interest rate policy is far higher than the dynamic structure of serial correlation in the economy alone can justify.

An excellent paper by Brian Sack (1998*a*; see also 1998*b*) of the staff in the Fed's Board examined, by using a VAR model, initially with additive uncertainty, what the expected policy in adjusting the fed funds rate would have been if policy had been optimised. He found (p. 4) that:

> The optimal policy displays a tendency to move in a particular direction over sustained periods of time, as found in the data. Still, the optimal policy responds more aggressively to changes in the state of the economy than the observed policy. As a result, the funds rate path under the expected policy is more volatile than the actual funds rate. Moreover, the observed policy tends to lag behind the expected policy, limiting any changes in the funds rate and gradually moving towards the optimal policy over a period of six months. The actual policy is therefore described by an excessive amount of interest

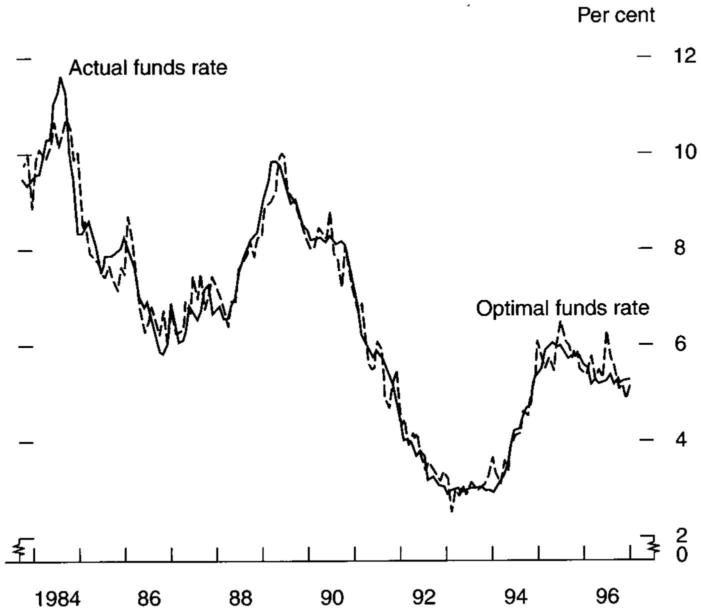

Chart 4. Actual and optimal funds rate under additive uncertainty.
Note: The optimal funds rate is based on the policy rule that solves the dynamic programming problem. It is the rate predicted by the policy rule given the actual history of the economy at each point in time.

rate smoothing that cannot be explained strictly by the dynamic behaviour of the variables to which the Fed is responding. The interest rate smoothing that is observed indicates that the analysis under additive uncertainty ignores an important element of policy making.

One way of expressing this difference visually is to compare the path of the calculated 'optimal' and actual fed funds rate, as Sack does in his figure 2, here Chart 4. You can see that the fainter optimal expected line is more jagged, with more reversals of direction than the actual fed funds path. As you can see from the time the path of the actual planned target rate (see Chart 5), most of the changes amount to small steps in the same direction. The cumulative distribution for the expected optimal policy with additive uncertainty is very different from that of the actual policy followed.

There are, however, some technical problems relating to the estimation and assessment of the calculated optimal interest rate change at any time. For example, should this be done on a one step ahead basis, starting from the actual level of interest rates in the preceding period, or on a dynamic basis starting from what would have been the optimal

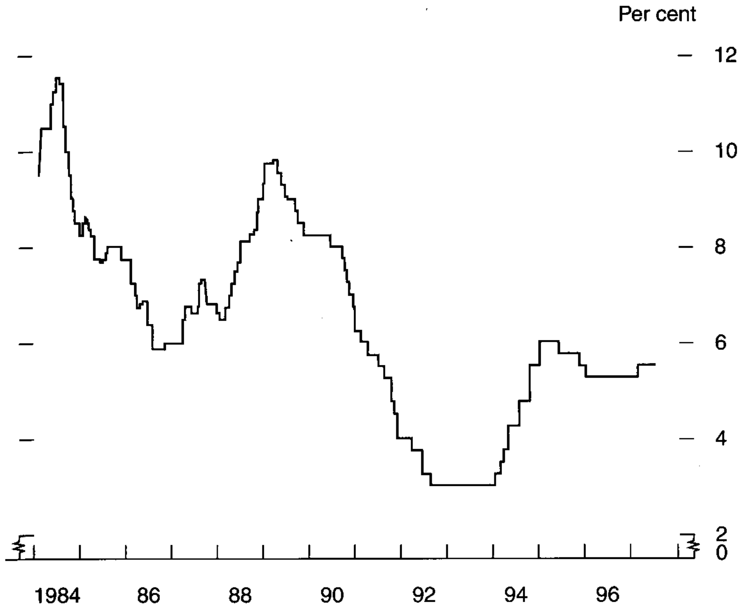

Chart 5. Actual target federal funds rate[4]

level of interest rates in the preceding period? In practice, when the actual level of interest rates is not too far from the estimated optimal level, the results are qualitatively pretty similar.

Anyhow, both sets of results are shown in Table B. This compares the actual changes in interest rates in each month in the United States with those that would have been made under the optimal policy rule(s), assuming stochastic additive uncertainty. The interest changes, which in the model can take any size, are here grouped into 'bins', whereby any optimal change between plus and minus $12\frac{1}{2}$ basis points is counted as a 'no change' decision, any optimal change between $12\frac{1}{2}$ and $37\frac{1}{2}$ basis points is grouped into the 25 basis point ($\frac{1}{4}$ %) change 'bin', and so on. You should also note that, for reasons that will become increasingly obvious, I have grouped all changes that were continuations of an existing direction of change on the left of the table, and all changes that reversed the direction of movement on the right-hand side. Let me draw three features to your attention. First, under the optimal policy,

[4] The bold line in Chart 4 is not exactly equal to the line in Chart 5. This is because the Fed sets the target rate (Chart 5), but allows market forces to cause minor deviations between the actual (Chart 4, bold line) and the target rate.

there would have been 55 (47) changes[5] over this time period of $^1/_2$ % or more; in reality, there were 23. So policy is less aggressive than the model would suggest was optimal. Second, no change was made in practice more than twice as often as this model indicated would be optimal. Third, whereas the number of continuations in the model, 76 (58), was very close to the number actually made, the number of reversals in the model, 36 (55), was about four times those made historically (10). Compared with the model predictions, the Fed has a bias to make no change, appeared extraordinarily reluctant to reverse the direction of change, and tended to eschew large, aggressive movements.

Because of the importance I attach to this kind of analysis, I have been encouraging the Bank staff to complete a companion study for the United Kingdom to that done by Sack for the United States—not that they needed much encouragement from me; it was already on their agenda. Unfortunately, the estimation of satisfactory VAR models for the United Kingdom is a much more complex exercise. The United Kingdom is a more open economy, which requires a model with a larger dimension; policy regime changes have been more frequent and most drastic; and the price puzzle[6] has been even more stubbornly pervasive in the United Kingdom than in United States models. Be that as it may, despite all the difficulties, Chris Salmon and Ben Martin of the Bank of England staff are now constructing a VAR model (on a broadly similar basis to that estimated by Sack for the United States) for the United Kingdom. I hope that their work will soon appear as a Bank of England *Working Paper*. This VAR is quarterly, from 1981 Q2 to 1988 Q2. A serious problem with this is that there were several major monetary policy regime changes during this period, which have, perforce, to be averaged out in this exercise.

Moreover, in the United Kingdom, for a variety of reasons relating to shifting policy regimes (e.g. Medium Term Financial Strategy, shadowing the DM, Exchange Rate Mechanism, etc), and/or possibly to policy errors, actual interest rates were often markedly out of line for persistent periods from the optimal policies estimated from VARs. So the only comparison that made sense in the United Kingdom was that

[5] The number refers to row (a) and the number in brackets refers to row (b) of Tables B and F throughout this article.

[6] In such VAR models, the initial response of inflation to an interest rate increase is often, perversely, to increase.

Table B. Optimal interest rate changes from the United States

Certainty	Number of continuations							Number of reversals						
	Up >0.5	Down >0.5	Up 0.5	Down 0.5	Up 0.25	Down 0.25	No change	Up 0.25	Down 0.25	Up 0.5	Down 0.5	Up >0.5	Down >0.5	
(a) One step ahead change on actual	9	6	11	10	21	19	40	8	9	7	6	3	3	152
(b) Dynamic change on own lag	7	3	4	11	12	21	39	20	13	5	8	3	6	152
(c) Actual policy	1	6	9	5	9	20	92	4	4	1	1	0	0	152

Table C. Actual number of interest rate changes

	Number of continuations									Number of reversals							
	Up >1	Down >1	Up 0.75	Down 0.75	Up 0.5	Down 0.5	Up 0.25	Down 0.25	No change	Up 0.25	Down 0.25	Up 0.5	Down 0.5	Up 0.75	Down 0.75	Up >1	Down >1
UK additive uncertainty[a]	4	6	2	3	3	5	3	1	1	2	4	7	5	2	2	8	8
UK actual policy[a]	2	8	2	3	2	9	2	8	14	1	0	1	2	2	1	5	4
US actual policy[b]	2	1	2	5	3	5	2	7	15	1	2	1	0	1	1	0	1

[a] 1981: 3–1998: 2 (66 observations).
[b] 1984: 3–1996: 4 (49 observations).

between actual policy and that estimated as the value dynamic change on the previous optimal value.

Anyhow, we have now used this quarterly model for the United Kingdom to try to replicate Sack's results. This is shown for quarterly data in Table C, on the assumption of stochastic additive uncertainty only (i.e. certainty-equivalence). Recall, however, that Sack's model was monthly, which accords more closely with the periodicity of monetary decision-making. So if there were three consecutive monthly 25 basis point changes in the quarter in the United Kingdom, this would come out in our quarterly figures as a single 75 basis point change. To facilitate comparison, we have also recalculated Sack's results for US actual policy at a quarterly frequency, and this is also shown in Table C for the actual members, and in Table D for exactly comparable proportions.

What this shows is that, as in the United States, 'optimal' policy, subject only to additive uncertainty, would be far more activist (only one 'no change' in 17 years, compared with 14 in reality), and much more prone to reversals (38 under the optimal policy, compared with 16 in reality); the number of continuations in practice (36) was again quite close to that under the optimal policy. What is, however, strikingly different between the two countries is the apparently much greater willingness in the United Kingdom to change interest rates by considerably larger steps. We believe that this is because United Kingdom policy had to respond to larger stocks, more regime changes and perhaps worse policy errors.

So the gist of my assessment is that, both in the United Kingdom and the United States, there are about the same number of steps in the same continuing direction, many more 'no change' decisions, and many fewer reversals of direction than might appear optimal under a certainty-equivalent model. In the United States, but not in the United Kingdom, there were also fewer large changes in interest rates than would have appeared optimal. Moreover, this is not just an Anglo-Saxon phenomenon. A general dislike of making large aggressive changes in interest rates, and the bias towards 'no change' decisions, is well documented for all developed countries. What I would like to emphasise here is that a concern to avoid reversals of direction is also well-nigh universal, as documented in the latest 1998 BIS *Annual Report*. This *Report* comments (p. 68), and I quote,

Table D. Percentage of total interest rate decisions

	Number of continuations									Number of reversals							
	Up >1	Down >1	Up 0.75	Down 0.75	Up 0.5	Down 0.5	Up 0.25	Down 0.25	No change	Up 0.25	Down 0.25	Up 0.5	Down 0.5	Up 0.75	Down 0.75	Up >1	Down >1
UK additive uncertainty[a]	6	9	3	5	5	8	5	2	2	3	6	11	8	3	3	12	12
UK actual policy[a]	3	12	3	5	3	14	3	12	21	2	0	2	3	3	2	8	6
US actual policy[b]	4	2	4	10	6	10	4	14	31	2	4	2	0	2	2	0	2

[a] 1981: 3–1998: 2 (66 observations).
[b] 1984: 3–1996: 4 (49 observations).

> There is some evidence that a dislike of reversals of this sort is not uncommon in the industrial countries. Central banks generally move interest rates several times in the same direction before reversing policy. Moreover, the interval between policy adjustments is typically considerably longer when the direction is changed. As the size of the steps at turning-points is not systematically larger than at other times, this pattern of adjustments risks being interpreted as a tendency to move 'too little, too late'. One possible rationalisation for such behaviour is uncertainty about the policy impulses. Such uncertainty is likely to be greatest at the turning-points of the interest rate cycle. A further reason for wishing to avoid frequent interest rate reversals is the desire to provide clear guidance to markets, both to strengthen the pass-through along the yield curve and to avoid destabilising markets.

If you rank countries in terms of the ratio of continuations to reversals, with the top being Austria with 63 continuations to 2 reversals, the United Kingdom comes ninth out of twelve, well below the median, so the evidence suggests that we have actually been comparatively more willing than most to change direction (Table E).

So the common practice among central banks is to make long series of small steps in the same direction. This behavioural pattern is partly, but only partly, picked up in the econometrics for the Taylor rule, in the guise of the near-unitary coefficient on the lagged dependent variable.

John Taylor, of the eponymous rule, has studied the comparative virtues of rules of this kind, both with and without smoothing of the form empirically observed, in simulations carried out in some ten models of various economies. His conclusions (1998*d*, p. 11) are that,

> Comparing such rules [with smoothing] with the two rules that do not respond to the lagged interest rate shows that neither type of rule dominates across all models. However, for a number of models the rules with lagged interest rates have very poor performance with extraordinarily large variances. These could be Great Depression or Great Inflation scenarios in some models. It turns out, however, that the models that predict very poor performance for the lagged interest rate rules are models without rational expectations, or in which forward looking effects are not strong in the model. Why? Interest rate rules which respond with a lag exploit people's forward-looking behaviour; these rules assume that people will expect later increases in interest rates if such increases are needed to reduce inflation.

Put another way, it is all right for the authorities to act slowly in a series of cautious small steps, just as long as a forward-looking public can effectively undo such cautious lags by immediate anticipation. In a similar vein, Marvin Goodfriend (1991) has argued that an anticipated

Table E. Policy rate adjustments

	Sequence of adjustment											
	Number of changes				Average duration[a]				Average change[b]			
	++	+−	−+	−−	++	+−	−+	−−	++	+−	−+	−−
United States	6	1	2	22	41	108	321	39	0.46	0.25	0.25	0.28
Germany	65	31	31	107	22	24	34	14	0.25	0.19	0.12	0.15
France	8	5	6	86	47	72	77	31	0.51	0.40	0.83	0.21
Italy	9	6	6	24	122	182	121	83	1.31	0.88	0.96	0.73
United Kingdom	28	17	18	84	36	69	49	23	0.94	0.50	0.77	0.37
Canada	10	1	2	21	22	57	103	21	0.43	0.25	0.25	0.25
Spain	4	5	4	33	56	72	67	35	0.42	0.24	0.35	0.38
Australia	2	1	1	17	43	413	264	67	1.00	0.50	0.75	0.79
Netherlands	55	27	28	108	16	15	32	15	0.42	0.53	0.40	0.21
Belgium	9	7	8	82	17	10	82	10	0.45	0.24	0.34	0.14
Sweden	14	1	2	24	16	132	146	10	0.12	0.25	0.27	0.18
Austria	15	1	1	48	70	42	150	34	0.38	0.50	0.25	0.16

Notes: ++ = two successive increases (tightenings); +− = increase followed by decrease; −+ = decrease followed by increase: −− = two successive decreases (easings).

Policy rates and starting dates of the sample periods: Australia, official target rate, 23 January, 1990: Austria, GOMEX, 6 May 1985; Belgium, central rate, 29 January 1991; Canada, operating bands 15 April 1994; France, tender rate, 4 January 1982; Germany, repurchase rate, 19 June 1979; Italy, discount rate, 1 January 1978; Netherlands, special advances rate, 1 January 1978; Spain, repurchase rate, 14 May 1990; Sweden, repurchase rate, 1 June 1994; United Kingdom, Band 1 bank bills, 1 January 1978; United States, federal funds target rate, 10 August 1989. End of sample periods: 31 March 1998.

[a] In days.

[b] In percentage points.

series of small steps in short rates will trigger off a large change in longer-term bond yields when the sequence starts, and that it may be the latter that has more effect in some economies in influencing demand. This may be particularly the case in countries where the objectives, and forecasts of the likelihood of reaching those objectives, are not regularly and publicly quantified.

It surely must be the case that the eventual determination to vary interest rates enough to defeat inflation is more important than the speed, or path, by which this is done: the Bundesbank, for example, is even more prone to smoothing than has been the case in the United Kingdom. When the reputation for determination is in place, then the ultimate measures will probably be broadly anticipated by the public. But even if it can thus be claimed that smoothing is, in general, a fairly harmless exercise, it still leaves the question of why the monetary authorities in virtually all major countries have adhered to this behaviour pattern so determinedly. What have we failed to understand?

The failings, of course, lie far more in the standard economic models than in the practical behaviour of central bankers. One of the central problems is that uncertainty is far more complex, insidious and pervasive than represented by the additive error terms in standard models. The more essential uncertainty is multiplicative, i.e. attached to the coefficients in the models—or, in simpler terms, we do not know the true workings of the economic system. In some cases, we do not even know which coefficients are non-zero, i.e. which variables are relevant. But even when we do know which variables to include in our equations, we certainly do not know what the true value of their coefficients may be.

Let me give you just two topical examples of such general uncertainties. First, in an open economy, one of the main ways in which interest rate changes have an impact on the economy is via their effect on exchange rates. But can anyone, you, me, the MPC, predict the market's response at all accurately in advance? Second, to revert to the Taylor rule, discussed earlier, life would be so much easier if we knew exactly, when we come to take decisions, what was the sign of the output gap, or of its kissing cousin, the natural rate of unemployment, let alone their true arithmetic values. The regressions on the Taylor rule that I showed you earlier were predicated on the assumption that the way we estimate the underlying rate of productive potential is absolutely correct, and known with certainty.[7] Whereas, in practice, most governments' supply-side measures are intended to give a beneficial shift to the growth of productive potential and to the natural rate of unemployment. Moreover, it is patently obvious that such supply-side factors have varied over time, though, as in continental Europe, not always for the better.

As the Governor recently said in his speech to the TUC,

> The truth is that neither we, nor they, nor anyone else, can know with any great certainty *precisely* where demand is in relation to capacity in the economy as a whole. Still less do we know where it is likely to be over the next couple of years—and that is the more relevant consideration, given the time it takes before changes in interest rates have their full effects.

What, even, is the current sign of the output gap? As is evidenced by our differing votes, we in the MPC can and do individually see the same

[7] There is some (slight) distinction between parameter uncertainty, whereby

$Y_t = a + (b + \varepsilon_t)X_t + u_t,$

$\mu\varepsilon = 0,\ \sigma^2\varepsilon = K_1,\ \mu u = 0,\ \sigma^2 u = K_2$

and measurement error of Y_t, (or less likely in most cases of X_t), whereby the ultimate best estimate of Y is inaccurately measured, especially at first, by $\acute{Y}_t$ with

$Y_t = \acute{Y}_t + \eta_t$, so that

$(\acute{Y}_t + \eta_t) = a + b(X_t) + u_t$

$\mu\eta = 0,\ \sigma^2\eta = K_3,\ \mu u = 0,\ \sigma^2 u = K_2$, ($K$s are constants),

as my discussant, Charlie Bean, has pointed out. As the above formulation indicates, however, their implications are very closely similar.

Orphanides (1998*b*, see also 1998*a*) commented as follows:

'In summary, the presence of noise in the data acts as a counterweight to the highly responsive policy that policy-makers might have otherwise adopted to stabilise the economy. This result can be understood intuitively. When a policy-maker suspects that the information he is being provided with regarding the state of the economy is subject to significant noise, he should be reluctant to adjust his policy instrument as much as he would if he could trust the picture of the economy being painted with the data. This suggests that policy will be less activist than would be efficient with better information. More generally, in an environment where the observed behaviour of the economy does not conform well with the policy-maker's beliefs about the underlying state of the economy, the policy-maker ought to properly take into account that much of the information he is provided with describes the economy with substantial error. This then will call for a cautious response to apparent imbalances in the economy.

It is worth noting that the motivation for this caution differs from the one associated with uncertainty regarding the model's parameters. Following Brainard (1967), it has been recognised that parameter uncertainty may lead a Bayesian policy-maker to reduce the policy instrument responsiveness to economic imbalances.'

underlying data having different implications for that gap. Even in the United States, where the natural rate has been historically most stable, there are always arguments that new developments, a new paradigm, may have caused significant shifts in underlying productivity and the natural rate.

Such uncertainty would matter less if it were not for the associated stylised fact that policy actions, notably monetary policy, only take effect with long lags. In the presence of multiplicative uncertainty, it would seem optimal to proceed cautiously, as Bill Brainard (1967) first demonstrated. Indeed, but if there were not such long lags, then the sensibly cautious tendency to underdo the dosage would become rapidly apparent, and just as rapidly rectified. But the problem is that it can take so long for cautious moves to become recognised as such, that the inherent dynamic of the economy can lead to inflationary, or deflationary, momentum building up in the meantime. Or in simpler terms, excessive caution, even though entirely understandable in an uncertain world, can lead to the syndrome of 'too little, too late', or, as the Americans put it, 'falling behind the curve'.

It is, perhaps, in this latter context that the publication of a central bank's inflation forecast becomes so crucial. Despite being properly hedged around with probability distributions, where our uncertainties decently peep out from under our fan charts, and with, of course, the repeated mantra that we never take the forecast either literally or slavishly, the publication of the forecast nevertheless acts as a discipline on us. Against the natural tendency to defer action in an uncertain context, the publication of the forecast holds the MPC's feet to the fire. If the projected outcome for prospective inflation is significantly different from the target (and please allow me just for today to duck the question of how one might assess exactly what is a 'significant' difference), then the MPC comes under strong pressure to rectify the situation. We all know that forecasts are fallible, but without a published forecast, in a world of long lags, the tendency towards 'too little, too late' would become much worse.

'Too little, too late' could, in principle, be perfectly symmetric, in the sense that the response to deflationary pressures could be just as delayed and hesitant as the response to inflationary pressures. And we can all think of episodes, though mostly in other countries, where we might have preferred a more aggressively expansionary response to deflationary pressures. Yet it is my personal opinion that this syndrome is likely to be somewhat asymmetric. Interest rate increases are rarely popular, while expansionary measures are. In a world of uncertainty, where what you surely know is that you do not know either the future, or even really the present state of the economy, there is in my view an absolutely natural, and perfectly human, tendency towards delaying restrictive action for longer than expansionary measures. I must, however, add that an equally common public perception is that central bankers so hunger for 'credibility' that they have an asymmetric bias towards tightening. Perhaps the two biases roughly balance out?

Again, my discussant, Charlie Bean, got the analysis absolutely right. Having, correctly in my view, largely dismissed the idea that politicians underhandedly try to aim for output levels intentionally in excess of the equilibrium, he goes on to say,

> A far more plausible explanation as to why governments might be inclined to push output above the natural rate is that they are expected to deliver a high level of output through the *whole range* of their policies, and are rewarded by the electorate if they achieve this, and punished if they do not. The level of economic activity thus becomes a signal of government competence. Furthermore the natural rate is not known with any certainty, and the beneficial output effects of monetary policy expansion typically show through a year or so ahead of their effects on inflation. Thus governments, particularly near election time, may be more prepared to risk an expansionary monetary policy than is really prudent, arguing that such a policy is not likely to be inflationary, but rather is consistent with their successful effects to raise the output potential of the economy.

The point that I would like to make here is that such pressures affect central bankers, and even independent members of MPCs, in exactly the same kind of way, even if not to the same extent, that they affect politicians. Nevertheless, there are reasons to hope, and indeed to expect, that an operationally independent monetary authority should be much more resistant to an asymmetric, and excessive, caution in response to uncertainty. First, we do not have colleagues who look to us for re-election. Second, we have a publicly stated, quantified, and symmetric, inflation target to meet, and we can and should be held accountable for achieving that. Third, we have imposed on ourselves the discipline of a regularly published forecast of inflation, which provides a continuing public score-card of how we feel that we are doing in meeting that objective, and we are more likely to respect that discipline than politicians have, perhaps, been in the past.

Let me revert to my central concern about the nature of uncertainty. Unless there is a good reason, and there usually is not, to believe that there is inverse correlation between the additive and multiplicative sources of uncertainty, then the existence of multiplicative uncertainty and measurement noise will generally cause the authorities to move in smaller steps. On average, they should underdo the dosage, since a larger change in the instrument, given multiplicative uncertainty, will add to the variance of outcomes. Given the loss function, there is a trade-off between getting as near as possible to the desired value of the target variable and increasing the prospective variance of the target variable(s).

From my personal viewpoint, the essential features of the economy that both set the agenda for, and complicate the life of, the monetary authorities are the interaction between the effects, and implications, of multiplicative uncertainty on the one hand and long lags in the effects of monetary policy on the other. I need hardly remind you that virtually all analysis of monetary policy games, going well beyond textbooks to what are presumed to be state-of-the-art articles, has been based on models in which neither feature appears at all.

We all know that, in principle, such multiplicative Brainard uncertainty should lead to greater caution in varying policy instruments, here interest rates, because a large change in rates will have an uncertain effect on outcomes, and hence raise the possibility of potentially large social losses. But a problem for practitioners is that until recently no one has made much empirical study of how quantitatively important such Brainard uncertainty should be regarded as in practice. Let me put it another way: the manner in which monetary authorities around the world appear to vary interest rates in a series of consecutive small steps of the same sign might be optimal if, and very likely only if, multiplicative uncertainty was indeed a problem of the first order of importance.

Is it? Even if practical central bankers may not have known that they were talking prose all their lives, have they in practice been acting almost optimally? Until recently, there was no serious attempt to measure this empirically. But now, Brian Sack of the staff of the Fed's Board of Governors has made an excellent first stab of doing just that in the article that I have already quoted. He uses a five-variable VAR model with production, unemployment, inflation and commodity prices as the non-policy variable, and the federal funds rate as the policy variable. This exercise can both incorporate the long lags involved, and allow one to estimate the variance/co-variance matrix for the coefficients, and hence the extent of multiplicative uncertainty.

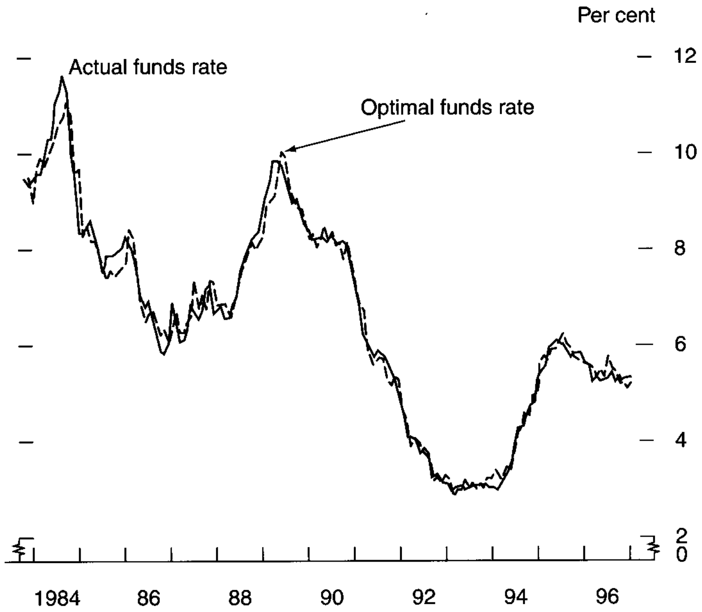

Chart 6 Actual and optimal funds rate under parameter uncertainty

Not surprisingly, he found that such an exercise brought the actual historical conduct of US monetary policy much closer into line with what the model indicated would be optimal—see, for example, his figure 5, here Chart 6. Thus he concluded (p. 28),

> Gradual movements in the federal funds rate do not necessarily indicate that the Federal Reserve has an interest rate smoothing incentive. Dynamic structure and parameter uncertainty can account for a considerable portion of the gradual funds rate movements that are observed. The intertemporal behaviour of the targeted variables causes the funds rate to move in a particular direction over substantial periods of time. However, under additive uncertainty, the expected path of the funds rate is much more volatile and reacts to changes in the economy more aggressively than the observed funds rate. This smoothing of the interest rate can be explained by the fact that the Fed does not know perfectly the structure of the economy. Uncertainty arising from imprecise estimation of the VAR coefficients is minimised at the level of the funds rate predicted by the policy rule that has been historically implemented. An aggressive policy would result in high expected variance for the targeted variables because the Fed has traditionally smoothed the funds rate. The policy rule that accounts for parameter uncertainty therefore reacts to changes in the state of the economy with gradual movements in the funds rate, which reduces the excess volatility of the expected

policy and limits the deviation of this policy from the observed level of the funds rate.

Although the uncertain dynamic structure results in gradual funds rate movements, there remains an element of interest rate smoothing that cannot be explained in this exercise.

Nonetheless, there are still several remaining differences between such central bank behaviour in practice and those actions that would appear optimal, even after taking account of multiplicative Brainard uncertainty. Let me revert to Table B, showing the implied distribution of interest rate changes, but this time also including the result with multiplicative Brainard uncertainty.

What this table, Table F, shows is that once one takes Brainard uncertainty into account, the paucity of large aggressive jumps in interest rates becomes largely explained. With Brainard uncertainty, there would only have been 23 (24) changes of 50 basis points, or more in the US case, compared with the 23 found historically.[8]

What, however, the empirical application of Brainard uncertainty still largely fails to explain is the small number of reversals. Under our VAR models, with or without Brainard uncertainty, the number of reversals of direction of policy should have been some three to five times as common as found in practice, depending on whether one uses as the basis for judgement the one step ahead or the dynamic prediction from the model.

Once again, I have been encouraging the Bank staff to replicate this same study for the United Kingdom, and for the VAR model, already briefly described, the results of the dynamic optimal policy under multiplicative uncertainty are shown in Table G (alongside the optimal policy with additive uncertainty only, and actual policy). As with the United States, recognition of multiplicative uncertainty should make policy-makers far more cautious, with many fewer large step changes. Indeed, what is remarkable from Table G is that the actual number of large step changes (more than 1% in a quarter), at 19, was more than four times the number (4) that should have been made in this period had policy-makers been consistently following an average optimal policy adjusted for multiplicative uncertainty.

What is also remarkable is that such reversals as occurred in practice in the United Kingdom were predominantly very large (9 of 1% or more, as compared with 7 under 1%), in contrast with actual continua-

[8] See above n. 5

Table F. Optimal interest rate changes for the United States

Certainty	Number of continuations							Number of reversals						
	Up >0.5	Down >0.5	Up 0.5	Down 0.5	Up 0.25	Down 0.25	No change	Up 0.25	Down 0.25	Up 0.5	Down 0.5	Up >0.5	Down >0.5	
(a) One step ahead change on actual	9	6	11	10	21	19	40	8	9	7	6	3	3	152
(b) Dynamic change on own lag	7	3	4	11	12	21	39	20	13	5	8	3	6	152
(c) Actual policy	1	6	9	5	9	20	92	4	4	1	1	0	0	152

Uncertainty	Number of continuations							Number of reversals						
	Up >0.5	Down >0.5	Up 0.5	Down 0.5	Up 0.25	Down 0.25	No change	Up 0.25	Down 0.25	Up 0.5	Down 0.5	Up >0.5	Down >0.5	
(a) One step ahead change on actual	1	0	7	9	31	18	50	12	18	5	0	1	0	152
(b) Dynamic change on own lag	1	0	5	8	19	35	57	8	9	3	3	2	2	152
(c) Actual policy	1	6	9	5	9	20	92	4	4	1	1	0	0	152

		Total continuations			Total reversals	
		Up	Down	No change	Up	Down
(a) One step ahead change on actual	Certainty	41	35	40	18	18
	Uncertainty	39	27	50	18	18
(b) Dynamic change on own lag	Certainty	23	35	39	28	27
	Uncertainty	25	43	57	13	14
(c) Actual policy		19	31	92	5	5

1984: 5–1996: 12 (152 observations).

Table G. Optimal interest rate changes for the United Kingdom

	Number of continuations									Number of reversals							
	Up >1	Down >1	Up 0.75	Down 0.75	Up 0.5	Down 0.5	Up 0.25	Down 0.25	No change	Up 0.25	Down 0.25	Up 0.5	Down 0.5	Up 0.75	Down 0.75	Up >1	Down >1
Additive uncertainty	4	6	2	3	3	5	3	1	1	2	4	7	5	2	2	8	8
Multiplicative uncertainty	0	3	3	2	1	7	6	10	14	4	4	3	3	3	2	0	1
Actual policy	2	8	2	3	2	9	2	8	14	1	0	1	2	2	1	5	4

1981: 3–1998: 2 (66 observations).

tions (10 of 1% or more, 26 under 1%). Under multiplicative uncertainty, the numbers for reversals were 1 of 1% or more, 19 under, and for continuations, 3 of 1% or more, 29 under. If we should make the (admittedly extreme) assumption that these really large reversals were mainly due to regime changes and recognition of prior policy errors, then the UK figures show roughly the same ratio of smaller reversals between optimal policy under multiplicative uncertainty to those in practice, i.e. 19 to 7, as in the United States.

Thus, in the United Kingdom, one problem is to explain why there were so many really large changes in interest rates in practice, given that under Brainard uncertainty, the optimal changes should ideally have been smaller. If these, especially the reversals, can be accounted for by regime changes/policy errors, then we are left, as in the US case, with a problem of accounting for a general, apparent reluctance to reverse the direction of change. And let me emphasise and repeat that I do not think that this latter is just an Anglo-Saxon propensity. It is, I believe, common to all major central banks.

The distributions from such a VAR model probably provide an upper bound on the degree of caution, and interest rate smoothing, that should theoretically be undertaken, because the construction of this model completely leaves out the advantage that can be obtained from more aggressive action, whereby one then learns more about the working of the economy—which should, in principle, reduce *future* uncertainty (see, for example, Sack (1998*b*)). Thus, Volker Wieland (1998, p. 2) wrote,

> There are a number of reasons to believe that such a Brainard-type analysis overstates the case for gradualism. For example, Caplin and Leahy (1996) show that in a game between a policy-maker who attempts to stimulate the economy and potential investors, a cautious policy move may be ineffectual, because investors anticipate lower interest rates in the future. Another reason, investigated in this paper, is that a more aggressive policy move may generate more information, which would improve the precision of future estimates and thereby future policy performance.

Indeed, two eminent American economists, Tom Sargent (1998) and James Stock (1998), have recently argued that a central bank seeking to insure against the worst risks coming about (a 'minimax' strategy) in the context of multiplicative uncertainty should actually be more aggressive, not less. The implied corollary, of course, is that if such aggression should prove to have been unnecessary, the measures can be reversed in a subsequent period. But such a reversal of policy is just what central banks appear, on this evidence, loth to do.

Not only the evidence that I have presented here, but also other anecdotal reports, suggest that central bankers are, as a class, notably reluctant to make a move on interest rates that might shortly need to be reversed (except under crisis conditions, e.g. relating to a pegged exchange rate target, or after a major policy regime change), and much more so than our currently best models suggest would be optimal.

There are two reasons, not mutually exclusive, why this might be so. The first I owe mainly to Michael Woodford (1998). Assume that for some reason the central bank wants to reduce the variance of the level of short-term interest rates. Nevertheless, the central bank wants to maintain the ability to have a quick and strong effect on the economy at a time of a major shock hitting the economy. If the central bank can commit to behaving in such a way that any small reversal in direction of change will be followed by several similar steps in the same direction, then forward-looking rational agents will make large changes to their behaviour whenever reversals occur. But the downside for the central bank, the corollary, is that it must be cautious about reversing direction in the face of minor shocks, since too many short-lived reversals would limit its power to combat major shocks, given of course the initial reluctance to increase the variance of short-term rates.

The second reason is tied up with the credibility issue. As I explained earlier, when policy is already just about on course, so that the decision is finely balanced, it might indeed be technically optimal to change one's views and one's decisions, and the direction of movement of interest rates, as news comes in, even from month to month, certainly from quarter to quarter. It seems difficult to explain this to outside commentators, who often perceive such reversals as evidence of inconsistency, patent error, and irresolution. We all react to criticism. As long as commentators castigate the monetary authorities for moves that turn out after the event to have been inappropriate and unnecessary, then that will tend to reinforce the tendency towards 'too little, too late'. The lessons from such outside criticism on changing one's mind is that no change in interest rates should be made unless and until the probability is quite strong that a subsequent change in the same direction will also soon be needed. That is, I would argue, not the optimal way to conduct policy, but it is, I believe, what happens around the world.

To conclude, there is an absolute yawning gap between the general perception of non-economist outsiders that reversals of policy, changes of mind, are to be deplored and castigated as evidence of error, irresolution and general incompetence, and the apparent findings from our economic models that such reversals should optimally occur some four, or so, times more frequently than they do in practice. Maybe our models are missing something important. If not, we have then singularly failed to explain to the world at large how policy should be carried out. Either way, there is still an enormous amount of work to be done.

Discussion

Charles Bean, London School of Economics

Charles's most insightful lecture focuses on an issue that is of the utmost importance to central bankers, and indeed to all policy-makers, but about which the academic literature—with the glowing exception of a venerable contribution by Bill Brainard (1967)—presently has relatively little useful to say. This issue is the question of how policy-makers should treat uncertainty: uncertainty about where the economy is and where it is going, and uncertainty about the impact of policy. This is not to say that the literature ignores uncertainty—far from it—but that usually the uncertainty enters in a relatively uninteresting way, most usually in the form of an additive disturbance that does not affect the optimal policy rule.

Now theory suggests, to a first-order of approximation and with high-frequency data, that short-term interest rates should be not far from being a 'random walk' (or more strictly a first-order autoregressive process), with changes in interest rates being largely a response to 'news' about the economic environment. Since 'news' is necessarily unpredictable, it then follows that roughly half the time an increase in interest rates should be followed by a decrease and *vice versa*. It is worth emphasising that this is only an *approximate* result, as if interest rates are above their long-run level (given by the equilibrium real interest rate plus the target rate of inflation), then they must be expected to decline over time. Similarly, if events are expected to cause a boom in the future, e.g. because of an announcement of future high levels of public spending, then the central bank might plan to raise interest rates in the future, but hold off from doing so at present. Nevertheless, the random walk model provides a useful benchmark against which to evaluate actual policy, which appears to deviate from this benchmark in a variety of ways. The question is: to what extent are these deviations a rational response to uncertainty (i.e. theory is wrong or incomplete), and to what extent do the deviations reflect sub-optimal policy?

In discussing the impact of uncertainty on the setting of interest rates, I think it is helpful to distinguish four distinct types of behaviour that seem to be characteristic of many central banks. These are: caution; conservatism; gradualism; and delay. Let me start with caution, by which I mean the tendency to move interest rates by only small amounts. There are two very good reasons for this. The first is that the data about the current state of the economy are frequently unreliable and prone to revision—witness the debacle over the earnings figures last year. Wise central bankers will thus tend to discount new information, particularly when it conflicts with other information that is available, and consequently the response to news will be muted. This is recognised in the literature as constituting a 'signal-extraction' problem, and such behaviour is entirely consistent with optimality. The second argument is that the effect of policy actions may be uncertain. In that case, large actions will tend to increase the amount of uncertainty in the economy, and a more cautious approach is warranted. This was Brainard's argument; in essence, he simply formalised Friedman's insight that the existence of 'long and variable lags' in the transmission mechanism of monetary policy should lead central bankers to be modest in their aspirations to control the level of nominal demand.

By conservatism, I mean the tendency for central bankers to tighten policy when there may be little sign yet of inflationary pressure to the man in the street (or the businessman in his office). In part, this is simply a recognition of the lags and inertia in the economy, but seemingly there is also something *asymmetric* about it: central bankers have a tendency to harp on about the dangers of inflation, but warnings about the dangers of recession or deflation are rarer. Such conservatism can be rationalised as constituting an optimal policy when the Phillips curve is convex (an $x\%$ positive output gap raises inflation by more than an $x\%$ negative output gap reduces it) and aggregate demand is imperfectly controllable, or the natural rate of output is uncertain.[9] This is a

[9] Charles mentions that uncertainty about the natural rate can induce Brainard-style caution without a non-linear Phillips curve. This is not strictly true if the uncertainty is about the natural rate *per se*. However, estimates of the natural rate are usually derived as a by-product of estimation of a model of wage and price formation. If the uncertainty, about the natural rate is then a *consequence* of uncertainty, about other parameters in the system, e.g. the effect of unemployment on wages, then the policy multipliers become uncertain and Brainard's analysis becomes relevant.

case of a 'stitch in time saves nine': prompt and modest action now avoids taking much nastier medicine later. This explains why a rational central bank would aim to hold activity not at the natural rate, but rather a little below it. There is, however, a counter-argument to this line of thinking, which runs as follows. Suppose we are unsure of the natural rate, then some judicious probing of the limits to expansion may be worthwhile.[10] This seems to be a pretty good description of what the US Fed have been doing in recent years.

Rather harder to rationalise from a policy optimisation perspective are gradualism and delay. By gradualism, I mean a tendency to make a large change in interest rates in a sequence of small steps (note that this is different from caution, which simply says that small rather than large changes are usually the appropriate action). In this class I would place the MPC's collective decisions over interest rates in summer 1997: it was hardly a secret that the Bank thought interest rates ought to have been higher in the run-up to the election, yet the MPC collectively chose not to raise rates significantly immediately on taking over responsibility for interest rates, preferring instead a sequence of ¼% point steps. This also shows up in the empirical results cited by Charles, particularly the serial correlation in the sign of the changes in interest rates that is apparent in many countries.[11] Such interest rate smoothing could be justified if there are costs of adjusting interest rates, particularly if those costs increase more than linearly with the size of the interest rate change. However, I find it difficult to see what those costs might be. In particular, I do not see how Brainard-style uncertainty about the policy multipliers plus lags in the transmission mechanism produce the desired result. What that does is generate smaller, but more persistent, changes in interest rates in response to news, rather than a lagged response to that news.

Finally, there is delay. It seems clear, both from the fact that the average length of time before a policy reversal greatly exceeds that between interest rate changes of the same sign, as well as a reading of

[10] This argument is due to C. Bertocchi and M. Spagat (1993). The analogy is with a new car: the easiest way to find out how fast it goes is to put one's foot on the accelerator and test it out. Of course, one does not want to put it down too far, which would be a recipe for having a nasty accident!

[11] The presence of lagged interest rates in estimated reaction functions is not evidence for such conscious interest rate smoothing, as inevitably central bankers respond to a whole range of economic indicators beyond those typically included in such models. In such circumstances, lagged interest rates will inevitably proxy such omitted variables, and consequently the coefficient will be biased.

the minutes of the MPC, that inaction is frequently justified on the grounds that a policy change might soon have to be reversed.[12] There is an analogy here with the literature on irreversible investment under uncertainty. If investment is costly to reverse and demand is uncertain, a wise businessman will not invest when the present value of expected profits just exceeds the cost of the investment; instead, he will want to take account of the possibility that a downturn in demand might occur. Waiting thus has an option value.

Now, while the 'wait and see' argument makes sense in an investment context, once again I find it harder to see what the real costs of interest rate reversals might be. Indeed, the possibility of a credit crunch or liquidity trap could push the argument the other way, for once such a phenomenon has developed monetary policy becomes much less effective; acting pre-emptively to head off the mere possibility of such an event then has value. Despite all this, it is clear that there is a presentational problem with policy reversals, as commentators are apt to see them as reflecting indecision or incompetence on the part of the authorities.

The problem, of course, with both gradualism and delay is that they tend to result in monetary policy being 'behind the curve' and thus inefficient. It also means that policy-makers may not get the credit they deserve, because their actions will sometimes appear belated. To the extent that all this is simply a response to ill-informed attitudes on the part of the media or the markets, it is rather unfortunate, to say the least. But let me finish on an optimistic note. In the region of an optimum, first-order changes in policy will have only second-order effects on welfare.[13] Consequently, it does not matter much whether policy is exactly right or merely approximately right. And I am pretty confident that the MPC has at least got it approximately right.

Charles Freedman, Deputy Governor, Bank of Canada.[14]

The Keynes lecture, like so much of Professor Goodhart's writing, presents thoughtful insights, dressed in elegant prose, on issues of real importance to policy-makers and economists. In 'Central bankers

[12] See, for instance, minutes of the February and October 1998 MPC meetings; in the latter case, the argument related to the size of the cut in rates, rather than whether to cut or not.
[13] This follows from the 'Envelope Theorem'.
[14] I would like to thank Pierre Duguay, Paul Jenkins, David Laidler, David Longworth, Tiff Macklem, Jack Selody, and Gabriel Srour for comments on an earlier drafts of these remarks.

and uncertainty', Professor Goodhart has two interrelated themes—the minor and less developed one relates to the various ways of characterising central bank behaviour in adjusting interest rates; the second and more developed theme addresses the question of why central banks tend to 'change interest rates, in response to shocks, by a series of small steps in the same direction, rather than attempting more aggressively to offset that shock quickly in order to return the economy to equilibrium'.

My comments are in two parts. First, I extend somewhat and complement Professor Goodhart's characterisation of central bank behaviour under explicit or implicit inflation targets; second, I comment on his explanation of the phenomenon of interest rates typically adjusting by small amounts and with infrequent reversals.

There are three related ways of characterising central bank policy-making in an inflation-targeting regime. The first, which is at the heart of much of the current academic literature,[15] involves the central bank minimising a loss function of the form:

$$L = E\{\Sigma\beta^i[(\pi - \pi^*)^2_{t+i} + \lambda\,(y - y^*)^2_{t+i}]\}$$

where π and π^* are the actual and target inflation rate, y and y^* are actual and capacity output, β is a discount factor, and λ is the weight of output deviations relative to inflation deviations in the loss function. Depending on the complexity of the model of the economy that constrains the minimisation, the outcome can be a complex or relatively simple interest rate setting equation.

The second characterisation of interest rate setting is the Taylor rule, which (in its principal variant) relates the short-term interest rate which the authorities are targeting to the current output gap and the current deviation of inflation from its target, along with the equilibrium real interest rate. To fit the data well, i.e. to pick up the gradualism in interest rate movements, the Taylor rule usually also contains a lagged dependent variable. The Taylor rule is typically, but not always, treated as descriptive rather than prescriptive. However, in some very simple models, a Taylor-like rule is the optimal rule.

The Taylor rule focuses attention on the importance for stability of

[15] One of the interesting aspects of inflation targeting is that it was developed in the central banks with virtually no academic input. Research by academics on inflation targeting began in the mid 1990s in response to the adoption of this new approach to policy by several central banks. In this respect, the situation was very different from that at the time monetary targeting was introduced in the mid 1970s, when a very large amount of academic research was available before central banks adopted the approach.

raising or lowering real interest rates when inflation rises or falls. At times in the past, as Professor Goodhart notes, this condition was not met. This insufficiently strong response to inflation pressures was very probably an important contributing factor to the high rates of inflation experienced in a number of countries in the post-war period.[16]

The third characterisation, based on the approach used in some central banks, makes the change in interest rates a function of the deviation of the forecast inflation rate in some future period from the target rate of inflation (sometimes called an 'inflation forecast based rule'). On the surface, this formulation appears to ignore fluctuations in output. In fact, by focusing on an inflation forecast six to eight quarters in the future, the central banks using this approach have effectively lessened output fluctuations. Consider, for example, a price shock to the economy. Attempting to get inflation back to its target very quickly would result in sharp swings in output to offset the inflation pressures. However, when the interest rate setting rule is based on a gradual return of inflation to its target, the effects on output are muted, at the expense of inflation remaining away from its target for a longer period.

I believe that one can summarise current thinking about the relationship of the three characterisations of interest rate setting as follows. Minimisation of the loss function in a given model by definition gives optimal outcomes in that model, but the resulting interest rate rule is not likely to be very robust across models, thereby giving rise to the risk of poor outcomes if the model being used is not a good representation of the economy. The Taylor rule appears to be relatively robust across models, which is a very useful attribute for a reaction function in circumstances of model-uncertainty. On the other hand, in most of its variants it totally ignores exchange rate movements, an important channel through which monetary policy operates in a small open economy under flexible exchange rates.[17] And it often treats the equilibrium real interest rate as a constant over the last thirty years, an assumption

[16] It is worth noting that one of the problems Canada faced in its monetary-targeting period (1975–82) was the high interest rate elasticity of the narrow monetary aggregate (M1) used as the target, which implied insufficiently aggressive interest rate responses to inflation shocks. See Thiessen (1983).

[17] Svensson (1998*b*) and Ball (1998) analyse policy-making in a small open economy with flexible exchange rates in the context of the loss-minimisation approach. In Ball's model, the optimal rule is like a Taylor rule but includes the real exchange rate.

that is inconsistent with other studies of the behaviour of real interest rates over this period.

Adjusting interest rates in respone to the deviation of forecast inflation from the target appears to provide a good approximation to the optimal rule in some models of the economy (e.g. Haldane and Batini (1998)) but not in others (e.g. Rudebusch and Svensson (1998)). Such a rule requires the same response to a forecast increase in inflation, regardless of whether the source is a supply shock or demand shock. Both the Taylor rule and the loss-minimisation approach require a less aggressive interest rate response to supply shocks than to demand shocks. Thus, in the case of supply shocks, output and inflation movements have offsetting effects on the interest rate in the Taylor rule, while in the case of demand shocks they push in the same direction. In practice, central banks using rules based on the deviation of forecast inflation from its target get a similar (but not identical) result to the other approaches by specifying the inflation variable on which they are targeting so as to exclude certain types of price changes that typically result from supply shocks (for example, food and energy prices). This eliminates the need to respond to such supply shocks unless they begin to affect the inflation process, i.e. to affect wage and price-setting behaviour in the economy. Also, by aiming at the rate of inflation six to eight quarters in the future, central banks do not need to react to what are perceived to be temporary price shocks.

The issues of the trade-off between output volatility and inflation volatility and the distance of horizon at which the central bank should aim are interesting and important questions, on which Professor Goodhart comments briefly. He argues that in the United Kingdom, the trade-off frontier is nearly rectangular (thereby effectively removing the trade-off as an issue), and that the central bank should target a rate of inflation six to eight quarters out. Two caveats are in order here. First, Bank of Canada research[18] suggests a negative trade-off curve between inflation volatility and output volatility in the context of inflation forecast based rules, implying that this issue remains on the table at least for some countries. Second, and perhaps more relevant for the United Kingdom, a recent Bank of Canada study[19] has indicated that the inflation horizon that the authorities should target can change with changes in certain types of economic behaviour. For example,

[18] Black, Macklem, and Rose (1998).
[19] Amano, Coletti, and Macklem (1998).

when the credibility of the central bank improves, as reflected by private sector expectations of inflation being more firmly anchored on the inflation target, it is possible to simultaneously reduce the variability of inflation and that of output. However, to reap these benefits, the central bank may have to adjust its rule to take account of the change in credibility. Using a Canadian model, the study illustrates the need to shorten the horizon for inflation at which the authorities are aiming as credibility increases. Moreover, and more strikingly, it shows that leaving the rule unchanged in the face of an increase in credibility may actually result in a deterioration of the performance of the economy.[20]

All this leads to the conclusion that the comparison of the benefits of complex but optimal rules, on the one hand, and simple but robust rules, on the other, remains an important subject for future research.

Now, let me turn to the central question posed by Professor Goodhart in this paper—why are central bank adjustments to the benchmark interest rate so gradual and why are there so few reversals in direction?

Let me begin by making a few comments on the data presented in Table E of the paper. First, while the characteristics of interest rate changes in terms of sign, duration and size of change are presented for twelve countries, a number of those countries were operating under a fixed-exchange regime for a good part of the sample period and consequently have tended to follow the behaviour of the country to which their currency was in effect tied. This is clearly the case for the Netherlands and Germany, although even here the table shows differences in the size of the average change that I found surprising. And the apparent differences between Austria and Germany relate to a difference in sample period, rather than to a difference in behaviour. Second, a couple of countries, Australia and Italy, show less gradualism in their changes, raising the question of why they behaved differently from the others. Third, it would be interesting, as more data become available, to address the question as to whether the introduction of formal targets for inflation has changed the behaviour of central banks operating under such a regime. This is similar to the point made by Professor Goodhart that increased independence for central banks may have resulted in a change of behaviour. Fourth, given all the discussion in recent years of pre-emptive actions and 'getting ahead of the curve', it

[20] According to some recent research at the Bank of Canada by Robert Amano, this result does not carry over to Taylor rules, which do not appear to require an adjustment in the interest rate response to benefit from increased credibility.

would be interesting to know if central banks behaved any differently in the 1990s than in early periods.[21]

Professor Goodhart's approach to assessing whether interest rate movements were too gradual and too frequently in the same direction is to compare the actual movements with those that would be implied by optimal policy, using a VAR model of the economy. The results for both US and UK models of the economy show that in the case of additive uncertainty, the actual movements are both more gradual and more one-way than in an optimal policy. In the case of multiplicative uncertainty, the difference between actual and optimal actions diminishes considerably with respect to the size of the movements, but the difference with respect to reversibility of movements largely remains, though less so in the United Kingdom.

I would pose a couple of technical questions about these results. First, Brian Sack's study (1998*a*) of the United States, used by Professor Goodhart for his assessment of the Federal Reserve's behaviour, uses an objective function that includes the difference of inflation from its target, unemployment from its target, and the growth of production from its target. The latter term, the deviation of production growth from its target (as opposed to the deviation of the level of output from its target), is unusual for such a study, and I wondered whether incorporating it made much difference to the results. I also worried about whether the use of a constant target rate of inflation of 2.8% reflected reality in a period during which the 'acceptable' rate of inflation in the United States seems to have fallen from about 4% to close to 2%, and whether having different inflation targets over sub-periods would influence the results. A second technical point to which I would draw attention is that there are two ways of interpreting multiplicative uncertainty—that parameters are random variables that change over time, and that the true values of parameters are unchanged over time but that our estimates are imprecise and may change over time. As Brainard showed in his original 1967 article, these alternatives have somewhat different implications for optimal policy. Sack used the second interpretation, that of imprecise estimate, in his study, and I would simply raise the question of whether the results would differ much if optimal policies were generated using the first interpretation, that of true parameter variability.

[21] The fact that the 1990s provided, for the most part, a more stable environment (until recently) might make it hard to reach any definitive conclusion, however.

More importantly, in addition to additive and multiplicative uncertainty, there is a third type of uncertainty, namely model-uncertainty, that deserves more attention than it typically receives, and that was not discussed by Professor Goodhart. We can never be certain that the (explicit or implicit) model we are using to help determine the appropriate setting of interest rates (or the appropriate level of monetary conditions) is an accurate representation of the economy. Indeed, in response to model-uncertainty, many central banks use alternative models (e.g. inflation forecasts based on money growth) as a cross-check to the forecast of inflation emerging from their central model or their judgement. It may well be that the relatively strong responses of interest rates to shocks using an optimal rule within a given model, VAR or otherwise, would lead to less good outcomes than the more cautious approach of the authorities, if the underlying economy were very different from that specified in the model. And this concern about model-uncertainty may help to explain the pattern of central bank behaviour on which Professor Goodhart is focusing.

That said, I believe that it is interesting and useful to address the questions of excessive gradualism and insufficiently frequent reversals on the part of central banks, even when account is taken of the different types of uncertainty. A variety of reasons for interest rate smoothing have been offered in the literature, by Professor Goodhart himself in an earlier study (1997) and by others.[22] Some have focused on the costs of interest rate volatility, an argument that is difficult to formalise and one that is increasingly difficult to make in a world with financial instruments that allow financial market participants to protect themselves to a considerable extent against interest rate volatility. Another argument emphasises that smoothing movements in short-term rates increases the effect of central bank action on medium and long-term rates, and that this could be an important factor in an economy in which spending behaviour is particularly sensitive to such medium and longer-term rates.[23] While it is undoubtedly the case that the adjustment by a central bank of its benchmark rate can lead to a larger response in long-term rates if such a movement is interpreted as the first of a series of movements in the same direction, the central bank might be able to achieve a similar outcome by

[22] Lowe and Ellis (1997), for example.

[23] This is less relevant for the United Kingdom and Canada than, for example, for the continental European countries or the United States.

larger moves in its benchmark rate, even if these were reversed more frequently.[24]

The third type of explanation, and the one favoured by Professor Goodhart, is a more psychological explanation, related to the credibility of policy-makers. There is certainly a tendency among commentators on central bank behaviour (both from financial markets and the media) to treat a quick reversal in the direction of interest rate movements as a sign of a central bank that is unable to make up its mind or is inconsistent. And this type of attitude, which has the potential to bring about a loss of credibility of the central bank, may make it more difficult for policy-makers to react appropriately to incoming data.

Let me begin my assessment of this explanation by examining the situation in which demand shocks have hit the system in such a way that the economy is clearly moving above or below potential, and the forecast rate of inflation is moving above or below its target. Even in such a case, where the direction of the appropriate interest rate movement is clear, the appropriate size of the adjustment to interest rates may not be clear. We know that such demand shocks are frequently autocorrelated and, moreover, that they are typically propagated through the economic system in a way that magnifies their effects. If policy-makers had perfect foresight, they might respond very aggressively to a demand shock, on the basis of the potential effects that it could have on the economy and on inflation. But policy-makers, sad to say, do not have perfect foresight. Shocks can be temporary or long-lasting, and it is rarely entirely clear at the time of the shock exactly what type of shock one is facing in reality, as opposed to in the models. And of course, there may be a number of shocks occurring at the same time, making interpretation even more difficult.

In the event, what seems to happen in response to these kinds of shocks is an adjustment of the benchmark interest rate to the shock that is perceived to be taking place, without taking fully into account the possibility that it may be the first in a sequence of shocks in the same direction. And if the initial interest rate movement is not sufficient, further action is taken. This is what we used to call 'successive approximation'. The outcome will be a cycle of inflation around its target, but if the central bank reaction is not excessively little or excessively late, it

[24] It is also of interest to note that some observers have complained that Federal Reserve policy in recent years has led to more volatility in longer-term rates than in the fed funds rate.

will be a limited cycle, without inflation or deflation becoming entrenched.[25] Nonetheless, inflation and output cycles may be more pronounced than if the central bank took more aggressive action, in expectation of a sequence of shocks in the same direction.

The alternative approach, and one that is implicit in a lot of modelling, is to take account of the average degree of autocorrelation of shocks when setting interest rates.[26] Though this approach would be reasonable in a situation where the degree of autocorrelation was fairly stable, policy-makers might find it hard to take the strong action in response to a shock indicated by such an approach, because of the difficulty in explaining and justifying such an action on the basis of inherently uncertain forecasts.[27]

Near turning-points, when even the sign of the needed action may not be clear or may change from one policy meeting to the next, the challenge facing policy-makers may be even more difficult. I agree with Professor Goodhart that there is currently some effect on the credibility of policy-makers of changing views as to the appropriate direction of policy on the basis of data that arrived between meetings. But this may change as we live through a longer period of very low inflation or price stability. Indeed, success in maintaining good inflation outcomes will itself bring credibility, not only to the inflation target, but also to the operational mechanism used by the central bank to achieve this result.

As far as the asymmetry of policy is concerned, I would add a couple of points to those made by Professor Goodhart with regard to it being easier to lower rates than to raise rates. It is certainly correct that it is usually much easier to convince the public and most of the media of the appropriateness of a rate cut than of a rate increase. But financial markets sometimes respond in the opposite way, expressing concerns about overly easy policies and the need for more vigilance against inflation. Moreover, in countries in which the exchange rate plays an important role in the transmission mechanism, it can some-

[25] To the extent that the inflation target is credible, the central bank has some room for manoeuvre and can act somewhat later than otherwise without setting off a wage-price spiral. See Freedman (1996).

[26] Srour (1998) shows that this is an optimal response.

[27] Ironically, even if a central bank were entirely accurate in its forecasts and its judgements, and if it were able to precisely offset the potential effect of shocks by prompt and strong action, it would still be faced with the complaint that there was no reason for it to have adjusted its interest rate since, in the event, there were no signs of upward or downward pressure on inflation.

times be more difficult to lower interest rates than to raise them. In particular, if there is a lack of confidence in the currency, lowering or, in some cases, even leaving unchanged the benchmark short-term interest rate can lead to a counterproductive rise in medium and long-term interest rates.

In short, I agree with Professor Goodhart that concern about credibility may have been an important factor in the gradual nature of interest rate movements and the infrequency of reversals that we have seen in the past. But the inherent difficulty of forecasting future developments, and uncertainty about the appropriate model of the economy and about the transmission mechanism have also been important factors. However, I think that the growing credibility of inflation-targeting regimes and the increased attention being paid by financial markets to the need for central banks to get 'ahead of the curve' bode well for future monetary policy actions being closer to the optimal path, with more reversals in response to changes in view or new information than we have seen in the past. Indeed, we are already seeing some signs of such a change in approach in a number of countries. And if I am wrong, we can always look forward to future papers by Professor Goodhart explaining why such a change in approach did not happen.

References

Amano, R., Coletti, D., and Macklem, T. (1998). 'Monetary Rules when Economic Behaviour Changes', paper prepared for the Monetary Policy under Uncertainty Workshop, Wellington: Reserve Bank of New Zealand.

Ball, L. (1998), 'Policy Rules for Open Economies', *Research Discussion Paper 9806*, Sydney: Reserve Bank of Australia.

Bank for International Settlements (1998), (BIS), *Annual Report*, Basle, Switzerland.

Bean, C. (1998), 'The New UK Monetary Arrangements: A View from the Literature', paper presented to the Academic Panel of HM Treasury, Centre for Economic Performance, LSE, March.

Bertocchi, G. and Spagat, M. (1993), 'Learning, Experimentation and Monetary Policy', *Journal of Monetary Economics*, 32 (1): 169–81.

Black, R., Macklem, T., and Rose, D. (1998), 'On Policy Rules for Price Stability', *Price Stability, Inflation Targets and Monetary Policy.* Ottawa: Bank of Canada.

Brainard, W. C. (1967), 'Uncertainty and the Effectiveness of Policy', *American Economic Review*, 57(2): 411–25.

Caplin, A., and Leahy, J. (1996), 'Monetary Policy as Process of Search', *American Economic Review*, 86(4): 689–702.

Clarida, R. and Gertler, M. (1997), 'How the Bundesbank Conducts Monetary Policy', C. Romer and D. Romer (eds.), *Reducing Inflation*, (Chicago: University of Chicago Press).

Fischer, A. M. (1996), 'Central Bank Independence and Sacrifice Ratios', *Open Economies Review*, 7: 5–18.

Freedman, C. (1996), 'What Operating Procedures Should be Adopted to Maintain Price Stability?—Practical Issues', *Achieving Price Stability.* Kansas City: Federal Reserve Bank of Kansas City.

George, E. A. J. (1998), 'The Objectives and Current State of Monetary Policy', *Bank of England Quarterly Bulletin*, 38(4): 376–8, November.

Goodfriend, M. (1991). 'Interest Rates and the Conduct of Monetary Policy', Carnegie-Rochester Conference Series on Public Policy. 34: 7–30.

Goodhart, C. A. E. (1997). 'Why do the Monetary Authorities Smooth Interest Rates', Chapter 8 in *European Monetary Policy.* S. Collignon (ed.), (Pinter: London).

Haldane, A. G., Batini, N., and Whitley, J. (1997). 'A Forward-Looking and Probabilistic Approach to Monetary Policy', paper prepared for the NBER Conference on 'Monetary Policy Rules' in January 1998, Bank of England, December.

Haldane, A. G., and Batini, N. (1998), 'Forward-Looking Rules for Monetary Policy', *Working Paper 6543.* Cambridge, Massachusetts: NBER.

King, M. A. (1997). 'The Inflation Target Five Years On', *Bank of England Quarterly Bulletin*, 37(4): 434–42, November.

Lowe, P., and Ellis, L. (1997). 'The Smoothing of Official Interest Rates', *Monetary Policy and Inflation Targeting.* Sydney: Reserve Bank of Australia.

Murchison, S. and Siklos, P. (1998). 'Central Bank Reaction Functions in Inflation and Non-Inflation Targeting Economies: Are They Informative About the Conduct of Monetary Policy', *Working Paper*, Department of Economics, Wilfrid Laurier University, Waterloo, Ontario, August.

Nelson, E. (1998). 'Taylor Rule Estimates for the UK. 1972–1997', *Bank of England Draft Working Paper*, October.

Orphanides, A. (1998*a*), 'Monetary Policy Rules Based on Real-Time Data', *Finance and Economics Discussion Series*, 1998–03, Board of Governors of the Federal Reserve System.

Orphanides, A. (1998*b*), 'Monetary Policy Evaluation with Noisy Information', *Working Paper*, Board of Governors of the Federal Reserve System, October.

Peersman, G., and Smets, F. (1998), 'The Taylor Rule: A Useful Monetary Policy Guide for the ECB?', paper presented at the Conference on Monetary Policy of the ESCB: Strategic and Implementation Issues, Bocconi University, Milan, 6–7 July.

Rudebusch, G. D., and Svensson, L. E. O. (1998). 'Policy Rules for Inflation Targeting', *Working Paper 6512.* Cambridge, Massachusetts: NBER.

Sack, B. (1998*a*), 'Does the Fed Act Gradually? A VAR Analysis', *Finance and Economics Discussion Series* # 1998–17. Board of Governors of the Federal Reserve System, April.

Sack, B. (1998*b*), 'Uncertainty, Learning and Gradual Monetary Policy', *Finance* *and Economics Discussion Series*, Board of Governors of the Federal Reserve System, July.

Sargent, T. J. (1998), Discussion of 'Policy Rules for Open Economies' by Laurence Ball, papers presented at the NBER Conference on 'Monetary Policy Rules', Islamorada, Florida, January.

Srour, G. (1998), 'Inflation Targeting under Uncertainty', forthcoming *Working Paper*. Ottawa: Bank of Canada.

Stock, J. H. (1998), 'Monetary Policy in a Changing Economy: Indicators, Rules, and the Shift towards Intangible Output', paper presented at the Eighth International IMES, Bank of Japan Conference, Tokyo, June.

Svensson, Lars E. O. (1997*a*), 'Inflation Forecast Targeting: Implementation and Monitoring Inflation Targets', *European Economic Review* 41: 1,111–46.

Svensson, Lars E. O. (1997*b*), 'Inflation Targeting: Some Extensions', *NBER Working Paper No 5962.*

Svensson, Lars E. O. (1998*a*), 'Inflation Targeting as a Monetary Policy Rule', in preparation.

Svensson, L. E. O. (1998*b*), 'Open-Economy Inflation Targeting', *Working Paper 6545*. Cambridge, Massachusetts: NBER.

Svensson, Lars E. O. and Rudebusch, G. R. (1998), 'Policy Rules for Inflation Targeting', paper presented at the Conference on 'Central Bank Inflation Targeting', FRB San Francisco, March.

Taylor, J. B. (1998*a*), 'An Historical Analysis of Monetary Policy Rules', in Taylor (1998*b*), forthcoming.

Taylor, J. B. (1998*b*), 'Monetary Policy Rules', *Chicago University Press*, forthcoming.

Taylor, J. B. (1998*c*) (ed), 'The Robustness and Efficiency of Monetary Policy Rules as Guidelines for Interest Rate Setting by the European Central Bank', prepared for Sveriges Riksbank-IIES Conference on Monetary Policy Rules, Stockholm, June 12–13.

Taylor, J. B. (1998*d*), 'Information Technology and Monetary Policy', paper prepared for the Eighth International IMES/Bank of Japan Conference, Tokyo, June.

Thiessen, G. (1983), 'The Canadian Experience with Monetary Targeting', Meek, P. (ed.), *Central Bank Views on Monetary Targeting*. New York: Federal Reserve Bank of New York.

Wieland, V. (1998), 'Monetary Policy and Uncertainty about the Natural Unemployment Rate', *Finance and Economics Discussion Series*, pp. 1,998–2,022, Board of Governors of the Federal Reserve System.

Woodford, M. (1998), 'Optimal Monetary Policy Inertia', paper presented at the Money Macro Conference in London, and at the Monetary Policy Conference in Frankfurt; Department of Economics, Princeton University, September.

Wright, S. (1997), 'Monetary Policy, Nominal Interest Rates, and Long-Horizon Inflation Uncertainty', *Working Paper*, Cambridge University, November.