Economic models and policy-making

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In this article[1] John Whitley describes and evaluates the role of macroeconomic models at the Bank of England in the process of policy advice. He outlines how large macroeconometric models were used in the 1970s and 1980s; the reasons why they did not meet the needs of policy-makers; and how the need to incorporate uncertainty about the workings of the economy into policy-making has led to a more eclectic and judgmental approach to models at the Bank of England.

Introduction

This article explains how new smaller models, drawing on a wider spectrum of approaches, have been adopted to fill the vacuum as the role of large macroeconometric models in the policy debate has lessened. The aim of this process has been to make policy-makers more aware of the underlying economic analysis so that the numerical conclusions can be understood and used with confidence. In other words, policy-makers and the model (or modeller) need to share the same economic paradigm. Instead of using a single large model designed to answer all questions—but in reality thought by many to be unable to do so—current approaches use a range of smaller, more stylised, models. Smaller models make the underlying paradigm more transparent; using a range recognises the inherent uncertainty about the underlying economic structure and its sensitivity to structural change as well as to specific parameter values.

The article gives examples of how this more eclectic approach can focus on understanding the nature of shocks and their relevance for policy. It shows how structural vector-autogressions (VARs), theory-based optimising approaches and macroeconometric models are natural allies rather than competitors and how uncertainty can be incorporated into conditional forecasts in a Bayesian spirit. It concludes that this approach conforms more closely than previous approaches to how policy-makers think about the economy. Models, collectively, can then be seen as flexible friends.

The rise and fall of large macroeconometric models

The development of macroeconometric models in the United Kingdom has probably been unique in that the institutional environment has encouraged a prominent role in the policy debate for competing models in both public and quasi-public areas. This has largely been a result of the central role played by the Economic and Social Research Council (formerly the Social Science Research Council) in funding macroeconomic modelling by academic modelling groups. By the mid 1970s there were four large 'traditional' macroeconometric models financed principally out of public funds. Two were in the policy-making institutions themselves, the Bank of England and the Treasury. The remaining two were at the National Institute of Economic and Social Research (NIESR) and the London Business School.[2] Two further projects were financed at Cambridge. The Cambridge Growth Project developed a large multi-sectoral model of the UK economy, and the Cambridge Economic Policy Group emphasised the importance of the balance of payments and its relation to the public sector deficit in analysing the economy.

Each of the four large funded models contained between 500 and 1,000 relationships. Although the models were used as systems they were mainly estimated using single-equation methods. They also shared the same underlying economic paradigm—a fairly basic Keynesian income-expenditure framework with little or no role for supply-side factors. These models were used both for forecasting and policy simulation exercises, typically with short horizons of between eighteen months and two years. The long-run properties of the four main models and their consistency with theory were rarely questioned. But because of their fundamental similarities, they were perceived to have failed at around the same time, and confidence in their use for policy was reduced.

The first major failures came after the expansionary fiscal policy of 1972–73 and the first major oil shock in 1974. The inflationary mechanism in the models was based around a Phillips curve that was downward-sloping, even in the long run. Problems in finding a stable econometric relationship meant that wages were often treated as exogenous in forecasting and policy analysis. The exchange rate was treated in much the same way, because of the lack of data on a flexible exchange rate regime. Thus two principal components of the transmission mechanism of shocks to inflation were essentially ignored in analysis, and inflation was consistently underestimated in this period. Even if the models could explain how an increase in

(1) This article has benefited from many helpful comments from Paul Fisher.
(2) A more detailed history is given in Ball and Holly (1991).

demand might be associated with higher inflation, they could not explain 'stagflation' in 1974–75, when output fell and inflation rose.

By the early 1980s it became clear that policy-makers had little confidence in macroeconometric models in general. This can be attributed partly to the failure of forecasts (Barker, 1985), but also to the perceived theoretical shortcomings of the models (and particularly the absence of a key role for money). The models were generally regarded as fairly primitive demand-driven systems. In his memoirs (1992), Lawson recalls the forecasts made in the Treasury during 1980 and remarks that 'Treasury forecasters were predicting the worst economic downturn since the Great Slump of 1929–31. Yet they expected no fall in inflation at all. This was clearly absurd and underlined the inadequacies of the model' (page 50). He describes several instances where he substantially changed the in-house forecast despite 'a deep in-house commitment not merely to the Treasury forecast, but to the Treasury model as a central tool of analysis and policy advice' (page 49). Followers of the policy debate around this time could not have failed to notice that the underlying economic analysis more closely reflected the properties of the London Business School model, which had recently been converted to an 'international monetarist' approach and whose former director of forecasting had become government chief economic advisor, than those of the official Treasury model. Some of the characteristics of the new Liverpool model of the economy were also apparent in contemporary economic analysis.

The Liverpool model was one of two new smaller models that were developed in the early 1980s. The Liverpool 'new classical' model and the City University Business School (CUBS) model were radical alternatives to the existing models. They emphasised the role of expectations (Liverpool) and both money and supply-side factors (Liverpool and CUBS). Some of these innovations (but not the role of money) also found their way into the existing models (see Wallis and Whitley, 1987). But this did not remove the inherent distrust of the models, which was shared by many academic economists, for example, Lucas (1976), Sims (1980) and Kydland and Prescott (1977). Earlier expectations of what models might achieve had evidently been set too high, with unrealistic claims about their reliability and scope.

The main continuing problem was that policy-makers were faced with apparently conflicting results from different models. Holden (1989, page 862) commented that 'the basic question of whether policy simulations give insights into the real world or just demonstrate the properties of the models (and the beliefs of the model builders) remains to be answered'. Users of models were essentially asked to take results on trust, yet they were aware that different models generated apparently different policy conclusions, the causes of which were not clear. There were several possible reasons for this. First, policy questions addressed to the models tended to be relatively broad. The various ways in which the broad question was interpreted could lead to differences in the conclusions. Second, even where the interpretation was common, many of the models were not designed to answer these policy questions without supplementary assumptions. Differences in these further assumptions could also generate differences in the conclusions revealed by identical models. Third, the apparent precision of the conclusions took no account of uncertainty. Finally, there was no way to discriminate between the different conclusions. As policy-makers were unable to understand why different results emerged, their natural inclination was to distrust them all.

By the early 1980s it was no longer clear whether these different results emerged because the models were themselves fundamentally different, or because they were being used or adjusted in different ways. The work of the ESRC Macroeconomic Modelling Bureau, set up at Warwick University in 1983 and surveyed by Smith (1990), began to show that many of the differences were the result of simulation methodology, in particular the need to make supplementary assumptions about the policy experiment (for example, Turner, Wallis and Whitley, 1989a). The work of the Bureau also showed that many of the models were not fundamentally different and that comparative econometric testing could resolve many of the differences in whole-model simulations (Turner, Wallis and Whitley, 1989b).

Although the work of the Bureau helped to make the UK macroeconometric models more transparent, it may have confirmed what policy-makers felt all along—that model results were unhelpful in taking a view about the effects of policy changes. There were as many different views as there were models. Models were judged to be inadequate on the grounds of their econometric and forecasting performance, and this appeared to include the in-house models in the policy-making institutions. If these had contained a clear and strong theoretical base, policy-makers might have felt more reassured that the economic analysis implicit in them was useful, even if there was a great deal of uncertainty about the numerical magnitudes.

In turn, modellers probably gave the misleading impression that their approach could deliver precise measures. Although they were almost certainly aware of the limitations and uncertainties of forecasts based on econometric models, they may have been reluctant to expose doubts to policy-makers in case it gave ammunition to those opposed to the modelling approach. In contrast, some supporters of modelling as a tool for policy analysis and forecasting emphasised the similarity to using an engineering control system. This was illustrated by the optimal control approach, based on the principle that the economy could be controlled in a mechanical way by setting the appropriate trajectory of policy instruments for given targets for key macroeconomic variables. This view was given some limited support by the Committee on Policy Optimisation chaired by Ball (1978). All that was needed was for the policy-makers to define their welfare function, with the role

of the model being to define the empirical trade-off between different policy objectives. But the result was that more was learnt about the idiosyncrasies of the model than about the workings of the economy (as illustrated in Wallis *et al*, 1987).

Academic economists also tended to regard macroeconometric modelling as rather an unproductive process. Deaton (1981) commented that 'little in the way of scientific knowledge is to be gained from the construction of large-scale models over what can be learned by other means'. Modelling was seen as a second-rate activity done by people who were not good enough to get proper academic jobs. Maintaining models was also very expensive, and public funding was being reduced. Both official models were scaled down and some models, such as CUBS, disappeared, although one major new model emerged, COMPACT, constructed at the University of Strathclyde.

One UK model that clearly represented a coherent theoretical paradigm was the Liverpool model with its new classical origin. It could be argued that its clear message and underpinnings were more consistent than many of the other UK models. The appeal of the Liverpool approach to policy-makers was twofold. It emphasised the role of money and inflation expectations, and its smaller, more stylised approach made its predictions and analysis easier to understand. This comes close to the main theme of this article—that policy-makers require a framework that gives them a stable and consistent way of interpreting an economic system subject to many and varied shocks. Large macroeconometric models were perceived by their users to have failed to meet this need. The failure of forecasts was probably the most important symptom of this, subsequently documented in Wallis (1989). Forecast failure could also be associated with the Liverpool model. But the models were also thought to give an inadequate representation of the impact of exogenous shocks, including policy changes.

Modelling and forecasting cannot claim to have led to many major insights or produced original research or findings, but they generated the issues and problems that encouraged developments in econometric techniques. For example, the stimulus to work on consumption by Davidson *et al* (1978), which led to the development of error correction models, came from the breakdown of empirical models of consumption behaviour. More recently, others have argued (Hall, 1995) that macroeconomic modelling has developed empirical applications of different expectations mechanisms.

The suggestion that large macroeconometric models have somehow lost their way might suggest a wholesale rejection of the model-based approach to forecasting and analysis of the economy. The risk then is that policy becomes wholly dependent on the implicit model(s) in the minds of policy-makers. These implicit models are less transparent; less likely to be consistent over time; less able to be judged against empirical criteria; and more likely to be internally inconsistent. Downgrading the role of formal models in the policy process may leave a vacuum that might be filled by an entirely subjective approach. That the formal approach has not been completely abandoned may in part be the absence of satisfactory alternatives. But it may also be a consequence of adaptations to the forecasting process and the way in which models are used, as well as improvements in the models themselves. These adaptations have been designed specifically to improve policy-makers' confidence in models. This can be achieved by satisfying the following conditions:

(i) Models can be explained in a way that is consistent with accepted economic analysis.

(ii) The model-based results are also consistent with relevant historical episodes.

(iii) Results are consistent over time; the policy-maker is likely to be impatient with results that differ because the economic model has been changed in some respect (for example, new estimates of parameters) without convincing reasons.

(iv) The judgmental part of the process is made explicit.

If these conditions are not met, econometric models may continue to have a low priority in many areas of economic policy-making. The second section of this paper describes how approaches to modelling are being developed at the Bank that still retain the role attributed to them by Higgins in his comments on the volume edited by Bryant *et al* (1988, page 294), namely that 'a formal and quantified framework is an irreplaceable adjunct to the process of policy thought'.

Filling the vacuum—new approaches

This section sets out how models can be more successfully integrated into the policy process. In particular, it outlines the approach that has developed at the Bank since 1993. Part of the new approach relates to the models themselves and how they are used, but the more important part relates to integration of senior policy-making officials into the judgmental process that invariably accompanies the use of formal models. The new approach has three main aspects: the use of several models; the treatment of uncertainty; and the co-ordination of the process in official institutions. At the Bank the process has been given additional focus by the adoption of new monetary arrangements since 1992, under which the Bank advises on monetary policy with reference to an externally determined inflation target, set two years out. Since monetary policy takes time to act on output and inflation, a forward-looking assessment is essential. The inflation target makes this assessment explicit. In the interests of transparency, the Bank publishes its analysis in its quarterly *Inflation Report*, including a projected path of future inflation. Before this the Bank did not publish its forecasts: they were supplied only to the Treasury (Treasury and Civil Service Committee, 1991).

The multi-model approach

The new approach to the use of models in the policy process recognises that all models are, at best, only a rough approximation to the workings of a modern economy, despite attempts to make them more theory-consistent and the use of more sophisticated econometric techniques. Matching the level of rigour of pure theory models would be extremely difficult. Empirical data are unlikely to be sufficiently informative to capture the range of shocks likely to be experienced and the closeness of fit of models is often not sufficient to pick up small changes (Fisher and Wallis, 1990). Essentially, models represent averages of past behaviour. Usually they are affected by changes in the policy regime, which is a major disadvantage for policy-makers. In principle, 'structural' parameters might be derived by explicitly allowing for changes in expectations and these could adjust when the policy regime changed. But expectations are not usually observed and can only be included in models by making restrictive assumptions about how the information set is formed and how it is updated. The use of rational, or model-consistent, expectations has a certain logical appeal but imposes informational assumptions that are often regarded as implausible. Modifications of this approach, such as rational learning, are still being developed and are not yet a standard part of the model builders' armoury, although they have been used regularly at the London Business School. Even if the expectations problem is avoided, parsimony of the model equations usually implies that most exogenous shocks are subsumed in the error terms of the estimated equations. Moreover, the effects of these exogenous shocks on different aspects of economic behaviour are usually assumed to be uncorrelated.

It would be unrealistic to expect a macroeconometric model to identify all the various shocks that can hit the economy and to condition estimates on them. In practice this means that only those shocks which can be quantified are included, and then only when they have been observed in the past. As a result, most models have very few explicit exogenous influences, and thus risk failing to satisfy standard identification criteria. If the macroeconometric model provides the model framework and gives a response to an average shock, then other approaches need to identify what types of economic shock are likely to occur (or have occurred) and to predict how these will affect economic behaviour in a different way from the average shock. This is the essence of the multi-model approach, which complements macroeconometric models with other types of model. For example, the structural VAR approach of Blanchard and Quah (1989) is much better designed to identify different economic shocks and has been used at the Bank by Astley and Garratt (1996) to decompose and identify sources of shocks to the nominal and real exchange rate. Analytical models can then be used to illustrate the qualitative responses expected. These analytical models can be based on micro-optimising approaches or stylised macro models. A second example is the Dornbusch-Buiter-Miller (DBM) model that has been used at the Bank to illustrate the consequences of monetary or real shocks (see *Inflation Report*, May 1995). This additional model analysis can then be used to ensure that the empirical macro model gives a result consistent with accepted theory.

A forthcoming paper by Fisher and Whitley (1997) will describe the suite of models that the Bank currently uses. These use different modelling methods, each of which has advantages and disadvantages. In combination, the different models allow a range of economic analysis to be performed that would be impossible (or at least highly flawed) for any single approach. The models cover the spectrum from almost entirely theoretical to almost purely statistical. They are briefly described below. There is a range of models in each category.

(a) Small analytical model project (SAM)

These models all derive theoretically from optimising behaviour of economic agents. Models currently in use at the Bank include a real business cycle model and a set of labour market models. Each is solved under the parameterised expectations method of den Haan and Marcet (1990) for a given choice of parameters. They are useful for predicting the economic consequences of shifts in deep structural parameters such as risk aversion, preference shocks etc. Their empirical support is gauged by their ability to explain the stylised facts of the UK economy (variances and correlations of economic variables).

(b) Stylised macro model

These models have been developed to reflect the aggregate macro approach to modelling in contrast with the micro-based optimising SAM models. One basic model is a Dornbusch overshooting approach, which is probably the best-known macro 'text book' model. In this context it is a simple five-equation model determining real output, money, prices, exchange rates and the interest rate. It was used to analyse the inflationary consequences of the exchange rate depreciation of early 1995. It can be solved as a static model with calibrated parameters or in a dynamic version with econometrically estimated coefficients. This approach has been applied to the issue of whether the monetary transmission mechanism differs in the United Kingdom from that of Germany and France, by estimating equivalent models for these other two economies (Britton and Whitley, 1997).

(c) Macroeconometric forecasting model

This model is in the mainstream of macroeconometric modelling and is constructed specifically to help project inflation up to a medium-term horizon. There is no fixed model; it is subject to regular revision and updating but most of these revisions occur as a result of the analysis agreed during the forecast round with the policy-makers. It is much smaller than other contemporary macroeconometric models of the United Kingdom (such as the models of the Treasury, the NIESR, the London Business School and the COMPACT model). It has fewer than 20 core equations and can be seen as an extension of the Dornbusch overshooting model described above. It is based on quarterly data and

forms the framework for the inflation projection made for the Bank's *Inflation Report*. The much larger model used by the Bank up to 1993 explained the output side of the economy in considerable detail, with less emphasis on price determination. The present model attempts to redress the balance, with relatively more emphasis on price determination and less on the income accounts. Money plays an important role. The model attempts to incorporate the key elements in the transmission of monetary policy to inflation. As noted above it is not used mechanically, but the forecast takes into account information and analysis from the other economic and statistical models as well as other statistical and survey-based information (such as reports from the Bank's regional Agents).

(d) Simple output gap models

These are simple two-equation models which relate inflation to measures of the output gap. They can be interpreted as a reduced-form representation of the macroeconometric model, allowing focus on the importance of the size of the output gap and the role of expectations/policy credibility in the inflation process. Point estimates of the output gap can act as a consistency check on the Bank's inflation projection.

(e) VAR models of inflation

At the other end of the spectrum from the purely theoretical SAM models there is the 'theory-free' VAR approach, which relates inflation to key indicators such as retail sales and narrow money. Monthly and quarterly Bayesian VAR models have been developed, following previous work by Henry and Pesaran (1993). Structural VAR models with some limited theory content are also used (Astley and Garratt, 1996).

The small macroeconometric models play a particular role: they provide a benchmark for average responses to average shocks and they are the vehicle for mapping the analysis from other models onto the inflation projection. They are deliberately small and highly aggregate. This allows modellers and model users to focus on key issues rather than become distracted by excessive detail, which can if necessary be handled quite easily in sub-models. The results of more disaggregated analysis can then be used only when relevant to the macro picture. The aim is not to forecast every detailed aspect of the economy but to help clarify and focus on the developments most relevant to the determination of inflation. Disaggregation does not always help, since there is often at least one very poorly fitting component of any disaggregated model. This is often the case, for example, when more attention is placed on explaining the manufacturing sector, where data is more accessible, than on the quantitatively more important service sector.

A small macroeconometric model, like any other formal model, evaluates the effects of shocks to included exogenous influences, such as aggregate government expenditure or the income tax rate. But as Turner *et al* (1989a) show, even these forecast or simulation properties may be misleading when the shock relates to a particular component of the exogenous variable that might then affect the economy in a distinctive way. The Bank's small forecasting model was specifically designed to evaluate the consequences of interest rate changes on output and inflation. This does not mean, however, that there is a unique ready-reckoner for the impact of a change in official interest rates on the inflation projection. For example, the reduced-form impact depends on whether the change in official rates has already been incorporated in market expectations.

The multi-model approach also allows different models to be used for forecasting and policy analysis. In the past these have often been treated as a joint purpose. This reflects the view that models should not be used seriously for policy when they cannot be shown to explain past economic history. But models designed for forecasting may not be designed for policy analysis. Particular policy instruments may not be specified, channels of transmission may be absent or poorly defined, or there may be inadequate allowance for policy to respond to prevent unstable outcomes (for example to maintain fiscal sustainability)—the model closure problem.

Two examples may help to show how the multi-model approach can be used. First, consider the hypothesis that job insecurity has increased in recent years in the United Kingdom. Most macroeconometric models would have nothing to say about this, because they have no variable akin to job security, but micro-based optimising models (such as search models) can be used to assess the implications of a change in the level both of general risk aversion and of idiosyncratic risk. If the implications appear consistent with historical data, they can be used to modify the relevant behavioural equation in the macroeconometric model (in this example consumption and labour supply behaviour).

A second example is an analysis of sources of an exchange rate appreciation (or depreciation). The exchange rate is endogenous to the macroeconomic system, and so it is inappropriate to evaluate the effects of an appreciation by simply changing the level of the exchange rate as if it were an exogenous influence, and then looking at the consequences for other endogenous variables. The impact of a shock to the exchange rate on output and inflation depends on its source. A shift in the exchange rate will only be truly exogenous if it is completely unrelated to the domestic economy, and even in that case its cause may have other effects on the domestic economy (eg on import prices measured in foreign currency). At the other extreme the exchange rate change may merely reflect a shock that primarily affects other endogenous variables in the system. Other approaches are needed to identify the nature of the shock. Structural VAR models may help to assess the relative probabilities of nominal or real shocks. Inspection of yield curves may help to identify whether the shock reflects a change in expected domestic or foreign monetary or fiscal policy. Use of stylised macro models (such as the DBM model) may also help in understanding the exchange

rate and other macro consequences of various shocks, and in comparing these with recent data.

The main requirement of the multi-model approach is that there is some basic consistency in economic paradigm across the various models. It would usually be inconsistent to use, for example, an analytical model based on market-clearing behaviour of the labour market in combination with a macroeconomic model that assumes that the labour market does not clear, so that there is involuntary unemployment. But sometimes the implications of these different assumptions may be at the heart of the matter. If, for example, we wanted to allow that labour markets have become more nearly market-clearing, the analytical model could be used to inform the macro model of the consequences of this change.

The multi-model approach is not as radical in practice as it may seem. It is common to use other information in forecast and simulation analysis, but perhaps not systematically and transparently. The emphasis of the Bank's approach is the use of models as a framework for analysis and for thinking about the economy. Using several models is by no means an attempt to obscure policy-makers' views of the economy. The policy-makers' response would be that their view of the economy has never been simple enough to be captured in even a large model. Nor were policy-makers ever signed up to the idea that they should adjust policy instruments mechanically to changes in key economic variables. What is important is that the overall economic analysis and judgment are as transparent as they can be. This is the aim of the Bank's *Inflation Report*. It is important to recognise that the publication and availability of models are not a substitute for the analysis itself. They are merely a necessary input. The Bank's small macroeconomic forecasting models are used to provide an overall framework within which this analysis is integrated in a consistent way. The multi-model approach implies that it is not possible to 're-run' history using the policy-makers' 'model' of the economy to test whether the policy decision could have been improved, relative to some welfare criteria. This is because there is no comprehensive model that is adequate for all situations. The Bank's view would be that it should be judged by the quality of its policy advice and the analysis that underlies it, not on particular features of a model which is a tool of analysis. One does not judge an artist by the quality of his brushes or paint but by the way in which he skilfully combines them.

For the Bank there is an additional reason why simulations or forecasts using the macroeconometric models may pose problems. Under the present monetary policy arrangements, the Bank gives advice based on what might happen if official short-term rates were to remain at the current level. As such, projections are based explicitly on constant nominal interest rates. This gives rise to two main issues: internal consistency and forecast validation.

It is important to maintain internal consistency between the exchange rate and interest rate projections. The yield curves prevailing in the market at any moment imply future paths for short-term interest rates and exchange rates in each country. The relationship between interest rates and future exchange rates is determined by uncovered interest parity. Normally the market yield curve will imply that the market expects some future change in UK short-term interest rates. However, the assumption made in the Bank forecasts is that UK short-term interest rates remain unchanged for the next two years, but that interest rates in other countries evolve as implied by current yield curves. On this basis, market expectations implicit in the current yield curve are unlikely to be fulfilled. To avoid inconsistency, markets are therefore assumed to be surprised by the fact that official UK rates in the projection differ from the market expectation. The assumption of constant nominal short-term interest rates in the United Kingdom cannot be sustained in the longer term, because it leads ultimately to accelerating inflation or deflation. This nominal indeterminacy can be prevented by use of a simple reaction function for official short-term rates beyond the forecast horizon.

The issue of forecast validation is more difficult. Since the Bank's inflation predictions are based on the assumption of constant interest rates, its forecasts cannot be directly compared with other forecasts or with actual outturns. This issue is discussed below.

The second key element in making models more relevant to policy-makers is to incorporate uncertainty in a helpful way. The following section describes how this has been tackled at the Bank.

Forecast uncertainty

A difficulty in presenting policy-makers with model-based forecasts is that these are typically point estimates, which nearly always prove wrong. But policy-makers are interested in the risks on either side, or in the distribution of possible outcomes. In the past, stochastic simulations with models have been used to estimate an error band around forecasts, but these are usually so large (reflecting the least well-fitting of the model equations) that they are unhelpful to the policy-maker. Wallis *et al* (1984) found standard error bands of around 1% of GDP over a one-year horizon for some of the main UK models, and Ireland and Westaway (1990) found that this could increase to more than 4% over three years for the NIESR model. More recently Blake (1996), also for the NIESR model, has found standard errors by stochastic simulation of 0.8 percentage points for inflation after one year, increasing to 1 percentage point after two years. Corresponding GDP growth errors are 1.3 percentage points and 1.5 percentage points.

Another approach is to conduct scenario analysis to indicate possible outcomes under a variety of assumptions about either exogenous influences or economic behaviour. But these may not be very helpful if they cover a wide range of possibilities without giving any indication of the relative probabilities of each scenario, or if the scenarios do not

relate to a binary choice (for example, the election of alternative political parties, each with distinct policy proposals).

The approach that has been developed at the Bank has a different emphasis. It distinguishes between general uncertainty and specific risks. General uncertainty is the uncertainty captured in the stochastic error variables in the model equations. Estimates of this are based on the previous forecast record, not on stochastic simulations with econometric models. These past errors have reflected the interaction of the model and forecaster's judgment and since judgmental intervention often reduces forecast error (Wallis and Whitley, 1991) this produces a smaller error band around forecasts than full stochastic simulation. Use of the forecast values rather than pure-model forecasts is consistent with a procedure in which the projections are not based solely on the forecasting model itself. We have described above how several models may be used to inform the forecast. It follows that there is no exact statistical representation of the underlying model which can be used. Use of forecast errors as a guide to uncertainty is not in itself new. The Treasury has regularly published mean errors alongside its forecasts and the NIESR also uses past forecast errors as a measure of uncertainty (Poulizac *et al*, 1996).

Ex post analysis of forecast performance should allow for the fact that the *ex ante* forecasts are conditional on unchanged nominal interest rates. If the projections formed in this way had led to a change in interest rates then the observed outturn would not necessarily be a good guide to the accuracy of the forecasts. Analysis of past forecasts can and should allow for this, preferably by recomputing the projection with endogenous interest rates. Current practice is to recalculate historical forecast errors as if nominal interest rates had been constant. This puts them on the same conditional footing as the projection itself.

Specific risk is the risk that structural change may be occurring, in other words the parameters of the model may be changing, or that there is uncertainty attached to the impact of particular shocks. For example, available evidence may be inconclusive as to whether there has been a structural change in real wage behaviour. Even if we are unable to reject the null hypothesis of no change, we may wish to allow for the possibility that real wages will be lower than indicated by the relevant estimated (behavioural) relationship. In this example we would say that the risks for inflation are skewed downward. Another recent example is the effect on consumers' expenditure of windfall gains to households as a result of the conversion of mutual institutions such as building societies to publicly quoted companies. In evaluating the likely impact of these conversions, there is little previous documented experience to act as a guide. In these circumstances the central forecast has to be based to a large extent on *a priori* reasoning. Such reasoning suggests that only a small proportion of the windfall gain will be spent in the short term. The risks to the central forecast in this case are skewed upward.

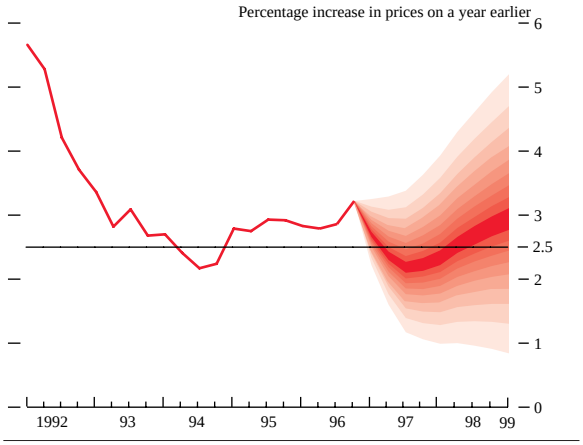
In principle, the overall risk around a forecast may be asymmetric. All that is required is that the underlying model is capable of a behavioural interpretation and that shocks are broadly independent (although some shocks might be expected to be correlated across different aspects of behaviour). Part of the appeal of the approach (which is Bayesian in spirit) is that it corresponds to the way in which policy-makers can contribute to forecast judgment. They can be presented with central assumptions (which in most cases will be based on the relevant behavioural equation in the macroeconometric model) together with evidence on why average historical experience may not be repeated (either because of structural change, new shocks, or differences in the marginal impact of a shock). There is nothing new in amending model equations to involve judgment; what is new is to make the judgmental decisions in agreement with policy-makers. The general approach is detailed further in Britton, Cunningham and Whitley (1997).

The macroeconometric models act as a benchmark for behaviour. The process works by considering risks around each of the main behavioural assumptions and projections of exogenous variables in a macroeconometric model. The overall risks to the inflation projection are a composite of the risks to the individual component projections. These can be summarised as net demand or supply risks if the behavioural equations of the model can be given a demand or supply interpretation. Ready-reckoners can then be used to estimate the impact of any shock to either demand or supply on inflation, using the properties of the model. But we have to accept that the resulting estimates are approximate.

It is possible, over all the factors in the model, that risks may turn out to be symmetrical either side of the central forecast. It is more likely that there are net risks either upward or downward for the Bank's inflation projection. But the central projection is seen as the mode, or single most likely outcome. This reflects the importance of having a central economic story behind the forecast, rather than attempting to minimise some statistical measure of bias. If the distribution is heavily skewed the expected (mean) outcome may be quite distant from the single most likely outcome.

The chart shows how this forecast uncertainty is presented in the *Inflation Report*. Since February 1996, we have published our inflation projection as a fan chart. This chart, which is taken from the February 1997 *Inflation Report*, shows our view of the relative likelihood of possible outcomes for inflation. That view is a combination of both our expectation of the most likely outcome for RPIX inflation and an assessment of the risks surrounding that central projection. The central band, shaded darkest, includes the central projection: we think that there is about a 10% chance that inflation will fall within the range described by that band at any date. The next deepest shade, on both sides of the central band, shows the 20% range; and so on, in steps of ten percentage points. Of course, it is

RPIX inflation central projection: February 1997



impossible to assess the probabilities with any precision, but this represents the Bank's best estimate.

The position of the mean relative to the mode depends on the degree of asymmetry of the risks. This approach uses the variance implicit in past forecasting performance and although it has a subjective element, it is conducted as part of a formal process and makes transparent how the policy-maker views the uncertainty and risks around economic forecasts.

Involvement of officials in the forecast process

A third key requirement for forecasts to be taken seriously in the policy process is that senior officials are part of the forecast process. Only in this way can they be persuaded to use the forecasts fully in policy advice and formulation. A collegiate approach is used at the Bank, as described by the Governor in his Loughborough speech in November 1996 (reported in the Bank's *Quarterly Bulletin*, February 1997):

'I am sometimes asked whose forecast exactly is it? Is it the analysts', or their managers' or the Directors', or the Governor's? The answer is that it is the Bank's with inputs at all those levels as well as points in between. In fact, we have a sequence of meetings at which we assess the 'news' since the last forecast (that's to say those developments that are not as we had expected), then we discuss the behavioural assumptions in the light of past relationships and the news in the current data, and we discuss the nature of the risks, then we review how the results are reflected in an initial forecast, in the light of which we may re-examine some of the assumptions of our assessment of the risks until we are all reasonably comfortable with the result. *It is important, given the crucial role it plays in the process, that the forecast should be something that all those involved in its preparation should feel that they own*.' (Page 101, italics added.)

In contrast, the forecasts produced in the Treasury are clearly the responsibility of the Chancellor. 'The forecasts are the Government's forecasts. . . it is for ministers to decide how far to accept officials' advice. This has been the case for many years' (Treasury and Civil Service Committee, 1991, page 6). This leaves it to the Chancellor to take or reject the forecast produced by the officials.

At the Bank there are regular meetings during the preparation of the *Inflation Report* forecast. The first meeting concentrates on the key issues that have arisen since the previous forecast. Central assumptions and risks are discussed but no numbers are presented at this stage. Emphasis is placed on the continuity of analysis and the relevance of new evidence and data. The next meeting sets out the central projection of inflation under the agreed central assumptions and the implied probability distribution derived from the agreed assessment of risks. The consistency of the analysis is discussed and this may lead to further changes in the projection or view of risks. Final projections are agreed at subsequent meetings. A key feature of the discussions is that the projections are formed from an agreement about the overall analysis of the economy rather than from committee decisions on each particular component of the forecast. The forecasters then translate the analysis into a quantitative framework.

The introduction of the new monetary arrangements in the United Kingdom since 1992 has provided a specific focus for the projection work and the way in which it is determined. In particular the process concentrates on issues that are relevant to the inflation outlook. This means that discussion and resources are not diverted to forecasting low priority variables. But the process that has been adopted for forecasting and analysis is flexible and could be adapted for other policy objectives or different monetary arrangements, subject to some of the key considerations outlined below.

For the approach to work effectively the Governor and Directors have to be prepared to spend time discussing economic analysis with the forecasters. For their part, the forecasters have to be able to identify the key issues clearly so as to facilitate a constructive discussion. One advantage is that over time both will tend to share the same analytical framework. Moreover, policy-makers become more familiar with the underlying models than they would from an abstract presentation of a single model and its properties. The risk approach stresses the ability to present the forecast as a central economic story and to distinguish separately the risks around the central case. This has more intuitive appeal than approaches that present a forecast as an amalgam of the central case and the net effect of risks. It also makes the risk assessment more transparent and enables senior officials to contribute to the necessary judgments.

A priori reasoning plays an important part in the process. For example, a new shock would require analysis of its expected effects on the behaviour of the economy, perhaps using stylised macro models or analytical micro-based models. The likely effects of the shock on key endogenous variables are then agreed in advance, at least in qualitative terms, including whether they are temporary or persistent.

Macroeconometric models can be used to quantify likely effects. The flow is from analysis to numerical estimates rather than the reverse.

The consistency of the forecast over time is an important consideration. The modeller/forecaster has to be able to explain *ex ante* to the policy-maker how new information might change the projections. This might consist of new data, analysis or empirical research. In the absence of new information the policy-maker would expect the forecast to remain unchanged.

Summary and conclusions

This article sets out the reasons why the role of large macroeconometric models in the formulation of economic policy in the United Kingdom has been reduced. It is argued that much of the distrust of models has resulted from attempts to use macroeconometric models in an unrealistically comprehensive way. A more eclectic approach has been adopted at the Bank. Its main features are the use of a range of models to help address the many issues that arise; a framework for assessing forecast uncertainty; and the focus on one task (in this case a two year ahead inflation target). This new approach has been encouraged by a change in the monetary policy arrangements but also by the willingness to make changes in the way that projections are formed and discussed. The general spirit of the approach makes it amenable to alternative policy objectives or changes in the nature of the monetary arrangements. Knowing exactly why projections are required and how they are used also focuses attention more effectively. Opening models up to policy-makers and revealing where judgment is needed may be more likely to encourage than discourage the use of models.

References

Astley, M and Garratt, A (1996), 'Interpreting sterling exchange rate movements', *Bank of England Quarterly Bulletin*, November, pages 394–404.

Ball, R J (1978), *Committee on Policy Optimisation Report*, Cmnd.7148, London: HMSO.

Ball, J and Holly, S (1991), 'Macroeconometric Model-building in the United Kingdom', in (eds R G Bodkin, L R Klein and K Marwah), *A History of Macroeconometric Model-Building*, pages 195–230, Aldershot: Edward Elgar.

Barker, T, (1985), 'Forecasting the Economic Recession in the UK 1979–1982: a Comparison of Model-based *ex ante* Forecasts', *Journal of Forecasting 4*, pages 133-51.

Blake, A (1996), 'Forecast error bounds by stochastic simulation', *National Institute Economic Review 156*, May, pages 72–8.

Blanchard, O and Quah, D (1989), 'The Dynamic Effect of Aggregate Demand and Supply Disturbances', *American Economic Review 79*, pages 655–73.

Britton, E, Cunningham, A W and Whitley, J D (1997), 'Asymmetry, Risks and the Probability Distribution of Inflation' Bank of England, *mimeo*.

Britton, E and Whitley, J D (1997), 'Comparing the monetary transmission mechanism in France, Germany and the United Kingdom: some issues and results', *Bank of England Quarterly Bulletin*, May, pages 152–62.

Bryant, R C, Henderson, D W, Holtham, G, Hooper, P, and Symansky, S (1988), (editors) *Empirical Macroeconomics for Interdependent Economies*, Washington D C: Brookings Institution.

den Haan, W J and Marcet, A (1990), 'Solving the stochastic growth model by parameterising expectations', *Journal of Business and Economic Statistics 8*, pages 31–34.

Davidson, J E H, Hendry, D F, Srba, F, and Yeo, S (1978), 'Econometric modelling of the aggregate time-series relationship between consumers' expenditure and income in the United Kingdom', *Economic Journal 88*, pages 661–92.

Deaton, A, (1981), 'On the usefulness of macroeconomic models', paper prepared for the *Bank of England Panel of Academic Consultants*, Bank of England.

Fisher, P G and Wallis, K F (1990), 'The historical tracking performance of UK macroeconomic models, 1979–85', *Economic Modelling 20*, pages 179–97.

Fisher, P G and Whitley, J D (1997), 'The Bank of England's Suite of Models', Bank of England, *mimeo*.

Hall, S G (1995), 'Macroeconomics and a bit more reality', *Economic Journal 105*, pages 974–88.

Henry, S G B, and Pesaran, B (1993), 'VAR models of inflation', *Bank of England Quarterly Bulletin*, May, pages 231–39.

Holden, K (1989), 'Review of Britton', *Economic Journal 99*, pages 861–63.

Ireland, J and Westaway, P F (1990), 'Stochastic models and forecast uncertainty in a forward looking model, *National Institute Discussion Paper No 183*.

Kydland, F and Prescott, E C (1977), 'Rules rather than discretion: the inconsistency of optimal plans', J*ournal of Political Economy 85*, pages 473–91.

Lawson, N (1992), *The View from No.11*, London: Bantam Press.

Lucas, R E (1976), 'Econometric policy evaluation: a critique', in Brunner, K and Meltzer, A H (editors), 'The Phillips curve and Labour Markets', supplement to the *Journal of Monetary Economics*.

Poulizac, D, Weale, M and Young, G (1996), 'The Performance of National Institute Economic Forecasts', *National Institute Economic Review 156*, May, pages 55–62.

Sims, C A (1980), 'Macroeconomics and reality', *Econometrica, 48*, pages 1–48.

Smith, R P (1990), 'The Warwick ESRC Macroeconomic Modelling Bureau: An Assessment', *International Journal of Forecasting 6*, pages 301–9.

Treasury and Civil Service Committee (1991), *Memoranda on Official Economic Forecasting, Session 1990–1*. 532:I, HMSO: London.

Turner, D S, Wallis, K F and Whitley, J D (1989a), 'Using Macroeconometric Models to Evaluate Policy Proposals' in Britton, A (ed.) *Policymaking with Macroeconomic Models*, pages 103–50, Aldershot: Gower.

Turner, D S, Wallis, K F and Whitley, J D (1989b), 'Differences in the properties of large-scale macroeconometric models: the role of labour market specifications', *Journal of Applied Econometrics, 4*, pages 317–44.

Wallis, K F (1989), 'Macroeconomic forecasting: a study', *Economic Journal, 99*, pages 28–61.

Wallis, K F, Andrews, M J, Bell, D N F, Fisher, P G and Whitley, J D (1984), *Models of the UK Economy: A Review by the ESRC Macroeconomic Modelling Bureau, Oxford*, Oxford University Press.

Wallis, K F, Fisher, P G, Longbottom, A J, Turner, D S, and Whitley, J D (1987), *Models of the UK Economy: A Fourth Review by the ESRC Macroeconomic Modelling Bureau, Oxford*, Oxford University Press.

Wallis, K F and Whitley, J D (1987), 'Macro Models and Macro Policy in the 1980s', *Oxford Review of Economic Policy 7*, No 3, pages 118–22.

Wallis, K F and Whitley, J D (1991), 'Sources of Error in Forecasts and Expectations: UK Economic Models 1984–88', *Journal of Forecasting 10*, pages 231–53.