Monetary Policy by Signal

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The way in which monetary policy is understood, both in practice and in the theoretical literature, has evolved in significant ways over the last few decades. Most significant, arguably, is an increasing awareness of the importance of the presentation of monetary policy. Central bankers have long been aware of the importance of the signalling effect of interest rate decisions on the one hand (Dow and Saville, 1988), and the care with which official pronouncements should be worded on the other. But it is only recently that there has been public discussion by central banks of the means by which monetary policy decisions are reached (e.g. Bank of England, 1999). At the same time, the theoretical literature has increased its focus on information, and information asymmetries between the monetary authorities and markets, as a critical element determining the outcome of monetary policy decisions. In particular there has been an increased focus on the transparency of monetary policy decision-making (see Geraats, 2002, for a review). But analysis of signals in relation to uncertainty qualifies the case for transparency. The purpose of this paper is to reflect on the signalling aspect of monetary policy in terms of an analysis of uncertainty. In particular, we consider how the central bank signals its own uncertainty.

The concept of uncertainty itself is problematic, being subject to a range of different understandings. It is not our purpose here to make the case for any particular meaning(s), being concerned primarily with identifying what is being signalled. Where agents are uncertain, then the signals provided by the monetary authorities take on a critical role; any actual repo rate change is known with certainty, but its effects in general are not. We distinguish uncertainty in the economic system in a global sense, from model uncertainty on the one hand, and signal uncertainty on the other. Given that in the particular institutional framework of UK monetary policy-making a suite of models is consulted

rather than a single most trusted model, model uncertainty, in a sense to be further specified, is a matter of fact of actual policy decisions. Likewise, given that the signals emanating from the decision-making process of monetary policy are both quantitative and discursive, signal uncertainty finds expression both in quantitative and non-quantitative ways. We are interested here in how model and signal uncertainty are related, and how to analyse non-quantitative signal uncertainty.

We start by tracing thought about the role of information in relation to monetary policy, and then consider specifically the uncertainty attached to the information content of monetary policy signals. Different conceptions of model uncertainty are then explored. To the extent that monetary policy is not based on forecasts derived from a single stochastic model, the authorities are experiencing a form of model uncertainty that extends beyond the parametric uncertainty usually considered in the model uncertainty literature. In such a context, signalling assumes added importance since, in addition to offering a mechanism for transparency, it adds a further dimension of information with respect to analysis and decision-making under uncertainty. The possibility is discussed of incommensurate models, not only as an input to decision-making, but also as an input to the public's understanding of monetary policy. Such incommensurability is resolved, by policy-maker and public alike, by the exercise of judgement, which we discuss in the fourth section. The foregoing analysis provides the basis for a discussion of how the central bank actually signals its uncertainty. In particular we discuss the scope for measurement of uncertainty by means of quantitative indicators and by means of discourse analysis. We then suggest an application of our approach to the monetary policy process of the Bank of England.

1. The role of information in monetary policy

Monetary policy operates in conditions of uncertainty, both in terms of a potential asymmetry between the knowledge of the monetary authority and market participants, and the uncertainty with which that knowledge is held. There is further an interdependence between the monetary authorities' knowledge, and uncertainty, and those of the market, since each enter into the expectations of the other. We will proceed on the assumption that it is sufficient to consider two types of economic agent: those who take the relevant decision on behalf of the monetary authority of an economy, and those who populate the markets of that economy, whom we will refer to as the 'economic public'.

Both types of agent will base their decisions on an understanding of the causal mechanisms at work in the economy, and the likely effects of monetary policy action. Formal economic models provide a mechanism for articulating these causal mechanisms, and are explicitly used by the monetary authorities and key market players. These models, and the data inputs, play a key role in conveying signals about the thinking of each type of agent. There is scope for asymmetry, in terms of differences in model employed, different data inputs, and different levels of awareness of each others' models. Issues of information asymmetry and transparency have been central to much of the development of the theory of monetary policy over the past three decades. We discuss these developments to consider how they have been qualified in the course of the growing focus on issues of uncertainty. We argue that this has involved a changing sense of the role of formal models relative to more discursive understandings of causal mechanisms.

Rational Expectations Hypothesis (REH)

The advent of rational expectations in economic modelling brought a new role for monetary policy. Based on the insight of Lucas (1972) that the general public cannot be systematically fooled by the policymakers, REH economists found that business cycles and movements in unemployment are compatible with dynamic stochastic general equilibrium models where agents' decisions are the result of optimising behaviour. According to the REH, the Central Bank (CB) and economic agents act on the same model: economic agents form their expectations on the basis of the CB model. That model is public (whether made public, or due to the general public being able to impute the CB model according to the best available economic model provided by economists).

The REH revolution brought two influential results: the policy ineffectiveness theorem (Sargent and Wallace, 1975) and the time-consistency policy (Kydland and Prescott, 1977; Barro and Gordon, 1983). According to the first, active monetary policy is impossible if private sector expectations are rational and are formed using the same model as the authorities. Temporary deviations from long-term equilibrium can only be achieved if the authorities are able to shock the private sector with unanticipated policy actions, thus confusing expectations. Time consistency on the other hand requires that, to attain a low and stable inflation level, monetary policy should be chosen such that, if it is chosen as optimal at time t, it should remain so at time $t+1$. As a result academics and the central bank started to look for predictable economic rules which could be applied to the day-to-day operation of a monetary policy.

New Keynesian Economics (NKE)

The REH in effect removes uncertainty from the monetary policy process in that it assumes a close alignment between the monetary authority and the economic public, with

both forming their expectations according to a single transparent model. In the last twenty years modern macroeconomics has taken a different perspective on the monetary policy context. Instead of simply assuming close alignment, attention has now focussed on how such alignment could be brought about in practice through CB efforts. In other words, the focus has shifted to the provision of microeconomic foundations to macroeconomic questions. Deviations from long-run equilibrium are located in market imperfections, particularly price stickiness and information asymmetries. Reducing such imperfections will facilitate long-run equilibrium. Clear central bank signals about monetary policy are an important element in eliminating asymmetries.

One of the main insights here has been the so-called New Keynesian Phillips curve, which results from the decisions taken by rational agents when bargaining their wages. Prices are shown to be sticky and to exhibit persistence over time, resulting in a forward-looking dimension to inflation (Taylor, 1979; Calvo, 1983; Fuhrer and Moore, 1995; see also Clarida et al., 1999). Using a model *à la* Calvo, Ball (1994) shows for example how monetary policy could reduce inflation and produce a boom at the same time. Provided that price setters are forward looking, the announcement of a lower level of money supply by the CB will prompt firms to lower their expectations of the future money stock level. This leads to a lower price level today, and at the same time boosts today's real money supply, and consequently output. In essence inflation can be costlessly reduced. The key here is the forward-looking nature of price setters, which in turn rests on a certain level of transparency between monetary authority and the economic public.

New Macroeconomic Consensus

Following Arestis and Sawyer (2004), a certain convergence on key issues can currently be identified in macroeconomics, which forms the basis of what may best be described as

a new monetary economics consensus. It is based on three propositions: nominal neutrality, inflation neutrality, and supply-side thinking. According to nominal neutrality, long-run equilibrium is not affected by the price level. According to inflation neutrality, real equilibrium is independent of the growth rate of nominal variables. The supply-side perspective, finally, implies that long-run unemployment is entirely determined by the supply side, so that there is no scope for a long-run trade-off between unemployment and inflation and between inflation and output.

Dynamic stochastic general equilibrium models based on these principles, put together with the aim of investigating optimal monetary policy, suggest that monetary policy can be regarded more as a science than an art, with applied modelling being in a position to steer monetary policy (e.g. Zimmermann, 2003). These models are usually based on the assumption that central bankers, before implementing their policies, solve a dynamic optimisation problem under the restriction of given resources, institutions, and information, in order to maximise the utility of a given representative household. A feedback rule is then derived assuming that the CB has a target function which is defined as a quadratic loss function with respect to negative as well as positive deviations of inflation and output from the respective targets or reference values.

This framework suggests, contrary to REH for example, that inflation as such is harmful for economic growth and efficiency, so that achieving low and stable inflation is the main step towards a sound macroeconomic environment. Moreover, there is a clear and direct link between the interest rate as a CB instrument and the level of inflation. Probably the biggest conceptual result of this literature is the inflation-targeting framework: monetary policy should explicitly declare an optimal level of inflation and act such that this target is met at every point in time. The advantage of such an approach,

apart from the reduction in inflationary bias, would be its positive ramifications in terms of credibility problems. In particular, inflation targetting encourages increased transparency regarding inflation objectives via improved communication with the economic public (Mishkin, 2004).

The question here is how far the information provided by the CB is rather part of a circular exercise in ensuring that CB expectations and those of the private sector converge on particular levels of the interest rate, which in turn are understood to conform to the achievement of the inflation target. It would then primarily be CB credibility in achieving the inflation target which would bring about wage and price settlements in the light of that target. But since changes in the repo rate do also have real effects, the possibility remains for expectations not to be self-fulfilling, and for credibility to be damaged. Further, the recent attention to model uncertainty suggests that central banks are not fully confident in any one model, and consequent interest rate rule implied, to determine the policy decision. Although many mathematically sophisticated micro-founded DSGE models propose policy rules that CBs should apply under different macroeconomic scenarios, no monetary institution has so far decided to adopt them. The reason is that the models cannot fully replicate the global uncertainty which governs the daily economic environment. The issue then is whether, and if so how, CBs communicate this uncertainty and its role in monetary policy and its transmission. We explore the meaning and significance of model uncertainty in the next section.

2. Model uncertainty: 'strong' versus 'weak' epistemic hypotheses

One implicit presumption behind the theoretical developments considered in the previous section was that each agent has one preferred model, and there is confidence in that

preference. Let us refer to this presumption as the ‘strong epistemic hypothesis’. Model uncertainty captures the fact that central bankers are not necessarily confident enough to rely on a single model as the basis for policy decisions. In other words, they doubt the strong hypothesis. To date, most efforts to take account of model uncertainty have relaxed the strong hypothesis while maintaining that one best model does exist, by allowing for the fact that there may be problems in identifying the best model correctly. Let us refer to this relaxation as the ‘weak epistemic hypothesis’.

Following Walsh (2004), let us consider a simple way of taking account of model uncertainty along the lines of the weak epistemic hypothesis by taking a look at the following macroeconomic model:

$$y_{t+1} = \mathrm{Z}_1 y_t + \mathrm{Z}_2 \hat{y}_{t/t} + \mathrm{K} i_t + u_{t+1} \qquad (1)$$

where

y_{t+1} is the state vector of macroeconomic variables;

$\hat{y}_{t/t}$ is the current estimate (best guess) of $y_{t/t}$;

i_t is the policy instrument

u_{t+1} is a vectors of error terms (i.e. stochastic exogenous shocks) assumed equal to $\mathrm{T}h_{t+1}$

$\mathrm{Z}_{1,2}$, K_{t+1}, and T are matrices of the model parameters

Uncertainty arises because estimates of $Z_{1,2}$, K_{t+1}, and T by the policymakers are different from the true values. Define these estimates as $\hat{Z}_{1,2}$, $\hat{K}_{t+1}$, and $\hat{T}$; while $\hat{y}_{t/t}$ denotes the policymaker's estimate of the current state $y_{t/t}$.

With $Z = Z_1 + Z_2$ and $\hat{Z} = \hat{Z}_1 + \hat{Z}_2$ we can rewrite the policy makers' perceived model as

$$y_{t+1} = \hat{Z}\hat{y}_{t/t} + \hat{K}i_t + \hat{T}(h_{t+1} + w_{t+1})$$

where

$$w_{t+1} = \hat{T}^{-1}\left[\left(Z - \hat{Z}\right)\hat{y}_{t/t} + \left(K - \hat{K}\right)i_t + \left(T - \hat{T}\right)h_{t+1}\right] + \hat{T}^{-1}Z_1\left(y_t - y_{t/t}\right) + \hat{T}^{-1}\hat{Z}\left(y_{t/t} - \hat{y}_{t/t}\right)$$

There are three separate sources of model error in the above representation (Walsh 2004):

- *Model-misspecification*

  This is given by $\left[\left(Z - \hat{Z}\right)\hat{y}_{t/t} + \left(K - \hat{K}\right)i_t + \left(T - \hat{T}\right)h_{t+1}\right]$; these are the errors which arise when the policymakers' estimates differ from the their true value. Moreover this term captures the errors made in modeling the structural impacts of exogenous disturbances, $\left(T - \hat{T}\right)h$.

- *Imperfect Information*

$Z_1(y_t - y_{t/t})$: errors arising from the estimate of the true state. Orphanides (2003) argues that these types of errors were the main cause of important policy errors in the 1970s.

- *Asymmetric and/or inefficient forecasting*

  $\hat{Z}(y_{t/t} - \hat{y}_{t/t})$; this term reflects both inefficiencies in the policy-maker's estimate of the current state vector (y_{t+1}) and informational asymmetries between the economic agents and the authorities.

We should add that model uncertainty can take various other forms. In the context of the above specification, uncertainty may also arise from missing variables in the vector y_{t+1} or from misspecification of an equation, or from misspecification in the functional form of the system.

To check how robust a specific policy is to model uncertainty that accords to the weak epistemic hypothesis researchers usually follow three steps: (1) choose a reference model of the economy; (2) define a set of shocks/perturbations around this model, where the set is structured so that the uncertainty is focused on potentially-important weaknesses of the reference model; (3) choose policy so that it works best for the worst model from the set. Hansen and Sargent (2004) suggest using a robust control method. Robust control amounts to acknowledgment and incorporation of model uncertainty of the above kind in optimal control models, allowing selection of the best policy for the best outcome for the possible worst model. It is always assumed, though, that the economic model is the same for the policy-maker and for the market participants.

Recently, more radical departures from the traditional line of model uncertainty have begun to emerge. Eusepi (2005) for example proposes a model in which the central bank and the economic actors are uncertain about the model environment. He distinguishes between uncertainty about the evolution of output and inflation on the one hand, and uncertainty about the central bank monetary policy strategy on the other hand. The main conclusion is that CB transparency renders 'the optimal policy rule robust to expectational mistakes, even in the plausible case where the economic agents face other sources of uncertainty about the economic environment. On the other end, lack of transparency can lead to a welfare-reducing outcome where self-fulfilling expectations destabilize the economic system' (Eusepi, 2005, p. 22).

The problem in trying to solve the model uncertainty issue lies in the inability of the researcher to work with the *true* economic model. In other words, the strong epistemic hypothesis assumes an omniscience on the part of economists which is, at best, an instrumental methodological assumption. This is born out by the fact that all the various scenarios generated in the literature are always model-specific; the competing reference models have marked differences in how expectations are formed, and on the persistence of output and inflation.

Dow (2004) has drawn out the inevitable conclusion of these further relaxations of the strong epistemic hypothesis, by tackling head-on the thorny issue of model uncertainty in terms of the question as to which is the best model among a set of incommensurable candidate models, none of which provides a complete account of causal mechanisms. The issue here is the possibility that no one model can conceivably provide an adequate base for monetary policy. Without a reference model, model uncertainty cannot be expressed

formally in terms of that model. Further there is no formal focal point around which all actors' expectations can converge.

The monetary policy decision and the basis on which it is arrived at then involve elements beyond any one model. In the context of policy signals, this means that what is being signalled goes beyond formal properties of models or datasets. The simple fact that monetary policy decisions are communicated via several channels at once, some quantitative and some discursive, lends credence to such an alternative hypothesis. So does commentary that finds that interest rate decisions are made by a committee where 'each member holds to a particular view of the behaviour of the economy, represented by a macro model' (Levin and Williams, 2003, p. 946).

3. Signals, uncertainty and ambiguity

In the previous section, we discussed a policy scenario that took account not just of the possibility that the economic public may be imperfectly informed about the model on which the monetary authority acts, but also of the possibility that decision-making within the monetary authority is subject to imperfect knowledge. The monetary authority may not have access to a single model of the economy which is regarded as encompassing all available knowledge, but instead is forced to rely on a suite of models that, if evaluated individually within a committee decision-making structure, may give rise to competing policy recommendations. We will now explore this scenario more systematically by distinguishing between three different kinds of uncertainty as they arise in a policy context.

Consider the following, not too uncommon, context of monetary policy decision making with an independent CB, whereby at regular intervals, interest rate decisions (the

repo rate) are taken by an independent Policy Committee (PC) whose meeting minutes are subsequently made public in one form or another. The PC takes account of the current state of the economy and its likely development in the future, evaluates this state according to a set of models, and communicates the outcomes of its deliberations via several communication channels (minutes, press conferences and speeches, hearings with parliamentary committees, various CB reports, etc). We call the information on the current state of the economy the PC's input data, the outcome of the set of procedures to which it has access to extrapolate from this data its empirical models, and the intellectual frameworks on the basis of which it evaluates the combination of input data and empirical models its theoretical models.

The first form of uncertainty, which we take for granted here by simply referring to it as global uncertainty, refers to the subject matter of the monetary policy decision: the economy. In the medium and longer term, knowledge derived on the basis of extrapolation from past data is subject to considerable uncertainty, in the sense that any given prediction is typically confounded by subsequent events. The various ceteris paribus clauses of the models informing PC decision-making will rarely if at all be sufficiently satisfied for the models to act as a precise and unambiguous guide to policy decisions. In other words, the economy is subject to unpredictable shocks, including structural shocks.

By contrast, on the level of models we encounter model uncertainty, in particular in the form of the multi-model interpretation of model uncertainty discussed above. The assumption here is that, even if the economy were to develop deterministically, our knowledge of it would be such that we are still unable to arrive at a single trusted model of it, be it an empirical or theoretical model. The reasoning is either that we would lack

access to crucial data, or that our conceptual understanding of economic phenomena would be bounded either in principle (due to limitations on human cognitive capacity, global uncertainty, etc.) or as a matter of fact.

Signal uncertainty, finally, is associated with the outputs of the PC decision-making process, rather than its inputs or models. These outputs as we have seen can take various forms, henceforth called ‘channels’. The first channel on which we will focus consists of the interest rate decision itself. The announced value of the repo rate is of course transparently known with certainty by the economic public. But we are concerned here with the uncertainty surrounding the analysis behind the setting of the value, and about its likely consequences. This analysis is important for the formation of the public’s expectations about the future path of the repo rate. In particular, correctly anticipating changes in the repo rate is critical to the operations of financial institutions.

But monetary policy may also be transmitted through other channels, in addition to the behaviour of financial institutions. The effect of a repo rate change itself is felt by the company and household sectors indirectly through the financial institutions from which they borrow, or with whom they invest. But the expectations generated by the signals accompanying the rate change can also have a direct effect on expenditure plans. A fall in the repo rate accompanied by signals that the PC is uncertain about the prospects for economic growth may have conflicting effects on company investment plans: the rate fall encourages investment, while the accompanying signal discourages it. The PC’s analysis is thus also important for the non-bank public’s interpretation of the significance of any repo rate change. If the MPC is uncertain about the effect of its monetary policy on expenditure and on inflation, and/or if the public are uncertain about the PC’s

expectations, then this will impact on the uncertainty with which the public interpret monetary policy.

The Bank's thinking about economic relations, including market uncertainty, and the PC's own uncertainty, are signalled through several channels which operate alongside the primary channel of the interest rate decision itself. Traditionally, effects of changes in policy variables have been discussed in the literature in terms of the 'transmission mechanism' of monetary policy. We are here concerned with the discursive dimensions of any such mechanism, however its precise shape and details. The second channel of PC decision making by which signal uncertainty is transmitted is a communication of the PC's evaluation of economic uncertainty as it can be extracted from official CB publications. A third channel which may be considered, finally, consists of the explicit or implicit communication of subjective views and evaluations of PC members.

If the output information arising from the PC decision-making process via these two additional channels, alongside the interest rate decision itself, is regarded as a signal to the economic public, then the presence of signal uncertainty will mean that the economic public are only imperfectly informed about this decision-making process. This may either be intended by the monetary authority as a strategic reflection of the PC's own uncertainty, or instead it may be an inadvertent, possibly even inescapable, consequence of signalling processes of this kind.

It is important to be clear about the source of signal uncertainty. We assume that signal uncertainty, like model uncertainty as discussed above, would prevail even if the economy would develop in a deterministic way, so that global uncertainty would not be an issue. Likewise, signal uncertainty does not depend on the presence of model uncertainty. This is due to the fact that the success of any act of communication relies not

just on the intentions of the sender but on how the signal is interpreted by the recipient, and that economic communication takes place in a strategic context. However, even if the monetary authority could commit itself in a way that would allow it to send credible signals, the very fact that these signals go beyond numerical expressions and include discursive material of the other two channels that we consider here makes them subject to the ambiguities any discursive attempt at communication is bound to exhibit (see further Winkler 2000, Klaes 2006).

To recap, global uncertainty relates to the state of the economy, model uncertainty relates to the state of our knowledge of the economy, and signal uncertainty relates to our ability to communicate about economic matters. These concepts are nested: global uncertainty precludes the identification of a single model to capture economic relations (even stochastically) and thus requires the exercise of judgement. Global uncertainty therefore implies model and signal uncertainty. Even without global uncertainty, model uncertainty of the multi-model scenario kind means that judgement is required for policy decisions and, given the discursive nature of the expression of judgment, it also implies signal uncertainty. Signal uncertainty finally can stand alone, even without global or model uncertainty, if a policy decision involves explicit or implicit channels of communication via verbal expressions over and above monetary policy measures such as the repo rate announcement as such.

4. Judgement and the signalling of uncertainty

Uncertainty and the role of judgement

Model uncertainty of the kind considered above has a noteworthy implication. In the absence of a single trusted model or of the possibility of expressing rationally a degree of

confidence in a suite of models and a mechanism for coordinating them, decision-making requires the exercise of judgement (Dow, 2004). This judgement is required with respect to the interpretation of information, and to the choice, and use made, of models, both empirical and theoretical. Judgement, by definition, is not the rational derivation of a single solution to a model. In the context of true model uncertainty, candidate models are incommensurate with each other; were they commensurate they could all be incorporated in one large model, potentially obviating the need for judgement. Even more open to judgement are model selection criteria, issues of interpretation of terms and of new data with respect to models, and the formulation of a coherent set of forecasts.

It is conventional at this point to discuss the relative merits of the basis for decision-making as an art rather than a science. But our analysis of uncertainty does not allow such a bifurcation. Rather, evidence and modelling are used as far as they can be justified. But selecting the evidence and the models, combining the insights from each into an understanding of the forces at work in the economy and the likely effects of monetary policy actions, and formulating a policy decision require judgement, or art. Under conditions of uncertainty science requires art.

Further, any monetary-policy decision-making process will need to consist of a set of institutionalised procedures that rely on expert input and follow a consensus mechanism that ensures that policy decisions, e.g. interest rate decisions, are arrived at. While such institutionalised procedures ultimately result in unambiguous repo rate decisions, they are nevertheless open to different interpretations by market participants, and may in fact be considered as a fourth communication channel, alongside the three considered above.

In the conventional literature on the theory of monetary policy, the challenge for policy is to ensure adequate transparency of the form and content of decision procedures for

revealing the collective judgement of the PC. This would make it more likely that behaviour would be conditioned by the same expectations as the PC, helping to ensure that the PC's predicted outcome does transpire. But also it would facilitate a closer anticipation of future decisions (thus avoiding policy shocks) if past PC thinking is well understood. Hence the central role of signals in monetary policy. The channels which send these signals, are thus of central significance.

We have referred to signal uncertainty, meaning a lack of clarity in the signals implicitly or explicitly sent by the PC. But if that thinking is conditioned by uncertainty, then an analysis of signals needs to include an indication of uncertainty and how it is being handled as part of the content being signalled. The transparency literature itself is not unambiguously in favour of signalling uncertainty. There has been some analysis of the uncertainty effects of transparency (reviewed by Geraats, 2002, F534-6) which suggests that transparency with respect to monetary authority uncertainty may actually be welfare-reducing by increasing the variance of target variables: knowledge of the authority's uncertainty increases the public's forecast errors.

But in any case, if judgement extends beyond knowledge or otherwise of white noise surrounding inputs to the policy model, then making sure that policy action is fully anticipated is more complex than being transparent about 'the' model and 'the' information set. Runde (1990) considers the implications of greater awareness of uncertainty of this kind. He shows how additional evidence, rather than reducing uncertainty, can actually increase awareness of the limitations of the preferred set of causal explanations, and thus reduce confidence in the explanations. How far increasing awareness of our ignorance is welfare-enhancing and how far welfare-reducing is a moot point (Dow, 1995). It may be possible to agree on the merits of reducing signal

uncertainty itself; but, if what is being signalled is a matter of judgement, where uncertainty is an inevitable element, then the issue remains as to whether that uncertainty should be signalled. Being transparent about uncertainty may reduce the effectiveness of monetary policy.

Here we confine ourselves to the empirical question of considering more generally how, and how far, a PC signals its uncertainty. We are interested in considering how a PC may explicitly express its own uncertainty, and what can be gleaned from more implicit forms of expression which may be intended or unintended. In the next section we consider two approaches to signalling uncertainty: a quantitative approach of 'uncertainty indicators', and a non-quantitative approach of 'discursive signals' in the form of published minutes, reports etc.

Conventional indicators of market uncertainty

The empirical literature has a long tradition in attempting to measure macroeconomic uncertainty. There are two broad classes of technique available to quantify uncertainty: ex-post versus ex-ante approaches. The former traces uncertainty in the historical data of the process that generates the variable of concern. This group of methods includes: (i) traditional statistical variance or similar, such as a moving standard deviation; (ii) variance of the irregular component of a given stochastic process; (iii) the conditional variance estimated via a General Autoregressive Conditional Heteroskedastic (GARCH) model where the mean equation is a first-order autoregression, allowing for ARMA errors. This is arguably the most popular methodology currently used to proxy uncertainty in whatever market or indicator the researcher is interested in. This approach is justified by Huizinga (1993, p.528) as follows: 'The use of an ARCH model reflects a decision that the particular measure of uncertainty to be evaluated is the conditional

variance of a series. This measure seems to best account for the idea that for series whose deviations from the unconditional mean can be reliably predicted, it is not fluctuations around an average value that are of concern (that is the unconditional variance) but rather fluctuations about a predicted future path.' (iv) Recently, unobserved components models have been used to extract a long and a short run uncertainty from historic time series (see Harvey, 1993; Kim, 1993).

The ex-ante method makes use of survey data to derive some statistical measure of the variance. The main advantage of using survey data is that uncertainty measures are able to represent individual perceptions of risks based on the information available to individual agents. The drawback is that it requires a large amount of respondents to obtain meaningful data. Moreover, the assumption underlining this approach is that the subjective probability distributions of events reflect objective probability distributions. In practice, the majority of the studies apply ex-post methods in quantifying uncertainty.

PC minutes and other discursive data

Uncertainty indicators that are designed to reflect market uncertainty are only one of several kinds of contextualising data available alongside formal PC decisions such as the repo rate. There is scope for deriving some indicators of uncertainty from the various other channels through which the PC communicates, implicitly or explicitly: minutes of PC meetings, to the extent that they are made public, any additional CB reports, etc. Additional indicators may thus be obtained, furnishing a potential proxy for the uncertainty as faced by the PC in their considerations. On the most basic level for example, a simple count of uses of the terms 'uncertain' and 'uncertainty' may be taken as an ordinal indicator of how much uncertainty the PC was experiencing. Further analysis may involve relating the incidence of the 'uncertainty' terms with economic

fundamentals, and also with indicators of uncertainty in financial markets and in the corporate sector. Thus, if a prior theory is formulated about how decision-making responds to particular developments (such as a financial crisis), how PC deliberations draw on a range of inputs, how uncertainty is understood by the PC, and how it affects policy decisions, then quantitative indicators can be used for an empirical test of such a theory.

5. The Bank of England and monetary policy signals

Having outlined our general approach, we will now take a first step of applying the framework to the analysis of a particular case. Our general framework of analysis proceeds from a policy scenario that takes account not just of the possibility that the economic public may be imperfectly informed about the model on which the monetary authority acts, but also of the possibility that decision-making within the monetary authority is subject to imperfect knowledge. The monetary authority may not have access to a single model of the economy which is regarded as encompassing all available knowledge, but instead is forced to rely on a suite of models that, if evaluated individually within a committee decision-making structure, may give rise to competing policy recommendations. This is the scenario expressed in the Bank of England's (1999) discussion of its modelling approach, which in our interpretation explicitly acknowledges the challenges posed by model uncertainty.

We will in the following restrict our attention to interest rate decisions as they are taken by the Monetary Policy Committee (MPC) of the Bank of England. The MPC meets monthly to consider changes in the interest rate under its control (the repo rate). In doing so, it takes account of the current state of the economy and its likely development in the

future, evaluates this state according to a set of models, and communicates the outcomes of its deliberations via several communication channels (minutes of MPC meetings, press conferences and speeches, hearings with parliamentary committees, and the quarterly *Inflation Report*; see further Bell, 2005).[1] The MPC has no expectation of their central projection being precisely met (Bell, 2005, p.7). In other words, the MPC accepts an overall context of global uncertainty as defined above.

The first channel for communicating the MPC's monetary policy is of course the interest rate decision itself. Its output is a numerical value (so far) on a 'quarter-percent scale' that indicates by which amount, if any, the rate is adjusted up or down. The second channel of MPC decision making is a communication of the MPC's evaluation of economic uncertainty as it can be extracted from the notation of the fan charts of the *Inflation Report*s. The third channel we will consider, finally, consists of the published minutes of the MPC meetings, which, since discursive in nature, must be regarded as a source of potentially significant signal uncertainty. If the output information arising from the MPC decision-making process is regarded as a signal to the economic public, then the presence of signal uncertainty will mean that the economic public are only imperfectly informed about this decision-making process. If the Bank of England is concerned with increasing transparency, it should therefore be concerned with signal uncertainty of this kind.

We argued above that once the strong epistemic hypothesis relating to models informing monetary policy is relaxed to the point where model uncertainty is explicit acknowledged, monetary policy will have to rely on the exercise of judgement, even though it may be informed by a suite of trusted models. The models employed by the

[1] In principle the MPC's thinking is communicated in a letter to the Chancellor of the Exchequer if the actual inflation rate deviates unduly form the target, but this has not so far been required.

Bank of England in its suite-of-models approach are themselves incommensurate; were they commensurate they could all be incorporated in one large model, potentially obviating the need for judgement. Were judgement not such a central aspect of the MPC's deliberations, there would be little scope for the kind of disagreement which arises between members in the exercise of judgement.

The MPC are quite explicit that their decision-making involves the exercise of judgement with respect to knowledge which is held with uncertainty (Bank of England 1999; Lomax, 2005). This openness about uncertainty is a relatively recent feature of central bank pronouncements, following the disappointment in the 1980s with relying on single large models for monetary policy-making. We are interested in considering how the MPC explicitly expresses its own uncertainty, and what can be gleaned from more implicit forms of expression.

We consider two approaches to signalling uncertainty: the quantitative approach of 'uncertainty indicators', and the non-quantitative approach of 'discursive signals' in the form of published minutes, reports etc. What we wish to stress here though is the complementary nature of discursive and quantitative channels, rather than discursive sources merely adding a secondary gloss on quantitative indicators. For example, while the fan charts express the uncertainty surrounding the two-year point forecast, the minutes express the uncertainty surrounding specific aspects of the analysis which led up to that forecast, and thus provide additional signals to the public. While summary statistics can thus tell us something further than the fan charts, a detailed study of the texts of minutes, as is done by market watchers and market participants, is an additional channel of communication.

We now turn to a more detailed consideration of the main signalling channels of MPC decision making.

The Bank of England Fan Charts

Since 1996, even before the current institutional arrangements for monetary-policy decision-making were established, the Bank of England has published its inflation and GDP projections in the form of fan charts. Rather than focusing on one central forecast, the fan shows a range of bands around the central forecast, in order to express its own model uncertainty. There are ten bands, and there is a 10% probability of the actual inflation rate falling within each band (at the end of the two-year forecast horizon – the intervening period's bands are simply interpolated).

As an expression of uncertainty, the fan chart is clearly quantified (indeed the Bank publish the precise data on which it is based). But how are we to understand what is being measured? The Bank's explanatory notes shed some light on this, explaining that 'the fan chart portrays a probability distribution that approximates to the MPC's subjective assessment of inflationary pressures evolving through time, based on a central view and the risks surrounding it' (Britton, Fisher and Whitley, 1998, p. 31, emphasis added). Further, 'the uncertainty in the subjective assessment of inflation relates to how likely it is that the future events will differ from the central view. It is therefore a forward-looking view of the risks to the forecast, not a mechanical extrapolation of past uncertainty.' (ibid. p. 32).

The language quoted above is that of the Subjective Expected Utility (SEU) approach whereby, even if there is no concrete objective basis for probability estimates, these can be assigned subjectively. Here the requirement is stronger, that the MPC arrive at a collective subjective assignation of ex ante probabilities to the risks attached to the

central forecast. But there is no formal basis for doing this, given the derivation of the central forecast from a suite of models to which judgment is applied following lengthy deliberations. Rather, the fan charts apply a forward-looking modeling approach to calculating the risks attached to the central forecast on the basis of past errors; it is only the degree of skewness which is the outcome of subjective judgment (Nikolov, 2002).[2]

An interesting characteristic of the Bank of England forecasts is that they are computed assuming both an unchanged repo rate and an interest rate based on market's interest rate expectations. This second case introduces the hypothesis that there may be a *reverse channel*, where the Central Bank acquires information from the market rather than vice versa. But since the market agents form their expectations on the signals given by policymakers, we are therefore faced with the potential of a circular policy environment with no economic leader.[3]

MPC minutes and other discursive data

But the fan charts are only one channel for communicating the MPC's thinking on uncertainty. There is scope for deriving some indicators of uncertainty from the other channels: the MPC Minutes, the *Inflation Report*, etc. The resulting indicators furnish a proxy for the uncertainty as faced by the MPC in their considerations. On the most basic level for example, a simple count of uses of the terms 'uncertain' and 'uncertainty' can be taken as an ordinal indicator of how much uncertainty the MPC was experiencing.

Such an approach can be taken further in order to glean more information about the MPC's thinking in relation to uncertainty. Comparing the relative uses of the terms 'uncertain' and 'uncertainty' on the one hand with 'risk' and 'risky' on the other provides

[2] It is still difficult to understand exactly how this collective subjective judgement is in practice quantified in order to be applied to the detailed fan chart's detailed numerical parameters.
[3] Bernanke and Woodford (1997) show that it is not optimal for a Central Bank to target private forecasts since it leads to indeterminacy of the rational expectations equilibria.

information on the relative importance of the two, as well as how far they are correlated, thereby opening up the possibility of an assessment of uncertainty along more than one conceptual dimension. Comparing the relative incidence of both sets of terms in the MPC minutes and in the *Inflation Report* provides some indication on such matters as how far the two documents are consistent (the latter bearing the imprint more of Bank staff), and/or how much additional uncertainty is expressed in the context of the policy decision. Further analysis involves relating the incidence of the 'uncertainty' terms with economic fundamentals, and also with indicators of uncertainty in financial markets and in the corporate sector. Thus, if a prior theory is formulated about how decision-making responds to particular developments (such as a financial crisis), how the MPC deliberations draw on inputs such as the *Inflation Report*, how uncertainty is understood by the MPC, and how it affects policy decisions, then quantitative indicators can be used for an empirical test of such a theory.

We are therefore suggesting going further than quantitative indicators, drawing on the discourse approach to studying texts which is already well-established in economics (see further Klaes and Sent, 2005). This requires a careful, contextual, analysis of the use of terms phrase by phrase in order to glean the intended meaning. This in turn requires that the analysis be embedded in a prior theory as to channels of information, and the decision-making process, incorporating feedback between information and decision-making among all the relevant parties. This is particularly apposite for an analysis of uncertainty, where reflexivities abound. The uncertainty faced by the Bank of England arises partly as a result of uncertainty faced by the general public, which in turn is influenced by the Bank's uncertainty.

In arguing for an discursive approach to analysing MPC decision making, we are not alone. Cobham (2003) provides an example of the form an explorative approach of this kind may take. In an analysis of the factors responsible for interest rate smoothing, he finds in an analysis of the UK monetary policy context that focuses on the decisions and minutes of the MPC that only limited influence, if at all, can be attributed to perceived uncertainty by the MPC. This perceived uncertainty is identified by considering the importance given in the MPC minutes to economics fundamentals (demand, output, etc.) relative to other factors, which, in Cobham's terminology, include 'uncertainty'. Out of the minutes of 62 MPC meetings considered, uncertainty was regarded as a decisive factor at 23 meetings. The forms of uncertainty considered were data uncertainty, parameter uncertainty, and 'wider uncertainty' associated for example with trends in the world economy. The outcome of 17 of those 23 meetings (74%) was no change in rates, comparing to a 'no decision rate' in all meetings of only 63%.

Rosa and Verga (2005a, 2005b) adopt a more sophisticated methodological framework, albeit in a study of European Central Bank (ECB) monetary policy. Based on the monthly ECB press conferences, they construct a discourse-based uncertainty index. They find that this index provides a complementary explanatory factor, alongside more conventional market-based measures of monetary policy expectations, when it comes to ECB interest rate policy. We argue for an extension of discourse analytic approaches of this kind. Quantitative indicators based on texts are subject to obvious limitations which need to be considered in any such approach. What is required is a more thorough discursive approach, starting out from close systematic study of CB communications such as minutes, press conferences and other sources.

6. Conclusion

Central bank documents are worded extremely carefully; there is a good understanding of the signalling value of texts and of the seriousness with which they are therefore poured over by the public. They therefore provide excellent case material for discourse analysis.

We have seen the conventional theoretical rationale for the authorities to adopt the stance that transparency is desirable, on the grounds that their projections are more likely to be met if they are understood and shared by the public. Monetary policy then no longer shocks the economy into a change of course. Rather policy documents, and the announced reasoning behind policy decisions, nudges the economy in the direction the monetary authority wants it to take; ideally the decisions themselves are fully anticipated (Friedman, 2004).

But full certainty is impossible given the possibility of developments unanticipated by the authorities, as well as uncertainty surrounding the interpretation not only of data but more seriously about causal mechanisms, and thus about forecasts. The uncertainty experienced by the authorities is then an input to the uncertainty of the public, and vice versa, and full transparency is open to question. This uncertainty is signalled through a range of channels. While there is some scope for quantitative analysis of texts as a way of identifying the MPC's signalling of its own uncertainty, along the lines described above, ultimately a more deeply probing semantic analysis may be required fully to grasp the wider dimensions of the signal.

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