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Inflation Targeting, Committee Decision Making and Uncertainty: The case of the Bank of England's MPC.*

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Abstract

The widely recognised transparency and openness since 1997 of the monetary policymaking process at the Bank of England has provided very detailed information on both the decisions of individual members of the Monetary Policy Committee and the information on which they are based. In this paper we conisder this decision making process in the context of a model in which inflation forecast targeting is used but there is heterogeneity among the members of the committee. We find that internally generated forecasts of output and market generated expectations of medium term inflation provide the best description of discrete changes in interest rates. We also find a role for asset prices through the equity market and housing prices. There is also identifiable forms of heterogeneity among members of the committee that improves the predictability of interest rate changes. This can be thought of as supporting the argument that full transparency of monetary policy decision making can be welfare enhancing.

JEL Classification:E420, E430, E500.

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1 Introduction

The practice of targeting inflation directly has been adopted since the early 1990s by a number of Central Banks to the extent that this is now the de facto standard for monetary policy in many industrialised countries. Both the US Federal Reserve and the European Central Bank have remained exceptions to this rule.

Since 1997 the model within the UK has been to grant the Bank of England control over short term interest rates with the instruction that it is to target inflation at 2.5% (and more recently 2%). In addition the Governor of the Bank must write an open letter of explanation to the Chancellor if inflation falls outside a 1% band on either side of this target. Despite the emphasis on inflation current arrangements do not constitute a pure inflation targeting system, since the Bank is also instructed to give some regard to general economic policy goals, which presumably means avoiding excessive movements in real output as well as inflation. The Bank has not been instructed as to the relative weight it should place on inflation and other policy goals This means that monetary policy is still far from a purely technical or mechanical process. There is still considerable room for disagreement over the stance of policy given the lack of definition of goals. The Bank has instrument independence but not goal independence.

Our paper touches on a number of issues in the literature on monetary policy. There is a large literature on the usefulness of trying to characterise monetary policy in terms of a rule that started with Taylor (1992). More recently, Orphanides (2003) has provided a historical analysis and has been able to show that there is a degree of consistency in the conduct of US monetary policy during the 1920s and since the 1951 accord that gave effective independence to the Federal Reserve. In many cases across the world, the Taylor rule provides an useful way of analysing policy.

However, as another theme running through much of the policy discussion has concerned the potential use of simple monetary rules such as those advocated by Taylor (1993). To some extent the use of a simple rule assumes the sort of well defined preferences which are conspicuously absent in the current monetary arrangement. However, simple rules have a number of advantages chiefly, perhaps, by making the operation of monetary policy transparent and therefore easily monitored by the private sector. The question remains as to what form such a simple rule should take. Taylor conditions short term interest rates on current deviations of output and inflation from target while Svensson (1997) argues that, given the long and variable lags inherent in policy, it might make more sense to target a forecast of inflation rather than its current value. Orphanides (1998) has also pointed out that decisions about interest rates are made in real time when there is considerable uncertainty about the current state of the economy. Policymaking in circumstances when information is partial has been laid out fully in Pearlman (1992). In this paper we assume that the filtering which is required of current (imperfect) measure of economic activity takes place as part of the internal procedures of the Bank of England (see Budd (1995) for a description).

In this paper we take advantage of the considerable volume of information that the Bank of England makes available about the decision-making processes of the Monetary Policy Committee to examine the kinds of policy rule that the MPC implicitly operates. As has been emphasised repeatedly by a number of commentators, it is clear that the Bank operates an inflation forecast type of rule, but with some evidence to suggest that developments in asset markets also matter.

The contrast between the degree of transparency that the Bank of England aspires to and the traditional practices of Central Bankers could not be greater. Transparency serves the need of accountability but it also improves predictability. We find in this paper that information about the individual decisions of MPC members improves the predictability of interest rate changes compared with the case where only the aggregate decision is known. The heterogeneity across the MPC is valuable information. This throws some light on the current debate about the extent to which central banks should make decision making processes as transparent as possible.

The granting of operational independence to the Bank of England in 1997 put in place a mechanism for making decisions on monetary policy based on a 9 member Monetary Policy Committee made of 5 internal and 4 external members. Operational decisions on interest rate policy are made by the MPC. It comprises the Governor of the Bank of England, the two deputy Governors, two members of the Bank with responsibility in the Bank for monetary policy and market operations and four outside members with relevant expertise who are appointed by the Chancellor. The internal members are permanent appointments while the external serve for a 3 year period, with the possibility of reappointment. A large amount of information is provided on both the information set that is at the disposal of the Committee and the eventual vote that each member casts. This provides an invaluable dataset to study what is actually the basis for decisions on interest rates. We find that the decision making process is best thought of as an inflation forecast regime (Svensson, 1997) but with some responsiveness to asset market developments.

There is now an extensive literature on the role that asset market developments should play in monetary policy decisions. For example, Bernanke and Gertler (2000) argue that policy should not respond to changes in assets prices, except in so far as they signal changes in expected inflation. Cecchetti et al (2000), by contrast, have argued that monetary policy should respond to bubbles or misalignments in asset prices[1]

The plan of the paper is as follows. In section 2 we briefly discuss some simple models of the inflation process and introduce a role for transparency and for a committee structure for decision-making and cosider the signal extraction problem that the MPC and the members individually face. In Section 3 we discuss the estimation problem. In section 4 we report some empirical results. Finally, in section 5, we present our conclusions.

2 Models of the inflation process

We adopt the most simple form of a model of the monetary policymaking process and abstract from many issues that have been the focus of much of the recent literature. The model is structured as follows:

$$\pi_t = \pi_{t-1} + \alpha y_{t-1} + \epsilon_t \quad (1)$$
$$y_t = \beta_1 y_{t-1} - \beta_2(i_{t-1} - \pi_{t-1}) + \eta_t \quad (2)$$

π_t is the inflation rate in period t, y_t is the output gap (the difference between the log of output and the log of potential output), i_t is the nominal interest rate. η_t and ε_t are iid shocks in period t not observable in period $t-1$. The coefficients α and β_2 are positive; β_1 measures the degree of persistance in the output gap and satisfies $\in (0,1)$. The output gap depends negatively on the real lagged interest rate. The (change in the) inflation depends on the lagged output gap. The output gap is normalised to zero in the long run. The intertemporal loss function is:

$$L_t = \frac{1}{2} E_t \sum_{\tau=t} \delta^{\tau-t} \left[(\pi_t - \pi^*)^2\right] + \lambda y_t^2 \quad (3)$$

E_t denotes expectations conditional on information available in period t. π^* is the inflation target; δ, the discount rate satisfies $0 < \delta < 1$. The

[1] For other views see Vickers (1999), Goodhart (2001), Bean (2003) and Bullard (2002).

policymaker minimises the present discounted value of squared deviations of inflation from its target and the output gap. λ is the weight the policymaker attaches to the output gap being zero, with the weight on inflation normalised to one.

For the special case of $\lambda = 0$, so the policymaker only targets inflation, the central bank can (in expectation) use the current interest rate to hit the target for inflation two periods hence. So perfect controllability in this case allows the intertemporal problem to be written as a sequence of single period problems. In this case (Svensson, 1997a)

$$L_t = \frac{1}{2}\left[\pi_{t+2|t} - \pi^*\right]^2 \tag{4}$$

$\pi_{t+2|t}$ is the forecast of inflation at time period $t+2$ based on information available in period t. The central bank minimises the squared deviation of the current two-year inflation forecast, $\pi_{t+2|t}$, from the target. The forecast of π_{t+2} at t is

$$\pi_{t+2|t} = \pi_{t+1|t} + \alpha y_{t+1|t} \tag{5}$$

and

$$y_{t+1|t} = \beta_1 y_{t|t} - \beta_2(i_t - \pi_{t|t}) \tag{6}$$

where the subscript t|t is indicating that current realisations of the output gap and inflation may well be imperfectly observed, and need to be forecasted. So:

$$\pi_{t+2|t} = \alpha\left[\beta_1 y_{t|t} - \beta_2(i_t - \pi_{t|t})\right] \tag{7}$$

Then the inflation 'feed forward' rule is

$$i_t = (\pi_{t|t} - \pi^*) + \frac{1}{\alpha\beta}\pi_{t+1|t} + \frac{\beta_1}{\beta_2}y_{t|t} \tag{8}$$

This satisfies the Taylor Principle since $\partial i_t/\partial\pi_t > 1$.So although there is not an explicit weight attached to output losses, current (forecasted) ouput appears in the rule because the current output gap is informative about future inflation. In Svensson's original formulation $\pi_{t|t}$and $y_{t|t}$ are known. In practice, as Orphanides (1998) has pointed out, in real time current inflation and the current output gap are not observed.

2.1 Committee decision-making

In contrast to the Federal Reserve[2] and the ECB, where decision making is by 'consensus' , the Monetary Policy Committee of the Bank of England uses majority voting so it is the median vote that decides the outcome for monetary policy. One way to model decision making by committee is to assume that preferences with respect to inflation and output vary across the committee (Sibert, 2002, Neuman, 2002). In this case we can write a loss function for the ith committee member as:

$$L_{it} = \frac{1}{2} E_t \sum_{\tau=t} \delta^{\tau-t} \left[(\pi_t - \pi^*)^2 \right] + \lambda_i y_t^2, \qquad \text{for } i = 1, ..., m \tag{9}$$

If we confine ourselves to the case considered earlier when only inflation matters, preference heterogeneity is meaningless. Instead we assume that heterogeneity arises from differing views about the state of the economy. Each member has the same (public) information set but will augment this with private information. This can take different forms. An individual member may dissent from the consensus forecast or an individual member may have particular expertise that leads to more weight being attached to particular kinds of information compared to the average. Since the internal dynamics of committee decision making can result in a measure of sharing of expertise, we shall assume that each decision is finally based utimately on information that cannot be shared fully with the MPC, or which the other members of the Committee do not attach importance to. The decision rule for the ith member is:

$$i_{it} = (\pi_{t|t} - \pi^*) + \frac{1}{\alpha\beta} \pi_{t+1|t} + \frac{\beta_1}{\beta_2} y_{t|t} + \varsigma_{it} \quad \text{for } i = 1, ..., m \tag{10}$$

ς_{it} is a zero mean process with a diagonal covariance matrix, with diagonal elements, $\sigma^2_{\varsigma_i}$.

2.2 Information Processing

[2] See Edison and Marquez (1998) for a detailed description of the decision making processes of the Federal Open Markets Committee.

The problem of determining $y_{t|t}$ and $\pi_{t+1|t}$ (and implicitly the uncertainty associated with the forecasts) can be cast as an optimal filtering or signal extraction problem (Holly and Hughes Hallett, 1989). Define the state vector $\widetilde{y}_t = (\pi_t, y_t)'$.So that

$$\widetilde{y}_t = A\widetilde{y}_{t-1} + Bu_t + e_t \tag{11}$$

where $\widetilde{y}_t$ is a 2×1 vector, A a 2×2 matrix, B is 2×1 vector and $u_t = i_t$. e_t is a 2×1 vector of iid shocks. We assume that we observe the current state of the economy imperfectly so

$$z_t = H\widetilde{y}_t + \psi_t \tag{12}$$

Where $E(\psi_t) = 0$ and $E(\psi_t'\psi_t) = \Gamma_t$ and z_t is a 2×1vector of observations of the state vector. We want the best estimate of $\widetilde{y}_t$ conditional on information available, which is $\widetilde{y}_{t|t}$.

Prior knowledge of the conditional density of $\widetilde{y}_{t-1}$ based on the information set Ω_t gives

$$E(\widetilde{y}_{t-1} \mid \Omega_t) = \widetilde{y}_{t-1|t} \tag{13}$$

and

$$E(\widetilde{y}_t \mid \Omega_t) = A\widetilde{y}_{t-1|t} + Bu_t \tag{14}$$

the conditional covariance of $\widetilde{y}_{t-1|t}$ is defined as

$$Cov(\widetilde{y}_{t-1} \mid \Omega_t) = \Lambda_{t-1} \tag{15}$$

so

$$Cov(\widetilde{y}_t \mid \Omega_t) = A\Lambda_{t-1}A' + \Gamma_t = \Lambda_t \tag{16}$$

In this framework the time varying quality and reliability of information is captured by Γ_t. The solution to this problem provides a way of optimally updating estimates of $\widetilde{y}_t$.

$$\widetilde{y}_{t|t} = \widetilde{y}_{t|t-1} + F_t(z_t - H\widetilde{y}_{t|t-1}) \tag{17}$$

where $F_t = \Lambda_t H'(H\Lambda_t H' + \Gamma_t)^{-1}$

So the best estimate is a linear combination of the previous best estimate and on a correction for the difference between the previous estimate and the latest observations.

The central point from the perspective of monetary control is that the usefulness of new observations on the economy varies over time. In some periods with a large Γ_t, little if any revisions to the optimal estimate of $\widetilde{y}_{t|t}$will take place, so a change in the interest rate setting will not take place.

We assume that this multivariate filtering is the domain of the Bank of England and the MPC. However, we can also allow for individual members of the MPC to optimally update their private forecasts. Assume that ς_{it} for each member follows an autoregressive process.

$$\varsigma_{it} = \theta_i \varsigma_{it-1} + \gamma_{it} \tag{18}$$

$$\gamma_{it} \approx N(0, \sigma^2_{\gamma_t})$$

and we observe this via

$$z_{it} = \varsigma_{it} + \delta_{it} \tag{19}$$

with

$$\delta_{it} \simeq N(0, \sigma^2_{\delta_{it}}) \tag{20}$$

Where now z is a scalar. Then the optimal private estimate for the i'th committee member is

$$\varsigma_{it|t} = \varsigma_{it|t-1} + [\sigma^2_{\gamma_{it}} / (\sigma^2_{\gamma_{it}} + \sigma^2_{\delta_{it}})] \tag{21}$$

Again the revisions to private information will vary with the quality of observations.

The standard separation of observation from control means that these optimal estimates of $\widetilde{y}_{t|t}$ and $\varsigma_{it|t}$ can be plugged into the feedback rule given in equation (10). Note, however, that whereas the form of the feedback rule is independent of the observation process, the *actual* interest rate decision is not. This will be affected by the quality and reliability of the information that flows into the monetary decision making process.

3 Data and Econometric models

3.1 The information set and measurement of variables

In this section we turn to an empirical examination of monetary policy in the UK. In the previous section the model suggested that an inflation forecast rule has been used and we attempt to test for this using information provided regularly by the Bank of England in the Inflation Report. We collected information on the kinds of data that the MPC looked at for each monthly meeting. Not all of this information is made use of in this paper but the important thing was to ensure that we conditioned only on what information was actually available at the time of each meeting.

Our dependent variable is the change in base rate agreed by the MPC at each of its meetings, from June 1997 to December 2003; these meetings are monthly and held in the first week of each month, except September 2001 when an additional meeting was held following the events on September 11. Our study of heterogeneity among the members of the MPC is based on decisions of the individual members. The source for these data are the minutes of the MPC meetings. We evaluate our models using data on monthly meetings in 2004.

Assessing monetary policy decisions in the presence of uncertainty about forecast levels of inflation and the output gap (including uncertainty both in forecast output levels and perception about potential output) requires collection of real-time data available to the policymakers when interest rate decisions are made as well as measures of forecast uncertainty. This contrasts with many studies of monetary policy which are based on realised (and subsequently revised) measures of economic activity (see Orphanides, 2002). The extent to which there is uncertainty about the forecast of the Bank of England can be inferred from the fan charts published in the Inflation Report (Britton, et al, 1998).

We also collected information on unemployment (where this typically refers to unemployment three months prior to the MPC meeting, as well data on the underlying state of asset markets (housing prices, share prices and exchange rates). We measure unemployment by the year-on-year change in ILO rate of unemployment, lagged 3 months. The ILO rate of unemployment is computed using 3 months rolling average estimates of the number of ILO-unemployed persons and size of labour force (ILO definition), both collected from the ONS Labour Force Survey. Housing prices are measured by the year-on-year growth rates of the Nationwide housing prices index (seasonally adjusted) for the previous month (Source: Nationwide). Share prices and exchange rates are measured by the year-on-year growth rate of the FTSE 100 share index and the effective exchange rate respectively at the end of the previous month (Source: Bank of England). The other current information included in the model is the current level of inflation; this is measured by the year-on-year growth rate of RPIX headline inflation lagged 2 months (Source: ONS).

Our model also includes expected rates of future inflation and forecasts of current and future output. One difficulty with using the Bank's forecasts of inflation is that they are not really informative. By definition, the Bank targets inflation over a two year horizon, so it always publishes a forecast in which (in expectation) inflation hits the target in two years time. To do anything else would be internally inconsistent. Instead, as a measure of future inflation, we use the 4 year ahead inflation expectations implict in bond markets at the time of the MPC meeting, data on which can be inferred from the Bank of England's forward yield curve estimates obtained from index linked bonds. For output, we use the Bank of England's model based mean quarterly forecasts of current and one-year-ahead GDP. As a measure of forecast uncertainty, we use the standard deviation of the one-year-ahead forecast. These measures are obtained from the Bank of England's fan charts of output; details regarding these measures are discussed elsewhere (Britton *et al.*, 1998).

3.2 An interval censoring model of base rate changes

Interest rate changes are highly clustered, with a majority of the meetings proposing no change in the base rate (see Figure 1). For the Bank of England MPC over the period of our analysis, 69 per cent of the meetings proposed that the base rate be maintained at its current level, 12 per cent recommended a rise of 25 basis points, 14 per cent recommended a reduction of 25 basis points, and 5 per cent a reduction of 0.50 per cent. This clustering has to be taken into account while studying decisions of the MPC. In this paper, we use an interval regression framework for analysis; other authors have used other limted dependent variable frameworks, like the logit/ probit or multinomial logit/ probit framework (for a recent contribution, see Chevapatrakul et al., 2001, and Gascoigne and Turner, 2003). Our choice of model is based on considerations of being able to utilize complete information available in the

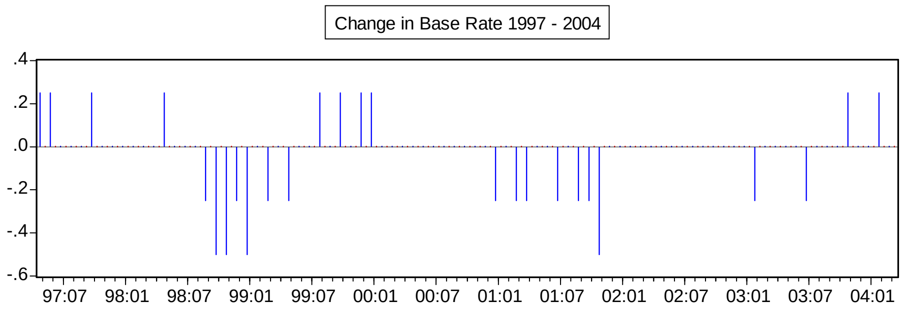

Figure 1:

monetary policy decisions, and problems relating to model specification and interpretation of multinomial logit models (Greene, 1993). We also explored a multinomial logit formulation, and found the broad empirical conclusions to be similar.

The interval regression formulation (Amemiya, 1973) is a generalisation of the tobit model where the truncation in the dependent variable is possibly different for different observation units, and the truncation cut-offs are known. The observed dependent variable in our case, $\triangle r_{t,obs}$, is the truncated version of the latent monetary policy response variable, $\triangle r_t$, where

$$\begin{aligned}\triangle r_{t,obs} &= -0.5 \quad \text{if} \quad \triangle r_t \in (-\infty, -0.375) \\ &= -0.25 \quad \text{if} \quad \triangle r_t \in [-0.375, -0.20) \\ &= 0 \quad \text{if} \quad \triangle r_t \in [-0.20, 0.20] \\ &= 0.25 \quad \text{if} \quad \triangle r_t \in (0.20, 0.375] \\ &= 0.5 \quad \text{if} \quad \triangle r_t \in (0.375, \infty)\end{aligned}$$

The wider truncation interval when interest rates are maintained (*ie.*, for $\triangle r_{t,obs} = 0$) may be interpreted as reflecting the conservative stance of monetary policy under uncertainty about forecast future output.

Under this observation scheme, we estimate the following model of MPC inflation targeting:

$$\begin{aligned}\triangle r_t &= \alpha + \beta_\pi . \pi_t + \beta_{E\pi} . \mathbb{E}\pi_t + \beta_{y0} . y_t + \beta_{y1} . \mathbb{E} y_t \\ &\quad + \beta_\sigma . \sigma(y_t) + \underline{\lambda}^{/} . \underline{Z}_{t-1} + \varepsilon_t,\end{aligned}$$

where $\underline{Z}_{t-1}$ represents current observations on unemployment ($\triangle u_t$) and the underlying state of the asset markets ($P_{hsg,t}$, $P_{FTSE,t}$ and $P_{exch,t}$). The term involving $\sigma(y_t)$ is included to incorporate the notion that the stance of monetary policy may depend on the uncertainty relating to forecast future levels of output and inflation. As was shown in the previous section increased uncertainty about the current state of the economy will tend to bias policy towards caution in changing interest rates. In particular, this strand of the literature suggests that optimal monetary policy may be more cautious (rather than activist) under greater uncertainty in the forecast or real-time estimates of output gap and inflation (Issing, 2002; Aoki, 2003; and Orphanides, 2003). Since, as previously discussed the published inflation forecast is not informative, we confined ourselves to uncertainty relating to forecast of future output growth.

3.3 Model of base rate changes with heterogeneity among members

Each member of the MPC arrives at his/ her own decision regarding interest rates, and consensus interest rate decisions are arrived at by voting on these individual proposals. In addition to consensus decisions, the Bank of England also publishes interest rate change proposals of each individual member of the MPC. The voting pattern of individual members of the MPC suggests substantial systematic differences across the committee[3]. These data on individual votes offers the opportunity to examine the voting pattern in MPC meetings, and resulting consensus decision that is arrived at as a consequence.

In the model of section 2 we have suggested that uncertainty about forecasts will affect monetary policy decisions. Moreover, that there will be heterogeneity in the way individual members incorporate this uncertainty about future levels of output (or different notions about full employment

[3]For example, of the 37 meetings which Allsopp attended, the votes for 11 were against the consensus decision, and all of these were for a lower interest rate. Similarly, Julius voted against the consensus motion in 14 of the 45 meetings; all of these in favour of a lower interest rate. Wadhwani disagreed 13 out of 37 times, each time in favour of a lower interest rate. On the other hand, King voted for a higher interest rate in 12 of the 82 meetings. Buiter disagreed from the consensus decision in 17 meetings out of 36, voting on 8 ocassions for a lower interest rate and 9 times in favour of a higher one. Nickell favoured a different interest rate decision in 10 of the 46 meetings; 6 for a lower interest rate and 4 for a higher interest rate.

level of future output) into their decisions. This appears to justify a model of individual MPC members' decisions, where there may be heterogeneity in the effect that $\sigma(y_t)$ has on the interest rate decisions (*ie.*, the coefficient β_σ).

Under a similar interval regression framework as above, we would then have the model:

$$\begin{aligned}\triangle r_{it} &= \alpha+\beta_\pi.\pi_t+\beta_{E\pi}.\mathbb{E}\pi_t+\beta_{y0}.y_t+\beta_{y1}.\mathbb{E}y_t \\ &\quad +\beta_{\sigma i}.\mathbf{I}\left[i\in MPC_t\right].\sigma(y_t)+\underline{\lambda}^{/}.\underline{Z}_{t-1}+\varepsilon_{it},\end{aligned}$$

where $\mathbf{I}\left[i\in MPC_t\right]$ is the indicator that member i was present at the MPC meeting on date t, and $\beta_{\sigma i}$ represents the responsiveness of member i's decision to uncertainty in future output. The latent variables $\triangle r_{it}$ are assigned to intervals in the same way as earlier[4]. $\mathbb{E}$ denotes the expected/forecasted value for inflation and output.

This fixed effects specification, however, cannot capture one important aspect of the heterogeneity in the decision processes of MPC members – namely, the degree of activism. As noted earlier, some MPC members' decisions are characterized by a greater degree of variability than some others'[5]. A convenient way of modeling the decision processes of MPC members would be through a random effects model. We consider the following model:

$$\begin{aligned}\triangle r_{it} &= \alpha+\beta_\pi.\pi_t+\beta_{E\pi}.\mathbb{E}\pi_t+\beta_{y0}.y_t+\beta_{y1}.\mathbb{E}y_t \\ &\quad +\underline{\lambda}^{/}.\underline{Z}_{t-1}+\left(\beta_\sigma^*+\beta_{\sigma i}\right).\mathbf{I}\left[i\in MPC_t\right].\sigma(y_t), \\ &\quad \begin{pmatrix}\beta_\sigma^* \\ \beta_{\sigma i}\end{pmatrix}\tilde{}N\left[\begin{pmatrix}\mu \\ \mu_i\end{pmatrix},\begin{pmatrix}\sigma^2 & \sigma_{0i} \\ \sigma_{0i} & \sigma_i^2\end{pmatrix}\right], \\ 0 &= n\mu+\sum_{i=1}^{I}n_i\mu_i, \\ &\quad \beta_{\sigma i}\text{'s are independent of each other,}\end{aligned}$$

where β_σ^* represents the typical response of monetary policy to uncertainty, $\beta_{\sigma i}$ is the response of the specific MPC member[6], and n and n_i's are the total

[4]There was one ocassion when an MPC member voted for a reduction of 40 basis points; this case we assigned to the interval $[-0.525,-0.275)$.

[5]Buiter and Nickell are prominent examples. Both have disagreed from the consensus interest rate decisions in a substantial number of meetings, but their proposals have not been predominantly above or below the consensus decision.

[6]Note that it is not necessary to assume that β_σ^* and $\beta_{\sigma i}$ are independently distributed, but that they are jointly normally distributed.

number of meetings, and the number of meetings that member i attends respectively[7]. This is a convenient framework, since this allows the segregation of the uncertainty term into two parts, one that is common to all members, and the other incorporates the heterogeneity.

We assume that new MPC members go with the general flow for a period of time (the first 3 meetings in our case) before their individual views start getting expressed[8]. Thus, we can use the votes in these three initial meetings to estimate μ and σ^2, and votes in the subsequent meetings to estimate the individual specific heterogeneity parameters. We further assume that $\sigma(y_t)$ is uncorrelated with the other regressors[9], so that we can first estimate the regression $\triangle r_{it} = \alpha + \beta_\pi.\pi_t + \beta_{E\pi}.\mathbb{E}\pi_t + \beta_{y0}.y_t + \beta_{y1}.\mathbb{E}y_t + \underline{\lambda}^{/}.\underline{Z}_{t-1} + u_{it}$ (using some heteroscedasticity-consistent estimator), then use the computed residuals to construct $\widehat{u}_{it}/\sigma(y_{t+12})$, and then compare the means in an analysis of variance (ANOVA) framework, taking specific care that the differences in variance for different levels of the design variable (in this case, one for each member and a common effect corresponding to β^*_σ) are adjusted for. In this way, we can identify significant contrasts between μ and the μ_i's, and between different μ_i's, while allowing the variances of the heterogeneity term to differ across the members.

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[7]A more typical application of random effects would have been through the model $\triangle r_{it} = \alpha + \beta_\pi.\pi_t + \beta_{E\pi}.\mathbb{E}\pi_t + \beta_{y0}.y_t + \beta_{y1}.\mathbb{E}y_t + \underline{\lambda}^{/}.\underline{Z}_{t-1} + u_{it}$, where $u_{it} = \beta_{\sigma i}.\mathbf{I}[i \in MPC_t].\sigma(y_t) + \varepsilon_{it}$, $\beta_{\sigma i}\tilde{}N(\mu_i, \sigma_i^2)$, $\varepsilon_{it}\tilde{}N(0, \sigma^2)$, ε_{it} and $\beta_{\sigma i}$ independently distributed. However, this model is not identifiable. One can only work with this model if $\sigma^2 = 0$, which is not satisfactory.

[8]Some recent work (see, for example, Sibert, 2003) would suggest that such an assumption is justifiable. This appears to be justified in the present context of members of the Bank of England MPC. The first vote against the motion for the 19 MPC members have been in meeting number $(1, 1, 2, 4, 4, 5, 8, 8, 8, 9, 9, 9, 9^+, 10, 18, 19, 20, 23, 74^+)$ ($^+$ denotes censored to the right). Further, none of the 19 members have proposed an interest rate lower than the consensus decision within the first 3 meetings.

[9]This is not an unreasonable assumption; the squared multiple correlation coefficient of $\sigma(y_{t+12})$ on all the other regressors is 0.336 and that on the two expected output terms is only 0.054, while the correlation coefficient between $\sigma(y_{t+12})$ and $\mathbb{E}y_{t+12}$ is only -0.096.

3.4 Another alternative random effects model

Consider the following random coefficients model:

$$\begin{aligned}\triangle r_{it} &= \alpha+\beta_{\pi}.\pi_t+\beta_{E\pi}.\mathbb{E}\pi_t+\beta_{y0}.y_t+\beta_{y1}.\mathbb{E}y_t \\ &\quad +\underline{\lambda}^{/}.\underline{Z}_{t-1}+\beta_{\sigma,it}.\mathbf{I}\left[i\in MPC_t\right].\sigma\left(y_t\right)+\varepsilon_{it}, \\ &\quad \beta_{\sigma,it}\text{ are random coefficients independent of each other and of }\varepsilon_{it}, \\ &\quad \beta_{\sigma,it}\tilde{\ }N\left(\mu_i,\sigma_i^2\right),\varepsilon_{it}\tilde{\ }N\left(0,\sigma^2\right).\end{aligned}$$

Under a interval regression framework as above, first estimate the slope-heterogeneity fixed effects model:

$$\begin{aligned}\triangle r_{it} &= \alpha+\beta_{\pi}.\pi_t+\beta_{E\pi}.\mathbb{E}\pi_t+\beta_{y0}.y_t+\beta_{y1}.\mathbb{E}y_t \\ &\quad +\underline{\lambda}^{/}.\underline{Z}_{t-1}+\beta_{\sigma i}.\mathbf{I}\left[i\in MPC_t\right].\sigma\left(y_t\right)+\varepsilon_{it}.\end{aligned}$$

Then, evaluate significance of contrasts, using

$$\widehat{\beta}_{\sigma,it}=\frac{\widehat{\varepsilon}_{it}}{\sigma\left(y_{t+12}\right)}+\widehat{\beta}_{\sigma i}$$

as a pseudo-sample from the distribution of $\beta_{\sigma,it}$.

This would constitute another way to identify significant contrasts between μ and the μ_i's, and between different μ_i's, while allowing the variances of the heterogeneity term to differ across the members.

4 Results

4.1 Consensus decisions of the MPC

Table 1 presents parameter estimates and goodness-of-fit measures for the estimated model for overall MPC interest rate decisions. These are the change in interest rates that are actually implented. Results using OLS and interval regression are presented here; the implications of estimates of a multinomial logit model are similar, but are not presented because these results are not directly comparable. It is clear that expected inflation and expected output matter for the interest rate decision, with currently observed inflation and output playing no role. This confirms the assertion of section 2 that the Bank of England follows an inflation forecast regime. It is also noticeable that movements in the stock market play a significant role. The coefficients on unemployment, house price inflation and the exchange rate have the right sign but are not significant. Output uncertainty has the expected sign, more uncertainty yends to militate against a change in interest rates, but it is not significant.

TABLE 1: Inflation Targeting Model Estimates, Consensus MPC Interest Rate Decisions

Variables	**Ordinary Least Squares**	**Interval Regression**
π_t	0.016	0.022
$\mathbb{E}\pi_t$	0.068*	0.088*
y_t	0.001	0.033
$\mathbb{E}y_t$	0.145**	0.192**
$\triangle u_t$	-0.077	-0.049
$P_{hsg,t}$	0.976^{+}	1.246
$P_{FTSE,t}$	0.305^{+}	0.731**
$P_{exch,t}$	0.005	0.007
$\sigma(y_t)$	-0.231	-0.200
constant	-0.543	-0.864*
Number of meetings	82	82
Goodness of fit	$F(9, 72) = 5.82$	Wald $\chi^2(9) = 175.42$
	$Prob. > F = 0.0000$	$Prob. > \chi^2 = 0.0000$
	$\mathbb{R}^2 = 0.4955$	Log pseudo-likelihood $= -52.1030$

Notes: 1. $^{**}, ^{*}, ^{+}$: Significant at 1 percent, 5 percent and 10 percent level respectively.

4.2 Decisions of individual members with fixed effects heterogeneity

Table 2 presents interval regression parameter estimates and goodness-of-fit measures for the estimated model of MPC members' interest rate decisions. In this case we are exploiting the extra information that is provided by the published voting records of each of the Committee members. In addition to taking advantage of the heterogeneity in individual members' decisions, we also estimated a model where the members belong to two types, depending on whether they are internal members (from the Bank of England) or external MPC members.

TABLE 2: Inflation Targeting Model Estimates, Individual MPC Members' Interest Rate Decisions

Variables	Heterogeneity: Indiv. members	Heterogeneity: Int. vs. Ext.	No heterogeneity
π_t	-0.023 (0.331)	-0.019 (0.436)	-0.020 (0.436)
$\mathbb{E}\pi_t$	0.092 (0.000)**	0.089 (0.000)**	0.089 (0.000)**
y_t	0.000 (0.999)	-0.009 (0.593)	-0.011 (0.513)
$\mathbb{E}y_t$	0.205 (0.000)**	0.202 (0.000)**	0.199 (0.000)**
$\triangle u_t$	-0.158 (0.001)**	-0.163 (0.001)**	-0.164 (0.001)**
$P_{hsg,t}$	1.587 (0.000)**	1.886 (0.000)**	1.885 (0.000)**
$P_{FTSE,t}$	0.655 (0.000)**	0.691 (0.000)**	0.694 (0.000)**
$P_{exch,t}$	0.006 (0.000)**	0.006 (0.000)**	0.006 (0.000)**
$\sigma(y_t)$			-0.308 (0.194)
– × Allsopp	-0.242 (0.312)		
– × Barker	-0.164 (0.500)		
– × Bean	-0.163 (0.497)		
– × Bell	-0.219 (0.374)		
– × Budd	-0.112 (0.637)		
– × Buiter	-0.184 (0.442)		
– × Clementi	-0.169 (0.478)		
– × George	-0.175 (0.463)		
– × Goodhart	-0.170 (0.476)		
– × Julius	-0.301 (0.202)		
– × King	-0.131 (0.581)		
– × Lambert	-0.198 (0.450)		
– × Large	-0.077 (0.753)		
– × Lomax	-0.136 (0.600)		
– × Nickell	-0.177 (0.463)		
– × Plenderleith	-0.183 (0.442)		
– × Tucker	-0.098 (0.687)		

TABLE 2 Contd.: Inflation Targeting Model Estimates, Individual MPC Members' Interest Rate Decisions

Variables	Heterogeneity: Indiv. members	Heterogeneity: Int. vs. Ext.	No heterogeneity
$- \times$ Vickers	-0.137 (0.563)		
$- \times$ Wadhwani	-0.287 (0.227)		
$- \times$ INTERNAL		-0.274 (0.243)	
$- \times$ EXTERNAL		-0.341 (0.149)	
constant	-0.828 (0.001)**	-0.717 (0.005)**	-0.697 (0.007)**
No. of member-meetings	696	696	696
Goodness of fit: Wald χ^2	$\chi^2(27) = 1182.01$	$\chi^2(10) = 1162.74$	$\chi^2(9) = 1077.37$
Prob. $> \chi^2$	0.000	0.000	0.000
Log pseudo-likelihood	-495.4422	-518.4123	-534.7516

1. p-values in parentheses.
2. $^{**},^{*},^{+}$: Significant at 1 percent, 5 percent and 10 percent level respectively.
3. Joint significance of the 19 individual member heterogeneity terms (LRT): $-2.\ln L = 79.444$, 19 d.f., p-value 0.000.
4. Joint significance of the INTERNAL and EXTERNAL heterogeneity terms (LRT): $-2.\ln L = 46.868$, 2 d.f., p-value 0.000.

The broad conclusions from the model are similar to those for the overall decisions of the MPC. However, we now find that developments in asset markets do have a significant role to play in monetary policymaking. None of the heterogeneity coefficients are individually significant, but they are jointly significant. However, the signs of the heterogeneity parameters are in the direction of our *a priori* expectations.

4.3 Decisions of individual members with random effects heterogeneity

The fixed effects estimates obtained in the previous subsection were not entirely satisfactory for two reasons. First, none of the estimated heterogeneity coefficients were significant at the 10 percent level, and second, this setup does not allow us to explore individual specific heterogeneity after controlling for the "activism" issue apparent in some MPC members. Further, these two issues may indeed be related; while the lack of significance may be a sample size issue, we would like to control for the differences in variance in a random effects framework to have a closer look at the contrasts.

Table 3 reports estimates of our random effects model.

TABLE 3: Inflation Targeting Model Estimates, Individual MPC Members' Interest Rate Decisions – Random Effects

Variables	$\widehat{\mu}+\widehat{\mu}_i$	$Var\left(\beta_\sigma^*+\beta_{\sigma i}\right)$
Allsopp	0.1452-0.7294$^+$	0.1517
Barker	0.1452-0.3270	0.1446
Bean	0.1452-0.2593	0.1197
Bell	0.1452-0.8361	0.1256
Budd	0.1452+0.2538	0.1541
Buiter	0.1452-0.0870	0.2070
Clementi	0.1452-0.0189	0.1389
George	0.1452-0.1146	0.1317
Goodhart	0.1452+0.0549	0.1317
de Julius	0.1452-0.7718**	0.1303
King	0.1452+0.1644	0.1373
Lambert	0.1452+0.0000	0.1569
Large	0.1452+0.2783	0.1717
Lomax	0.1452+0.0000	0.1569
Nickell	0.1452-0.3346	0.1635
Plenderleith	0.1452-0.0444	0.1383
Tucker	0.1452+0.0006	0.1210
Vickers	0.1452+0.1279	0.1642
Wadhwani	0.1452-0.7698*	0.1534

1. **,*,$^{+}$: Significant at 1 percent, 5 percent and 10 percent level respectively.
2. The estimates do not explicitly assume independence of β_σ^* and $\beta_{\sigma i}$.
3. Other significant contrasts are: $\mu_{\text{King}}-\mu_{\text{Allsopp}}$: 0.8938^{**}, $\mu_{\text{King}}-\mu_{\text{Bell}}$: 1.0275^{+}, $\mu_{\text{King}}-\mu_{\text{Julius}}$: 0.9362^{**}, $\mu_{\text{King}}-\mu_{\text{Wadhwani}}$: 0.9342^{**},and $\mu_{\text{Clementi}}-\mu_{\text{Julius}}$: 0.7529^{*}.

The estimates in Table 3 capture several of the interesting features of heterogeneity discussed earlier. There are several significant contrasts, both with respect to the typical average response of monetary policy μ and between member-specific average responses (μ_i's), and that the estimates reflect the expected direction of these contrasts. The degree of "activism" in any member is reflected in the estimated variance of $\beta_\sigma^* + \beta_{\sigma i}$. For example, Willem Buiter is the most activist of all MPC members, but he did not have a particular bias in favour of lower or higher interest rates on average. By contrast, Anna de Julius had a significant bias in favour of lower interest rates, along with Christopher Allsop but they were more activist thatn the average. Charlie Bean stands out as being both close on average to the actual MPC decision and the least activist. Thus, this appears to be a reasonable model of monetary policy decision-making in the presence of uncertainty.

4.4 Forecast performance of the estimated models

The comparison of actuals and (in sample) predicted decisions of the MPC, in terms of level of the base rate and interest rate changes are shown in Figures 1 and 2 respectively. These predictions based on estimates in Table 1, *ie.*, they do not incorporate heterogeneity in the decisions of the individual MPC members.

Figure 1 indicates good conformity between the model predictions and the actual level of the base rate. Figure 2 indicates that monetary policy decisions follow the direction predicted by our model, while at the same time indicating a degree of cautiousness in policy. To explore whether such policy cautiousness may be reflected in the heterogeneity of the individual MPC members' decisions, we use the model with fixed effects heterogeneity to predict the decisions of individual members (and consequently consensus decisions of the committee) for the first two months of 2004. These out-of-sample predictions are summarised in Tables 4a, 4b and 4c. The estimated model predicts MPC decisions fairly well.

TABLE 4a: Predictions of MPC Members' Decisions, January 2004

	Actual: 0.00	**Actual: 0.25**	
Predicted: 0.00	5	0	**5**
Predicted: 0.25	3	1	**4**
	8	**1**	**9**

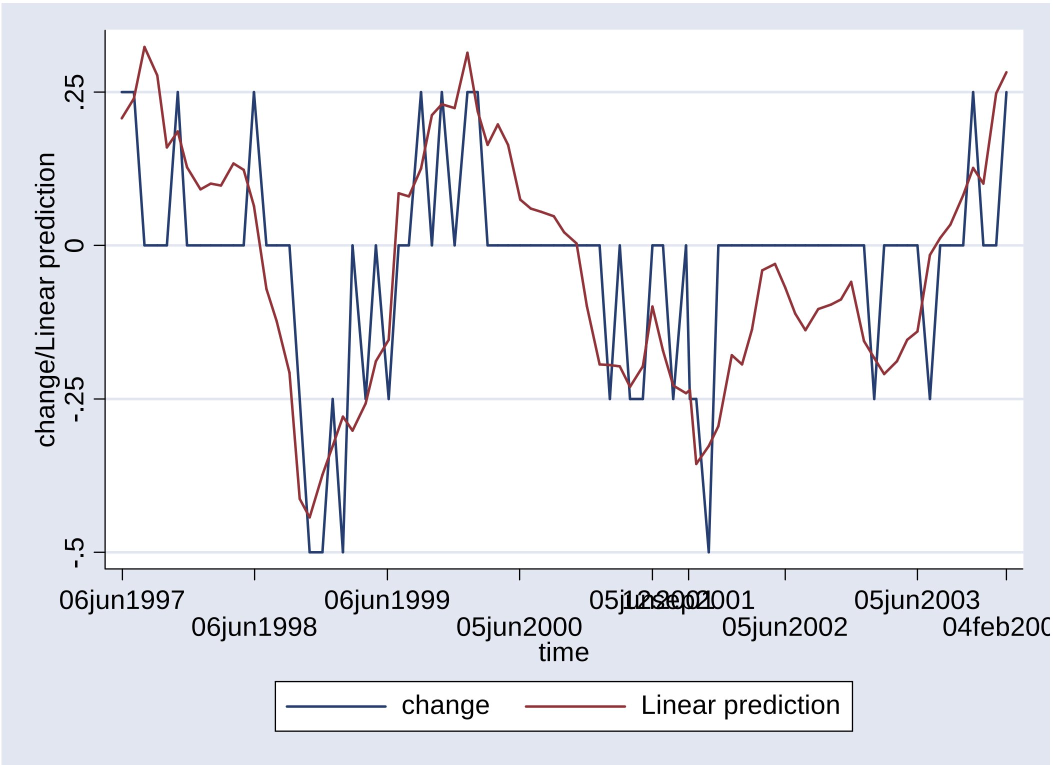

Figure 2: Interest rates, predicted and actual (Based on Table 1)

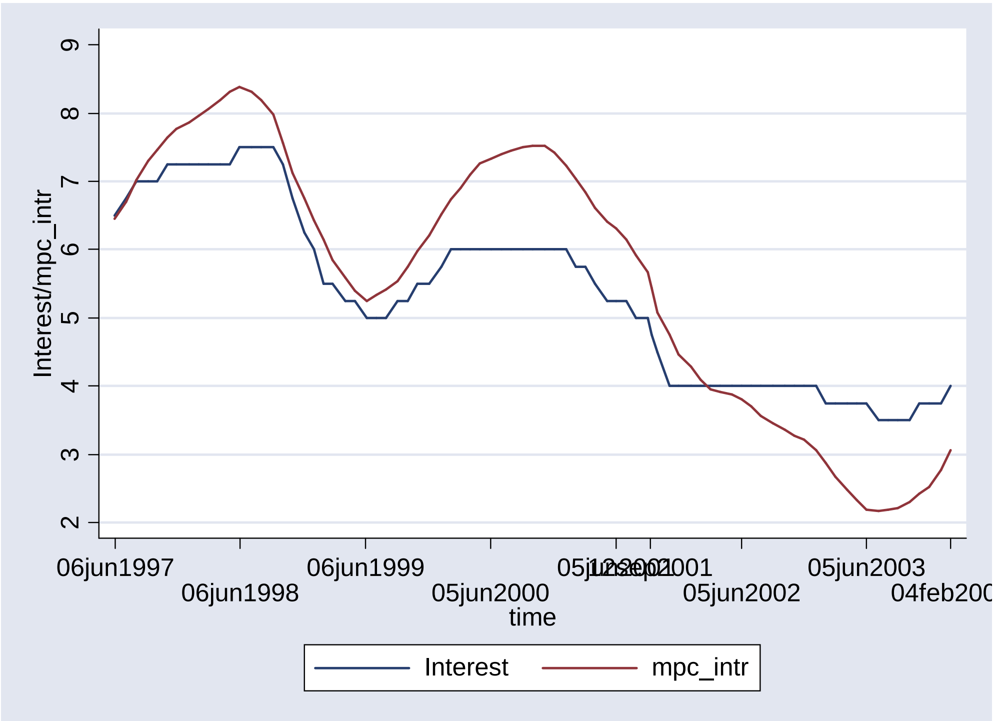

Figure 3: Interest rate changes, predicted and actual (Based on Table 1)

TABLE 4b: Predictions of MPC Members' Decisions, February 2004

	Actual: 0.00	Actual: 0.25	
Predicted: 0.00	0	2	**2**
Predicted: 0.25	0	7	**7**
	0	**9**	**9**

TABLE 4c: Predictions of MPC Consensus Decisions

Meeting	Actual	Predicted
January 2004	0.00	0.00
February 2004	0.25	0.25

5 Conclusions

In this paper we have considered the conduct of UK monetary policy from 1997. Since then the Bank of England has had operational independence and decisions on interest rates made by the majority verdict of a Monetary Policy Committee. An enormous amount of information is provided about the data made available to the MPC and the decisions on interest rates decided upon by individual members. We find that an inflation forecast regime best describes what the MPC does but we also find an important role for developments in foreign exchange, equity and housing markets, once we exploit the extra information that is available in the individual voting records of MPC members. A role can also be found for unemployment.

References

6 References

References

[1] Amemiya, T. (1973). Regression Analysis when the Dependent Variable is Truncated Normal. *Econometrica* **41**. 997–1016.

[2] Aoki, K. (2003). On the Optimal Monetary Policy Response to Noisy Indicators. Journal of Monetary Economics 50(3), pp. 501-23.

[3] Bean, C. (2003) "Asset Prices, Financial Imbalances and Monetary Policy: Are Inflation Targets Enough?", mimeo.

[4] Bernanke BS and M Gertler (2001), 'Should central banks respond to movements in asset prices?', American Economic Review, 91(2), pp 253–257.

[5] Cecchetti SG, H Genberg, J Lipsky and S Wadhwani (2000), Asset prices and central bank policy, Geneva Reports on the World Economy No 2, International Center for Monetary and Banking Studies and Centre for Economic Policy Research, Geneva.

[6] Cecchetti SG, H Genberg and S Wadhwani (2003), 'Asset prices in a flexible inflation targeting framework', in WC Hunter, GG Kaufman and M Pomerleano (eds), Asset price bubbles: the implications for monetary, regulatory, and international policies, MIT Press, Cambridge, Mass, pp 427–444.

[7] Gascoigne, J. and Turner, P. (2003) "Asymmetries in Bank of England Monetary Policy ", Sheffield Economic Research Paper Series No. 2003007.

[8] Greene, W. (1993). Econometric Analysis. Prentice-Hall, Inc.

[9] Issing, O. (2002) "Monetary Policy in a World of Uncertainty". Presented at the Economic Policy Forum, Banque de France, Paris, 9 December 2002..

[10] Batini, N., Harrison, R., and S. Millard, (2001), 'Monetary Policy Rules for an Open Economy', Bank of England Working Paper.

[11] Britton, E., Fisher, P. and Whitley, J. (1998). The Inflation Report Projections: Understanding the Fan Chart. Bank of England Quarterly Bulletin 38, February 1998. 30–37.

[12] Budd, Alan (1998), "The Role and Operations of the Bank of England Monetary Policy Committee ", Economic Journal , 108, 451, pp 1783-94.

[13] Chevapatrakul, T., Mizen, P. and Kim, T.-H. (2001). Using Rules to Make Monetary Policy: The Predictive Performance of Taylor Rules versus Alternatives for the United Kingdom 1992 - 2001. Mimeo.

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

[15] Clarida, R, Gali, J and Gertler, M (1997b), 'Monetary Policy Rules in Practice: Some International Evidence', paper prepared for the 20th International Seminar on Macroeconomics.

[16] Edison, Hali J. and Jaime Marquez (1998) "U.S. Monetary Policy and Econometric Modeling: Tales from the FOMC Transcripts 1984-1991", Economic Modelling, 15, pp. 411-428

[17] Herrendorf, Berthold & Neumann, Manfred J.M. (2003) 'The Political Economy of Inflation, Labour Market Distortions and Central Bank Independence', Economic Journal, 113 (484), 43-64.

[18] Holly, S. and Hughes Hallett, A. (1989) *Optimal Control, Expectations and Uncertainty*, Cambridge University Press.

[19] Neumann, M.J.M (2002) "Transparency in Monetary Policy", Atlantic Economic Journal, 30, 4, 353-365.

[20] Orphanides, A. (2003). Monetary Policy Evaluation with Noisy Information. Journal of Monetary Economics 50(3), Special Issue on the Swiss National Bank/Study Center Gerzensee Conference on Monetary Policy under Incomplete Information. 605–631.

[21] Sibert, A. (2003). Monetary Policy Committees: Individual and Collective Reputations. Review of Economic Studies 70(3). 649–665

[22] Svensson, L (1997a), 'Inflation Forecast Targeting: Implementing and Monitoring Inflation Targets', European Economic Review, Vol 41, No 6, pages 1,111-46,

[23] Svensson, L (1997b), 'Inflation Targeting: Some Extensions', Working Paper IIES, Stockholm, February.