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# Misperceptions and monetary policy in a New Keynesian model

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**Abstract**

This paper studies the consequences for the monetary policy design of information shortages on the part of the private sector. We model these shortages as exogenous shocks to expected output, which through an IS curve, disturb demand and output themselves. We constrain policymakers to follow Taylor-like rules but allow them to optimise coefficients: we find that the presence of misperceptions makes the optimised Taylor rule respond more aggressively to inflation and the output gap. We also find that if the policymaker is uncertain about misperceptions, then it is less costly to assume they are pervasive when they are not than the reverse. In other words, setting policy on the basis that the private sector is subject to misperceptions is a 'robust' policy.

**Summary**

Over the past decade, equity prices in the United Kingdom and other major industrial countries have risen sharply and have subsequently fallen back. Towards the end of the period in which equity prices were rising, UK household borrowing and house price inflation also picked up. One – but by no means the only – explanation for these events might be that people expected future incomes to be higher and so increased their borrowing to bring forward this higher expected future income in order to smooth consumption. But what if these expectations for future income were over-optimistic – what if the private sector expectation of higher future income were a misperception? How should monetary policy respond in a situation where behaviour today is influenced by misperceptions? In this paper, we discuss how monetary policy might react in an environment where behaviour may have been driven by over-optimistic expectations – misperceptions – about future output.

We develop a model to analyse how monetary policy might respond to these potential misperceptions about future output. Our laboratory economy is a calibrated New Keynesian model in which both the output gap and inflation depend on the expected future output gap and inflation. Both inflation and the output gap also display persistence. Misperceptions are modelled as persistent demand shocks, which feed through the expectations channel of current demand into the determination of output. It is assumed that while policy cannot create or dispel misperceptions, it can offset their effects. We assume that policy takes the form of a 'Taylor rule', that is, the central bank sets the interest rate in response to two variables – inflation and the output gap. Within this class of simple policy rules, we describe how optimal weights on output and inflation in the policy rule change in response to misperceptions. We also calibrate the costs and benefits of responding to misperceptions under uncertainty.

Using this laboratory we come to the following conclusions. First, and unsurprisingly, we find that misperceptions cause welfare to be lower. Furthermore, varying the persistence of the misperceptions, we find that welfare decreases as persistence increases – the longer agents are wrong, the worse are the effects of a given misperception. Second, by allowing for some rule-of-thumb behaviour, we look at how the degree of forward lookingness interacts with misperceptions. We find that in our set-up forward lookingness is bad – the more forward looking agents are, the more welfare is reduced by a given misperception. Intuitively, this result comes

from the fact that agents who are more forward looking will try to bring forward more of their misperceived higher expected future income. Third, policy can partially offset the effects of misperceptions by responding more actively to both deviations of inflation from target and to output gaps. Because misperceptions distort demand, output and inflation are pushed in the same direction and so policy should respond more to both in order to offset the effects of misperceptions. Policy should, however, place relatively less weight on output gap fluctuations. How policy should react to misperceptions depends crucially on the persistence of the misperception – the more persistent the misperception, the less weight the policymaker should place on output. This result is intuitive; as the noise in the target variables increases the less weight should be placed on it. Fourth, we consider situations in which policymakers are uncertain about the process driving misperceptions. We find that unless the policymaker is confident there are no misperceptions, or that any misperceptions will be quickly corrected, the policymaker should assume that persistent misperceptions are present: policy rules derived on the assumption that misperceptions are persistent do better in the event that this assumption is incorrect than do policies based on assuming no misperceptions when in reality the opposite is true. When we also include policymaker uncertainty about the degree of output persistence, we note that, in the presence of misperceptions, the robust 'safe' strategy is to overestimate the degree of forward-looking expectations (and so the size of the misperception).

## 1 Introduction

Recently, there has been an active discussion on asset price misalignments and the relationship between asset price booms and monetary policy. Changes in asset valuations, especially the rise in technology/new economy stock prices from the mid-1990s and their subsequent collapse in 2000, were dramatic, and these changes probably influenced private spending as well. These asset price movements may have been rooted in some deep fundamental changes – for example productivity may have increased. Alternatively, they may have been based on incorrect estimates of future income. And if there had been such a misperception about future income, one might expect a pickup in demand and inflation as agents tried to bring this illusory extra income forward. How should monetary policy react in an environment where behaviour may have been driven by over-optimistic expectations – misperceptions – about future output?

In this paper, we develop a dynamic New Keynesian model to analyse how monetary policy might respond to potential misperceptions about future output. Our model set-up is based on that used by Bean (2004). We model misperceptions as persistent demand shocks, which feed through the expectations channel of current demand into the determination of output, driving up both the output gap and inflation. We assume that policy cannot correct these misperceptions; it can only respond to them by designing its policy rule accordingly. We constrain policy to take the form of a Taylor rule,(1) and within this class, study optimal policy responses to misperceptions – in the form of optimal relative weights on output and inflation.

The key insights from our model are as follows. First, and obviously, we find that misperceptions cause welfare to be lower. Furthermore, we find that welfare decreases as the persistence of the misperceptions increases – the longer agents are wrong, the worse are the effects of a given misperception. Second, by allowing for some rule-of-thumb behaviour in the determination of output, we study how the degree of forward lookingness in output expectations interact with misperceptions. We find that forward lookingness can be dangerous – the more forward looking agents are, the more welfare is reduced by a given misperception. Third, we find that, in the face of a misperception, policy should place relatively less weight on output gap fluctuations (and more on inflation fluctuations). And, the more persistent the misperception, the less weight the policymaker should place on output. Third, even if the policymaker cannot observe

(1) This is a theoretical assumption and not intended to claim that the Bank of England or any other authority follows such a rule.

misperceptions, setting policy on the basis that the private sector's behaviour is subject to misperceptions is a 'robust' strategy. Finally, when we also include policymaker uncertainty about the degree of output persistence (in addition to uncertainty about misperceptions), it is found that the robust strategy is to overestimate the degree of forward-looking expectations - so to overestimate the size of the misperception.

This paper is obviously related to the growing literature on asset price bubbles and how monetary policy should react to them; for example see Bernanke and Gertler (2001) and Cecchetti *et al* (2000). This literature discusses asset price bubbles specifically, where these bubbles can be seen as a manifestation of a misperception about the future earnings of firms. In our paper, we focus on the broader effects of a more general private sector misperception about future output (see also a companion paper Jääskelä and McKeown (2005), which characterises misperceptions in an analytically tractable static framework). So while an asset price bubble would be consistent with the misperceptions in our paper, these misperceptions about future output are likely to have non asset-price specific effects on current behaviour. In studying private sector misperceptions our paper is closest to that of Bordo and Jeanne (2002). They use a highly stylised three-period model and explicitly consider the interaction of private sector misperceptions and policy. Bordo and Jeanne find that, in the face of private sector misperceptions, optimal policy is more likely to be pre-emptive - by changing interest rates to reduce how much firms might want to borrow today - in order to prevent a credit crunch in the future.

In studying misperceptions, our paper can also be seen as similar to some of the literature on bounded rationality and learning. For example, Orphanides and Williams (2004, 2005) consider policy where the private sector has to learn about – or has misperceived – the structural parameters of the economy. Similarly, Gaspar *et al* (2003) consider learning about structural parameters in a model very similar to the one outlined in our paper. While both of these papers are concerned with private sector misperceptions about parameters (but they incorporate the 'learnable' reduced-form structure of the economy), in our paper we consider misperceptions about (future) variables. And despite this difference in emphasis, the findings in all these papers suggest that policy can improve welfare by adopting more 'conservative' monetary policy.

The remainder of the paper is structured as follows. Section 2 describes the model economy and particularly explains how we model misperceptions shocks. Section 3 illustrates the properties of optimised simple policy rules when the policymaker has the precise knowledge of the form and magnitude of animal spirits. Section 4 describes robust policy strategies when the policymaker potentially fails to identify misperceptions. Finally, Section 5 summarises our findings.

## 2 The model economy

The model we use to evaluate the performance of monetary policy rules is a simple, two equation closed economy, New Keynesian model. Our set-up is a slight modification of that used by Bean (2004). We assume the following structural equations for the output gap $x_t$ and inflation $\pi_t$

$$x_t = \alpha_1 E_t x_{t+1} + (1-\alpha_1)x_{t-1} - \alpha_2 \left[ i_t - E_t \pi_{t+1} \right] + g_t \quad \textbf{(1)}$$

$$\pi_t = \beta_1 E_t \pi_{t+1} + (1-\beta_1)\pi_{t-1} + \beta_2 x_{t-1} + h_t \quad \textbf{(2)}$$

where $x_t$ is the output gap, $\pi_t$ is the inflation rate, $i_t$ is the nominal short-term interest rate, $E_t$ is the expectations operator (based on time $t$ information), $g_t$ is a shock to the output gap equation and $h_t$ is a shock to the inflation equation. We assume that the shocks follow AR(1) processes:

$$\begin{aligned} g_t &= \rho^g g_{t-1} + \varepsilon_{g,t} \\ h_t &= \rho^h h_{t-1} + \varepsilon_{h,t} \end{aligned}$$

The model exhibits both output and inflation persistence. There are various ways to add endogenous inertia into the model. For example, Amato and Laubach (2003) assume that a fraction of the consumers (and price-setters) are allowed to optimise consumption (prices) every period, and the fraction $\omega_c$ uses a rule of thumb instead of reoptimising.[(2)(3)] We do not intend to provide a fully-fledged microfounded model here, but focus on an empirically plausible parameterisation of the model (which can be obtained from the first principles).

The model is closed with a policy rule for the nominal interest rate

$$i_t = c_1 \pi_t + c_2 x_t$$

The policymaker's problem is to set interest rates to minimise expected loss by choosing the coefficients ($c_j$) in the policy rule. We assume that the central bank has a conventional quadratic loss function with the periodic loss given by:[(4)]

$$L_t = \mu_\pi var(\pi_t) + var(x_t) + \mu_{\Delta i} var(i_t - i_{t-1}) \qquad \textbf{(3)}$$

where $\mu_\pi$, $\mu_{\Delta i}$ denote weights attached to the stabilisation of inflation and the change in nominal interest rates. We assume that policymakers can commit to the optimised simple rule. Restricting the policymaker to a set of simple policy rules provides an easy way to quantify how policy reacts to changes in the economy. Furthermore, the simple Taylor rule is able to mimic the much more complicated optimal reaction function under commitment (Levin *et al* (1999); Rudebusch and Svensson (1999)[(5)] and forward-looking Taylor rules provide a reasonably accurate description of actual interest rate behaviour (Clarida *et al* (1998)).

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(2) This gives the following structural model parameters, which are important when studying the cost of potential misperceptions as will be seen below. $\alpha_1 = \frac{1}{1+\omega_c}$, $\alpha_2^{-1} = \frac{1+\omega_c}{1-\omega_c}\sigma$, $\beta_2 = \frac{\beta\theta}{\theta+\omega_p(1-\theta(1-\beta))}$, where the parameter $\omega_c$ is the fraction of rule-of-thumb consumers, $\sigma$ is the elasticity of intertemporal substitution, $\omega_p$ is the fraction of rule-of-thumb firms, $\beta$ is the discount factor and $\theta$ is the Calvo parameter.

(3) Alternatively, the utility function could display internal or external habit formation. As the importance of habits increases, consumers are less willing to substitute consumption over time, that is, the elasticity of intertemporal substitution $\gamma \equiv -\frac{u'(C_t^i)}{u''(C_t^i)C_t^i}$ falls as habits increase. Utility maximisation (with external habits) of form $U\left(C_t^i\right) = Z_t \frac{\left(C_t^i - hC_{t-1}\right)^{1-\sigma}}{1-\sigma}$, subject to a standard budget constraint $P_t C_t^i + (1+i)^{-1} B_t = B_{t-1}$, (and assuming that $C_t^i = C_t$) in equilibrium leads to the following log-linearised consumption Euler equation $c_t = \frac{1-h}{1+h} c_{t-1} + \frac{1}{1+h} E_t \pi_{t+1} - \frac{1-h}{(1+h)\sigma}[i_t - E_t \pi_{t+1}] + \varepsilon_t$.The real interest rate has a negative impact on current consumption iff $0 < h < 1$.

(4) In the following experiments the weights of the loss function are held constant, while the parameters of the IS curve are changed. The potential problem in microfounded models, where the loss function is a measure of a representative household's welfare, is that the parameters in the loss function (and also its functional form) depend on the underlying details of the model. However, an *ad hoc* loss function can be more robust to model misspecification than the maximisation of representative agent's utility function (see Levin and Williams (2003); and also Levin *et al* (1999, 2003); Orphanides and Williams (2002)).

(5) Dennis (2004), however, points out that in some model settings, if the policymaker is not allowed to respond to current period shocks, the performance of the (lagged) Taylor rule becomes noticeably inferior to the fully optimal precommitment rule.

The model above sets out the full information benchmark case. The values of the model parameters are chosen to represent 'compromise values' in the literature. For example, Smets (2003) estimates a similar model for the euro area, using annual data with GMM over period 1977-97 and obtains a parameter set as follows: $\alpha_1 = 0.56$, $\alpha_2 = 0.06$, $\sigma_y = 0.65$, $\beta_1 = 0.52$, $\beta_2 = 0.18$, $\sigma_\pi = 0.7$.

A quick glance at other estimates reveals a range for $\beta_2$ from 0.06 (Smets (2003)) to 6 (Rotemberg and Woodford (1999)). Turning to our inflation equation, Rudebusch (2002) concludes that a plausible range for $\beta_1$ would be from 0.4 to 1. The benchmark parameter values we use in our simulations are as follows:

**Table 1: Benchmark parameter values $\rho^s = \sigma_s^2 = 0$**

| Output | | Inflation | | Preferences | |
|---|---|---|---|---|---|
| $\alpha_1$ | 0.67 | $\beta_1$ | 0.60 | $\mu_\pi$ | 1.00 |
| $\alpha_2$ | 0.33 | $\beta_2$ | 0.21 | $\mu_{\Delta i}$ | 0.10 |
| $\rho^g$ | 0.10 | $\rho^h$ | 0.10 | | |
| $\sigma_g^2$ | 0.55 | $\sigma_h^2$ | 0.55 | | |

### *2.1 Modelling a misperception shock*

In this paper, we model misperceptions by assuming that agents perceive that there is a positive shock to expected future income (and hence to consumption as well). We assume that misperceptions feed into the economy *via* the expectations channel as follows.

$$\begin{aligned} E_t\widehat{x}_{t+1} &= E_t x_{t+1} + s_t \\ s_t &= \rho^s s_{t-1} + \varepsilon_{s,t} \\ \varepsilon_{s,t} &\sim N(0, \sigma_s^2) \end{aligned} \quad \textbf{(4)}$$

In other words, we assume that the misperception shock can be approximated by a first-order autoregressive process. This stochastic process captures the potential persistence in the misperception: some part of the misperception in the present period is expected to be carried over into the next period's value. Bean (2004) assumes that 'animal spirits' are white noise shocks.

Bernanke and Gertler (2001), and Batini and Nelson (2000) assume a bubble process, where the asset price bubble always grows at a certain rate and exists for a few periods before breaking (and will not occur any more after that).

Essentially, misperception shocks add noise to the output gap (aggregate demand) process, and the IS schedule under the influence of 'animal spirits' now reads

$$x_t = \alpha_1(E_t x_{t+1} + s_t) + (1 - \alpha_1)x_{t-1} - \alpha_2 \left[i_t - E_t \pi_{t+1}\right] + g_t$$

Although this is a very crude and simple way to model misperceptions, we think an exogenous disturbance added to the expectations augmented output gap highlights nicely some characteristics of 'animal spirits' by allowing us to think about how the persistence of a misperception affects behaviour and policy. Hansen and Sargent (2004) assume that model misspecifications distort the approximating model by modifying the error vector, which is our approach as well. In particular, they assume that uncertainty is a linear function of the predetermined variables of the model. Our approach is, however, different to Hansen and Sargent's because we want to focus on a specific 'misspecification' – that is about future expected income – and because we do not specify the misspecification as a function of other variables in the model – to keep the exposition simple.

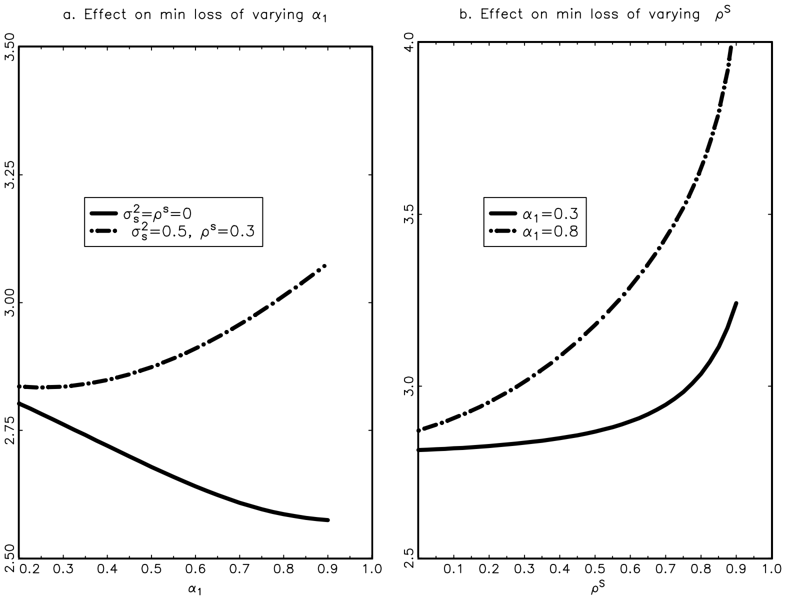
## 3 Optimal policy

Now that we have specified our model and our specification of misperceptions, we can turn to the analysis of how optimised policy rules respond as we experiment with the 'misperception shock'. We do this by comparing the unconditional variances of the goal variables under different scenarios, with varying assumptions about the degree of misperception involved.

### *3.1 Policymaker understands misperception*

We assume here that the policymaker knows the process driving private sector misperceptions and can set policy accordingly. The policy rule contains the current period variables $\pi_t$ and $x_t$, so implicitly it also contains the current period shocks $g_t$, $h_t$, and more importantly a potential misperception shock $s_t$. The policymaker acts like a Stackelberg leader: the equilibrium is calculated assuming that the private sector takes the policy rule (and its coefficients) as given when forming (model consistent) expectations, which may or may not contain misperceptions ($s_t$).

**Chart 1: Minimised losses as function of $\alpha_1$ and $\rho^s$**




As a benchmark, optimal policy in the absence of misperceptions, and subject to a calibration of the other parameters is given by(6)

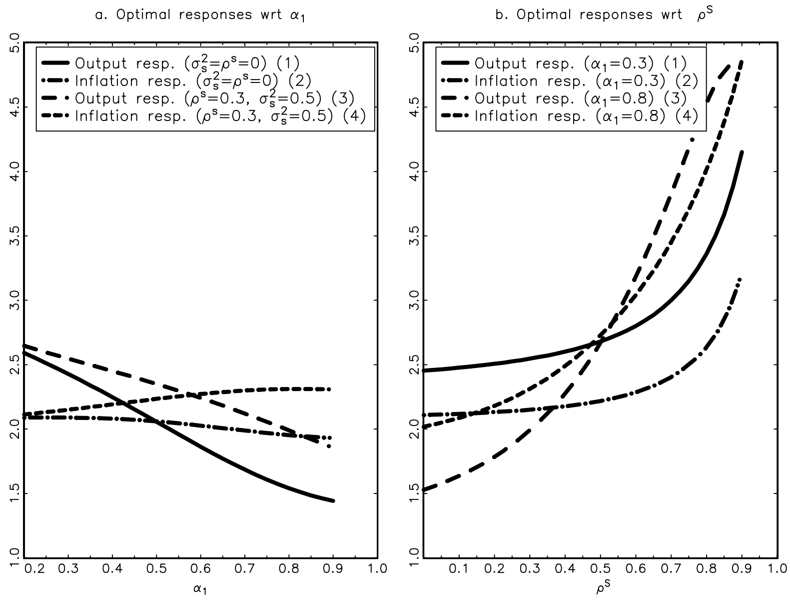
$$i_t = 2.00\pi_t + 1.74x_t$$

We turn now to see how $\alpha_1$ (the degree of forward-looking output expectations) and $\rho^s$ (the persistence of the misperception shock) affect policy design and welfare. When modelling misperceptions we have assumed that $\alpha_1$ multiplies the size of the 'expectations shock' $s_t$. Intuitively, more forward-looking consumers are more prone to misperceptions, and hence this forward-looking mechanism increases the degree of misperceptions. Conversely, it can be argued that if the economy exhibits lots of inertial features it is more difficult to correct a mistake made in the past (even in the case of a one-off misperception). This is because inertial consumers and firms carry forward the effects of past misperceptions.

In Chart 1 losses are recorded on the vertical axis, and the horizontal axis records the values of the free parameter, in each case, $\alpha_1$ in panel (a) and $\rho^s$ in panel (b). Panel (a) in the left-hand side highlights that the welfare losses are always higher under the misperceptions model. The solid line shows the minimised loss as a function of $\alpha_1$ (the degree of forward-looking expectations in the determination of the aggregate demand process) when there is not a misperceptions shock

(6) To solve the policy problem we use algorithms, as explained, for instance, in Söderlind (1999).

**Chart 2: Optimal policy responses when the misperception shock is observable**




present, and the dashed-dotted line records losses under a misperceptions shock as function of the $\alpha_1$ parameter, which now multiplies the effects of a shock as the degree of forward-looking expectations increases. Note that apart from the misperception shock and varying of the $\alpha_1$ parameter we keep the model specification as it is the benchmark setting. In this experiment, we are only interested in looking at the effect of changing the importance of misperceptions shocks relative to that of the benchmark model.

Under a modestly persistent misperception shock ($\sigma_s^2 = 0.5$ and $\rho^s = 0.3$), welfare losses increase as expectations become increasingly forward looking. On the other hand, losses decline monotonically in the degree of forward-looking expectations when there are no misperception shocks present. This is because the effects of the standard demand shocks wane rapidly. The persistence of the misperception shock determines the relative importance of misperception shocks in creating volatility in the economy. In panel (b), the persistence of a misperception shock increases along the horizontal axis, and the vertical axis records the values of minimised losses attached to two different values of $\alpha_1$, 0.3 (the solid line) and 0.8 (the dashed-dotted line), respectively. It can be seen that as the persistence of the misperception shock increases the loss increases as well. Again losses are higher as the agents become more forward looking.[7]

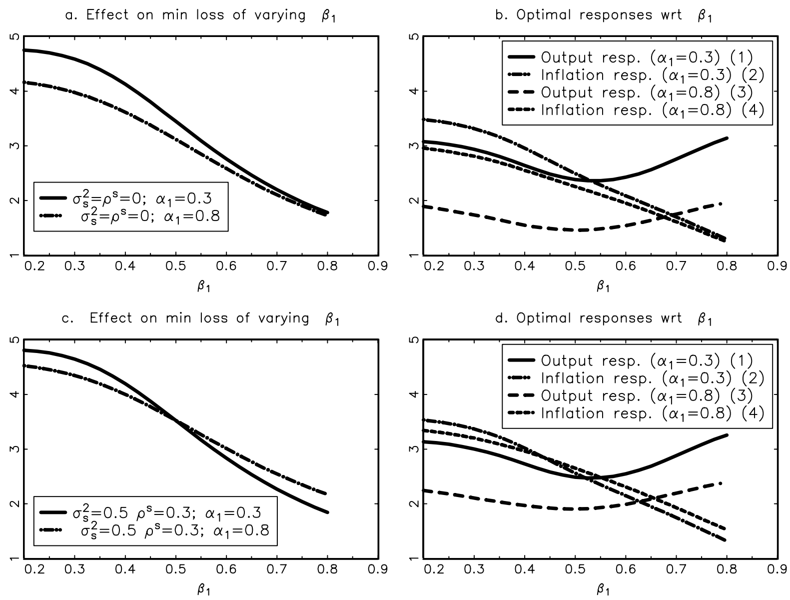
(7) Of course, if we allowed interest rates to react directly to the misperceptions shock, that is, $i_t$ =Taylor + $s_t$, the performance would be enhanced. However, uncertainty about the process followed by the misperceptions shock is likely to make a rule like this undesirable (see next section, and Leitemo and Söderström (2004)).

Chart 2 plots the optimised coefficients in a Taylor rule, again as a function of $\alpha_1$ (the degree of forward-looking expectations in the determination of the aggregate demand process) and $\rho^s$ (the degree of persistence of the misperceptions shock). A number of interesting observations can be made. First, in the presence of a misperception shock optimal policy always responds more strongly to the output gap and inflation. This can be seen in panel (a) where both output and inflation response coefficients under the misperception shock are always above the benchmark responses, that is, line 3 is above line 1 and line 4 is above line 2. Furthermore, as the importance of forward-looking expectations ($\alpha_1$) increases the difference between the two rules (under the benchmark or the misperception scenario) widens further. Generally, as the degree of the forward-looking behaviour increases, the weight put on output decreases. In panel (a) we have assumed that the effects of misperception shocks are relatively temporary, so even though the effects get bigger as $\alpha_1$ increases, they are relatively short-lived, because as the agents become more forward looking they increasingly treat bygones as bygones. The weight put on inflation, however, increases as the size of the misperception shock increases. This is because the degree of forward lookingness in the determination of inflation is fixed and, as $\alpha_1$ increases, the noise resulting from misperceptions increases as well, calling for a tougher response to inflation. Second, the optimal coefficients in a simple rule depend on the serial correlation properties of the disturbances. Increasing the persistence ($\rho^s$) in panel (b) increases the optimal coefficients on the output gap and inflation (lines 1-4 are upward sloping). When the misperception shock becomes more persistent, its effects on the economy become more long-lived, and these shocks become a more important source of volatility. Thus, the motivation for offsetting such shocks becomes stronger, and the coefficients on the output gap and inflation all increase. Now, as the private sector becomes more exuberant, leaning against the wind requires more radical and potentially more costly monetary actions.[8]

Chart 3 shows how forward lookingness of the Phillips curve affects the losses and policy responses. Panels (a) and (b) plot minimised loss and rule dynamics under the benchmark specification, where there are no misperceptions; while, in panels (c) and (d) the economy is subject to a misperception shock $s_t$. Now, $\beta_1$ is a free parameter and the misperception shock enters to the system through the output gap equation with a constant weight $\alpha_1$. In panel (a) it can be seen that the effect of $\alpha_1$ declines steadily as the inflation process becomes more dependent on the forward-looking component. Panel (b) shows how inflation responses converge (lines 2 and

(8) Note that simple rules are not certainty equivalent; the feedback coefficients depend on the variance covariance matrix of shocks (see Dennis (2004)).

**Chart 3: Optimised dynamics as a function of $\beta_1$**




4), but the distance between the output responses remains more or less constant (lines 1 and 3). Panel (c) tells a more interesting story. Here, we have introduced a misperception shock ($\sigma_s^2 > 0$). We find that, as in the case with no misperceptions, when the Phillips curve is less forward looking (ie $\beta < 0.5$), increasing the forward lookingness of the output gap leads to lower losses. However, when the Phillips curve is more forward looking (ie $\beta > 0.5$), this result is overturned, with more forward lookingness of the output gap leading to increased losses due to misperceptions.

### *3.2 Optimal policy when the policymaker not confident of private sector behaviour*

One possible criticism of the previous section is that the policymaker is too well informed. McCallum (1988, 1999) argues that the policymaker should find a policy strategy which is robust to uncertainty about misperceptions under different scenarios. In this section, we assume that the policymaker is not able to observe the misperceptions shock directly – there may, or may not, be misperceptions, and analyse two scenarios. In the first, uncertainty about the processes followed by the exogenous disturbances is manifested through uncertainty about the autocorrelation coefficients $\rho^s$. In the second, we consider uncertainty about $\alpha_1$.

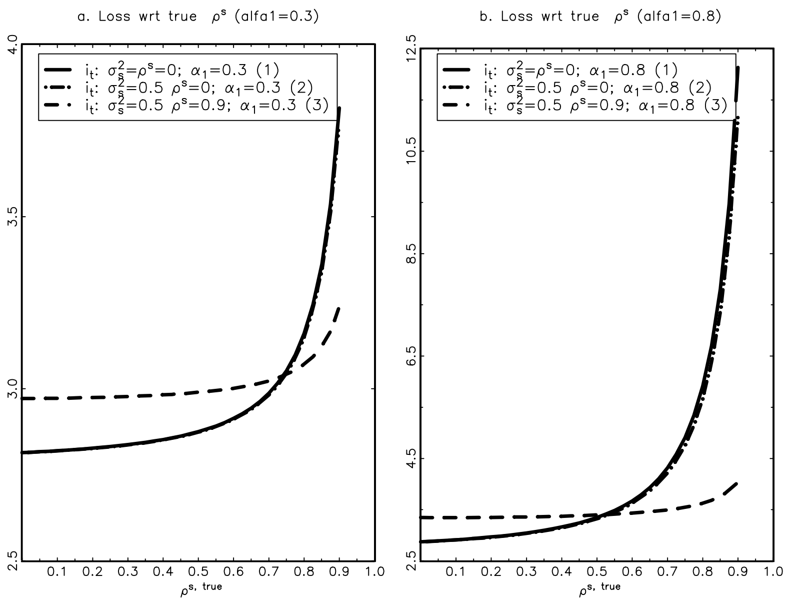
We ask two questions. First, how sensitive is performance under a simple rule to getting structural features of the economy right? For example, if it turns out that the true value of $\rho^s$ differs from the value on which the policymaker based its simple rule, how much does performance deteriorate? Second, if the policymaker is uncertain about the true value of $\rho^s$, should it err towards overestimating or underestimating it? To address these questions, we optimise policy rules under three different scenarios: no misperceptions, a one-off misperception shock, and a very persistent misperception shock – these scenarios encompass the policymaker's estimate or belief about misperceptions. We then measure the performance of these policy rules when the variance and persistence of the misperceptions shock is different from the policymaker's estimates. In the following charts the 'true' parameter value, which is unknown to policymakers when optimising policy rules, is on the horizontal axis and the vertical axis records the values of the loss function.

Chart 4 shows that the performance of rules deteriorates as the persistence of shocks increases, even if the policymaker is prepared for more persistent shocks (see, for instance, panel (a) line 3). However, overestimating the value of the persistence parameter provides a minimum of a potential maximum loss, and is hence a robust policy response in the sense of Hansen and Sargent (2004): the maximum loss occurs with high $\rho^s$, and line provides the minimum loss in this situation (note that lines 1 and 2 overlap). On the other hand, underestimating $\rho^s$ when it actually turns out to be high is more problematic. The naive use of the optimised 'non-misperception Taylor rule' can be very costly indeed. This is even more evident in panel (b) where we have assumed that the determination of the output gap is predominantly forward looking. It should, however, be recognised that there is much to be said in favour of the rule $\rho^s = \sigma_s^2 = 0$. We can see that the policy rule $\rho^s = 0$ dominates strategy $\rho^s = 0.90$ for low values of $\rho^s$. However, $\rho^s = 0.9$ is an optimal choice in the sense that it provides the best worst state. So, in a high-uncertainty setting, it may be better to overestimate the degree of misperception rather than to underestimate it.[9][10] However, if the misperception shock does not materialise, monetary policy actions induce higher welfare losses, creating possibly disinflation and a costly recession. Analogous reasoning explains why policymakers should not attempt to prick asset price bubbles; it is difficult to distinguish between fundamental causes that raise the asset prices and the existence of misalignments in asset prices (eg Vickers (1999)). In conclusion, a more active policy strategy may be appropriate in the

(9) This seems to be a robust result: in the context of learning models, Orphanides and Williams (2004, 2005) show that if the policymaker assumes perfect knowledge (RE) on the part of the private sector, when they are actually learning, leads to inefficient policy outcomes.

(10) Orphanides and Williams (2002) also argue that the costs of underestimating the degree of uncertainty are much larger than the costs of overestimating it. Leitemo and Söderström (2004) argue that on robustness grounds the policymaker should overestimate the degree of persistence in an exchange rate risk premium term. Jääskelä and Yates (2003), in a slightly different context, point out that robust strategy would call for overemphasising the problem of data uncertainty and measurement errors.

**Chart 4: Losses under different (fixed) policy rules. 'True' $\sigma_s^2 = 0.5$ and (true) $\rho^s$ is allowed to vary**

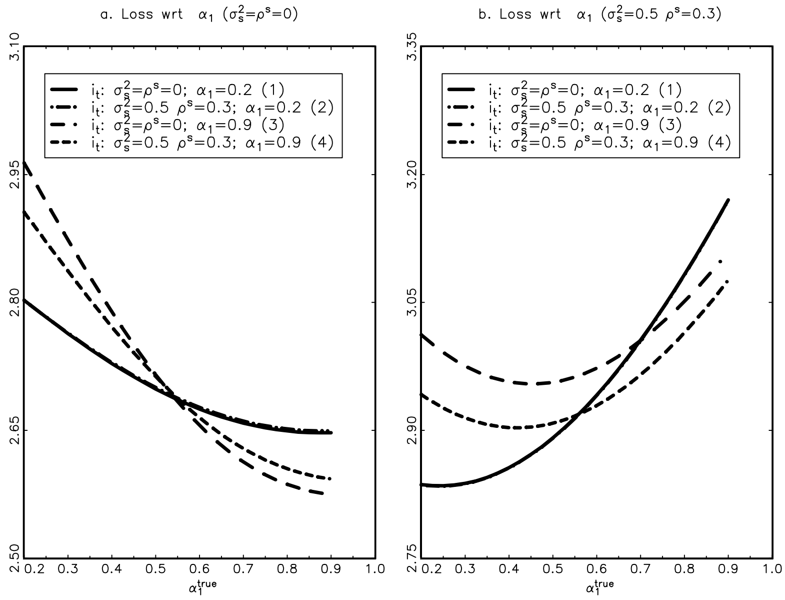



face of uncertainty about the presence of misperceptions.

Chart 4 considers uncertainty which is essentially generated by an exogenous, additive shock; and uncertainty was associated with persistence of the misperception shock. However, what if the policymaker faces uncertainty about the degree of forward-looking output expectations, in addition to the presence of misperception shocks? How will the combination of additive and multiplicative shocks affect our results? To answer these questions we assume that the policymaker faces uncertainty about the $\alpha_1$ parameter, and recalibrate costs in terms of this parameter. First, we assume that there are no misperceptions shocks in the 'true' model ($\sigma_s^2 = 0$), and compare losses under policy rules optimised assuming different sizes of misperceptions shocks for the different degrees of output persistence (Chart 5, panel (a)). Second, we repeat this experiment allowing for misperceptions in the 'true' model (Chart 5, panel (b)).

Interestingly, the shape of the loss profiles is a decreasing function of $\alpha_1$ when there are no misperceptions and increasing when we assume there is a misperception shock, which grows in size with $\alpha_1$. Panel (a) shows that in our model the structural parameter $\alpha_1$ is more likely to drive results than the assumed misperception shock. So, if there are no misperception shocks, our results suggest that policymakers aiming for robustness should act as if the output process was

**Chart 5: Losses under different (fixed) policy rules. 'True' $\alpha_1$ is allowed to vary**




more backward looking than they perhaps believe it is: the line 1 shows that policy, which assumes a backward-looking output process, minimises the potential maximum loss under uncertainty about the true value of $\alpha_1$.[(11)] This result is overturned when there is a moderately persistent misperception shock in the 'true' model (panel (b)). In this case, the robust (min-max) strategy is to overestimate the degree of forward-looking expectations (ie $\alpha_1$), and hence the size of misperception shock: the policy strategy 4 is now most robust. In general, assuming that there is a misperception shock present seems to be a relatively robust policy strategy here. In the first case (no misperceptions present) policy rules assuming misperceptions behave almost as well as rules that ignored the possibility of misperceptions. In the second case, policy rules assuming misperception shocks provide significantly more robust performance, especially if the policymaker overestimates the degree of forward-looking behaviour. So far so good, but if the policymaker faces uncertainty about both the additive misperception shock and the structural parameters of the model there is an interesting tension between how the policymaker should think about misperceptions and model misspecifications. In particular, even in this relatively simple setting, there are no longer clear-cut answers when uncertainty is allowed to feed into the economy as a combination of both additive and parametric model uncertainty, and when these uncertainties are allowed to interact. Whether the policymaker can deal with this by using model averaging techniques (see Brock *et al* (2003)) for instance, is an open question and is left for future research.

(11) Jääskelä (2002) shows that the performance of policy rules, which rely heavily on forward-looking features of a model (eg a price level rule), deteriorates significantly if the true model is, in fact, backward looking.

## 4 Conclusions

Recently, there has been active discussion on asset price misalignments and the relationship between asset price booms and monetary policy. One explanation for these misalignments is that asset price and private sector behaviour have evolved as they have because of some 'misperception' about future income. In this paper, we discuss how monetary policy might react in an environment where behaviour may have been driven by over-optimistic expectations – misperceptions – about future output.

Modelling misperceptions as persistent demand shocks which feed through the expectations channel of current demand into the determination of output, we studied how policy might respond to such misperceptions. We assumed that policy cannot correct misperceptions, but can only respond to them. Within a class of simple policy rules, we calculated optimal policy responses to misperceptions – in the form of optimal relative weights on output and inflation – and calibrated the costs and benefits of responding to misperceptions under uncertainty.

Our results can be summarised as follows. First, misperceptions cause welfare to be lower. Furthermore, varying the persistence of the misperceptions welfare decreases as persistence increases – the longer agents are wrong, the worse are the effects of a given misperception. Second, by allowing for some rule-of-thumb behaviour we studied how the degree of forward lookingness interacts with misperceptions. In our set-up, we found that forward lookingness is bad – the more forward looking agents are, the more welfare is reduced by a given misperception. Third, in the face of a misperception, policy should place relatively less weight on output gap fluctuations. How policy should react to misperceptions depends crucially on the persistence of the misperception – the more persistent the misperception the less weight the policymaker should place on output. This result is intuitive; as you increase the noise in one of your target variables the less weight you want to place on it. Fourth, we analysed how the introduction of uncertainty affected policy. Assuming that the policymaker does not observe the misperception we found that a safe strategy is to react assuming that there is a misperception present and that it is very persistent. When we also include the policymaker's uncertainty about the structural parameters we found that, in the presence of misperceptions, the robust (min-max) strategy is to overestimate the degree of forward-looking expectations – so as to overestimate the size of the misperception.

Although our paper has generated several interesting insights into how a general misperception about future output might affect the economy and how policy might respond to it, we have said little about the sources of misperceptions. Furthermore, and connected to this point we have not explained how misperceptions might propagate through the economy. Modelling misperceptions as exogenous not only prevents us from thinking about the dynamics of misperceptions themselves but also prevents policy from being able to dispel these misperceptions. An obviously interesting and important area for further work would be to think more about these issues by studying models in which misperceptions are endogenised in some way.

**References**

**Amato, J and Laubach, T (2003)**, 'Rule-of-thumb behavior and monetary policy', *European Economic Review*, Vol. 47, pages 791-831.

**Batini, N and Nelson, E (2000)**, 'When the bubble bursts: monetary policy rules and foreign exchange market behavior', manuscript.

**Bean, C (2004)**, 'Asset prices, financial stability, and monetary policy', *American Economic Review*, Vol. 94 (2), pages 14-18.

**Bernanke, B and Gertler, M (2001)**, 'Should central banks respond to movements in asset prices?', *American Economic Review Papers and Proceedings*, Vol. 91 (2), pages 253-57.

**Bordo, M and Jeanne, O (2002)**, 'Boom-bust in asset prices, economic instability, and monetary policy', *NBER Working Paper Series no. 8966.*

**Brock, W, Durlauf, S and West, K (2003)**, 'Policy evaluation in uncertain economic environments', *Brooking Papers on Economic Activity*, Vol. 1, pages 235-322.

**Cecchetti, S, Genberg, H, Lipsky, J and Wadhwani, S (2000)**, *Asset prices and central bank policy*, Geneva Reports on the World Economy 2, International Center for Monetary and Banking Studies and CEPR, Geneva/London.

**Clarida, R, Gali, J and Gertler, M (1998)**, 'Monetary policy rules in practice: some international evidence', *European Economic Review*, Vol. 42, pages 1,003–67.

**Dennis, R (2004)**, 'Solving for optimal simple rules in rational expectations models', *Journal of Economics & Dynamics*, Vol. 28, pages 1,635-60.

**Gaspar, V, Smets, F and Vestin, D (2003)**, 'Private-sector learning, expectations and persistence. The role of conservative central bank', manuscript.

**Hansen, L P and Sargent, T (2004)**, 'Robust control and model uncertainty in macroeconomics', manuscript.

**Jääskelä, J (2002)**, 'Inflation, price level and hybrid rules under inflation uncertainty', *Scandinavian Journal of Economics*, forthcoming.

**Jääskelä, J and McKeown, J (2005)**, 'Monetary policy and private sector misperceptions about the natural level of output', *Bank of England Working Paper no. 279*.

**Jääskelä, J and Yates, T (2003)**, 'Monetary policy and data uncertainty', manuscript.

**Leitemo, K and Söderström, U (2004)**, 'Simple monetary policy rules and exchange rate uncertainty', *Journal of International Money and Finance*, Vol. 24, pages 481-507.

**Levin, A, Wieland, V and Williams, J (1999)**, 'Robustness of simple monetary policy rules under model uncertainty', in Taylor, J (ed), *Monetary policy rules*, University of Chicago Press, Chicago.

**Levin, A, Wieland, V and Williams, J (2003)**, 'The performance of forecast-based monetary policy rules under model uncertainty', *American Economic Review*, Vol. 93, pages 622-45.

**Levin, A and Williams, J (2003)**, 'Robust monetary policy with competing reference models', *Journal of Monetary Economics*, Vol. 50, pages 945-75.

**McCallum, B (1988)**, 'Robustness properties of a rule for monetary policy', *Carnegie-Rochester Conference Series on Public Policy*, Vol. 29, pages 173-203.

**McCallum, B (1999)**, 'Issues in the design of monetary policy rules', in Taylor, J (ed), *Monetary policy rules*, University of Chicago Press, Chicago.

**Orphanides, A and Williams, J (2002)**, 'Robust monetary policy rules with unknown natural rates', *Brookings Papers on Economic Activity*, Vol. 2, pages 63-145.

**Orphanides, A and Williams, J (2004)**, 'Imperfect knowledge, inflation expectations, and monetary policy', in Bernanke, B and Woodford, M (eds), *The inflation targeting debate*, University of Chicago Press, Chicago.

**Orphanides, A and Williams, J (2005)**, 'Inflation scares and forecast-based monetary policy', *Review of Economic Dynamics*, Vol. 8, pages 498-527.

**Rotemberg, J and Woodford, M (1999)**, 'Interest rate rules in estimated sticky price models', in Taylor, J (ed), *Monetary policy rules*, University of Chicago Press, Chicago.

**Rudebusch, G (2002)**, 'Assessing nominal income rules for monetary policy with model and data uncertainty', *Economic Journal*, Vol. 112, pages 402-32.

**Rudebusch, G and Svensson, L (1999)**, 'Policy rules for inflation targeting', in Taylor, J (ed), *Monetary policy rules,* University of Chicago Press, Chicago.

**Smets, F (2003)**, 'Maintaining price stability: how long is the medium term?', *Journal of Monetary Economics,* Vol. 50, pages 1,293-309.

**Söderlind, P (1999)**, 'Solution and estimation of rational expectations macro models with optimal policy', *European Economic Review*, Vol. 43, pages 813-23.

**Vickers, J (1999)**, 'Monetary policy and asset prices', Speech given at the Money, Macro and Finance Group 31st Annual Conference, Oxford University.