# Monetary policy under uncertainty

Uncertainty is an integral element of many economic decisions, especially those extending into the future. Monetary policy geared to price stability is also faced with considerable uncertainty. A distinction can be made between model uncertainty and data uncertainty. Data uncertainty denotes incompleteness and inadequacy of information on economic variables. Model uncertainty, however, refers to a lack of knowledge of the exact transmission mechanism in the economy.

This article describes these forms of uncertainty and analyses their consequences for monetary policy decision-making. It finds that data uncertainty further increases the risks associated with attempts to fine-tune the economic cycle. Monetary policy decision makers should therefore exercise caution regarding uncertain data and take account of a broad range of relevant information in order to avoid policy errors in this field. The best way for monetary policy makers to deal with model uncertainty is to base their decisions on a monetary policy strategy which achieves satisfactory results across a broad range of competing models.

## Introduction

The impact of central bank interest rates on prices, economic growth and other macro-

economic variables is characterised by long time-lags. Interest rate decisions are therefore by their very nature forward-looking. In the Eurosystem, which – like the Bundesbank before it – is clearly committed to the primary objective of price stability, decision makers are chiefly interested in counteracting medium to long-term risks to price stability at an early stage.

*Myriad and interdependent uncertainty factors*

However, there is generally considerable uncertainty surrounding the future development of the target variable and the exact impact of monetary policy instrument variables on the target variable, and even surrounding the state of the economy when the decision is being made. The uncertainty factors faced by central banks are myriad and interdependent. They are created by, for instance, competition between different theoretical models, constant structural change and the limited availability and reliability of key economic data.

## Forms of uncertainty

In this context, it makes sense to draw a distinction between data uncertainty and model uncertainty. Data uncertainty denotes incomplete and unreliable information about economic developments up to the current observation period. Model uncertainty refers to limited knowledge of the transmission mechanism and therefore to the choice of data relevant to monetary policy and their interpretation.

## Model uncertainty

*Necessity of theoretical models*

In order to analyse economic phenomena, economists generally need to simplify complex realities. Such simplifications, which do not necessarily have to be formalistic, are generally referred to as "models".

Monetary policy makers need models to gain an idea of future price movements and to gauge the impact of their own monetary policy measures. The models they use must adequately represent the relevant structural relationships between the price level, the monetary policy instruments and other factors affecting price movements. These other factors include, for instance, changes in oil prices or exchange rates as well as the introduction of new technologies or changes in the political and institutional framework.

*Uncertainty about the adequacy of the model*

Since models simplify reality, they can only stress specific relationships while disregarding others. However, the question of which relationships are actually "relevant" and which simplifications are "adequate" is certainly a contentious one. Accordingly, there often exist competing theoretical models which explain the same phenomenon, differing in terms of the selection of explicitly included variables and the type of interrelatedness but also in terms of other core assumptions, such as the way expectations are formed.

This becomes a problem for the monetary policy maker if the relevant models characterise the current situation differently and/or suggest differing monetary policy actions. It is therefore possible, for example, that an as-

sessment of the price outlook based on the quantity theory, which emphasises the long-term relationship between monetary growth and inflation, may lead to a policy recommendation that is at odds with the results of a corresponding analysis based on a Phillips curve model, which stresses the link between inflation and unemployment or overall capacity utilisation.

*Uncertainty about the model's parameters*

But, even if economists were able to agree on the appropriate model, the next step would be to determine the values of the model's parameters, which provide information on the strength and dynamics of the relationship between the individual variables. Since, as a general rule, parameter values can only be estimated based on an empirical analysis, the results will be subject to an inherent statistical uncertainty. Moreover, the results will also depend on the choice of the estimation method. Policy makers are thus faced with an interlocking system of different forms of model uncertainty, with uncertainty about the adequate theoretical model being joined by uncertainty about which empirical model is suited to adequately quantify the relationships being studied.

*Uncertainty about adequately defining variables*

In addition, theoretical models are often not very precise in how they define the key variables. It thus remains unclear for the most part how to operationalise the "money stock" variable or "price level" variable used in a theoretical model for the empirical analysis. This problem is also significant in light of the fact that different operationalisations (eg using M1 instead of M3 to measure money or using the GDP deflator instead of the CPI to measure the price level) can lead to different results regarding the strength and dynamics of the estimated relationships.

*Estimation periods*

The fact that empirical models can only capture basic features and behaviour patterns during a certain estimation period in the past remains a problem. The choice of observation period can, under some circumstances, have a considerable impact on the estimation result, especially if the relationships in question have changed fundamentally at some point in time.

*Structural breaks*

This problem is particularly severe regarding the assessment of the economic situation at the current end of the data, since such "structural breaks" can often not be detected in a timely manner by econometric tests. And even if a regime shift has been detected, the parameters of the new structure cannot be captured with sufficient precision shortly after the break, owing to the small number of observations.

It goes almost without saying that the extent of uncertainty about macroeconomic relationships in the euro area has been, and continues to be, especially large. After an event as pivotal as the establishment of a monetary union between eleven nation-states, the likelihood of structural breaks will grow, and their impact on the monetary transmission process will initially be nearly impossible to gauge empirically because of the above-mentioned problems.

In addition, empirical analyses for the euro area require all member states to have a set

of comparable data which should also go back sufficiently far into the past. Long series of harmonised data, however, only exist for a very few key variables such as the M1, M2 and M3 monetary aggregates. For other areas, it is necessary to fall back on non-harmonised data for the period prior to monetary union, provided such data are available in the first place. In that case, model uncertainty and parameter uncertainty are amplified further by the inadequacy of the data.

## Data uncertainty

Along with the problem of model uncertainty described above, in practice there is also the problem of data uncertainty. This kind of uncertainty arises because the relevant statistics (economic, financial and monetary statistics) provide incomplete or unreliable information about the "true" state of the economy.

The underlying data can be incomplete for several reasons. One possible reason is that not all data which are relevant to analysing the economic situation are statistically collected. Another reason is that some data which are collected are available only after a certain time-lag. In addition, some key data (especially real economic data) are subject to measurement problems, due to which the initially available data end up being revised over time.

*Gaps in collected data*

Although gaps in collected data are a problem shared by just about all central banks, they particularly affect the Eurosystem. The data needed by the Eurosystem must not only be timely and reliable but also comparable across all participating countries. As this problem was known to all participants, major efforts were undertaken even prior to monetary union to ensure the provision of sufficiently harmonised data, at least in the most important spheres of activity, once monetary union was launched. As regards the Harmonised Index of Consumer Prices (HICP) and the data on monetary aggregates, this endeavour has been largely successful. By contrast, however, data on some key indicators in the areas of business cycle statistics and labour market statistics are not yet available as harmonised data. There are, for instance, no euro-area monthly employment statistics or quarterly labour volume calculations.

The New Orders Index for the euro area, which Eurostat has been publishing since November 2003, is a further example of the particular data problems facing the euro area. Although its publication represents progress as such, the new statistics, unlike the matching German statistics, cannot be broken down into domestic and foreign orders, nor is it possible to calculate a volume series, since producer prices are not calculated for foreign sales in most euro-area countries.[1]

*Time-lag in the provision of data and revisions*

In addition, many key data, especially from the real sector, are available only with a time-lag of several weeks (if not months). For instance, Eurostat presents a flash estimate of aggregate output in the euro area six weeks after the end of the quarter under review. Around two months later, this is followed by a first estimate of production, broken down more precisely into components. But even

1 This is explained in greater depth in Deutsche Bundesbank, *Monthly Report,* February 2004, pp 16-17.

then, data may still be expected to undergo a process of at times considerable revision which may last years (see adjacent chart).

*Data that cannot be observed directly …*

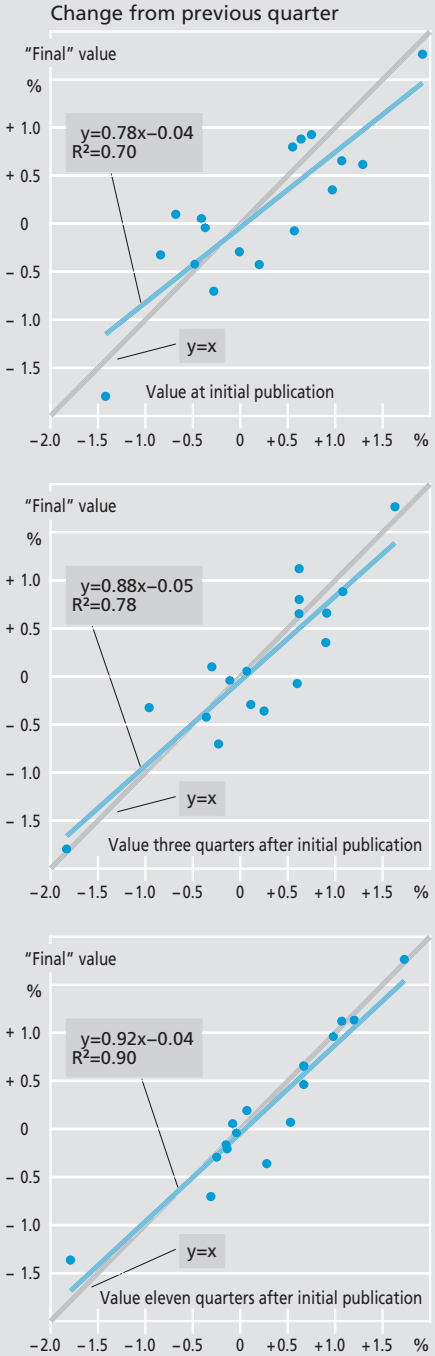
Besides the above cited problems of availability, timeliness and reliability of the underlying data, an additional type of data uncertainty exists. It occurs because many variables which play a decisive role in theoretical models cannot be observed directly in the real world and therefore have to be estimated. The estimation results, for their part, are strongly dependent on the underlying model. This shows how closely intertwined data uncertainty and model uncertainty are.

*… such as potential output*

That applies to the calculation of equilibrium exchange rates as well as to determining the "natural" or equilibrium level of interest rates or the adequate valuation of assets. The most prominent examples of this, however, are undoubtedly potential output and the output gap, the latter defined as the deviation of real output from potential output. A number of recently published research papers have shown that estimates of potential output and therefore also of the output gap are fraught with considerable uncertainty, which is reflected also in the fact that the relevant time series are often revised years, if not even decades, later. This is due not so much to revisions in the data used for the estimations but to the fundamental difficulty inherent in correctly estimating an economy's growth trend – and especially changes in this trend. Since such trend reversals are simply another example of the structural breaks described above, this is another region in which the

## The revision process of German real GDP*

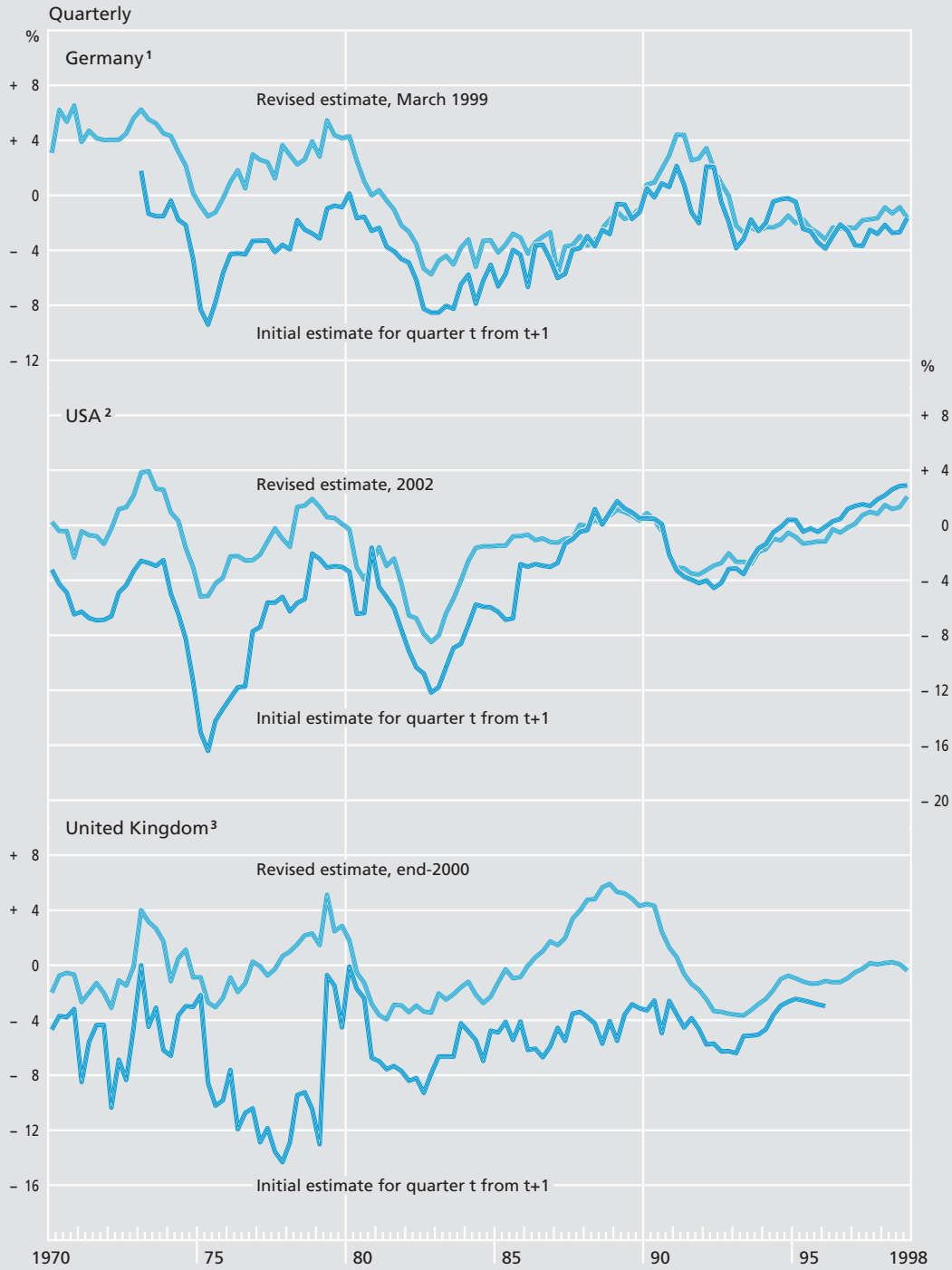
Change from previous quarter




* Values adjusted for seasonal and calendar-day variations. Observation period: 1992 Q1 to 1996 Q1; vintages: June 1992 to March 1999 ("Final" value). From the second quarter of 1995, Germany as a whole. Sources: Federal Statistical Office and the Bundesbank's own calculations.

Deutsche Bundesbank

## Initial and revised estimates of the output gap*




* Relative deviation of GDP from potential output. — **1** Source: C Gerberding, F Seitz und A Worms (2004), How the Bundesbank really conducted Monetary Policy: An Analysis based on Real-Time Data, Discussion paper, Economic Research Centre of the Deutsche Bundesbank, forthcoming. — **2** Source: A Orphanides (2003), Historical monetary policy analysis and the Taylor rule, *Journal of Monetary Economics*, 50, pp 983-1022. — **3** See E Nelson und K Nikolov (2003), UK Inflation in the 1970s and 1980s: The Role of Output Gap Mismeasurement, *Journal of Economics and Business*, 55, pp 353-370.

Deutsche Bundesbank

boundary between data uncertainty and model uncertainty becomes blurry.

As a case in point, until well into the 1980s it was not clear to what extent the oil price shocks of the 1970s had reduced potential output and the trend growth rate of developed industrial nations. This uncertainty apparently peaked in early 1975. Orphanides' research has shown that estimates of the US economy's output gap for early 1975, which were originally -16%, were gradually revised upwards by over 10 percentage points in the following years.[2] Similar studies for the UK and German economies show that the output gap figures were revised to a similar extent in those countries (see chart on page 20).[3]

Another case in point is the discussion about the "New Economy". In this case, uncertainty about whether, and by how much, the technology boom of the late 1990s really pushed the US economy's trend growth rate upwards is likely to persist for some time.

*Close link between data uncertainty and model uncertainty*

These examples indicate how difficult it is to assess the economic situation at the point in time when monetary policy decisions need to be taken. Furthermore, they illustrate the connection between data uncertainty and model uncertainty. Consequently, the suitability of a theoretical model to monetary policy decision-making depends not only on how well it can explain past observations but also on the extent to which the data necessary for the model's empirical application are reliable and available in real time.

## Consequences for monetary policy decision-making

Central banks face a dilemma: they must take timely decisions while having only provisional, and thus often incomplete, data. In addition, there exists uncertainty about assessing the future and about the impact of a given measure. This raises the question as to what lessons monetary policy makers should learn from the various forms of uncertainty.

### Rejecting fine-tuning

*Danger of amplifying the business cycle*

The realisation that the transmission of monetary policy stimuli to real income and prices is associated with major uncertainty owing to long and variable time-lags led Milton Friedman to argue as early as 1961 against using monetary policy instruments in an attempt to fine-tune the economy.[4] He held that, given uncertainty about the time-span between a monetary policy measure and the occurrence of its impact on the target variable, fine-tuning the economy carries with it the danger of amplifying the business cycle. Accordingly, an interest rate cut designed to jump-start a flagging economy might only exert its full effect when the economy has already returned to maximum capacity utilisation. In

2 See A Orphanides (2003), The Quest for Prosperity without Inflation, *Journal of Monetary Economics,* 50 (3), pp 633-663.
3 See E Nelson and K Nikolov (2003), UK Inflation in the 1970s and 1980s: The Role of Output Gap Mismeasurement, *Journal of Economics and Business,* 55, pp 353-370, and C Gerberding, F Seitz and A Worms (2004), How the Bundesbank really conducted Monetary Policy: An Analysis based on Real-Time Data, Discussion Paper, Economic Research Centre of the Deutsche Bundesbank, forthcoming.
4 See M Friedman (1961), The Lag in Effect of Monetary Policy, *Journal of Political Economy* 69, pp 447-466.

that case, the monetary policy measure would exert undesirable inflationary pressure. What makes reservations about fine-tuning the economy all the more severe is that estimates of potential output, in particular, are fraught with considerable uncertainty.

Recent research papers by Orphanides and others have shown that these problems must by no means be underestimated. The overly optimistic view of the US economy's potential output in the 1970s was probably a key reason for the US Federal Reserve's excessively expansionary (from today's perspective) monetary policy, which was only halted as the 1970s reached their close. Similar research based on data for the United Kingdom likewise concludes that the high inflation rates of the 1970s and 1980s were due at least in part to policy errors based on the persistent overestimation of aggregate potential output.[5]

Germany's lower inflation rates during this period suggest that the Bundesbank succeeded in avoiding these types of policy errors. A relatively new research paper examines this hypothesis by analysing the Bundesbank's interest rate decisions on the basis not of revised data but of those data available to decision makers in "real time", ie when the decision was made.[6] The paper concludes that the relative success of the Bundesbank's policy is not due to the fact that Germany's data were less prone to revision than those of other countries. Apparently, the more decisive factor was that the Bundesbank did not base its decisions so much on the current level of the output gap as on monetary growth and real economic growth. Furthermore, it attached much weight to its assessment of expected price developments, which was based on these and other indicators.

## "Steady-as-she-goes monetary policy"

The less certain the environment, the greater the danger, naturally, that decisions may prove to be wrong in retrospect. Such policy errors create problems, not only because they lead to direct and undesirable effects on the target variables but also because they increase the probability of frequent changes in direction. Such "back and forth" movements would jeopardise the central bank's credibility, contribute to existing uncertainty and destabilise expectations.

*Cautious monetary policy reaction given parameter uncertainty ...*

Early on, the literature called for partial or gradual monetary policy reactions to incoming information in order to avoid such effects.[7] It had been recognised that uncertainty about the real income or price effects of monetary policy increases in line with the strength of the monetary policy measure.

*... and data uncertainty*

More recent studies conclude that data uncertainty strengthens the case for a more cautious monetary policy approach. They assert that monetary policy should not react nearly as strongly to the initial publication of revision-prone data as it would have without

5 See Orphanides (2003) and Nelson/Nikolov (2003), loc cit.
6 C Gerberding, F Seitz and A Worms (2004), loc cit.
7 See W Brainard (1967), Uncertainty and the Effectiveness of Monetary Policy, *American Economic Review,* 57, pp 411-425.

*Use of broadly-based estimates for revision-prone data*

data uncertainty.[8] Furthermore, they recommend not incorporating preliminary statistical information on revision-prone variables, such as GDP, at face value into monetary policy decisions, but instead to make a more broadly-based estimate of such variables. This estimate should also avail itself of information from other, less revision-prone sources, as well as of the past history of revisions to the variable in question. Along those lines, there is now a battery of research papers which assert that money stock data can make a valuable contribution to monetary policy by providing important information on the "true" level of real income. In contrast to data on aggregate income, they have the advantage of being available with little time-lag and needing virtually no revision.[9]

## Taking all relevant information into account

The problem of data uncertainty generally suggests that, when assessing risks to price stability, policymakers should not concentrate on only one indicator variable, but instead should analyse as wide a range of information variables as possible. Under such an approach, the importance of individual data used in the monetary policy decision-making process also depends on how serious their measurement errors are compared to other relevant variables. Taken in isolation, this argument speaks in favour of attributing less importance to real economic variables such as output and the output gap than to indicators from the monetary and financial sphere that are far less affected by the problem of data uncertainty (see chart on page 24).

Data quality, however, cannot serve as the sole criterion for choosing which indicators to use. Rather, the usefulness of an indicator for monetary policy purposes depends, above all, on how reliably it flags risks to price stability. If uncertainty exists about the stability of the relationship between a given indicator variable and the ultimate monetary policy objective – which will almost always be the case in the real world – this also reduces the informative value of this indicator for future price movements.

*Tension between model uncertainty and data uncertainty when selecting the indicator*

The quantity theory and the Phillips curve, as two competing approaches to explaining inflation, provide a good example of the tension between data uncertainty and model uncertainty. A criticism of the quantity theory often voiced in the more recent literature is that the relationship between monetary growth and inflation (even if it is stable over the long term) is distorted by short-term fluctuations in the velocity of circulation of money. In defence of the quantity theory, it can be said that the mismeasurement of the output gap can be just as problematical in quantitative terms as fluctuations in the velocity of circulation of money.[10] Against that background, it may make quite a lot of sense for decision makers to contrast the results produced by the two approaches and to test them for their informative value in terms of future

8 See K Aoki (2003), On the optimal monetary policy response to noisy indicators, *Journal of Monetary Economics,* 50, pp 501-523.
9 See G Coenen, A Levin and V Wieland (2001), Data Uncertainty and the Role of Money as an Information Variable for Monetary Policy, ECB Working Paper No 84.
10 See E Nelson (2003), The Future of Monetary Aggregates in Monetary Policy Analysis, *Journal of Monetary Economics,* 50 (5), pp 1029-1059.

## The significance of revisions to key monetary policy indicators for Germany

Quarterly, annual percentage change


**1** Changeover from west German data to data for all of Germany in the second quarter of 1995. Source: Federal Statistical Office. — **2** Until end-1987, central bank money stock (currency in circulation plus minimum reserve requirements on domestic deposits calculated at constant reserve rates of January 1974); from the beginning of 1998, the money stock M3. Changeover from west German data to data for all of Germany in the first quarter of 1991. Calculations performed by the Bundesbank.

Deutsche Bundesbank

price movements, taking the different forecast horizons into account.

## Robustness of the monetary policy strategy

Some academics have therefore also proposed measuring the usefulness of a monetary policy strategy in terms of its robustness against alternative specifications of the monetary transmission process. Accordingly, central banks should opt for a strategy that obtains sufficiently good results under various assumptions regarding the transmission process.

In the past few years, a number of simulation studies have sought to find out which strategy is robust in this regard. Most of them advocate a (modified) Taylor rule monetary policy, which links the nominal interest rate to current inflation and business cycle data.[11] However, since these studies largely disregard the problem of data uncertainty, their value for practical monetary policy is rather limited. In principle, this approach could be supplemented by an analysis of data uncertainty. Under this extended approach, a strategy that attains good results despite data uncertainty and model uncertainty would be considered robust.[12]

As already discussed, the problems in estimating potential output provide a strong argument against using strategies that give a prominent role to the current level of the output gap. More recent research therefore proposes that central banks take less account of the output gap and devote more attention instead to the growth rate of real income.[13] However, it is too early to judge this hypothesis conclusively.

## Avoiding extremely unfavourable developments

The arguments listed thus far generally favour a non-activist, cautious monetary policy. However, it is pointed out in the literature that this is not always the adequate reaction to uncertainty. Rather, there may conceivably be cases in which waiting is inappropriate because it would lead to situations that generate major macroeconomic costs. For instance, if an economy is in danger of slipping into a self-reinforcing deflationary spiral which is very difficult to combat using the available policy instruments,[14] hesitation by monetary policy makers could make matters worse. In order to hedge against the worst conceivable case in such a situation, policymakers may be required to act quickly and decisively despite – or precisely because of – the high uncertainty.[15]

---

11 See Deutsche Bundesbank, Taylor interest rate and Monetary Conditions Index, *Monthly Report,* April 1999, pp 47-63.
12 An approach may be found in C Walsh (2004), Implications of a Changing Economic Structure for the Strategy of Monetary Policy, in *Monetary Policy and Uncertainty,* Jackson Hole Symposium 2003, Federal Reserve Bank of Kansas City, forthcoming.
13 See Orphanides (2003), loc cit and C Walsh (2003), Speed Limit Policies: The Output Gap and Optimal Monetary Policy, *American Economic Review* 93/1, pp 265-278.
14 See eg Deutsche Bundesbank, The debate on deflationary risks in Germany, *Monthly Report,* June 2003, pp 15-28.
15 See eg L Hansen and T Sargent (2001), Acknowledging Misspecification in Macroeconomic Theory, *Monetary and Economic Studies,* February 2001, pp 213-227, and A Greenspan (2004), Monetary Policy under Uncertainty, in *Monetary Policy and Uncertainty,* Jackson Hole Symposium 2003, Federal Reserve Bank of Kansas City, forthcoming.

*The "robust control" approach given the absence of probability of occurrence*

In technical terms, uncertainty under such circumstances can be so great that no probability of occurrence can be associated with the conceivable scenarios any more, rendering it impossible for monetary policy to be oriented to the expected aggregate benefit. In this case of extreme uncertainty, the "robust control" approach recommends choosing that particular monetary policy which avoids the worst-case scenario. It can thus be regarded as an insurance policy against the worst case.

A problem with this, though, is that the monetary policy decision depends heavily on what scenarios are regarded as likely in the first place. Ultimately, monetary policy makers cannot get around judging some scenarios as possible and others as not possible – ie even robust control requires a certain probability assessment, albeit a rough one.

In addition, a monetary policy conducted according to the robust control principle can create moral hazard as this approach implies that market participants are insured against worst-case scenarios by the central bank at virtually no cost. In other words, business and financial market players assume that the costs of their risk taking will be borne by all but that they alone will reap the benefits of their actions. This may encourage them to take risks in excess of macroeconomically efficient levels.

For the reasons mentioned above, such discretionary intervention as that envisaged by the robust control approach should not come into general usage but should instead be restricted to potential crisis situations. Otherwise, monetary policy itself would be in danger of becoming a source of uncertainty.

## Uncertainty and the Eurosystem's monetary policy strategy

*Role of transparency*

To reduce economic agents' uncertainty about the central bank's behaviour as much as possible, the monetary policy decision-making process should be rendered as transparent as possible. A clear definition of the ultimate objective, now standard practice in many countries, plays a major role in this respect. In that vein, the Governing Council of the ECB, in early 2003, clarified its previous definition of price stability. According to ths definition, the Eurosystem's monetary policy is geared to maintaining the year-on-year increase in the HICP of the euro area below, but close to 2% over the medium term.

Uncertainty about the future path of monetary policy can be reduced not only by clearly defining the ultimate objective but also by announcing an understandable and coherent monetary policy strategy. In this context, however, there is a conflict of goals between the desire for clarity, which would suggest announcing the simplest possible decision-making rule, and adequately addressing model uncertainty and data uncertainty, which would tend to favour the use of as many indicators as possible.

Owing to the myriad of uncertainty, most central banks have taken a broad-brush approach to the analysis of information, one which takes account of differences of opinion

on the transmission of monetary policy. That is also – and maybe particularly – the case regarding the Eurosystem's monetary policy strategy. However, the complexity of such a strategy means that communications policy must be to a high standard.

The Eurosystem is rising to this challenge by publishing and commenting on the data relevant to its decisions as well as by extensively and coherently laying out the reasons for its monetary policy decisions. The structuring of the relevant information into a monetary analysis and an economic analysis has proven to be a big help in this regard. The monetary analysis focuses on the long-term monetary nature of inflation. The economic analysis, by contrast, examines real and financial indicators that are of importance for assessing the short to medium-term price outlook.