Uncertainty in macroeconomic policy-making: art or science?

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Uncertainty is pervasive in economic policy-making. Modern economies share similarities with other complex systems in their unpredictability. But economic systems also differ from those in the natural sciences because outcomes are affected by the state of beliefs of the systems’ participants. The dynamics of beliefs and how they interact with economic outcomes can be rich and unpredictable. This paper relates these ideas to the recent crisis, which has reminded us that we need a financial system that is resilient in the face of the unpredictable and extreme. It also highlights how such uncertainty puts a premium on sound communication strategies by policy-makers. This creates challenges in informing others about the uncertainties in the economy, and how policy is set in the face of those uncertainties. We show how the Bank of England tries to deal with some of these challenges in its communications about monetary policy.

Keywords: uncertainty; complex systems; financial crises; monetary policy; communication

1. Uncertainty and public policy

Most questions of public policy relate to uncertainties. Answers depend on an ability to understand and evaluate those uncertainties. Yet, many commentators and members of the public want to believe in certainties. They want to cut through the thickets of caveats and technical difficulties to the ‘bottom line’. We see this in economic policy, weather forecasting and the interpretation of secret intelligence.

Five years ago, the Bank of England and the Met Office held an informal seminar to exchange ideas on how to communicate measures of uncertainty to the general public. Although we failed to persuade broadcasters to explore the issues of economic and weather forecasting in more depth, the bilateral relationship that developed between the Bank and Paul Hardaker, who moved from the Met Office to take over the Royal Meteorological Society, flourished. Today’s conference is a tribute to Paul’s persistence. It could hardly be more timely. At the heart of

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One contribution of 15 to a Discussion Meeting Issue ‘Handling uncertainty in science’.
debates about climate change, the Chilcot Inquiry into the war in Iraq and the speed of the necessary fiscal consolidation of our public finances lie questions about how to evaluate and respond to considerable uncertainties.

Reference to economics and meteorology is not just because the interests of some of us span both. They are two disciplines united by a common need to grapple with complex systems and communicate forecasts to a wide audience. It is not enough to explain only to experts. Much of the value of forecasts is in the forecasts being understood—in all their subtleties—by the general public, or at least sub-groups such as the agricultural industry in the case of meteorology and those involved in wage bargaining in the case of economics.

The use or misuse of forecasts has caused problems for both the Bank of England and the Met Office in recent years. The Bank’s forecasts of inflation were criticized for overstating the size of confidence intervals during the period from 1995 to 2007, the so-called ‘Great Stability’, and then understating them once the financial crisis occurred. And the Met Office has recently announced that it will no longer publish forecasts for the weather in forthcoming seasons after it ‘failed’ to predict the cold winter or the wet summer (in some parts of the country) of 2009. The seasonal forecasts will be replaced by monthly predictions. In a statement, the Met Office said, ‘by their nature, forecasts become less accurate the further out we look. Although we can identify general patterns of weather, the science does not exist to allow an exact forecast beyond five days, or to absolutely promise a certain type of weather’ [1]. But to publish forecasts only when the outcome is virtually certain would be an admission of at least partial defeat.

In this paper, we return to the issues we discussed at the 2005 seminar and update our analysis. We consider why complex systems can be unpredictable, and what that suggests about controlling them. Then we focus on what is different about economic systems—namely that their behaviour is determined by the decisions of individuals, operating in an uncertain environment—and highlight how this places special emphasis on communication as a tool of policy. But this presents challenges: if descriptions of probability distributions are misinterpreted by the media or the public, how can we discover which messages are robust and which are too fragile to survive the process of communication to a wide audience?

We argue that there is a fine line for policy-makers to tread in communicating that we are not wholly ignorant, but nor can we or should we purport to be too precise. We show how the Bank of England tries to deal with some of these challenges in the context of monetary policy by communicating our assessment of the uncertainty we face in an accessible way.

2. Unpredictability in economics and science

Unpredictability is a challenge faced by practitioners in many disciplines. As Kenneth Arrow, Nobel Laureate in Economics, said about his 4-year experience as a weather officer in the US during World War II, ‘one thing I learned from meteorology is that being an actual science was no guarantee of exactness’ [2].

Economics may or may not be an actual science, but it certainly suffers when trying to predict the future. There are at least three explanations for this unpredictability that are common to economics and other scientific disciplines.

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First, assigning probabilities is particularly difficult for infrequent high-impact events such as financial crises, tsunamis or climate change, for which there are few precedents. Because the samples of such events are so small, as we learn about these processes our assessment of their likelihood will change, possibly sharply.

Second, even systems that are deterministic rather than stochastic can be very unpredictable. Small differences in starting conditions can imply very different outcomes. Weather systems display chaotic dynamics, so small initial forecast errors may lead to large revisions to the forecast further out. Economists, in contrast, often rely on simple linear models, but with additive stochastic errors. In modelling any phenomenon there is a choice, and among the experts in the area often a live debate, about whether it is more useful to use deterministic but chaotic or stochastic models (e.g. [3]). But the motivation in both cases is to bring out the importance of unpredictability.

Another feature that hinders predictability is that \textit{a priori} indistinguishable shocks can have very different effects in some systems. If you drop a grain of sand randomly on a sand pile, drop a lit match at random in a forest, or infect a random person with a disease, it may have very minimal, localized effects or may lead, respectively, to an avalanche, wildfire or epidemic. The outcome depends on the state of the system when the shock hits (the steepness of the sand pile, dryness of the forest or density of the population) and the precise point at which the system is hit.\footnote{In relation to the latter, key nodes or players may be instrumental in the spreading of shocks [4]. This thinking has been applied to the financial system showing that \textit{a priori} identical shocks can have differing effects depending on where the shock hits. And, inspired by the literature on sand piles, Scheinkman & Woodford [5] show in a model of inventory dynamics how small shocks may cause aggregate fluctuations.}

Third, systems can be subject to sudden transitions between locally stable states. In both economics and science, we can find examples of systems that have multiple stable states. And switches between these may be hard to predict. Models of the circulation pattern in the North Atlantic Ocean suggest that it can either be vigorous, helping to warm the Northern Hemisphere as water is transported from lower latitudes, or can shut down almost entirely [6]. Many economic systems also exhibit forms of hysteresis or path dependence. For example, changing social attitudes towards personal bankruptcy, inflation or unemployment may affect equilibrium outcomes for those variables.

3. Policy responses to unpredictability

Predicting the incidence of instability in all of these settings is very difficult. It is, however, possible to identify a sand pile or forest as being prone to large-scale instability and determine the factors that contribute to that instability. Analogously, many people, including people at the Bank of England, did identify the vulnerabilities of the financial system before the crisis without actually being able to predict when or how the crisis would begin.

Economists have been able to learn from other disciplines about how to cope with these types of instability. For example, insights from ecology and epidemiology have been applied to financial networks (for more discussion,
see [7]), and economists have learned much from engineers about how to control dynamic systems.

The key is for policy-makers to focus on making the structure of the underlying system more robust to shocks. For example, in avalanche areas, the snow may be ‘seeded’ so that, by inducing small avalanches, the chance of a large avalanche is mitigated. And in fire-risk areas, controlled burns or fire breaks are sometimes used to limit the risk of a large fire. In the context of the financial system, policymakers could impose a ‘Glass-Steagall’2 style separation between the payments system network and risky activities.

Actions can also be taken to mitigate the impact of a bad outcome. For example, this might mean building an avalanche net or fence, funding a firefighting service or launching a lifeboat. In the context of financial regulation, this might entail reducing the costs associated with resolving financial institutions, for example, by requiring banks to develop resolution and recovery plans, or requiring forced subsidiarization of foreign bank branches.

As always, however, there is the risk that such interventions can have unintended consequences: shortly after the Titanic sank, a steamer (the S.S. Eastland) capsized on Lake Michigan, with the loss of around 850 lives, because it had been destabilized by the extra lifeboats required by post-Titanic regulations!3

4. Decision-making under uncertainty and the role of beliefs

The analogies between economics and science can be taken only so far. A key difference between economics and the physical sciences is the role played by active decision-makers—such as households and businesses—whose presence substantially complicates the dynamics of the system.

In particular, economic outcomes are sensitive to the way people behave under uncertainty, and to their beliefs about the past, present and future. Perceptions of uncertainty affect behaviour. If enough people are uncertain about their future job prospects and save more as a precaution, that may lead firms to cut employment, so increasing the chance that jobs are indeed lost. But uncertainty about whether it will rain today does not change the weather.

Beliefs adapt over time in response to changes in the environment; and this in turn affects how economic systems behave. Because the surrounding environment can affect economic decision-making, there are probably few genuinely ‘deep’ (and, therefore, stable) parameters or relationships in economics. In contrast, in many settings in the physical sciences there are stable ‘rules of the game’ (e.g. the laws of gravity are as good an approximation one day as the next).

The study of decision-making under uncertainty has a distinguished ancestry in economics. Frank Knight wrote about the difference between risk (where frequencies could be used to calculate probabilities) and uncertainty (where there was no objective basis on which to derive probabilities) [8]. Of course, a true Bayesian would assume that people would be able to construct subjective probabilities, and their behaviour would be governed by those beliefs. But Keynes

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2 The Glass-Steagall Act was a piece of legislation, enacted in 1933 in the United States, which aimed to restore confidence in the banking system in the aftermath of the preceding banking crisis. Among its provisions were an effective separation of commercial and investment banking activities.

made much of the pervasive nature of uncertainty in his explanation of business cycles because of the instability of those subjective probabilities [9]. Occasional sharp changes in expectations could, and did, result. That is exactly what happened in the autumn of 2008, with the sudden and synchronous collapse in business confidence around the world.

So the behaviour of economies depends in part on the beliefs about future events held by the various players: consumers, businesses and governments. Outcomes are endogenous to beliefs about the likelihoods of the outcomes. In some contexts there may be self-fulfilling equilibria.

Sudden shifts in beliefs are particularly relevant when many decision-makers interact. The behaviour of a bank’s depositors has many equilibria, each of which depends on beliefs about whether other depositors are likely to run on the bank. Changes in perceptions of uncertainty may be transmitted rapidly, and amplified, with the potential to affect behaviour in a coordinated way.4 A restaurant may be much busier than an identical competitor if the first customers of the evening dine there and the next customers suspect that the first may know something they do not, and so follow, with others subsequently joining the herd. The reverse may occur on the following evening.

Disentangling the incremental role of shifts in beliefs is often difficult. For example, a fire sale of assets by one bank may have a mechanical amplifying impact on other banks through its effect on market prices, but could simultaneously affect other banks via confidence and beliefs, if people become less optimistic about valuations of other assets when one asset class is in distress.5

The role of beliefs and behaviour in affecting outcomes means that there is a premium on understanding decision-making under uncertainty. In economics, broadly speaking, there are two approaches to modelling decision-making under uncertainty: the standard, ‘rational’ approach of ‘*homo economicus*’ (which assumes that beliefs are based on an efficient processing of all available information) and the ‘behavioural’ approach, informed by the psychology literature (which highlights psychological traits that violate the assumptions underlying the ‘rational’ view).

There is strong experimental evidence that people are subject to biases when collecting and processing information under uncertainty, and that such processing occurs only intermittently.6 The evidence suggests that people are also frequently incoherent in assessing, assigning and processing probabilities—even in highly artificial settings where information is complete—and find it particularly difficult to assess probabilities that are very low or very high, partly because there is less scope for learning in these cases. There is also evidence that, when making complex decisions or when lacking full information, such as when deciding whether to have eye surgery, people often use rough heuristics, or go on first impressions, appearances, gut instinct or intuition.

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4For example, Caballero & Krishnamurthy [10] show how liquidity shocks in the presence of Knightian uncertainty can cause investors to hoard liquid assets. This occurs because all firms assume a worst-case scenario—that they will be unable to access liquidity when required—and this causes them to hoard liquidity. Alternatively when information is dispersed across a large number of people, each with a noisy signal about economic fundamentals, outcomes may be determined by an ‘information cascade’, the outcome of which is hard to predict [11,12].

5See May & Arinaminpathy [13] for a model of the financial system which makes this distinction.

6See the collection of articles in Kahneman *et al.* [14].
We want to highlight four main aspects of the behavioural view:

— Perceptions of risk have been shown to be unduly influenced by recent or personal experience. After an earthquake, demand for earthquake insurance at first increases and then declines, while the probability of the next large earthquake may grow over time. So-called ‘Depression babies’ seem to take less financial risk than other generations. Such an effect may explain why the fear of financial crises declines over time as memories of the last crisis fade.

— Decisions under uncertainty have been shown to be sensitive to the way questions are presented. People understand probabilities better if they are expressed in terms of natural frequencies (1 in 10,000) rather than percentages (0.01%). This is one symptom of a wider confusion over probabilistic concepts. Research by Gerd Gigerenzer and others shows that doctors, for example, are often misled by information presented in the form of probabilities rather than sample frequencies. The statement that a diagnostic test has a 5 per cent probability of a false positive is misinterpreted more often than the statement that five patients out of every hundred taking the test will show a false positive (e.g. [17]). This is compounded by the fact that many forecasts are not of the kind where reference back to a sample frequency is informative. Forecasts made today of the weather or the inflation rate at some date in the future are unique; they are not the outcomes of a repeated experiment. Decisions about saving for future pension provision, for example, are difficult to make the subject of experimentation, although we can learn from the experience of others.

— People tend to follow the actions of others. That can be an effective strategy. For example, on the game show ‘Who Wants To Be A Millionaire?’, the ‘Ask the Audience’ lifeline has a 91 per cent success rate, showing that there can be wisdom in crowds [18]. But experiments also show that a substantial proportion of people choose a glaringly incorrect answer to a simple question when told it is the answer others have chosen, even though the same question is answered correctly in isolation (e.g. [19]). In a sporting setting, goalkeepers facing penalties tend to dive, rather than stay in the middle of the goal, more than the direction of penalties suggests is appropriate [20]. Such types of behaviour reflect the fact that people are unwilling to risk failure by pursuing strategies that are different from the norm. The penalty of failure may be less if others fail in the same way—as Keynes pointed out was true of banks.

— People have excessive faith in their own judgements and are subject to confirmation bias and wishful thinking. An experiment, well known in the literature, asked respondents to report 90 per cent confidence intervals around estimates of a set of unknown quantities (e.g. the diameter of

7For example, see Palm [15], who found that those most affected by earthquakes were most likely to take out insurance afterwards. But this effect faded as time elapsed after an earthquake.

8For example, Malmendier & Nagel [16] report that those who experience high stock returns during their life are more likely to hold stocks and report lower risk aversion; those who have experienced high inflation are less likely to hold bonds.

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the moon). But the true answer lay outside the reported confidence intervals half of the time. This reflects a general finding that people are overly confident in their own judgements. A corollary may be a tendency to understate uncertainty, and this could explain why the ‘severe’ stress testing scenarios used by banks before the crisis were so mild.

In practice, the relative applicability and usefulness of the ‘behavioural’ and ‘rational’ views is likely to depend on the question at hand. While rationality is a useful starting point, empirical studies support the contention of behavioural economists and psychologists that people often make decisions using simple or ‘fast and frugal’ heuristics because of limited time, information and cognitive capacity [23].

5. Some implications for policy design

These observations about decision-making under uncertainty in economics have implications for policy along three dimensions.

First, decision-making under uncertainty affects the dynamics of the economy. Some of the psychological biases discussed earlier can offer an explanation for ‘herding’ behaviour and ‘risk illusion’ (a tendency to over/underestimate likelihoods of different types of events). Taken together, these biases could offer an explanation for periodic bouts of exuberance in the economy and the financial system in particular. As such, they should bear on our assessment of the likelihood of the range of possible outcomes. Our ignorance of how people behave under uncertainty, together with the presence of feedbacks between behaviour, out-turns and beliefs, highlights some of the difficulties and pitfalls of economic policy-making.

Second, the recognition that beliefs and behaviour play an important role in the dynamics of the system affects the type of policy actions that are desirable. Once it began, the run on Northern Rock in September 2007 could be understood as a rational response to the incentives faced by its depositors, given the incomplete deposit insurance provisions that prevailed at the time. Ensuring that panic did not spread is one reason why guaranteeing all bank deposits was subsequently necessary.

Third, communication is part of the policy response to uncertainty. In this respect, economic and financial systems differ from physical systems. In the latter, there is no one listening. The control strategy in a physical system is defined by a scheme that relates the settings of policy instruments to certain features of the environment (e.g. fire left booster rocket if rocket veers to left of target). But in an economic system—because people’s beliefs about future policy actions affect their behaviour today—the control strategy has to comprise not only a plan for setting the instruments (e.g. raise Bank Rate if expected inflation rises) but also a plan to condition beliefs about how policy-makers will respond in future. That involves communication.

9 This experiment is owing to Russo & Schoemaker [21], cited in Plous [22].

10 Tucker [24] discusses how this might create a friction that could be countered through the use of so-called macroprudential instruments.
6. Communication

A communication strategy involves deciding how much information to communicate, and in what form. Revealing information entails costs and benefits. An optimal communication strategy balances those costs and benefits.

Consider first the benefits. Information is valuable and can improve the quality of decisions. Many government agencies have valuable information that private citizens cannot easily obtain for themselves. An example is the information collected by the Office for National Statistics on the economy and social trends. Central banks, too, may have information about the shocks hitting the economy, or about how they will be propagated, or indeed about the way in which policy is likely to respond. Provision of information about these issues may help people to reduce their forecast errors and take more informed decisions.

As we discussed earlier, complex economic systems may have multiple equilibria. Movements between them depend on expectations and beliefs about others’ beliefs. That is especially so if there are strategic complementarities where the benefits of a strategy depend on the choice of strategies by others. Communication might help us to coordinate beliefs so that a good rather than bad equilibrium results. Suppose that private investors begin to doubt the health of a bank that the central bank knows to be fundamentally solvent. A signal from the central bank that the bank is solvent may help to change the beliefs, thus ensuring the continued liquidity, and hence solvency, of the healthy bank. But it may not be clear that the bank is solvent, and in practice there is rarely smoke without fire.

Communication may help in improving the credibility of public policy. Economic policy-makers often confront the problem that a future policy setting that is optimal today is not likely to be the policy that it would be optimal to follow tomorrow. Before central bank independence, a problem for monetary policy was that a government promise to deliver low inflation was not credible. Wage and price setters knew that if contracts were based on the assumption that future inflation would be low, the government would not be able to resist the temptation to generate inflation higher than promised because that would temporarily boost employment and output. So the initial promise was not believed. Once expectations of high inflation were embedded into prices and wages, it was at that point rational for the government to tolerate high inflation, because the cost of reducing it would be a deep recession. The idea of giving central banks independent control over monetary policy was to remove this temptation to inflate. Communication is a potential solution to the credibility problem. If policy-makers are transparent about the objectives of a policy—and the strategy to be followed in pursuit of those objectives—it will be easier to hold them accountable for their actions. This increases the incentives for policy-makers to meet their objectives.

Despite all these benefits, it does not always follow that more communication is beneficial. More communication can be costly and self-defeating. First, private participants face costs in collecting and processing information that could mean important messages are lost. The Bank of England could publish all of the many

11For an exposition of the credibility problem in monetary policy, see [25]; for an account of the benefits of central bank independence, see [26].
documents that it creates internally each month. But that would simply make it harder for the really important information to get through. Less can be more. We could have minute-by-minute revisions to weather forecasts or terrorism threat estimates, but that might overwhelm genuine flood or bomb warnings to which we want people to respond.\textsuperscript{12}

Second, communication can sometimes aggravate market failures. Suppose the Royal Society for the Protection of Birds knows a secret location where rare birds are nesting. To preserve biodiversity, there may be a great benefit to ensuring that the birds can nest undisturbed. If the RSPB reveals its secret, bird watchers may converge on the location. Here, less than full transparency mitigates the problem.

An example in the same spirit is whether or not the use by commercial banks of the Bank of England’s lending facilities should be concealed. If the use of the facility were made public, depositors would ask themselves why it had been used: if they attached even a small probability to the possibility that the bank was in trouble, it would be rational for them to withdraw their deposits—triggering a run on the bank. Anticipating this reaction, there is a risk that banks would choose not to use the facilities. Further, some market participants might use the information that the facilities were being used to spread malicious rumours in the hope of profiting from the market reaction. Such rumour-spreading would be privately beneficial for the rumour-spreaders, but socially harmful. That is why when designing its discount window lending facilities, the Bank decided only to disclose average usage over a quarter, and then only with a lag.\textsuperscript{13}

It is clear, then, that more communication is not always better. Nor is it always easy to get the message across. Take, for example, the communication of forecasts. A forecast is not just a number, but rather an estimated probability distribution and people tend to find probabilities hard to understand.\textsuperscript{14} Moreover, we cannot assume that people obtain information in a neutral form. Most people receive information via the media, which may filter or reinterpret the message. This leads to an incentive problem. Instead of simply reporting the information about future prospects made available in the forecasts, there is an incentive to summarize the prospects in a single number or to describe one part of the probability distribution in a way that makes for a good story. That suggests there is merit in trying to communicate directly to the public.

Forecasts, or probabilistic statements in general, can easily be misunderstood or misinterpreted. As a result, forecasters may decide to withhold information,\textsuperscript{12} This idea has received theoretical attention recently following the encouragement of Sims [27]. He sketches a model in which agents are ‘rationally inattentive’, focusing only on information which they diagnose makes an important contribution to minimizing forecast errors.\textsuperscript{13} Morris & Shin [28] study a case in which a central bank can only reveal a noisy signal. That signal, which is unavoidably inaccurate (e.g. a central bank forecast), is given an inappropriately high weight in private decisions because each private participant expects others to use it, and each wants to ensure that his action is not too far out of line with others. This is an example where a public communication coordinates on an inferior equilibrium. Morris & Shin also show that public information can crowd out private information. By ensuring that all agents overweight public information in their decisions, that means that other agents observing those decisions can infer less from them about the private information others have that motivated them. In the limit, if everyone took decisions solely on the basis of public information, those decisions would reveal nothing about private information they may also have, but did not act on.\textsuperscript{14} Dale et al. [29] illustrate how welfare can fall if the private sector overestimates the accuracy of central bank forecasts.

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even when, correctly understood, there is something useful in the forecast—a case in point being the recent Met Office withdrawal of medium-term seasonal forecasts.

When experts retire from the field, it is left wide open to quackery—and there is no shortage of quacks whether in medicine, economics or meteorology. So there is a major challenge in explaining that, although we may not have a precise prediction of the effects of a particular policy action, nor are we wholly ignorant of its consequences. Finding illuminating ways of expressing those judgements is difficult but important. We must not pretend to know more than we do, and we must avoid the delusion of spurious precision.

7. Communication in practice: fan charts

It is time to put some flesh on the bones of these abstract discussions by looking at how the Bank of England communicates in practice.

The Bank of England publishes its analysis of the economy in a range of documents, of which the longest running, and perhaps the best known, is the quarterly \textit{Inflation Report}.

In the \textit{Inflation Report}, the Monetary Policy Committee (MPC) describes the uncertain current state of the economy, and sets out its latest projections for key economic variables. The most important of these is the projection for inflation. The Committee has a clear target to meet, set by the government. Inflation, as measured by the change in the Consumer Prices Index (CPI), should be 2 per cent at all times. But because interest rates take time to affect inflation, forecasts of inflation are integral to setting monetary policy. Each forecast covers a 3 year period, because that is the horizon over which we expect monetary policy to have the majority of its effect. And because the MPC’s forecast is a probability distribution, rather than a single number, it is communicated in a fan chart depicting the MPC’s view of the probability of a range of different outcomes.

Figure 1 shows the inflation fan chart published in the February 2010 \textit{Inflation Report}. Each fan chart is conditioned on a particular path for the Bank’s policy instruments: this one assumed that Bank Rate would follow the path implied by financial market prices. The MPC also publishes a fan chart conditioned on the assumption that Bank Rate remains at its current level throughout the forecast.

These charts have been helpful in communicating the big picture of the outlook for the economy. The fan chart works by showing what the MPC believes would happen to inflation if today’s economic circumstances were repeated on 100 occasions. In any given quarter in the future the rate of inflation of the Consumer Prices Index (CPI) should lie somewhere in the red shaded area on 90 out of 100 occasions: 10 times in the darkest red band, and 10 times in each pair of lighter red bands. The darker shades refer to increasing probability densities at any given point. On the remaining 10 out of every 100 occasions, inflation is expected to lie outside the shaded part of the fan altogether. But the distribution of these tail events is not specified, as to do so would imply a spurious degree of precision on the part of the MPC.

Take, for example, the February 2010 fan chart in figure 1. It shows that inflation had been volatile in 2008 and 2009, first rising sharply to around 5 per cent and then falling back. Looking ahead, the MPC had judged it likely that
Inflation would rise again in the first quarter of 2010, with the entire 90 per cent of the distribution covered by the shaded fan lying above the out-turn for the fourth quarter of 2009. Remember, though, with 10 per cent of the distribution outside the shaded bands, the MPC had not ruled out the possibility that inflation might have remained unchanged or fallen.

We can now compare the actual inflation data for January, shown by the green marker in figure 1, to the projection. Inflation had indeed risen at the start of the quarter, suggesting the MPC’s forecast for Q1 was on track. Thereafter, the MPC had judged that inflation was more likely than not to fall below target for a period. You can see that the most likely outcome, shown in the darkest band, was for inflation to be below the target at the end of the forecast period. But the MPC had also seen upside risks to that projection, stemming from the possibility that the current high level of inflation might become embedded in inflation expectations, so making inflation itself more persistent. To make such risks easier to discern, the MPC also makes available charts of the cross section of the probability distribution at particular points on the forecast horizon, like the one shown in figure 2. The upside risks meant that, at the end of the forecast horizon, the MPC had judged that inflation was as likely to be above the target as below it. This can be seen in the chart, because the narrower bands towards the left-hand side mean that the mass below the vertical line marking 2 per cent is about the same as the mass above it.

But why do we show our projections like this? Many other economic forecasters publish their forecast as a single, most likely outcome. In our view, this sort of forecast is not very informative, as the actual probability of it being correct is very close to zero. In contrast, the whole distribution contains much more information.
And it is the entire distribution of outcomes that matters for policy. The fan charts are useful because they contain information relevant to the likely distribution of Bank Rate. To explain its current policy setting, and to provide information on the likely path of policy, the MPC needs to communicate its judgement of the outlook as a whole.

Most other central banks also try to illustrate uncertainty around their projections, albeit in slightly different ways. The European Central Bank (ECB), for example, presents its forecasts as a range defined as twice the mean absolute projection error (excluding outliers)—see ‘New procedures for constructing eurosystem and ECB staff projection ranges’ December 2009.

The Federal Reserve produces projections that show the range of individual (most likely) forecasts—as viewed by each Federal Reserve Bank President and Governor. This is shown by the spread of the whiskers in figure 4. They also produce a measure of ‘central tendency’ which truncates that distribution by excluding the three highest and three lowest forecasts, here represented by the boxes in the same figure. This representation of the differences of view within the Federal Reserve is very different from a probability distribution of future outcomes. In our experience, communication of the uncertainty about future inflation is important in explaining monetary policy.
The Swedish Riksbank adopts an approach similar to ours and uses fan charts as their key tool for communicating views on the outlook.

Looking back, we can see how the Bank’s communication strategy has evolved in light of the experience over the past 17 years. Figure 5 shows that, even in the early days of the Inflation Report, we tried to get across the uncertainty around our projections, illustrating it with a ‘trumpet’ of uncertainty as shown in the left-hand panel. It was not until 1996 that the more sophisticated fan chart, on the right, was introduced as our main device for communicating about the outlook.

As part of that evolutionary process, and to complement our projections for inflation, the MPC has also produced fan charts for activity in the economy—specifically gross domestic product (GDP)—since November 1997. Ordinarily, this has been shown as a projection for the four-quarter growth rate, which, for most commentators, is the standard way of looking at GDP. Figure 6 shows data for GDP in the grey line, portraying a sharp decline in output over the preceding

\[\text{Figure 4. Federal Reserve forecast uncertainty. Full ranges from 17 individual forecasts from Fed presidents and governors. ‘Central tendency’, shown as grey shaded area, excludes three highest and three lowest forecasts. Source: ‘Monetary Policy Report to the Congress’, Federal Reserve, February 2010.}\]

\[\text{Figure 5. Early inflation fan charts. (a) November 1995 trumpet (red dashed line, RPIX inflation forecast; blue dashed line, RPIX inflation forecast from previous Inflation Report) and (b) February 1996 fan chart. Source: ‘The Inflation Report projections: understanding the fan chart’, Britton, Fisher & Whitley. Bank of England Quarterly Bulletin, February 1998.}\]
2 years. There are two points to highlight with this chart. First, there is a fan around the historical data, to the left of the black vertical line. That reflects the fact that output data are frequently revised over time—sometimes heavily. The CPI, in contrast, is rarely revised. The chart shows that there was a lot of uncertainty about the past data. The MPC believes it is more likely than not that current vintages of data will be revised up slightly. But the big picture of a large decline in output was expected to remain even in the mature data. Uncertainty about the past is an important component of our uncertainty about the future, and is reflected in the forward-looking part of the GDP fan, to the right of the black vertical line. The second point is that the forecast part of the chart shows that a return to growth was thought likely. But if you just focused on this chart you might feel that the MPC was quite optimistic in expecting such a rebound in growth after a painful, deep recession.

In some ways, that is true. But by itself that would be a misleading inference. The reality was that, even if growth had rebounded, the level of activity would still very likely have remained weak for a considerable period compared with its peak at the start of 2008. The economic environment was likely to continue to feel far from normal for some time. After all, it is ultimately the level of activity, rather than its growth rate, that matters for employment and the degree of inflationary pressure. It was precisely to draw out this point that recent editions of the Inflation Report have included an extra chart, shown here as figure 7. This shows the level of output corresponding to the growth chart. In practice, we have found that, even though these charts show the same information, the levels chart can be more effective at getting that big picture message across.
Despite these efforts, there are still nuances that we have found challenging to communicate. The fan chart conveys a rich view of the uncertainties in the current forecast. But it does so at the cost of it being hard to see how the distribution has changed compared with the preceding forecast. So perhaps it is unsurprising that some commentators have found it hard to grasp the subtleties of our forecasts. That has led some to suggest that we publish tables of key summary statistics on the same day as our forecasts—the mean, median and mode of the distribution. We fear that if we made such statistics available, all of our hard efforts to communicate the outlook as a whole would get washed away in an extreme focus on point estimates. We do not want media commentators to summarize that outlook in a single number, appealing to people’s tendency to look for simple rules and heuristics, thereby preventing us getting the broader view across.

As well as leading to over simplification, publishing the information can also promote over interpretation of our forecast. While the fan chart represents the Committee’s probabilistic view of the future, it is important to recognize that it has only incomplete information on that distribution. We therefore should not overplay the particular parametric form of the chart. As a result, it makes little sense to place a lot of weight on particular summary statistics of the distribution. Rather, what the Committee can do is make broad statements—such as ‘inflation is more likely than not to be above the target’. Being more precise risks overstating the MPC’s degree of knowledge about the distribution.

So the MPC’s concern is that early publication of the numerical parameters risks not only trivializing the policy-makers’ overall view of the economy, but also misrepresenting that view by being overly precise. The fan chart is designed
to strike the right balance between these two hazards, by giving a broad brush articulation of the distribution that the Committee judges appropriate.

But there is always room for improvement. So we turn to some of the ideas we have considered for providing additional information on particular aspects of the distribution, to help deal with some of these difficulties. For example, the next chart shows how the distribution has changed since the previous forecast by placing the two distributions side by side, as in figure 8. This chart shows that the most likely outcome in the dark red band has shifted down compared with the earlier forecast. But that change in the most likely outcome is not reflected to the same degree in the rest of the fan chart—and that is because there has been an offsetting upwards shift in the balance of risks. This is most clearly seen by noting how the dark line is flatter than the light one on the right-hand side of the chart, and steeper than it is on the left.

As we discussed earlier, the aim of MPC communication is to convey useful information about the broad distribution, without being driven to spurious accuracy. There are many ways we can do this. One idea that we investigated was to show charts of the MPC’s view of the probability that inflation will be above the 2 per cent target at a particular point in time. Such a chart does speak to the whole distribution, and it facilitates easy comparison with the previous forecast round. This is shown in figure 9.

But it still has the problem that it assigns a precise probability to a given outcome. A solitary Bayesian policy-maker may be comfortable with that. But in reality, there is no unique answer that encapsulates the collective judgement of the MPC. In the Bank’s experience, MPC members find it more important to focus on distinguishing between the different broad orders of magnitude of future events, and are less interested in debating whether something will happen 49 times out of 100 or 52 times.
Figure 9. Likelihood of inflation exceeding target. Blue line, February 2010 *Inflation Report* projection; magenta line, November 2009 *Inflation Report* projection.

Figure 10. Likelihood of inflation exceeding target. Black region, consistent with February 2010 *Inflation Report*.

One answer to this tension is to describe the problem in words. But that carries its own difficulties. An alternative is to design a graphical device that prevents the illusion of spurious precision. Simple graphical changes to the chart, such as figure 10, emphasize that the MPC’s view is not best expressed by a precise number for the probability. But a downside of this sort of representation is that it does not readily permit comparisons between successive forecasts.

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Instead, a further alternative that the MPC was considering at the time of the conference, in March 2010, was to present this as a ‘probability ribbon’ as in figure 11. This chart has subsequently been adopted in the *Inflation Report*. The chart shows a range estimate of the probability that inflation would exceed the target, defined by the edges of the relevant band of the fan chart. In doing so, it preserves the broad impression of the Committee’s overall view, yet filters out the artificial accuracy.

We can once again use the February 2010 forecast to highlight a few of the key messages that the MPC wanted to communicate. In the early part of the forecast period, the probability of inflation being above the target was very high. This was because the data for inflation were well above target at that time, and also because the fan chart here was relatively narrow. But the projection for inflation fell over the forecast period. This implied a fall in the probability of inflation being above target. For instance, the Committee thought that the chance that inflation would be 2 per cent or higher in 2011Q1 was between 15 and 20 per cent. Towards the final part of the projection, the probability of inflation being above the target rose back to broadly one half. This chart emphasizes that, in spite of the most likely outcome for inflation being below target, the nature of the distribution of risks implied that the probability of exceeding the target was about one in two.

We can also combine the usual top-down fan chart with the information in the cross-sectional densities to produce a three-dimensional fan chart shown in figure 12. The particular advantage of this chart is that it shows how the overall density changes over time. For instance, when the distribution is very narrow, such as at the start of the forecast period, the probability density at the centre of the fan is higher, simply because the MPC is more confident about its central forecast here.
Overall, however, both from the point of view of how policy is determined, as well as how it is communicated, it is the broad distribution of likely outcomes that matters.

8. Conclusions

Self-confidence is infectious. It can also be dangerous. How often have we drawn false comfort from the apparent confidence of a professional advisor promising certain success only to be disappointed by subsequent performance? Uncertainty pervades almost all public policy questions. Economics and many other disciplines are united by a common need to grapple with complex systems. As the crisis of the autumn of 2008 showed, such systems can sometimes be subject to abrupt changes, the precise timing of which cannot easily be identified in advance. But policy-makers are often expected to anticipate the unpredictable. How can they retain the trust of the public while being open about the true degree of uncertainty? Or, to put it another way, what is the appropriate bedside manner for policy-makers when dealing with complex uncertain problems in a public debate? There is a fine line to tread. We are not wholly ignorant, but nor can we or should we purport to provide precise predictions. We have explained how the Bank of England tries to deal with some of those challenges in the context of monetary policy by communicating our assessment of the uncertainty we face in an accessible way. We are sure we have much to learn, and our efforts to improve communication will continue for a long time to come.

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