A FRAMEWORK FOR

FORECASTING AND EVALUATING INFLATION RISKS [1]

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Introduction

Following the gradual process of disinflation over the last two decades the consensus that the paramount objective of monetary policy is to safeguard against the danger of high inflation appears to be disintegrating. It is being replaced by the realization that high inflation is but one of the dangers facing policy makers. A second and equally important danger is that of deflation. Thus, the central banker faces the problem of balancing the risks of excessive inflation against the risk of deflation.

In two recent papers, Lutz Kilian of the University of Michigan and Simone Manganelli of the European Central Bank have developed a formal framework for thinking about this problem (see Kilian and Manganelli 2003a, 2003b). This framework allows us to quantify and forecast the risks of inflation spinning out of control in one or the other direction. It also allows us to assess whether these risks have become unbalanced and require corrective action by the central bank. In this sense, the central banker may be viewed as a risk manager.

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[1] The views expressed in this paper are our own and do not necessarily reflect the views of the European Central Bank (ECB) or its staff.

At first sight the view that central bankers set the interest rate to balance the risks of excessively high or excessively low inflation may seem novel, but actually this type of "policy rule" is consistent with the way central bankers themselves characterize their objectives. The language of risk management is already commonplace in policy announcements and speeches. For example, Alan Greenspan, the Chairman of the Federal Reserve, on August 29, 2003, at the annual Jackson Hole conference, stressed that "monetary policy based on risk management appears to be the most useful regime by which to conduct policy." He further elaborated that "the conduct of monetary policy in the United States at its core involves crucial elements of risk management".

This risk management view of monetary policy contrasts sharply with the way many academic macroeconomists think about the conduct of monetary policy. Much academic research has analyzed simple policy rules of the form

$$i_t = a + b(p_t - p^*) + c(y_t - y^*)$$

that stipulate that the policy instrument i_t, typically the short-term interest rate, is set as a function of the deviation of inflation from its target and the deviation of output from potential output. Once the parameters *a*, *b*, and *c* are set, there is little left to do for the policy-maker.

Interestingly, no central bank to date has made a commitment to such a simple instrument rule (see Svensson 2003). In fact, most policy-makers explicitly reject the view that policy can be reduced to a simple rule of this form. They instead stress their commitment to *objectives*, as opposed to rules. The primary objective since the 1980s has been that of achieving "price stability". In practice, this objective means setting the interest rate to keep medium-term inflation under control. How this objective is implemented differs from country to country. Many countries have declared themselves to be *inflation targeters*. For example, the

Bank of England sets a medium-term inflation target of currently 2.5%; the Riksbank of Sweden sets a target of 2%; so does the Bank of Canada. In most cases, inflation targeters allow for an explicit level of tolerance of +/- 1 percentage point about the target.

Another group of countries explicitly targets a zone of inflation. For example, the European Central Bank (ECB) aims to keep medium-term inflation between a lower bound of about 1% and an upper bound of 2% (see Duisenberg 2003). In practice, the distinction between *inflation-zone targeters* and inflation targeters with a tolerance band about the target becomes blurred.

Other central banks, such as the Federal Reserve Board explicitly allow for dual objectives. For example, in a press release dated January 19, 2000, the Federal Reserve Board referred to "the FOMC's consensus about the balance of risks to the attainment of its long-run goals of price stability and sustainable economic growth". Unlike most other central banks, the Board uses the language of risk management without an explicit target range.

For expository purposes, we will focus on inflation targeters and inflation zone targeters in what follows. We note, however, that our methodology can easily be adapted to allow for additional objectives such as output or employment, and that measures of inflation risk may be computed independently from output and employment risks under mild assumptions.

What does it mean to be an inflation (zone) targeter in practice? Fortunately, we do not need to guess what central banks actually do to achieve an inflation target, because their approach is a matter of public record. For example, Charles Goodhart, a former member of the Monetary Policy Committee (MPC) of the Bank of England, in the year 2000 summarized his experience as follows: "When I was a member of the MPC … I was trying, at each forecast round, to set the level of interest rates, on each occasion, so that without need for future rate changes prospective (forecast) inflation would on average equal the target at the policy horizon." (Goodhart 2000) Similar accounts are available for other inflation targeting countries. For example, Lars Heikenstein, Deputy Governor of the Riksbank, in 1999 summarized the operating procedure of the Riksbank as follows: "Monetary policy is normally conducted so as to be on target, defined in terms of the CPI, one or two years ahead." (Heikensten 1999)

This description of actual operations naturally suggests a definition of the central bank risk management problem. A situation is said to involve risk if the randomness facing the decision-maker can be expressed in terms of specific probabilities. Thus, any measure of inflation risk must be related to the probability distribution of future inflation outcomes. If monetary policy is guided by the objective of achieving an inflation target, as in the case of many central banks, risk management must refer to the risk of failing to attain that target. The policy-decision of the central bank involves a trade-off between the risk of excessively high inflation and the risk of excessively low inflation relative to the stated objective of the central bank. It is this trade-off that must be managed by the central banker.

Some examples underscore that this is indeed the way central bankers approach the risk management problem. The first example is an explanation of ECB policy by Otmar Issing, a Member of the Executive Board of the European Central Bank in a speech before the European Finance Convention in December 2002. Issing stressed that "… we analyse risks of deflation as well as inflation and will act accordingly to prevent both phenomena in case we detect risks in one or the other direction". A second example is provided by a comment by Yukata Yamaguchi, Deputy Governor of the Bank of Japan, made in 2002 in the context of discussions of the dangers of deflation: "Suppose a central bank adopts dramatic easing actions … The central bank pursuing such a strategy would have to be fully convinced, substantiated by quantitative analyses, and strongly concerned about the risk of deflation a few years into the future."

Figure 1 proposes a framework for thinking about the sources of risks faced by the central banker. Inflation risks are related to the probability distribution of future inflation. This probability distribution may be estimated based on a forecast model. The underlying forecast model may be a simple univariate time series model or a large-scale macro-econometric model. Any variable that we condition on in constructing forecasts will be a risk determinant. Risk determinants affect risks through their effect on the distribution of future inflation. As the value of the risk determinant changes, so does the distribution of the inflation forecasts and hence the associated risk of failing to attain the inflation target. Although any variable that enters the forecast model may be considered a risk determinant, there are some variables that are particularly important risk determinants for inflation such as exchange rates, oil prices or changes in productivity. Since we do not know the precise value of the risk determinants we typically start by specifying a distribution for each risk determinant. These distributions may be viewed as inputs into the forecast model. The output produced by the forecast model is the projected distribution of inflation conditional on the probability-weighted average of the settings of the risk determinants. Given the distribution of inflation forecasts, risks of excessively high or low future inflation may be quantified based on a suitable risk measure.

Central bankers indeed represent their assessment of future inflation in terms of distributions. For example, the Philadelphia Fed uses tables to assign probability values to different ranges of inflation rates (see Table 1). The Bank of England instead uses graphical representations of inflation uncertainty in the form of a fan chart (see Figure 2). Interestingly, no central bank uses formal procedures for quantifying the risk of failing to attain the inflation target.

Given a distribution of inflation forecasts, how can we quantify the risks that inflation may be too high or too low relative to the central bank's intentions? Figure 3 provides a graphical presentation of the parts of the distribution of future inflation that are relevant to risk management. By construction, risks will not be related to the center of the distribution, but to the tails of the distribution, defined as the areas in which inflation exceeds the target. Thus, a risk manager would not be interested in the most likely (or modal) forecast value, nor would a risk manager focus on the conditional mean forecast of inflation typically reported by forecasters. Rather he would be interested in the event that realizations of inflation fall into the tails of the distribution, defined as the areas exceeding the upper bound ($\overline{p}$) and falling below the lower bound ($\underline{p}$) set by the central bank. The key question addressed by Kilian and Manganelli (2003a) is how to quantify this risk in a manner that is consistent with the preferences of the central banker. Once we understand the nature of this risk, we may forecast it in real time, and we may characterize the trade-off between upside and downside risks to inflation.

We will attempt to answer these questions based on the model of central bank risk management proposed by Kilian and Manganelli (2003a). We begin by formally defining measures of risk. We then highlight some implications of inflation risk management for the conduct of monetary policy.

Measures of Inflation Risk

We cannot define measures of risk without first discussing the preferences of decision-maker. For expository purposes we will think of the decision-maker as the central banker, although the same analysis could be applied to a private sector agent attempting to gauge the risks of excessively high or excessively low inflation.

The decision-maker's preferences incorporate both the target range of inflation and the weight that the decision-maker attaches to violations of the target. Kilian and Manganelli (2003a,b) propose a simple, yet general parameterization of the preference function. A particular example of this preference function is shown in Figure 4.

The plot in Figure 4 can be thought of as an index of the degree of satisfaction a central banker receives, as we vary the inflation rate. For expository purposes we set $\underline{p} = 1\%$ and $\overline{p} = 3\%$ and impose symmetry. Figure 4 shows that the highest possible satisfaction (or utility) is achieved when inflation remains within the target zone. We normalize this level of satisfaction to zero. As inflation exceeds the target (whether it is too high or too low), the central banker experiences dissatisfaction (negative utility), represented by the downward-sloping lines in the graph. The degree of dissatisfaction increases with the extent to which inflation exceeds the target. A key feature of the central banker's preferences is the pair of parameters a and b that govern his attitude toward violations of the target. The larger these parameters are, the more quickly the central banker becomes dissatisfied, when inflation exceeds the target by a given amount. We will illustrate the role and interpretation of these parameters shortly. Note that by choosing alternative values of a and b we are able to approximate a wide range of attitudes toward inflation. We also are able to allow for asymmetry. Moreover, the analysis allows both for point targets of inflation ($\underline{p} = \overline{p} = p^*$) and for zone targets of inflation ($\underline{p} < \overline{p}$).

Given these types of preferences, Kilian and Manganelli (2003a,b) propose the following measures of the risk of deflation (*DR*) and of excessive inflation (*EIR*).

$$DR_a(\underline{p}) \equiv -\int_{-\infty}^{\underline{p}} (\underline{p} - p)^a \, dF(p), \quad a > 0$$

$$EIR_b(\overline{p}) \equiv \int_{\overline{p}}^{\infty} (p - \overline{p})^b \, dF(p), \quad b > 0$$

where $F(p)$ denotes the distribution of inflation. Note that we define deflation as inflation below $\underline{p}$ and excessive inflation as inflation above $\overline{p}$. Also note that the first measure is indexed by a, whereas the second measure depends on b. We define the measure of deflation risk to be a negative number by multiplying the integral by minus 1. This convention does not affect the interpretation, but will facilitate the graphical interpretation of the empirical evidence.

The interpretation of these risk measures in the general case is not straightforward. Instead we will explain the interpretation of these risk measures under specific assumptions about a and b, for which these measures have an intuitively appealing interpretation. For example, consider the case of $a = b = 0$. In this case, we obtain:

$$DR_0 = -\int_{-\infty}^{\underline{p}} dF(p) = -\Pr(p < \underline{p}) \qquad EIR_0 = \int_{\overline{p}}^{\infty} dF(p) = \Pr(p > \overline{p}) .$$

Thus, the general measures of risk simply reduce to the probabilities of exceeding the target range at either end. This result is intuitive because for $a = b = 0$ the central banker is only concerned about not missing the target zone, but, conditional on missing the target zone, does not care at all by how much inflation will exceed the target.

Who would have such preferences? One example is a central banker whose contract states that he will be fired if the target is exceeded. This example is reminiscent of the Bank of New Zealand. A second example would involve a central banker who has to report to parliament each time the inflation target is exceeded, as is the case for the Bank of England. In both cases, the consequences are presumed to be the same, whether the target is missed by a small amount or by a lot.

As it turns out, this set of preferences is empirically implausible. One reason is that central bankers in practice would be not be indifferent to whether inflation misses the target zone by a small amount or by a large amount. Suppose that a central banker faces the choice between two situations: (1) 2.001% inflation with probability 100%; and (2) 10% inflation with probability 20% and inflation below 2% with probability 80%. If we go by the probabilities of missing the target, situation (1) is clearly worse. In practice, most central bankers would prefer (1) over (2), however, suggesting that their preferences are inconsistent with $a = b = 0$.

A second reason is that central bankers such as Alan Greenspan have recently discussed risks at the Jackson Hole conference in terms of "the product of a low-probability event and a severe outcome, should it occur". In doing so, Greenspan has ruled out $a = b = 0$, because in that case it would have been sufficient to express risks in terms of probabilities alone.

Greenspan's language is actually much closer to what our general risk measure would imply, if $a = b = 1$. In that case, we obtain:

$$DR_1 = -\int_{-\infty}^{\underline{p}} (\underline{p} - p)\, dF(p) \qquad\qquad EIR_1 = \int_{\overline{p}}^{\infty} \left(p - \overline{p}\right) dF(p)$$

By construction DR_1 is a measure of expected deflation, and EIR_1 a measure of expected excess inflation. A different way of writing these measures is to interpret them as the product of a conditional expectation and a tail probability. For example, we may write:

$$DR_1 = E(p - \underline{p} \mid p < \underline{p}) \Pr(p < \underline{p}) .$$

In other words, this measure of deflation risk is given by the product of the expected shortfall of inflation given that the inflation rate falls below the lower threshold, times the probability that this event occurs. A symmetric interpretation holds for the risk of excessive inflation. This language closely mimics that used by Greenspan in describing risks in the quote above. In practice, the interpretation of this risk measure is best illustrated by an example. Let the upper threshold of inflation be 2%. Suppose that the inflation rate can be either 4% with probability 1/2 or 0% with probability 1/2. Then the *expected excess inflation* would be (4%-2%) 1/2 = 1%.[2]

A third leading example is $a = b = 2$. In that case, our general risk measure reduces to the target semi-variance:

$$DR_2 = -\int_{-\infty}^{\underline{p}} (\underline{p} - p)^2 \, dF(p) \qquad EIR_2 = \int_{\overline{p}}^{\infty} \left(p - \overline{p}\right)^2 dF(p)\,,$$

a concept familiar from finance. Here the central banker aims to minimize the expected squared deviation of inflation from the lower threshold and the expected squared deviation of inflation from the upper threshold. An important special case of this measure is obtained under quadratic utility for inflation.

$$u(p) = -0.5(p_t - p^*)^2$$

In that case, the optimal risk management strategy reduces to minimizing the variance about the target, as shown for example by Svensson (1997). Note that this result holds only in the special case that $\underline{p} = \overline{p} = p^*$ and $a = b = 2$.

Implications for Monetary Policy

In what follows we will take as given the preference parameters of the decision-maker. Let $F(i)$ denote the predictive distribution of inflation as a function of the policy instrument i. The presumption is that the central banker can influence future inflation rates by adjusting the interest rate. Standard economic theory suggests that the central banker should choose the interest rate to maximize the expected utility he derives from the level of inflation. Thus, the

[2] It may be tempting to conclude that the expected inflation conditional on missing the target would be 3% (=2%+1%) therefore. That conclusion would be wrong, because the expected inflation rate conditional on exceeding the 2% target is 4%.

optimal interest rate setting i^* is given by the maximum of $E\{u(p(i))$ over all possible choices of the interest rate.

An important result by Kilian and Manganelli (2003a) is that, given the set of preferences discussed earlier, we can write the expected utility of the central banker equivalently as a weighted average of the upside and downside risks

$$E[u(p(i))] = aDR_a(\underline{p}, F(i)) + (1-a)EIR_b(\overline{p}, F(i))$$

Thus, the decision-problem of the central banker reduces to choosing the interest so as to affect the distribution of inflation over the horizon of policy interest (typically one or two years) such that the weighted average of the risks associated with that distribution is maximized. In practice, this maximum can be found by simply evaluating this expression for a grid of interest rates with increments of, say, 25 basis points.

It is common for central bankers to stress the need to "balance" the upside risks and the downside risks to price stability. As Kilian and Manganelli (2003a) show, under plausible assumptions there is indeed a close link between the "balance of risks" and the optimal choice for the policy instrument. Optimal policy implies that the upside and downside risks to inflation should be balanced.

Given our risk measures, the balance of risks (*BR*) can be formally defined as a weighted average of the risks of excessive inflation and of deflation:

$$BR_{a-1,b-1}(i) = wDR_{a-1}(i) + vEIR_{b-1}(i),$$

where the appropriate weights $w = aa$ *and* $n = (1-a)b$ depend on the preference parameters of the central banker. The parameter a here governs the relative importance of the upside and downside risks in the utility function. Note that the balance of risks depends not on a and b, but on $a-1$ and $b-1$. For example, under quadratic and symmetric preferences, as commonly assumed in macroeconomics, we obtain $BR_{1,1} = DR_1 + EIR_1$.

If the central banker is risk averse in the sense that $a > 1$ and $b > 1$, optimal monetary policy under weak assumptions is equivalent to aiming for a balance of zero:

$$BR_{a-1,b-1}(i^*) = 0 .$$

This analysis shows that indeed the language used by central bankers in describing their policy objective can be given a formal interpretation that is consistent with rational optimizing behaviour.

Clearly, however, this approach cannot be implemented without knowledge of the preference parameters a and b and the weight *a*. In principle, these parameters may be elicited from the central banker by means of a questionnaire. In practice, of course, central bankers are unlikely to reveal their preferences in public. An alternative approach would be for central bank staff members to prepare a risk management software program that allows each Board member to input his or her personal preference parameters in the privacy of their office. The program would then compute the associated balance of risks to be used by the Board member, given the latest economic data. Of course, in practice, decisions on interest rates will reflect the personal judgement of Board members about future economic and geo-political developments. They will also reflect different attitudes toward the risk of excessive inflation or deflation. Therefore, any measure of the balance of risks should be viewed as a useful input for the decision-making process rather than a mechanical rule the policy-maker should follow. A sensible approach to monetary policy risk management will allow the decision-makers to explore the sensitivity of risks to different scenarios for the risk determinants as well as alternative degrees of risk aversion. We will illustrate the role of the latter in the empirical section. A final option that we are pursuing in ongoing research is the estimation of preference parameters from the data under the assumption of ex ante optimal policy.

The Global Risk Outlook as of September 2002

We now turn to an empirical application of the risk methodology. The empirical example is taken from Kilian and Manganelli (2003b). Recently, the concern has been increasing that the risks of price stability have tilted noticeably toward deflation. This concern has been expressed for example by The Economist (2002a,b,c) in a series of articles published between September and November 2002. For example, in October 2002 The Economist warned that "the risk of falling prices is greater than at any time since the 1930s". Similarly, in November 2002 the Goldman-Sachs Global Economics Weekly concluded that "investors continue to worry about the spectre of global deflation" (see Wilson 2002).[3] These concerns in turn have elicited a response by central bankers. For example, Bernanke (2002) discussed measures the "central bank can take to reduce the risk of falling into deflation" and makes the case that "the chance of a significant deflation in the United States in the foreseeable future is extremely small". Similarly, Issing (2002) made the case that based on current data as well as conditional mean forecasts of inflation for next year there are no apparent risks of deflation in the Euro area or for that matter in Germany. There has been no formal analysis of these risks, however, for any of the major OECD countries.

Our methodology is designed to provide answers to precisely these types of questions. Note that our analysis suggests that neither the actual inflation rate today nor the conditional mean forecast of inflation is an appropriate measure of

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[3] Similar concerns have been expressed in Business Week, the Wall Street Journal and the Financial Times, among others (see Issing (2002), p. 4, for additional references).

risk. Rather risks are related to the tails of the distribution of inflation forecasts. We will use data for Germany, Japan and the United States to asses these risks for horizons of one year and of two years, as they existed in September of 2002, when the issue of deflation risks was first raised. We will assess these risks from the point of view of a private sector company or investor.

Our starting point is a forecast model of inflation. Risk forecasts of course are only as good as the underlying forecast model. In practice, we use statistical model selection criteria to help us select the best possible forecast model among a number of time series forecast models involving lags of inflation and lags of other variables such as money growth rates and percent changes in oil prices. The forecast models selected include lagged inflation or a combination of lagged inflation and lagged money growth, depending on the horizon and country.

A Snapshot of the Balance of Risks in September 2002

The risk forecasts are shown in Tables 2, 3 and 4. Clearly, these results should be viewed with some caution, as the effective sample size is small, especially for the two-year horizon. Nevertheless, it is of interest to obtain at least a preliminary and tentative assessment of the risks. All risk measures shown are conditional on the implicit interest rate forecast that underlies the inflation forecast model. Thus, any statement about risks being unbalanced must be viewed relative to this benchmark.

As discussed earlier, we cannot assess risks without reference to a preference function. Here we explore three alternative preferences settings for illustrative purposes. The baseline is a set of quadratic symmetric preferences, as postulated by many macroeconomists. Later we will consider asymmetric preferences incorporating either a disproportionately strong aversion to deflation or a disproportionately strong aversion to excessive inflation. Throughout, we presume for expository purposes that the decision-maker is concerned about inflation exceeding $\underline{p} = 1\%$ and $\bar{p} = 3\%$.

Table 2 shows the projected risks of deflation (DR_1), the risks of excessive inflation (EIR_1) and their balance ($BR_{1,1}$) by geographic area and horizon, when $a = b = 2$. We also include the conditional mean forecast for comparison. The third panel of Table 2 shows that for all countries there is some evidence of deflation risk, although the magnitudes differ greatly. The U.S. estimate of –0.02 at the one-year horizon is likely to be negligible. The corresponding estimate of –2.19 for Japan appears large, whereas the practical significance of the estimate of –0.29 for Germany is unclear.

It may be tempting to interpret the mere existence of deflation risks as a reason for concern, but this interpretation ignores the simultaneous presence of risks of excessive inflation. One-sided attention to one of these risks at the expense of the other clearly is a recipe for disaster. It therefore makes sense to put these numbers into perspective by focusing on the degree to which the balance of risks is tilted in favour of the inflationary or the deflationary region.

The second panel of Table 2 shows the balance of these risks ($BR_{1,1}$). It is clear that the United States at the one-year horizon are well within the inflationary region on balance, and the existence of minor deflation risks is inconsequential. In contrast, Japan is clearly in the deflationary region. In contrast, Germany is only slightly in the deflationary region on balance. For Germany and for the United States forecasts for the two-year horizon indicate a slight improvement of the balance of risks.

How robust are these results? Suppose for expository purposes the existence of a strong aversion to deflation in the form of preference parameters of $a = 3$ and $b = 2$ (“deflation paranoia”). Table 3 shows that in that case there is some evidence at the one-year horizon that the balance is tilted in favour of deflation not just for Japan, but also for Germany. In contrast, the United States on balance remains in the inflationary region even for this strong form of deflation aversion. For the two-year horizon there is some evidence of the balance being shifted toward deflation for both Germany and the United States, but the magnitudes of the imbalances are very small. Thus, one would be hard pressed to make a case for serious risks of deflation in Germany or in the United States at the horizons that matter to policy makers, whereas for Japan there is overwhelming evidence of deflation risks.

Conversely, we may take the point of view of an observer with strong aversion to excessive inflation in the form of preference parameters of $a = 2$ and $b = 3$ ("inflation paranoia"). It is only with such extreme inflation aversion that we might hope to explain away the earlier evidence of disproportionate deflation risks for Japan. As Table 4 shows, in that case Japan indeed is on balance in the inflationary region, but interestingly Germany is not, although only by a small margin. Intuitively, this happens because German inflation rate predictions are so close to the target range that raising them to higher powers lowers the disutility, rather than compounding it (see Figure 4). This result is a consequence of the assumption of risk aversion. For the United States, as expected, the results are qualitatively the same as in Table 2. Thus, on balance none of three countries would appear to suffer from important deflation risks under this form of "inflation paranoia".

This example highlights the importance of preference parameters in assessing the risks to price stability. It shows that unless one appeals to extreme

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[4] For example, Greenspan pointed out in his testimony before the Senate Budget Committee on January 21, 1997, that "because monetary policy works with a lag, it is not the conditions prevailing today that are critical but rather those likely to prevail six or twelve months, or even longer, from now".

forms of “deflation paranoia” the risks of deflation appear to be rather negligible for the United States and Germany, especially when we extend the horizon to two years.

Putting Deflation Risks into Historical Perspectives

A different approach to assessing how serious the evidence of deflation risk is, is to put the numbers in Table 2 into historical perspective. In taking this historical point of view, we implicitly read the historical evidence through the lense of today’s preferences. For expository purposes we impose the baseline symmetric quadratic preferences in this historical analysis and focus on the one-year horizon. Figure 5 shows the evolution of the risks of deflation and of excessive inflation since the 1960s. The plots allow us to address, at least in part, the recent claim in the The Economist that “the risk of falling prices is greater than at any time since the 1930s”. We find that deflation risks for the United States today are not unlike those in the 1960s, for example. Then as now the balance of risks is well inside the inflationary region on average. For Germany, deflation risks were much higher in the late 1980s than they are today, but went largely unnoticed. Only for Japan there is evidence that deflation risks have reached unprecedented levels by post-war historical standards. Moreover, the risks of deflation in Japan are highly persistent.

Conclusion

We reviewed some recent advances in the literature on risk management that help us understand the language used by central banker’s in describing their policy objectives and operating procedures. We discussed some formal tools of risk management developed by Kilian and Manganelli (2003a) that may be used to quantify and forecast the risks of failing to attain the objective of price stability. These tools are equally useful for central bankers and for private sector agents in assessing the risks of excessively high or excessively low inflation. Drawing on recent empirical work by Kilian and Manganelli (2003b), we used these tools to assess the risks of worldwide deflation for horizons of up to two years, as of September 2002. Notwithstanding recent concerns about renewed global deflation, we showed that, with the exception of Japan, there is no evidence of substantial deflation risks. We also showed that only for Japan the estimated deflation risks are high by historical standards and persistent.

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Table 1 – Density Forecasts of U.S. Inflation in 1999

Year-on-Year Inflation Rate (%)	Probability (%)
8.0 or more	0.07
7.0 to 7.9	0.11
6.0 to 6.9	0.14
5.0 to 5.9	0.25
4.0 to 4.9	1.21
3.0 to 3.9	8.96
2.0 to 2.9	20.00
1.0 to 1.9	49.54
0 to 0.9	17.89
Will decline	1.82

Source: Philadelphia Fed, *Survey of Professional Forecasters*.
http://www.phil.frb.org/files/spf/spfq498.pdf

Table 2 – Forecasts of the Risks to Price Stability as of September 2002

$a = 2$ **and** $b = 2$ **(Symmetric Preferences)**

		Horizon of 1 Year	Horizon of 2 Years
Inflation risk forecast EIR_1	*United States*	1.03	0.82
	Germany	0.07	0.00
	Japan	0.10	0.10
Balance of Risks forecast $BR_{1,1}$	*United States*	1.00	0.78
	Germany	-0.22	-0.18
	Japan	-2.09	-2.09
Deflation risk forecast DR_1	*United States*	-0.02	-0.04
	Germany	-0.29	-0.18
	Japan	-2.19	-2.19
Conditional mean forecast	*United States*	3.68	3.06
	Germany	1.45	1.20
	Japan	-0.92	-0.99

Table 3 – Forecasts of the Risks to Price Stability as of September 2002

$a = 3$ **and** $b = 2$ **("Deflation Paranoia")**

		Horizon of 1 Year	Horizon of 2 Years
Inflation risk forecast EIR_1	*United States*	1.03	0.82
	Germany	0.07	0.00
	Japan	0.10	0.10
Balance of Risks forecast $BR_{2,1}$	*United States*	0.66	-0.07
	Germany	-0.46	-0.05
	Japan	-15.69	-9.35
Deflation risk forecast DR_2	*United States*	-0.37	-0.89
	Germany	-0.53	-0.05
	Japan	15.79	-9.45

Table 4 – Forecasts of the Risks to Price Stability as of September 2002

$a = 2$ **and** $b = 3$ **("Inflation Paranoia")**

		Horizon of 1 Year	Horizon of 2 Years
Inflation risk forecast EIR_2	*United States*	5.85	15.75
	Germany	0.16	0.00
	Japan	4.30	2.31
Balance of Risks forecast $BR_{1,2}$	*United States*	5.82	15.71
	Germany	-0.13	-0.18
	Japan	2.11	0.12
Deflation risk forecast DR_1	*United States*	-0.02	-0.04
	Germany	-0.29	-0.18
	Japan	-2.19	-2.19

Figure 1 – A Framework for Modelling Inflation Risk

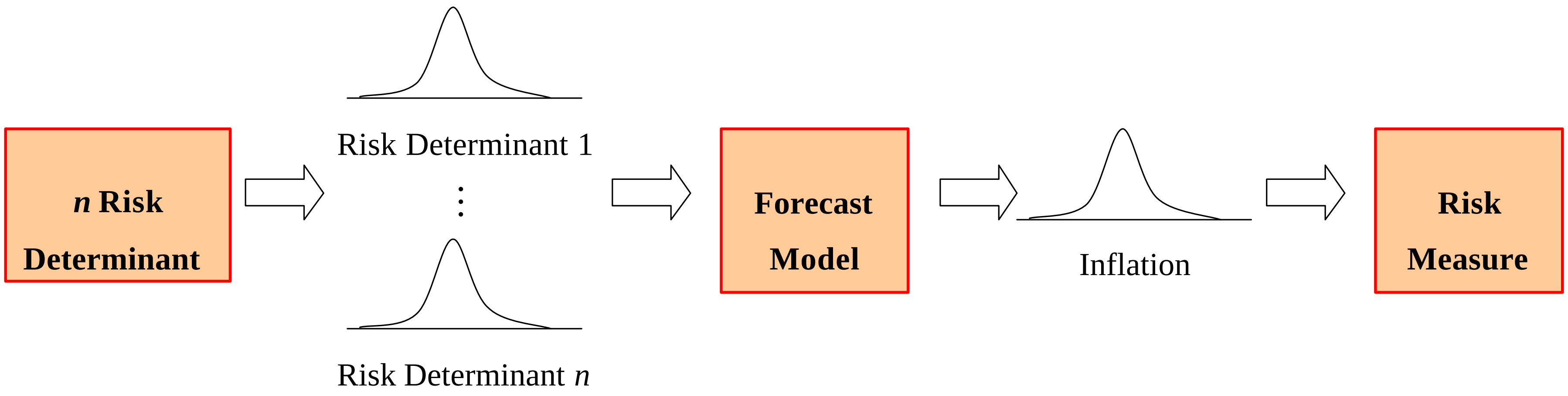
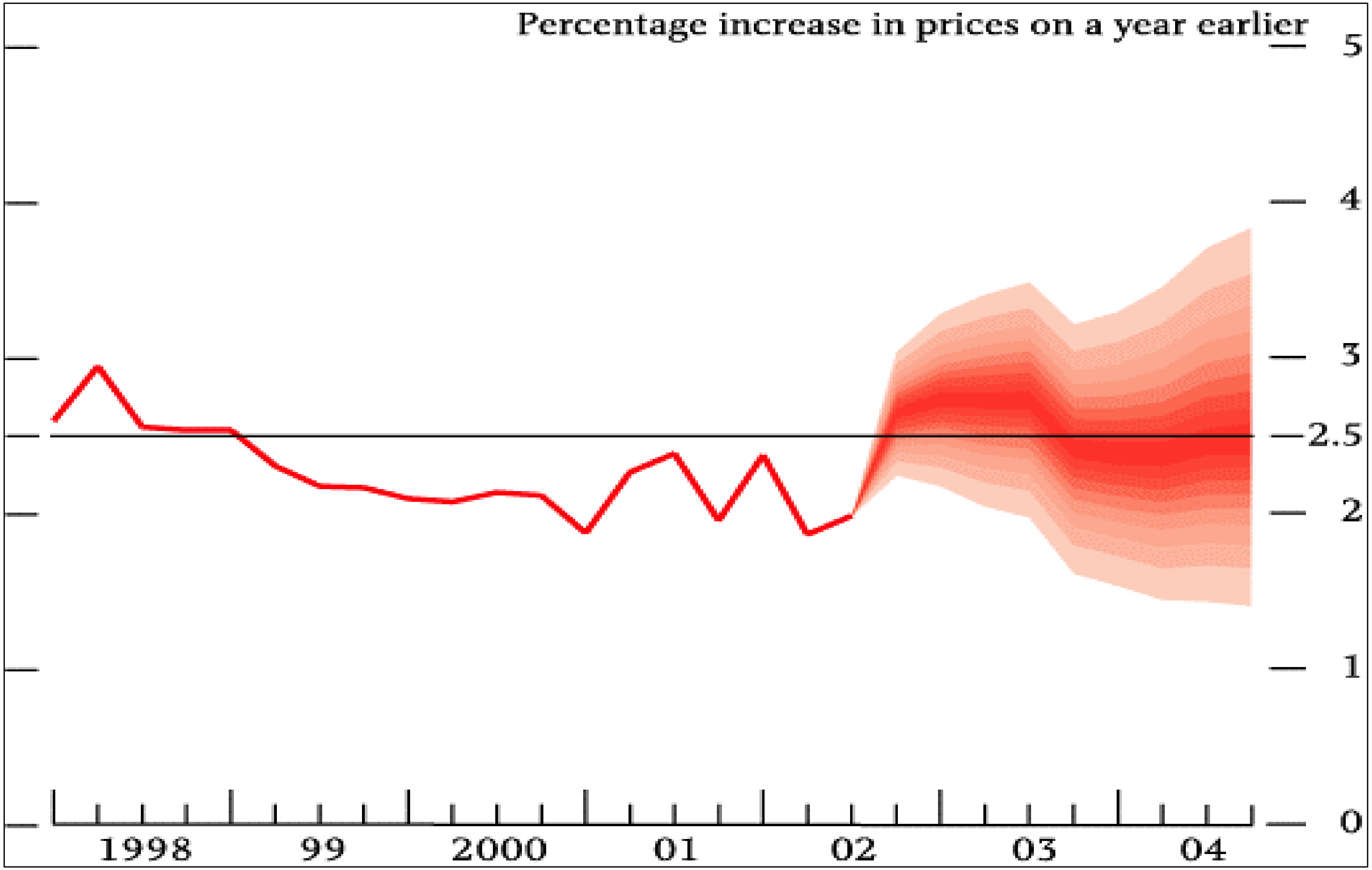


Figure 2 – The Bank of England Fan Chart



Source: www.bankofengland.co.uk/inflationreport

Figure 3 – Areas of the Distribution of Inflation that Matter for Risk Management

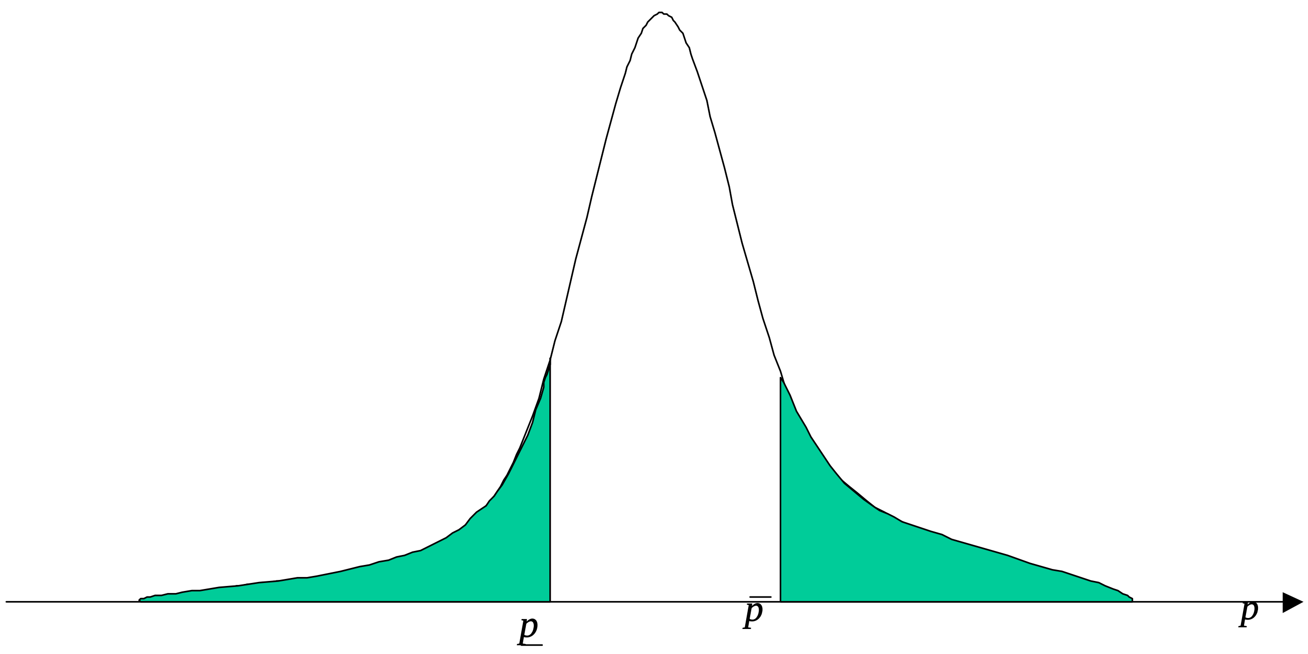


Figure 4 – Alternative Central Bank Preferences

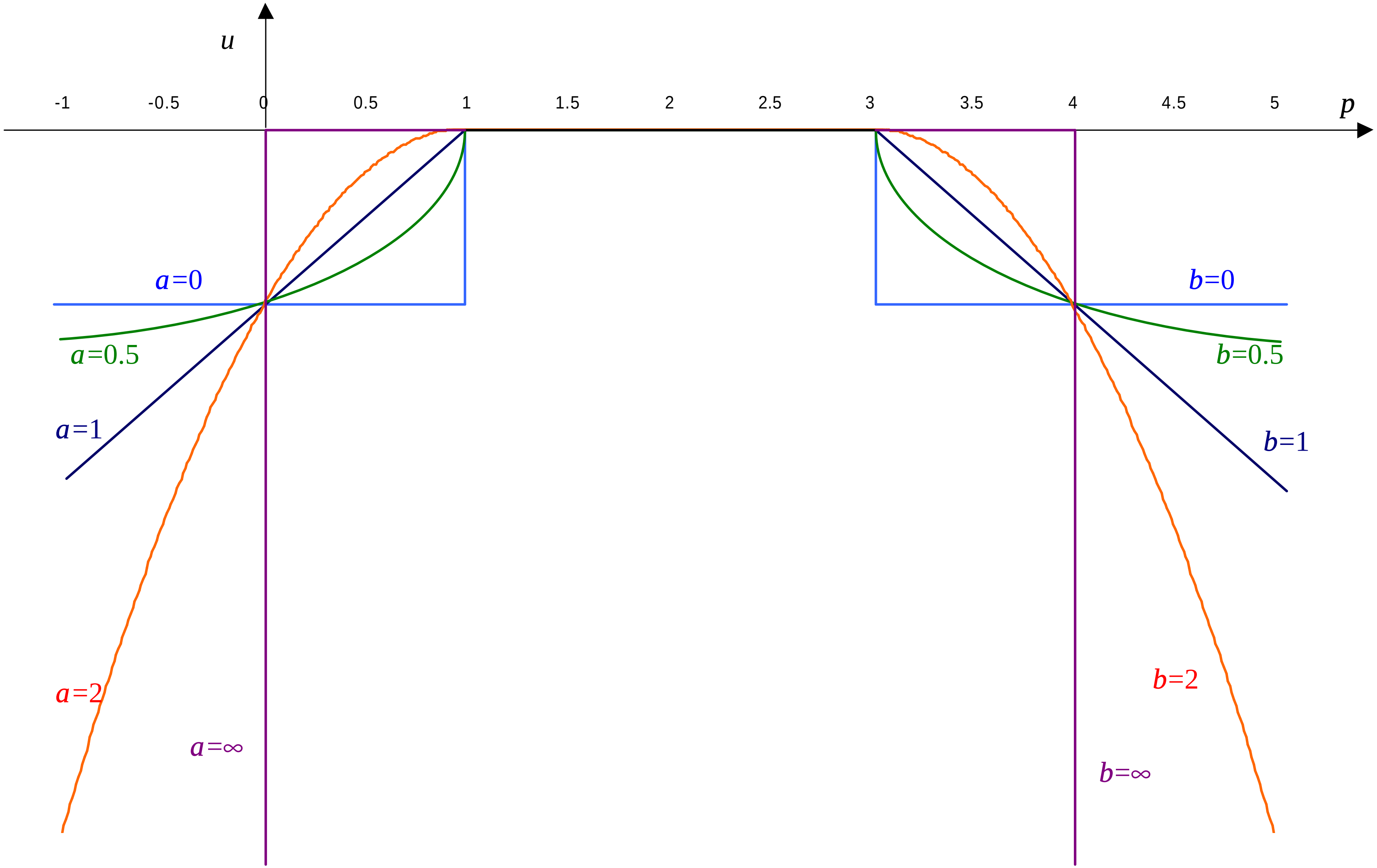


Figure 5 – Historical Evolution of Year-on-Year Risks by Country

Symmetric preferences: $a = 2$ **and** $b = 2$