

BOARD OF GOVERNORS OF THE FEDERAL RESERVE SYSTEM
DIVISION OF MONETARY AFFAIRS

Date: May 2, 2007
To: Federal Open Market Committee
From: Vincent R. Reinhart
Subject: Attached Memo on Forecast Uncertainty

The attached memo by Spencer Dale and Athanasios Orphanides considers different ways to quantify uncertainty about the central tendency of the economic projections of the governors and Reserve Bank presidents. This may provide useful background as you prepare your forecast submissions for the upcoming meeting. I would note that today is Mr. Orphanides' last day as a Board employee—tomorrow he will be sworn in as the Governor of the Central Bank of Cyprus.

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Date: May 2 2007
To: Vincent Reinhart
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Subject: Quantifying Forecast Uncertainty

The recent memorandum from the subcommittee on communications suggested that as part of the trial run of an enhanced projections process, participants provide information on their subjective assessment of the uncertainty surrounding their point forecasts. As background to that request, this note reviews some alternative approaches to quantifying forecast uncertainty.

Experience of foreign central banks

Although central banks in every advanced economy now publish some form of economic forecast, there are significant differences in the way these forecasts are constructed and communicated.¹ Earlier this year, staff of the Division of International Finance circulated a note describing nine major foreign central banks' experience with publishing economic forecasts.² That note summarized three main approaches to characterizing forecast uncertainty.

(i) No formal quantification (New Zealand, Canada, Australia, Switzerland, and Japan). Although these central banks do not provide quantitative estimates of forecast uncertainty, the text describing the forecasts recognizes that forecasts are uncertain, and for a majority of the central banks, includes a discussion of the main economic risks to the forecasts.

(ii) Confidence bands/fan charts (UK, Sweden, Norway). These central banks provide estimates of their forecast distributions in the form of probability ranges or confidence bands. All three central banks illustrate forecast uncertainty up to a 90 percent probability range, i.e. there is judged to be an expected probability of 0.9 that future

¹ It should be noted that some central banks, such as the Reserve Bank of Australia, provide a largely qualitative rather than quantitative description of the economic outlook.

² "The experience of Foreign Central Banks with Published Forecasts", Brian Doyle, Linda Kole and Paul Wood, 3 January 2007.

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outcomes will lie in this range. The central banks also provide additional information about narrower probability ranges.

(iii) Forecast range (ECB). The ECB publishes information about the forecast produced by the staff of the European System of Central Banks in the form of a range, without explicitly specifying a central forecast or midpoint. The size of this range is twice the average absolute value of historical forecast errors, which roughly corresponds to an 80% confidence band under the assumption that the errors are normally distributed. But the ECB describe this as a forecast range, rather than a confidence interval.

Of the nine central banks reviewed in the IF note, only the Bank of Japan publishes forecasts that illustrate explicitly the diversity of views across Committee members. The fact that the FOMC publishes information about the central tendency and range of participants' forecasts, rather than a common central forecast, affects the way in which measures of forecast uncertainty are interpreted and illustrated. This is discussed in more detail below.

Alternative approaches to quantifying forecast uncertainty

There are three broad alternative approaches to quantifying forecast uncertainty.

(i) Past forecast errors

This approach, which assumes that forecast errors made in the past provide a guide to current forecast uncertainty, is used by the Riksbank and the ECB. In the case of the FOMC, the most natural comparison would be to consider errors from previous central tendency forecasts. However, there are limits to the information that can be directly obtained from an analysis of past central tendency forecasts. First, the forecasts extend only to the end of the next calendar year, and so it is not possible to use this information to derive forecast confidence bands for horizons beyond two years.³ Second, forecasts for core PCE inflation have been collected only since 2004, prior to which participants provided forecasts for PCE inflation (2000-2003), CPI inflation (1989-1999) and the GNP deflator (1979-1988). So there is not a consistent series from which to derive confidence bands for inflation forecasts. And third, the reduction in economic uncertainty associated with the "Great Moderation" period means that measures of forecast uncertainty based on forecast errors (or model simulations) are likely to vary markedly depending on the sample period considered.

A related approach would be to use Federal Reserve Board staff forecast errors, which are used to produce confidence intervals which are routinely reported in a table in the

³ Prior to 2005, the economic projections collected for the February Monetary Policy Report extended only to the end of the current calendar year. As such, there is only a very small sample of forecasts extending out to (almost) two years.

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Greenbook, and for which there is a more comprehensive set of past forecasts. However, many of the drawbacks associated with central tendency errors would be shared by staff forecast errors: forecast coverage of some variables is spotty (in particular, although staff forecasts for core PCE inflation are available since the early 1980s, this measure was less prominent in the staff projection for much of this time than is currently the case); forecast errors are not available at a horizon exceeding two-and-a-half years; and confidence bands derived from Greenbook errors depend importantly on the sample period considered. Moreover, the use of Greenbook forecast errors introduces the additional complication that staff forecasts often differ from participants' forecasts, and so may not provide an accurate guide to past uncertainty faced by FOMC participants. However, to the extent that the information and analysis used to produce staff forecasts are similar to that used by FOMC participants, the errors from the Greenbook forecast should provide a reasonable guide to the uncertainty faced by FOMC participants.

A third possible approach would be to use errors from external forecasts, such as the Survey of Professional Forecasters conducted by the Federal Reserve Bank of Philadelphia, or Blue Chip Economic Indicators. But these surveys would not allow construction of two- or three-year ahead forecast errors. In addition, the information set used in the production of external forecasts could differ quite substantially from that available to FOMC participants, so past errors from external forecasts may not provide an accurate guide to the uncertainty faced by FOMC participants.

(ii) Model simulations

It is possible to use estimates of past economic disturbances to calibrate the uncertainty associated with model-based forecasts. This is the approach followed by the Norges Bank. Likewise, the charts routinely shown in the Greenbook illustrating the uncertainty surrounding the staff's forecast are based on confidence intervals derived from simulations of the FRB/US model. These intervals were used to illustrate forecast uncertainty in the draft forecast narrative included in the note by Vincent Reinhart circulated ahead of the March FOMC meeting.⁴ The chief advantage of this type of approach is that it allows an explicit economic accounting of the sources of economic fluctuations and uncertainty. However, as a number of participants noted at the March FOMC meeting, this is also a drawback of the model-based approach as the results depend upon the assumed structure of the model. Since FOMC members do not derive their projections directly from FRB/US, and may not share the assumptions embedded within it, the forecast intervals derived from FRB/US (or any economic model) may not provide an accurate measure of the uncertainty associated with participants' forecasts.

A related approach would be to derive forecast intervals from more general statistical models, which are designed to capture the time-series properties of the macroeconomic variables of interest. These models provide a simple and statistically well-grounded

⁴ "Format of Upcoming Discussions of Communication Issues", Vincent Reinhart, March 14 2007.

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approach to quantifying uncertainty. However, they would not embody the analysis and judgment used by FOMC participants, and hence may not provide an accurate measure of participants' forecast uncertainty.

The memorandum circulated by the communications subcommittee included a table summarizing estimates of 70 percent confidence bands derived from different measures of forecast errors and model simulations. For convenience, a copy of that table is included as an Appendix to this note.⁵ Despite the potential differences, the ranges of uncertainty implied by the different approaches appear broadly similar. The forecast bands based on Greenbook forecast errors are somewhat wider than the other approaches, but this appears to reflect the fact that these types of confidence bands are very sensitive to the precise sample period and definitions used. The Greenbook forecast bands are derived from all Greenbook forecasts over the sample period, i.e. the same basis as the confidence bands routinely reported in the Greenbook. In contrast, the central tendency forecasts (and external forecasts) consider only forecasts made in January/February of each year. Recalculating the Greenbook confidence bands on this basis produces more comparable confidence bands.

(iii) Subjective confidence bands

Given the difficulty of using forecast errors or model simulations directly to derive measures of forecast uncertainty, the communications subcommittee suggested that for the trial run participants provide subjective assessments of the uncertainty attached to their forecasts.⁶ These assessments can be informed by measures of past forecast uncertainty, but have the advantage that participants can deviate from these past estimates as they judge appropriate. This may be because participants feel that measures of uncertainty based on forecast errors or model simulations do not correspond exactly to the uncertainty associated with their individual forecasts. Moreover, participants might judge that past measures of forecast uncertainty may not accurately capture the uncertainty surrounding their current forecasts.

This approach is similar to that followed by the Bank of England. The fan charts produced by the Bank of England are based on an average of the Bank's forecast errors over the past 10 years, but the actual forecast bands typically differ from that implied by

⁵ The confidence bands pertaining to participants' forecasts need to take account of the differing horizons of the forecasts submitted at the January/February FOMC meetings relative to those submitted at the June FOMC meetings. The estimates presented in the table in the Appendix are derived for forecasts submitted for January/February meetings.

⁶ This approach is similar to that used by the Survey of Professional Forecasters (SPF), which asks respondents to provide information on their entire forecast density. Although the SPF approach would potentially provide more detailed information about participants' assessment of forecast uncertainty, it would substantially increase the amount of information that participants would need to provide. Moreover, a number of additional assumptions and some estimation would need to be applied to the type of density estimates collected by SPF before they could be mapped into the confidence bands shown here.

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a simple translation of past forecast errors. In particular, the fan charts are generally wider than that suggested by historical forecast errors, reflecting the Bank's judgment that the greater stability of activity and inflation since the early 1990s may not persist. Moreover, the Bank occasionally varies the uncertainty bands in response to particular episodes or economic shocks. For example, the Bank of England recently widened the confidence bands surrounding its near-term inflation forecast in response to a sharp rise in wholesale gas prices and the resulting uncertainty about the extent to which this was likely to pass-through into retail prices.

Design of confidence bands

Symmetry of confidence bands

The confidence bands used by most central banks, including the Riksbank, the Norges Bank, and the ECB, are designed to be symmetric. However, some central banks, such as the Bank of England, allow for the possibility that the risks to the central projection may be skewed to one side or the other. This is consistent with the emphasis placed by the Bank of England on the assessment of the risks to the economic outlook, and the possibility that these risks may not be balanced. The Bank of England uses the asymmetry of its forecast distribution to quantify and communicate this assessment. For the trial run, the subcommittee has suggested that participants provide estimates for the overall width of confidence intervals, rather than estimates for the upper and lower bands of the confidence intervals. However, if participants judge that the probability distributions surrounding any of their projections are especially asymmetric, this could be mentioned in the accompanying narrative.

Size and number of confidence bands

As noted above, the UK, Sweden and Norway all show confidence intervals extending out to 90 percent. In addition, the Bank of England separately identifies each decile of the forecast distribution. Norway and Sweden provide somewhat less detail: Norway shows three additional confidence bands, for 70%, 50% and 30%; and Sweden two extra bands, for 75% and 50% bands. Similarly, the Greenbook routinely shows two forecast bands, for 90% and 70%. However, as some participants noted at the March FOMC meeting, there is a risk that if the forecast bands are very wide they may be less effective as an external communications device. For the trial run, the subcommittee has suggested that participants provide estimates only for 70 percent confidence intervals.

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Appendix

Alternative Estimates of the Width of 70% Confidence Bands¹

	Forecast Errors ²				Model Simulations ³
	Central tendency of participants' forecasts	Greenbook	Survey of Professional Forecasters ⁴	Blue Chip Economic Indicators	FRB/US
Real GDP (percent change, Q4 to Q4)					
1-year ahead ⁵	2.5	3.0	2.5	2.5	2.2
2-years ahead ⁵	NA	3.4	NA	NA	3.0
3-years ahead ⁵	NA	NA	NA	NA	3.5
Unemployment rate (percent, Q4)					
1-year ahead ⁵	0.9	0.9	0.8	1.0	0.7
2-years ahead ⁵	NA	1.8	NA	NA	1.1
3-years ahead ⁵	NA	NA	NA	NA	1.5
Core PCE prices (percent change, Q4 to Q4)					
1-year ahead ⁵	NA	1.1	0.8	NA	0.9
2-years ahead ⁵	NA	1.8	0.8	NA	1.3
3-years ahead ⁵	NA	NA	NA	NA	1.4

1. The width of estimated confidence bands are expressed in percentage points

2. Derived from historical forecast errors over the period 1986-2005. Central tendency forecast errors are based on participants' forecasts submitted at January/February FOMC meetings. Similarly, forecast errors for the SPF and BCEI are based on forecasts made in February of each year. Greenbook forecast errors are based on all forecasts made over the sample period. For Greenbook forecast errors, outcomes are defined as the first estimate published in the Greenbook at least one full quarter after the relevant event. For GDP growth and PCE price inflation, this is typically the "first final" or "second revision" published by the BEA. Comparable data are used to derive central tendency, SPF and BCEI forecast errors.

3. Shocks underlying FRB/US stochastic simulations are randomly drawn from the 1986-2005 set of model equation residuals.

4. The confidence bands for core PCE inflation are derived from the SPF question on the uncertainty regarding core PCE inflation.

5. The 1- 2- and 3-year ahead forecast horizons correspond to forecasts produced around the time of January/February FOMC meetings, i.e. 3 and 7 and 11 quarters ahead.