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Measuring Uncertainty and Disagreement in the European Survey of Professional Forecasters*

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Abstract

Survey data on expectations and economic forecasts play an important role in providing better insights into how economic agents make their own forecasts, what factors do affect the accuracy of these forecasts and why agents disagree in making them. Uncertainty is also important for better understanding many areas of economic behavior. Several approaches to measure uncertainty and disagreement have been proposed but a lack of direct observations and information on uncertainty and disagreement lead to ambiguous definitions of these two concepts. Using data from the European Survey of Professional Forecasters (SPF), which provide forecast point estimates and probability density forecasts, we consider several measures of uncertainty and disagreement at both aggregate and individual level. We overcome the problem associated with distributional assumptions of probability density forecasts by using an approach that does not assume any functional form for the individual probability densities but just approximating the histogram by a piecewise linear function. We extend earlier works to the European context for the three macroeconomic variables: GDP, inflation and unemployment. Moreover, we analyze how these measures perform with respect to different forecasting horizons. Looking at point estimates and disregarding the individual probability information provides misestimates of disagreement and uncertainty. Comparing the three macroeconomic variables of interest, uncertainty and disagreement are higher for GDP and inflation than unemployment, at short and long horizons. Besides this, it is difficult to find a common behavior between uncertainty and disagreement among the variables: results do not support evidence that, if uncertainty or disagreement are relatively high for one of the variable than it is the same for the others.

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1 Introduction

Survey data on expectations and economic forecasts play an important role in providing better insights into how economic agents make their own forecasts, what factors do affect the accuracy of their forecasts and why agents disagree in making them.[1] During the last two years (2007 and 2008), many forecasters show a failure in their predictive ability. Uncertainty and disagreement in forecasting plays an important role as we want to understand many areas of economic behavior. Several approaches to measure uncertainty and disagreement include, among others, cross-sectional measures, based on dispersion of individuals' expectations, and time-series measures, that consider the dispersion over time and relate uncertainty to specific macroeconomic variables. Lack of direct observations and information on uncertainty and disagreement leads to ambiguous definitions of them.[2]

Most of the professional surveys, such as the Consensus Economic Forecast (CEF), lack quantitative measures of uncertainty and disagreement: they present a simple indication of disagreement and uncertainty using an aggregation of the information of individuals' assessment on the economic variable. On the other hand, the Survey of Professional Forecasters (SPF) represents an exception. It directly asks for the point forecast, and for the probability distribution, associated with the macro variables of interest, to a panel of professional forecasters.

One particular approach to measure uncertainty and disagreement focuses on studies related to the SPF, which provides the point estimates forecasts and also probabilities associated with each of the forecasts for macro variables as GDP, inflation and unemployment. In practice, three measures of uncertainty are frequently considered: disagreement among forecasters (i.e. dispersion of the point forecasts which can be estimated by variance or standard deviation), average individual forecast error variance and variance of the SPF aggregate histogram (i.e. aggregate uncertainty estimated as the variance of the aggregate histograms which are constructed by averaging the individual histograms). Even so commonly used, these measures have some shortcomings. For example, in the first measure, as shown in

[1] An interesting discussion is Lahiri and Wang (2006).

[2] "There is no consensus about the appropriate way to proxy uncertainty in an empirical formulation" as Carruth et al (2000).

Zarnowitz and Lambros (1987), even if disagreement and uncertainty on point estimates are positively correlated, the first quantity underestimates the second one. As solution, the authors propose to model the probability density distribution of each forecaster, as uniform or mid-point distribution, before assessing disagreement and uncertainty. Giordani and Soderlind (2003) consider as benchmark the findings of Zarnowitz and Lambros (1987) and extend them fitting normal distribution to approximate the probabilistic density of each forecaster.[3] Alternatively, D'Amico and Orphanides (2008) propose a new method to directly model the distribution of the individual uncertainties under Gamma assumptions: in such a way they compare average uncertainty, not only with disagreement about the mean of the variables of interest, but also with disagreement about the uncertainty itself. In contrast with the existing literature based on probability density, Lahiri and Sheng (2009) establish an interesting relationship between uncertainty and disagreement on point estimates using a standard decomposition of forecasting errors into common and idiosyncratic components.

A main concern of the paper is to show the importance of correctly measuring uncertainty and disagreement using the whole information available on the SPF dataset. We believe that assumptions made *a priori* on the probability distribution as midpoint, uniform, normal or gamma, engender some doubts. In this study, we overcome the problem associated with distributional assumptions by using a different approach to measure disagreement and uncertainty, i.e. a technique that does not assume any functional form for the individual probability densities. The approach approximates the histogram, representing the probability density forecast, by a piecewise linear function. In this way, the obtained approximation takes into account any asymmetries of the density and its real characteristics. Given the approximation, it is possible to compute individual disagreement and uncertainty, and in a second step relate individual results to the aggregate ones and we examine their developments over time, i.e. how they depend on the forecasting horizon. Furthermore, in contrast with earlier works that focus on US data, we focus on European data, considering GDP, inflation and unemployment.

We obtain the following results. First, we show that in previous approaches based on point estimates and that disregard the probability information, disagreement and uncertainty are not correctly computed. Evaluating disagreement on point estimates underestimates it compared to result obtained on density estimates, for all the forecast horizons: there is a robust evidence for GDP and inflation and a less evident result for unemployment. The estimate of individual probability densities, which makes use of a piecewise linear approximation, provide results that are differ-

[3] A similar approach can be found in Boero, Smith and Wallis (2008).

ent from the a priori functional form cases. The disagreement under the piecewise linear approximation results quite/somewhat smaller than the one estimated under functional form assumptions (midpoint and uniform), and the uncertainty under piecewise approximation is in between the two uncertainties obtained as midpoint and uniform (midpoint underestimates and uniform overestimates uncertainty). Results confirm what we expected, since they prove that restriction on the probability distribution with an a priori functional form ignores the real asymmetry and other characteristics of the entire distribution. Second, comparing the three macroeconomic variables of interest, we notice that for GDP and inflation disagreement and uncertainty are higher than for unemployment in all the three horizons (two short horizons and one long horizon). Third, it is difficult to find a common behavior between uncertainty and disagreement among the variables. Results do not support evidence, that if uncertainty or disagreement is relatively high for one of the variable, then it is the same for the others. Disagreement and uncertainty about inflation are the most unstable through time; on the other hand, GDP shows more stable path in both measures, in particular for the 1 year ahead rolling horizon. Unemployment presents an almost flat path for disagreement and uncertainty, showing only two anomalies.

The plan of the paper is as follows. Section 2 introduces the data of the SPF. Section 3 briefs the model. Section 4 provides information on the probability density estimation. Section 5 presents the estimation results for the three variables of interest, and section 6 concludes.

2 The SPF data

The Survey of Professional Forecasters is a quarterly survey of forecasters' expectations on key economic variables as inflation, GDP growth and unemployment rate for the European area.[4] The European Central Bank runs the SPF since the first quarter of 1999 over a panel of around 75 forecasters within the European Union.[5] The structure of the survey before and after 2001Q1 slightly differs. Starting on the first round of 2001, the information on the three macroeconomic variables is

[4] Inflation is defined on the basis of the HICP published by Eurostat; forecasters give their expectation of the year-on-year change in HICP in percent. GDP is defined following the ESA definition; forecasters give their expectation of the year-on-year change in GDP in percent. Unemployment is defined using the definition of the Eurostat; forecasters give their expectations of the unemployment rate in percentage of the labour force.

[5] Currently, the forecasters are from the 12 Euro Area countries, Denmark, Sweden and United Kingdom. On average, the number of respondents in each round is around 59 (usually the lowest is in the third quarter of the year).

collected for short (current and 1 calendar year ahead), medium (2 calendar years ahead) and long horizon (5 calendar years ahead). For the first two rounds of each year forecasters should not provide expectations for the two calendar years ahead. In addition, for 1 year and 2 years ahead it is also collected the so-called rolling horizon forecast, i.e. the forecasts for the month (or quarter) of one year or two years ahead for which the latest data are available.[6] Referring to these rolling horizons (rh) it ought to be noticed that in two subsequent survey rounds there is an overlap period of forecasting, e.g. in the first round of 2007 (i.e. January 2007 with last available data on November 2006) the forecasters forecast unemployment for November 2007 (1 year rh) and November 2008 (2 years rh); on the following round (i.e. April 2007 with last available data February 2007) the unemployment's forecasts are for February 2008 (1 year rh) and February 2009 (2 years rh). It means that there is a forecast's overlap period, in two subsequent rounds, from February 2007 to November 2007 (referring to the 1 year ahead) and from February 2008 to November 2008 (referring to the 2 years ahead).

The most important feature of the SPF is that forecasters should provide the point expectation of the variable of interest and the probability distribution of forecasted variables, i.e. the probability values that the economic variables of interest fall in pre-specified ranges.[7]

Usually, the lower bottom interval and the upper interval are open intervals, and the interior intervals have equal length (0.5 percentage points). From 2001, forecasters also provide their assumptions regarding the ECB's interest rate, oil barrel price, the USD/EUR exchange rate, and the year on year rate of change of labour costs.[8]

Before analyzing uncertainty and disagreement among forecasters and through time at individual level, we evaluate the performance of the aggregate forecasts, in order to have a general overview of the economic sentiment. we consider a set of statistics, Mean Error (ME), Mean Absolute Error (MAE) and Root Mean Square Error (RMSE), reported in Table 1. If the ME is zero on average, the forecasts are unbiased; the MAE gives information on the average size of the forecast errors. The RMSE is an alternative measure of the forecast accuracy: it penalizes more the agent who makes some large errors compared with the one who makes only small ones. The

[6] For example, in the first survey round of 2007, the latest released data available are from December for inflation, from November for unemployment and from Q3/2006 for GDP.

[7] The intervals associated with the three economic variables have slightly changed over time, in particular for inflation and GDP, there are 3 rounds in which there is a difference; unfortunately, the situation regarding unemployment is more complicated and differences are more remarkable.

[8] In particular, for interest rate, oil prices, USD/EUR exchange rate forecasters provide assumptions for the same period of round quarter and the following 4 quarters. For labour costs the assumptions are for 1, 2 and 5 years ahead.

1 year and 2 years ahead rolling horizons forecasts underestimate inflation of about 0.4 percentage points, on the other hand, the 1 year ahead rolling horizon slightly underestimates the GDP and the 2 year ahead rolling horizon overestimates it of 0.57 percentage points. Finally, unemployment is overestimated for both forecast horizons, albeit for the 2 year ahead the overestimation is relatively small. Regarding the MAE, the highest error is made when forecasting GDP. For all variables the forecast error is smaller for 1 year ahead rolling horizon than the 2 years ahead one. Values of 0.45 and 0.48 for inflation and unemployment, respectively, indicate that the underestimation varies consistently over time. As final point, RMSEs are slightly higher than the MAE, implying some variability in the size of the errors across survey rounds.

[INSERT TABLE 1 HERE]

Another common check is to test for biases in forecast errors. I estimate biases by testing whether forecast errors have zero mean using the Mincer Zarnowitz regression, $real_t = \alpha + \beta fore_t + \varepsilon_t$, with null hypothesis that $\alpha = 0$ and $\beta = 1$.[9]

As shown in Table 2, the forecasts of GDP are biased both on 1 year ahead rolling horizon and for 2 years ahead rolling horizon. Likewise for the forecast of unemployment 1 year ahead rolling horizon.

[INSERT TABLE 2 HERE]

In addition, I present a general overview of aggregate figures for each variable plotting the aggregate histogram of the probability distribution and the mean point estimates for different horizons (See Appendix 1). Charts show the aggregate histograms for the 3 forecast horizons under analysis and also the means of the distributions as vertical lines. Considering inflation in Figures 7 and 8, for most of the years the aggregate histograms have symmetric shapes with more mass in the central intervals. On the contrary, for GDP as shown in Figure 9, histograms are slightly asymmetric between 1999 and 2003 and become more symmetric in Figure 10 from 2004 to 2008. Finally, unemployment's histograms in Figures 11 and 12 are usually asymmetric to the left in the first years, then they become rather symmetric

[9] The null hypothesis is tested by using F-statistics. If we reject the null, we conclude that the forecast is biased.

in the middle years and in the last years they have asymmetry to the left once again.

3 Disagreement and Uncertainty

The degree to which a survey average answer is representative of several forecasters' economic view depends upon the level of consensus among forecasters. From this concept, the opposite concepts of disagreement and uncertainty arise: generally speaking, a high (low) dispersion associated with the point forecast is interpreted as high (low) uncertainty. This concept does not provide a measure of disagreement and one of uncertainty; forecast uncertainty is often not directly observable and its right estimation poses methodological problem. To get a direct measure, we should say that uncertainty is a function of the probability distribution of the variable of interest, which is usually characterized by a histogram. There has been a long discussion of using measure of individual's dispersion on point forecasts, disagreement and consensus as proxies of uncertainty.

In practice, there are three main ways of measuring and presenting uncertainty: disagreement among forecasters (which becomes a poor measure as the numbers of forecasters reduces), the average individual forecast error variance or standard error, and the variance of the SPF for the aggregate figures. In these ways not all the available information is properly used. Indeed, using information at individual level offers an opportunity to exploit a richer information set: it poses a challenge on how to improve the individual density approximation and the measure of aggregate disagreement and aggregate uncertainty. A correct approximation of individual density leads to a good aggregate figure made of individual uncertainty plus individual disagreement.

3.1 The Model

Let's denote n individual density forecasts associated with the variable of interest $f_i(z)$ and assume that the individual density forecasts correspond to variables with individual variances σ_i^2 and means μ_i.[10] A possible representation for a combined density forecast is given by

$$f_{aggr}(z) = \sum_{i=1}^{n} w_i f_i(z) \tag{1}$$

[10]The majority of the forecasters provide the point estimate which corresponds to the mean of their probability distribution.

where w_i are the weights, summing one, associated with each forecaster. The SPF aggregate reported figures correspond to the case of $w_i = 1/n$.[11]

The aggregate mean, second moment and variance of the distribution are:

$$\mu_{aggr} = \frac{1}{n}\sum_{i=1}^{n}\mu_i, \tag{2}$$

$$\mu_{2aggr} = \frac{1}{n}\sum_{i=1}^{n}(\mu_i^2 + \sigma_i^2) \qquad \text{and} \tag{3}$$

$$\sigma_{aggr}^2 = \mu_{2aggr} - \mu_{aggr}^2 = \frac{1}{n}\sum_{i=1}^{n}\sigma_i^2 + \frac{1}{n}\sum_{i=1}^{n}(\mu_i - \mu_{aggr})^2. \tag{4}$$

The variance σ_{aggr}^2 is decomposed into two parts: the average of forecasters' variances and the variance of the forecasters' means.[12] The first term is the average of individual uncertainty (it captures uncertainty of individual respondents but it does not capture any difference among forecasters), the second term is a measure of disagreement of the mean forecast (cross sectional variance of the individual means).

4 Probability Forecast Estimation

The main issue concerns how correctly measure individual probability densities and get accurate individual results before aggregating them. Since Zarnowitz and Lambros (1987), there are two common techniques of measuring disagreement and uncertainty via probability intervals[13]: one with no assumption for the probabilistic distributions and one sophisticated that assumes each individual histogram coming from a normal distribution (Giordani and Soderlind 2003). In the first case, a measure of disagreement and uncertainty arises when computing the mean and the variance of the histogram and assuming that the probability mass in each interval is distributed either uniformly or mid-point (Diebold et al. 1999).[14] The second approach is more sophisticated, because it assumes the fitting of a normal distribution

[11] See Genest and Zidek (1986), for a survey review in combining probability distributions. A frequent finding is that a simple average of individual point forecasts provides better aggregated results than more complicated weighting schemes (Timmermann, A. (2005)).

[12] The same decomposition is in Giordani and Soderlind (2003) even if the assumptions behind the model slightly differ. See also Hall and Mitchell (2007). A different approach which provides similar results is in Lahiri and Sheng (forthcoming 2009).

[13] Respondents attach probabilities to a specific range but we do not know how the probability is distributed within that range.

[14] If the distribution underlying the histogram is approximately bell-shaped then the uniformity assumption will tend to overstate the dispersion.

to approximate the probabilistic beliefs of each forecaster (Giordani and Soderlind 2003). The parameters of the normal distribution are chosen such that the normal density matches the individual empirical density function as much as possible, i.e. minimizing the sum of squared differences between the theoretical and empirical density function.[15]

Both approaches carry some drawbacks. The first approach usually misestimates the density in each bin. Indeed, it is reasonable to think the probability in each interval having an asymmetric distribution. For example, assume that two subsequent bins $[a, b]$ and $[b, c]$ are associated with probabilities of 0.3 and 0.7, respectively, then it is possible to conclude that the distribution in $[a, b]$ is skewed toward the upper bound b rather than uniform in the interval or concentrated in the midpoint.

The same drawback applies to the normality assumption; in particular, lacks arise for those forecasters who use less than three bins to provide their probabilistic beliefs (it is difficult to fit a normal distribution on a histogram with 1 or 2 bins, as shown in Figures 1 and 2). Furthermore, just a small number of forecasters officially declare that their probability distributions are based on functional form assumptions.[16]In that respect, we want to pursue the idea that any restrictive assumption made *a priori* on the distribution within each interval can provide misleading results.

To overcome these problems, we estimate individual probability densities using a piecewise linear approximation of the histograms. Bear in mind that the histogram is a step function with heights being the proportion of the sample contained in that bin divided by the width of the bin, we take into account the asymmetry of the underlying probability distribution: an increasing slope line from a low height bin to an upper one and a decreasing slope line from an high bin to a lower one.

The statistical characteristics of the individual density are computed by piecewise approximation, integrating piecewise the function on the entire interval. Given $f_i(z) = Az + B$, the first moment and the second moment in each interval are:

$$\mu_{ij} = \int_{k_{low}}^{k_{up}} z f_i(z) dz = B \frac{(k_{up}^2 - k_{low}^2)}{2} + A \frac{(k_{up}^3 - k_{low}^3)}{3} \qquad \text{and}$$

[15]The fitting of a normal distribution to the probabilistic density relies on the assumption that point forecasts and individual density function are consistent, i.e. that under the assumption that the individual probability is normally distributed we assume that the point estimate corresponds to the mean of the density. Clements (2007) and Engelberg et al.

[16]ECB *Results of a special questionnaire for participants in the ECB Survey of Professional Forecasters* 2008.

$$m_{2ij} = \int_{k_{low}}^{k_{up}} z^2 f_i(z)dz = B\frac{(k_{up}^3 - k_{low}^3)}{3} + A\frac{(k_{up}^4 - k_{low}^4)}{4}.$$

Summing over all intervals:

$$\mu_i = \sum_{j=1}^{J} \mu_{ij} \qquad \text{and} \tag{5}$$

$$m_{2i} = \sum_{j=1}^{J} m_{2ij}. \tag{6}$$

Then the individual variance is given by

$$\sigma_i^2 = m_{2i} - \mu_i^2. \tag{7}$$

Finally, the aggregate figures arises from the individual results in (2)-(4).

[INSERT FIGURES 1 and 2 HERE]

5 Empirical results

In this section, we assess uncertainty and disagreement using the ensemble methodology described above. This study covers 63 professional forecasters who participated in at least 20 of the 40 quarterly survey rounds taken from 1999 first quarter up to 2008 fourth quarter. We begin the analysis by computing a basic measure of disagreement based on point estimates, i.e. the cross sectional standard deviation of individual forecasts which does not explain uncertainty in terms of probability, but provides an overview of differences among forecasters over the whole period 1999-2008.

[INSERT TABLE 3 HERE]

As it could be seen from the results, disagreement at short horizon is higher, on average, than the one of 5 years ahead in the case of GDP and inflation. Opposite path is showed by unemployment forecasts' disagreement: the more the horizon increases the more disagreement is high.[17] I turn now to the theoretical assessment of measuring uncertainty and disagreement using individual probability densities. For each of the macroeconomic variable I would like to analyze the behavior of disagreement on point estimate trough time, and compared it with uncertainty and disagreement on probability densities.

5.1 GDP

For the first macro variable taken into account, results are summarized in Fig. 3(a) and Fig. 4.

[INSERT FIGURE 3 HERE]

Disagreement computed using the piecewise linear approximation (Fig.4 line disPL) and the mid-point or uniform (Fig.4 line disMIDUNI) is almost the same. The two lines behave following a similar path.[18] Looking at disagreement at different forecaster horizons in both figures, we see how in the point estimate case (Fig. 3(a)), disagreement is underestimated with respect to the probability density case. The same holds both for 1 year ahead forecast horizon and for 2 and 5 years ahead forecast horizons. Disagreement on point estimate shows an increasing path in the last part of 2008 and we do not find the same behavior in Fig. 4, indeed, for 1 year ahead horizon it slightly goes up for 2 and 5 years ahead it decreases.

Considering uncertainty, it is higher than disagreement itself thanks to the model assumption. Indeed, it considers disagreement among forecasters plus an average of individual uncertainty. Finally, regarding the three different estimates of uncertainty, we can conclude that on one hand uniform distribution assumption (line sigma2UNI) overestimates it and the mid-point underestimates it (line sigma2MID). The piecewise linear approximation (line sigma2PL) is mostly in between the previous two: it proves the idea that the probability distribution restricted to be mid-point or uniform does not consider the real asymmetry over the interval. Analyzing the path through time, we see that the short forecast horizon 1 year ahead is rather

[17]The same behavior is visible in the following Fig.1, Fig.2 and Fig. 3.

[18]We report only one line for disagreement computed as midpoint and uniform cases since the results is the same.

more stable than the two others; it shows just three jumping points in 2000 Q1, 2007Q3 and at the end. The 2 years and 5 years ahead forecast horizons vary more during years. Regarding uncertainty's values, the greatest one are found for the 2 years ahead forecast horizon in particular from 1999 until 2003 third quarter.

[INSERT FIGURE 4 HERE]

5.2 Inflation

For inflation we see that disagreement computed on point estimates, as shown in Figure 3(b), is often lower than the disagreement obtained considering the individual probability densities approximated as piecewise linear function (line disPL) or using the midpoint and uniform assumptions(line disMIDUNI).

In the 1 year ahead rolling horizon, the three measures of uncertainty, midpoint (line sigma2MID), uniform (line sigma2UNI) and piecewise linear (line sigma2PL), show a similar comovement, but in general, as before, the uniform uncertainty is higher than the piecewise linear function and the mid point ones. Exceptions of this comovement result in the first chart of Fig. 5, where the uncertainty line uniformly estimated has a sudden kink in 2006 first quarter and a deep increase from 2007 third quarter onwards. Beside this the three measures of uncertainty better take on the same path of the disagreement on point estimates (blue bold line, disagreement 1 year rolling horizon on Fig.3(b)).

For the 2 years ahead rolling horizon, the same arguments of before related to disagreement are still valid, i.e. the point estimates disagreement (dotted green line Fig. 3(b)) underestimates it with respect to the piecewise linear function case (in Fig. 5). Even so, I point out that in Fig. 5 we cannot see the same huge peak we found in Fig. 3(b) between 2003 and 2004. Uncertainty's measures still comove, and midpoint and uniform lines continue to behave as a kind of confidence band to the piecewise linear function.

Finally, the long forecast horizon, 5 years ahead, shows that disagreement computed on the individual probability densities is slightly more stable than the two short forecast horizons; even in this case, if we correctly take into account the probability density, results on disagreement are higher than in the simple point estimates case. Moreover, as shown in Fig. 3(b), disagreement has a decreasing behavior after 2005-2006 and it is not the same in the bottom chart of Fig.5. Considering uncertainty, it is clearly visible that under the piecewise linear approximation we get an in between uncertainty measure (boundaries are more outlined). Overlooking to the behavior of disagreement and uncertainty at different forecast horizons, the short horizons are the one in which the two measures are higher than the long forecast horizon. For the 1 year rolling horizon, disagreement and uncertainty present a slightly increasing trend over time. The other two forecast horizons have not a so clear trend over years.

[INSERT FIGURE 5 HERE]

5.3 Unemployment

In the end, we analyze the last macroeconomic variable of interest, which is unemployment. As previously specified, unemployment is the most problematic variable, because it is the one mostly affected during the years by changes in the definition and changes of the probability density support. Indeed, figures related to unemployment are the more complicated ones to be read and commented. As presented in Fig. 3(c) disagreement on point estimates increases with the horizons length: low, medium and high values for 1 year, 2 years and 5 years ahead, respectively. Furthermore, as the low and medium lines increase from 2007, the upper one decreases.

Considering the individual density function case, Fig.6, disagreement is very low almost everywhere and it shows a sudden peak around the third quarter of 2003 and the second quarter of 2004 for the 1 year rolling horizon and the 5 years ahead horizon, respectively. For the 2 years rolling horizon case, it is almost everywhere flat. Looking at disagreement and uncertainty, the assumed model specification is respected and in general uncertainty is higher than disagreement but their difference is notably reduced compared to GDP and inflation. For the long forecast horizon (last chart Fig. 6), the difference is slightly more clear and the gap between uncertainty and disagreement is bigger.

The three measures of uncertainty have the same path of before, i.e. low value for midpoint approximation (line sigma2MID), high value for uniform one (line sigma2UNI) and a medium value for the piecewise linear case (line sigma2PL). However, uncertainty on unemployment forecasts is not so evident except for the first round of the survey, first quarter 1999, where it was very high and just after decreased. As for disagreement, the top and the last chart of Fig. 6 present a jump around the end of 2003 and the mid of 2004, respectively.

[INSERT FIGURE 6 HERE]

6 Conclusion

This work studies disagreement and uncertainty on inflation, GDP growth and unemployment at European level using information from the Survey of Professional Forecasters dataset. Disagreement among forecasters has been widely used as a proxy for uncertainty, albeit it is difficult to find a unique empirical evidence to support this relation. Using information contained in the probability density forecasts, associated with the point estimates, that respondents provide during the survey, we apply a technique, which differs from the commonly used ones, to approximate each density forecast before aggregating the individual information. We show that the difference between disagreement and uncertainty exists: disagreement is just one element of the aggregate uncertainty.

The first result shows how just looking at point estimates and disregarding the individual probability information provides with misestimates of disagreement and uncertainty. Indeed, since the information of the probability density forecast is large, it is reasonable to compute the aggregate uncertainty as the sum of the average of forecasters' variances (uncertainty of individual respondents) and the variance of forecasters' mean (measure of disagreement of the mean forecast). The main issue related to the assessment of disagreement and uncertainty concerns the correct estimation of the individual densities in order to get accurate individual results before aggregating them. In that respect, we estimate individual probability density using a piecewise linear approximation, avoiding any a priori distributional assumption. The piecewise approximation allows to estimate the individual density forecasts without imposing any restrictions, which could otherwise mislead the results. The obtained estimates take into account the asymmetry of the underlying probability distribution.

The estimate of individual probability densities, which makes use of a piecewise linear approximation of the histograms, provides results which differ from the a priori functional form cases. Disagreement is slightly affected by the piecewise linear approximation compared to the cases mid-point and uniform assumptions, and the uncertainty is in between the two measures obtained as midpoint and uniform (midpoint underestimates it and uniform overestimates it). It supports the idea that the probability distribution restricted to an a priori functional form ignores the real asymmetry on the entire distribution. Furthermore, we notice that for GDP and inflation disagreement and uncertainty are greater than for unemployment for all the three horizons (two short horizons and one long horizon). Besides this, it is difficult to find a measure between uncertainty and disagreement among the variables. Results do not allow concluding that if uncertainty or disagreement is relatively high for one variable, then it holds for the others.

Table 1: Summary Statistics 1999-2008 and Forecasts Performance

	Inflation		**GDP Growth**		**Unemployment**	
Real data						
Mean	2.1		1.98		8.302	
Standard Deviation	0.64		1.22		0.59	
Survey data	1year	2years	1year	2years	1year	2years
Mean	1.8	1.83	2.02	2.31	8.4	8.1
Standard Deviation	0.22	0.11	0.64	0.38	0.85	0.78
ME	0.4	0.39	0.08	-0.57	-0.33	-0.06
MAE	0.45	0.53	0.83	1.08	0.48	0.71
RMSE	0.57	0.76	0.98	1.34	0.71	0.9

Table 2: MZ Regression - Beta Coefficients

		Inflation	**GDP**	**Unemployment**
Rolling Horizon				
1 year		0.543	0.900	0.372
		(0.431)	(0.264)	(0.111)
	F-test	1.59	7.22*	11.04*
2 years		0.538	-1.071	-0.056
		(1.520)	(0.366)	(0.109)
	F-test	0.13	8.54*	0.26

*Note: * indicates a significant F-test at 0.05 in the Mincer-Zarnowitz regression. In parentheses the Newey-West standard errors.*

Table 3: Disagreement* on point estimates forecasts.

	1 year (rh)	2 years (rh)	5 years
GDP	0.33	0.30	0.26
Inflation	0.25	0.23	0.19
Unemployment	0.25	0.38	0.64

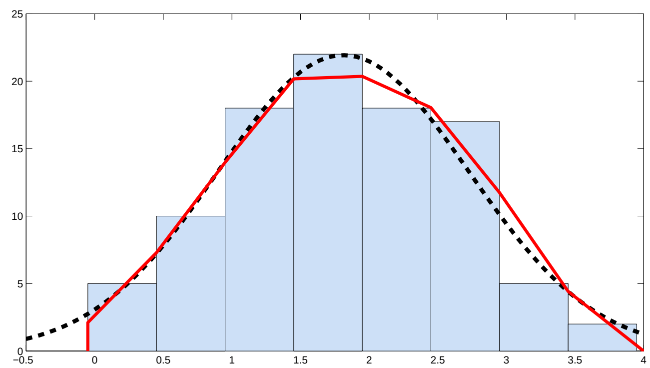
Period 1999-2008

* as mean of standard deviation across forecasters

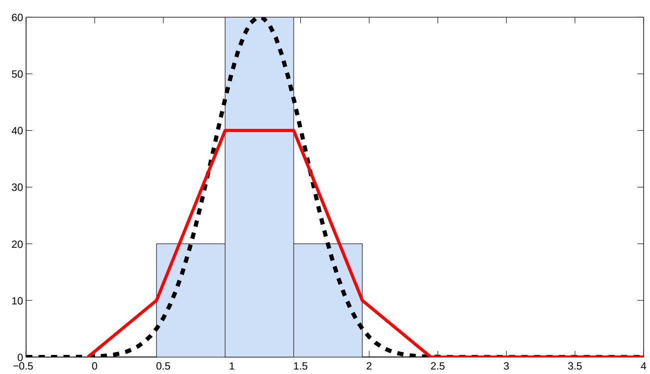
A Appendix

[INSERT FIGURES 7-8-9-10-11-12 HERE]

Figure 1: Normal VS Piecewise approximation

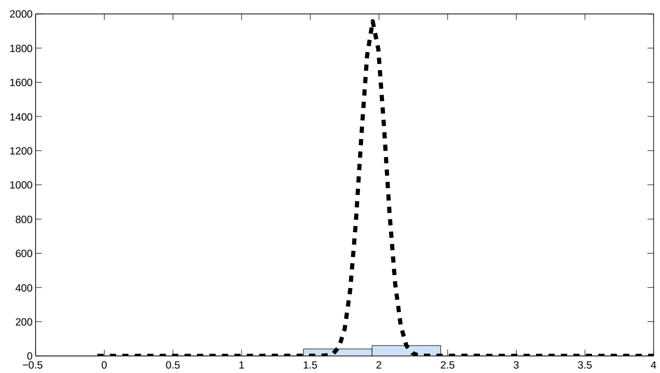


(a)

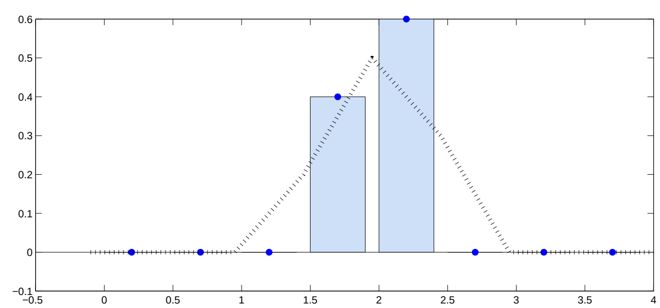


(b)

Figure 2: Normal VS Piecewise approximation - 2 Bins Histogram

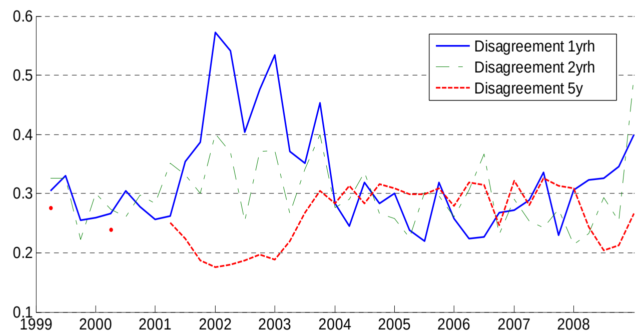


(a)

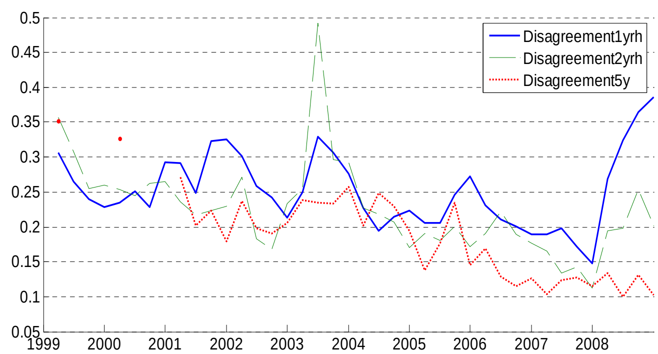


(b)

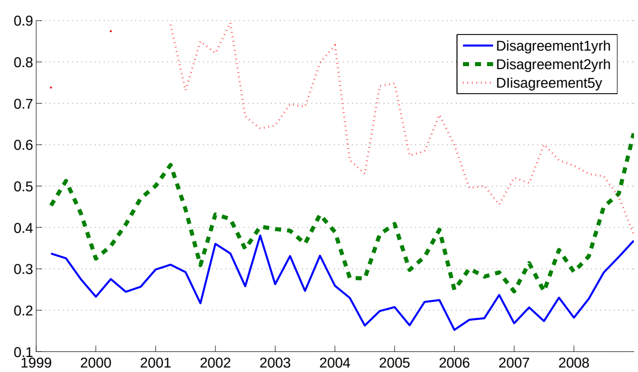
Figure 3: Disagreement on point estimate: GDP, inflation and unemployment



(a)

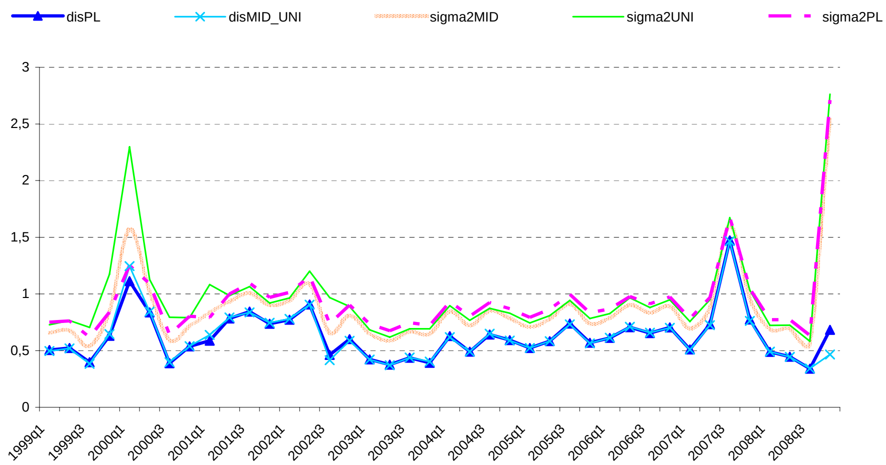


(b)



(c)

Figure 4: Disagreement and uncertainty: **GDP**



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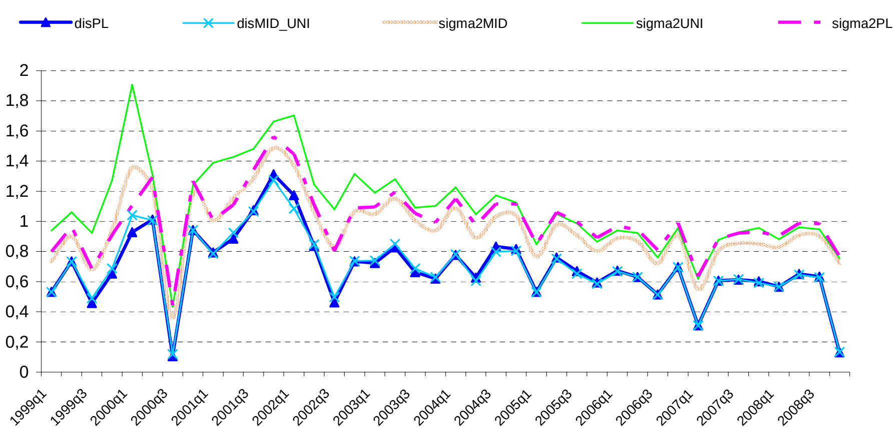
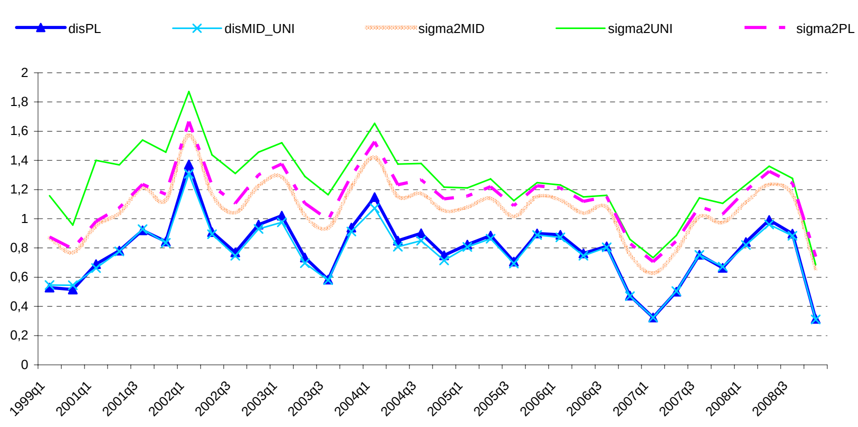
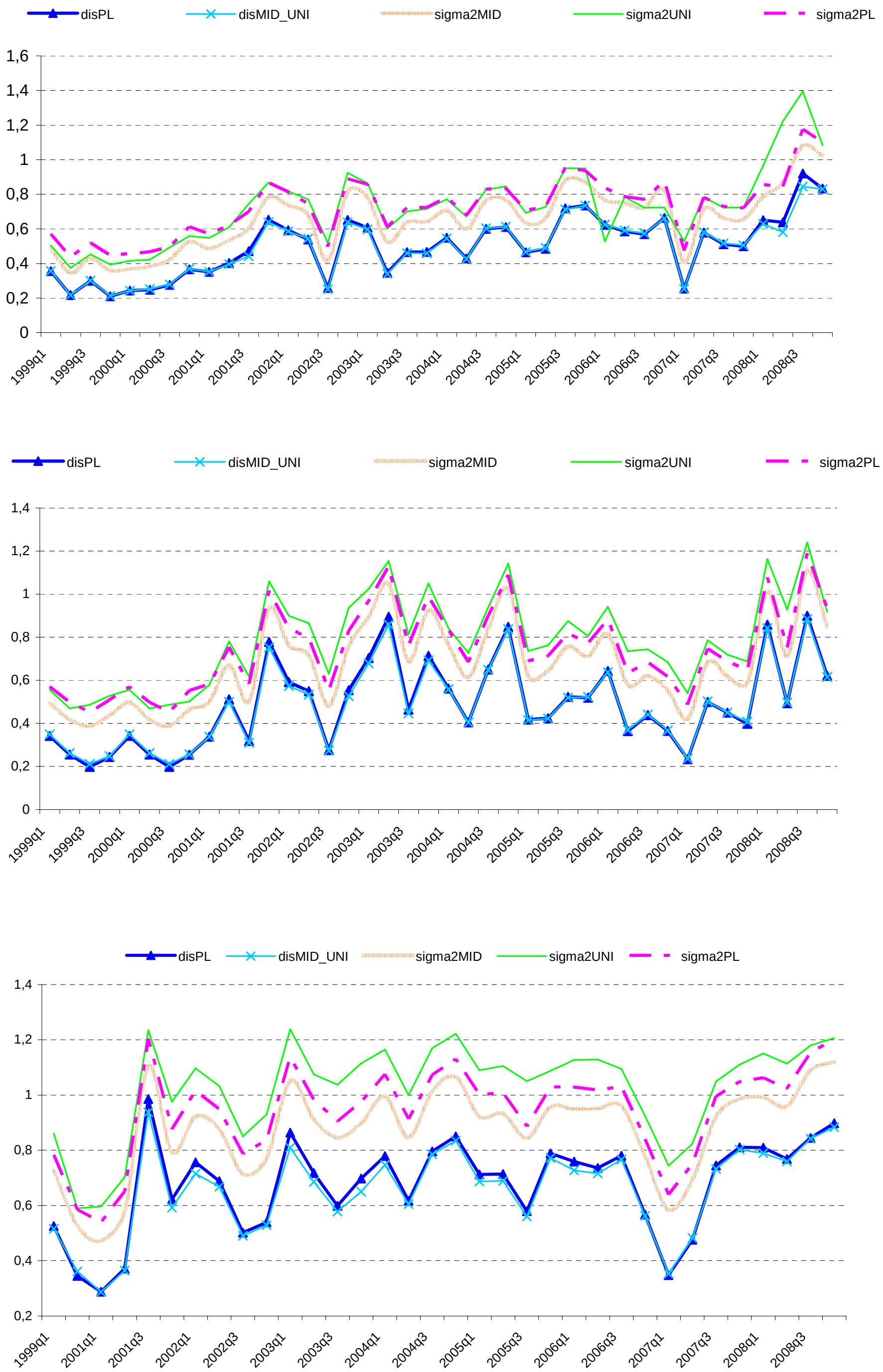




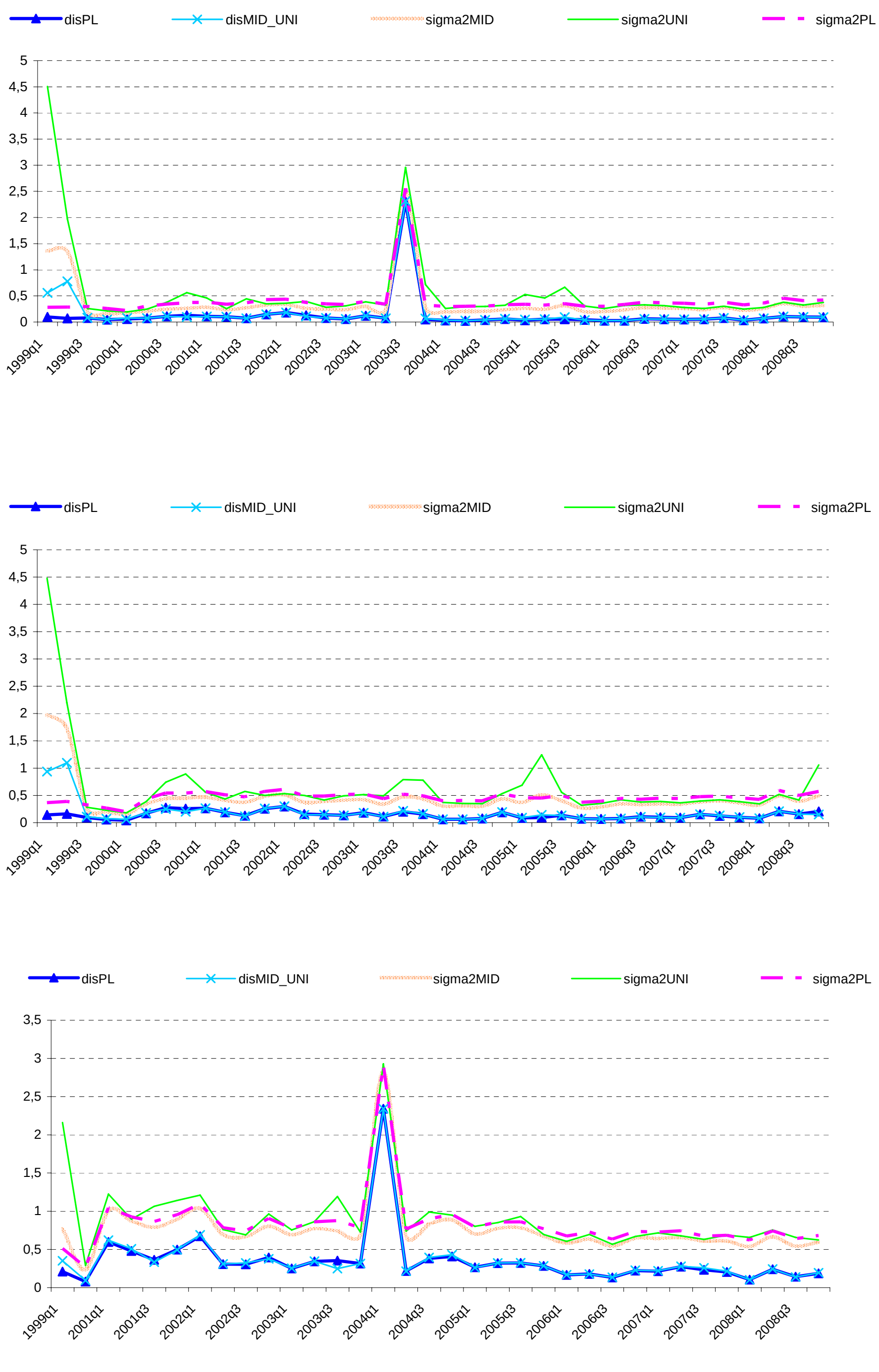
Note: 1 year rolling horizon (top), 2 years rolling horizon (mid) and 5 years ahead horizon (bottom)

Figure 5: Disagreement and uncertainty: **inflation**



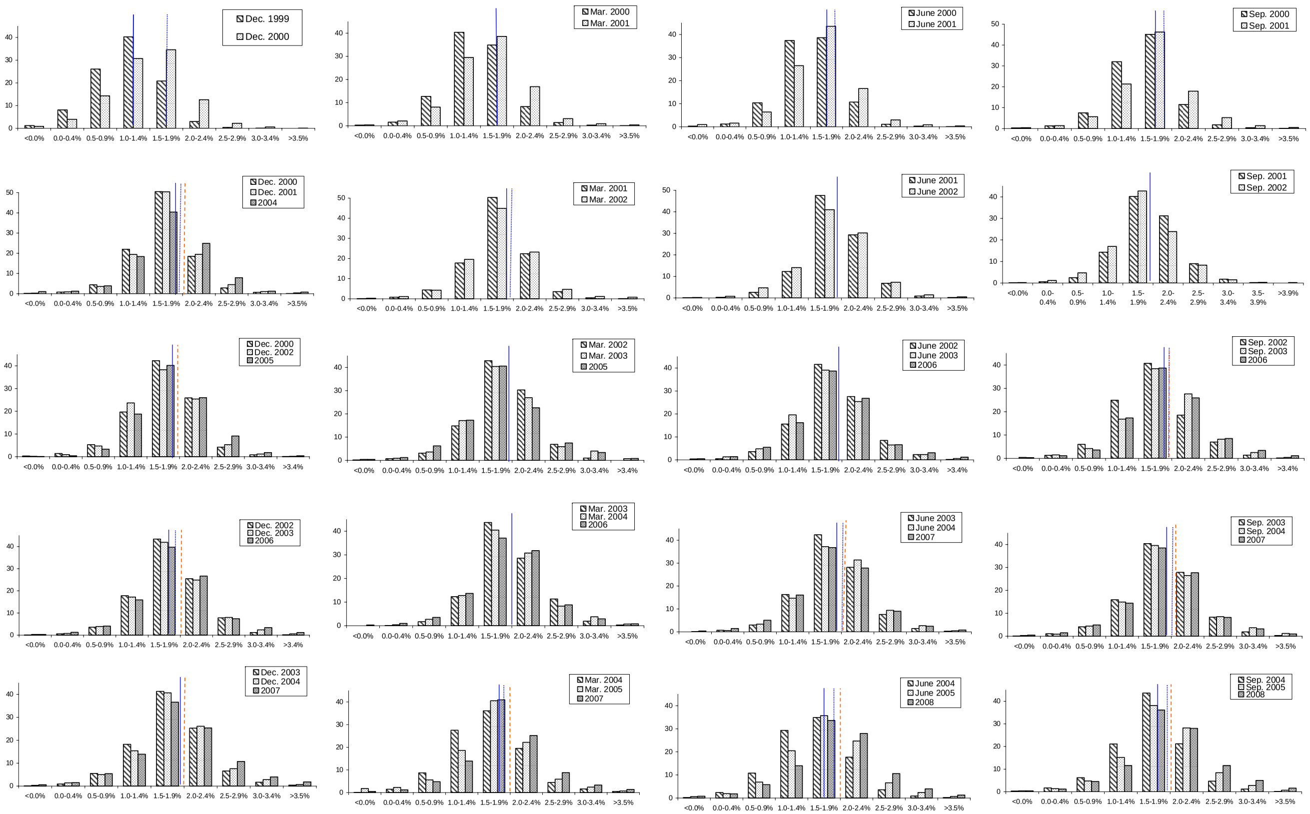
Note: 1 year rolling horizon (top), 2 years rolling horizon (mid) and 5 years ahead horizon (bottom)

Figure 6: Disagreement and uncertainty: **unemployment**



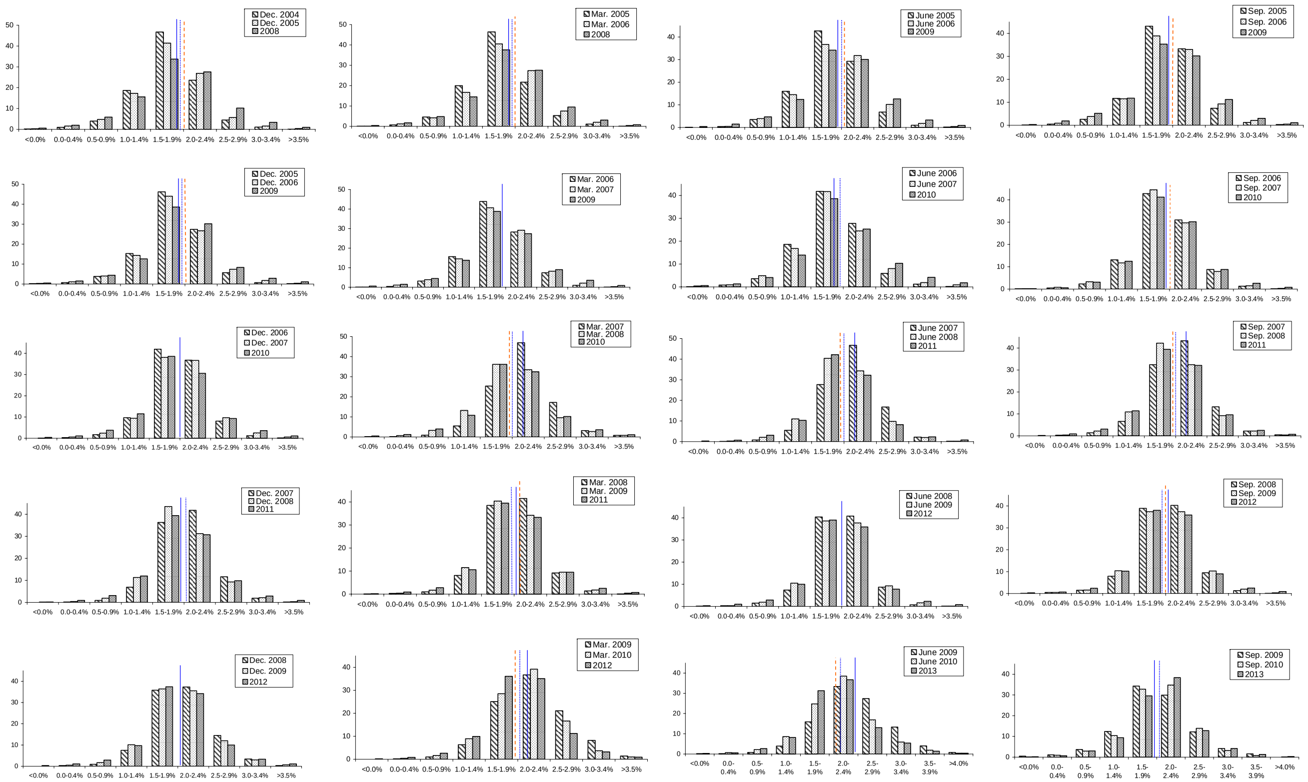
Note: 1 year rolling horizon (top), 2 years rolling horizon (mid) and 5 years ahead horizon (bottom)

Figure 7: Inflation aggregate histograms 1999q1- 2003q4.



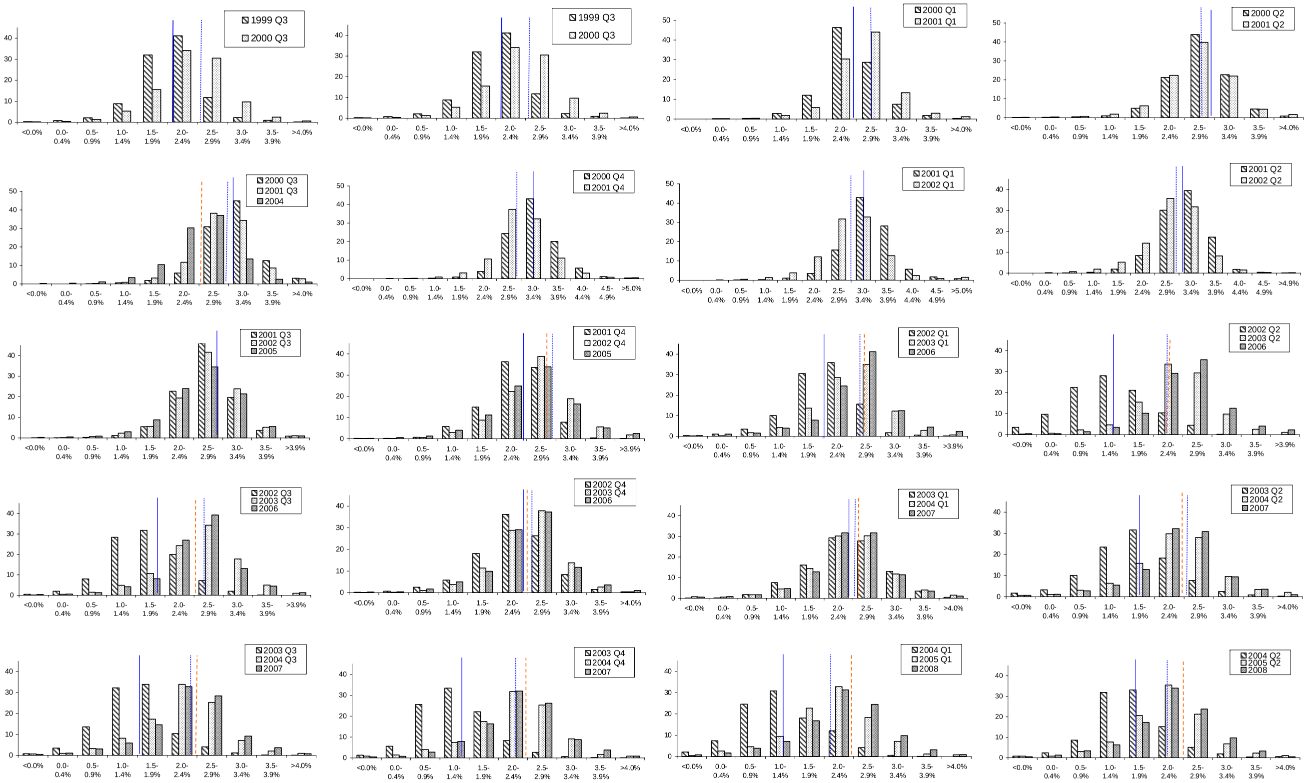
Vertical lines represent mean point estimates: blue tick line(1 year RH), blue small dotted line (2 years RH), orange bold dotted line (5 years).Case of just one blue stick line means all point estimates are the same for different horizons. Case one blue stick equal point estimate for 1 and 2 years RH and one orange bold dotted for 5 years. Case one blue stick for 1 years RH and one orange bold dotted for 2 years RH and 5 years.

Figure 8: Inflation aggregate histograms 2004q1- 2008q4.



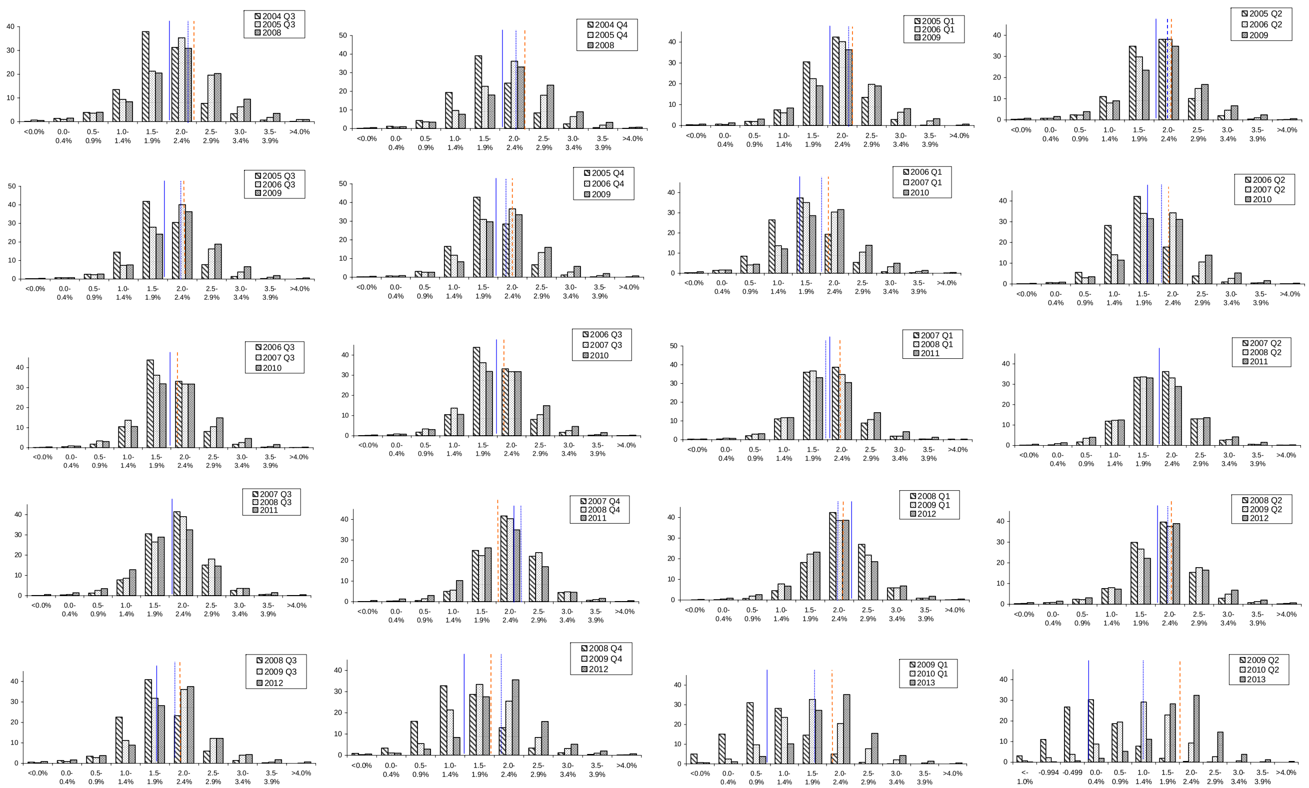
Vertical lines represent mean point estimates: blue tick line(1 year RH), blue small dotted line (2 years RH), orange bold dotted line (5 years).Case of just one blue stick line means all point estimates are the same for different horizons. Case one blue stick equal point estimate for 1 and 2 years RH and one orange bold dotted for 5 years. Case one blue stick for 1 years RH and one orange bold dotted for 2 years RH and 5 years.

Figure 9: GDP aggregate histograms 1999q1- 2003q4.



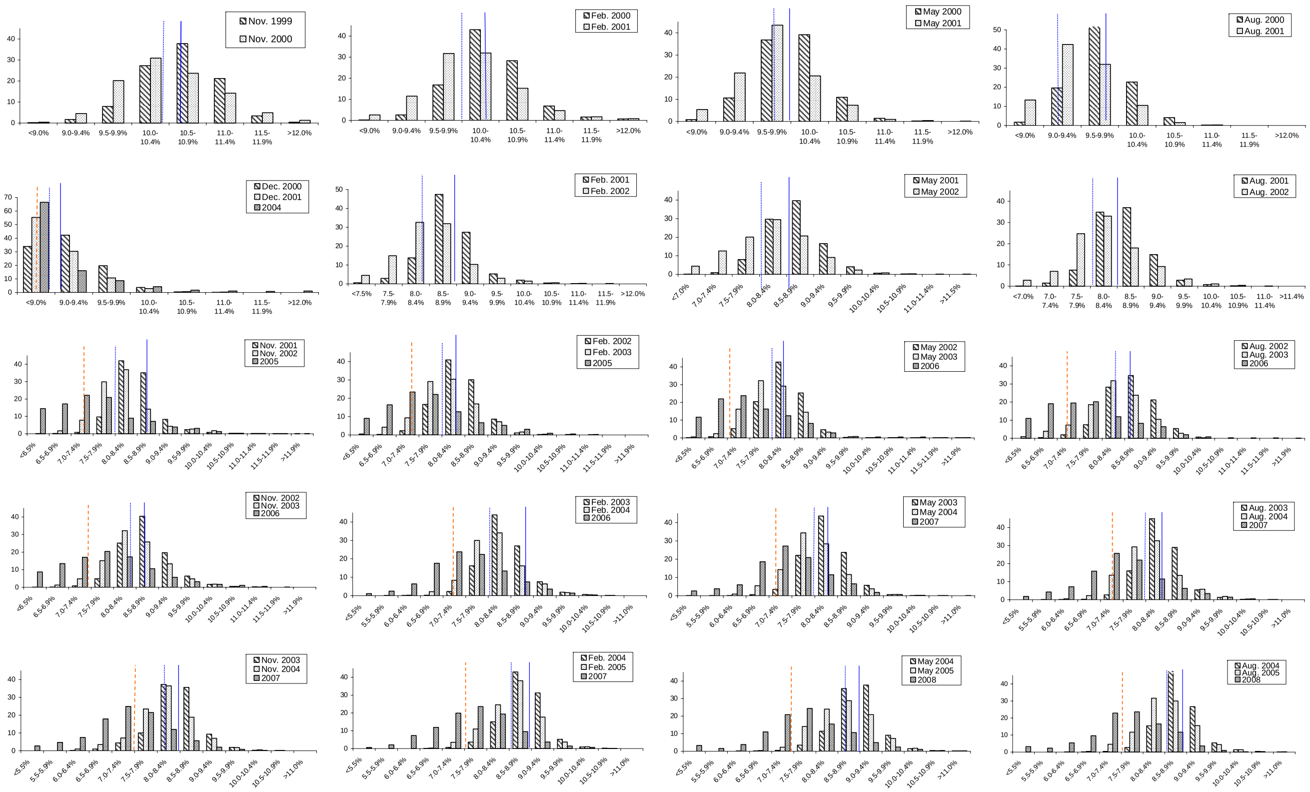
Vertical lines represent mean point estimates: blue tick line(1 year RH), blue small dotted line (2 years RH), orange bold dotted line (5 years).Case of just one blue stick line means all point estimates are the same for different horizons. Case one blue stick equal point estimate for 1 and 2 years RH and one orange bold dotted for 5 years. Case one blue stick for 1 years RH and one orange bold dotted for 2 years RH and 5 years.

Figure 10: GDP aggregate histograms 2004q1- 2008q4.



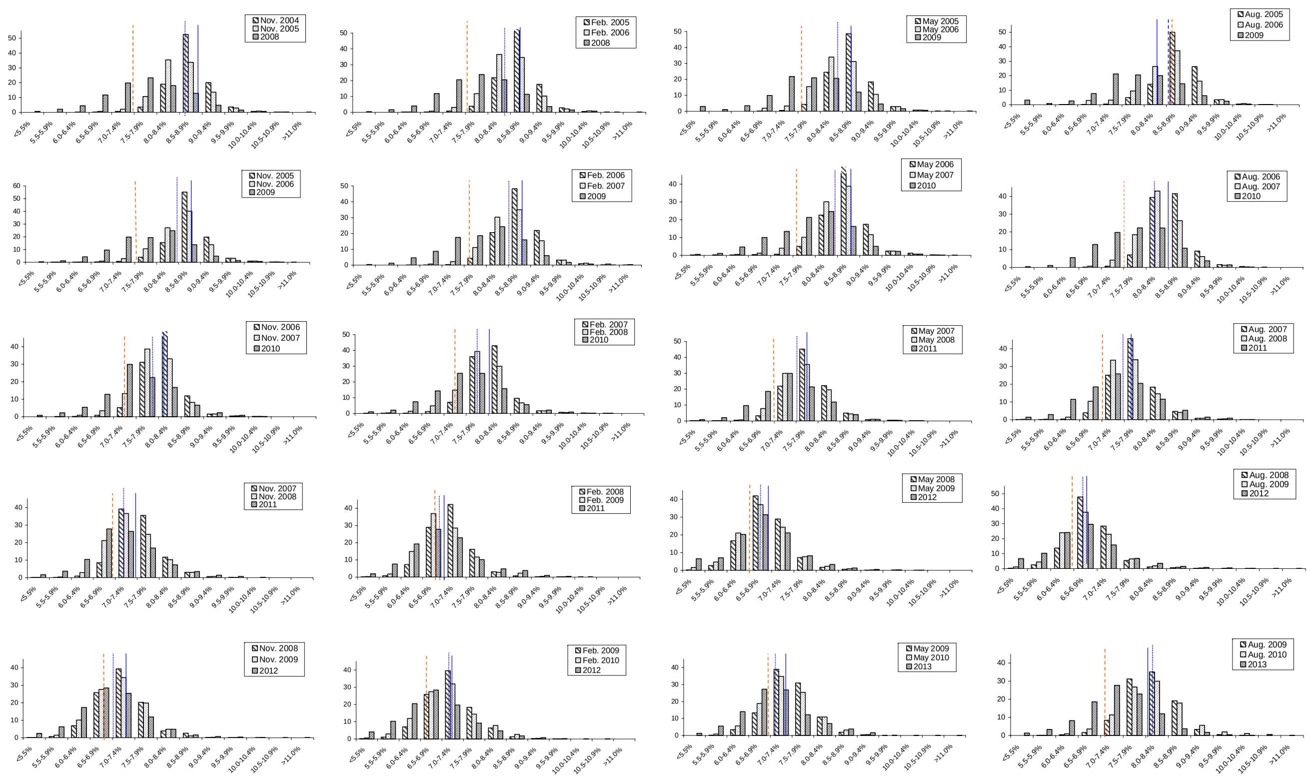
Vertical lines represent mean point estimates: blue tick line(1 year RH), blue small dotted line (2 years RH), orange bold dotted line (5 years).Case of just one blue stick line means all point estimates are the same for different horizons. Case one blue stick equal point estimate for 1 and 2 years RH and one orange bold dotted for 5 years. Case one blue stick for 1 years RH and one orange bold dotted for 2 years RH and 5 years.

Figure 11: Unemployment aggregate histograms 1999q1- 2003q4.



Vertical lines represent mean point estimates: blue tick line(1 year RH), blue small dotted line (2 years RH), orange bold dotted line (5 years).Case of just one blue stick line means all point estimates are the same for different horizons. Case one blue stick equal point estimate for 1 and 2 years RH and one orange bold dotted for 5 years. Case one blue stick for 1 years RH and one orange bold dotted for 2 years RH and 5 years.

Figure 12: Unemployment aggregate histograms 2004q1- 2008q4.



Vertical lines represent mean point estimates: blue tick line(1 year RH), blue small dotted line (2 years RH), orange bold dotted line (5 years).Case of just one blue stick line means all point estimates are the same for different horizons. Case one blue stick equal point estimate for 1 and 2 years RH and one orange bold dotted for 5 years. Case one blue stick for 1 years RH and one orange bold dotted for 2 years RH and 5 years.

References

[1] Boero, G., Smith,J. and Wallis, F. (2008), "Uncertainty and Disagreement in Economic Prediction: The Bank of England Survey of External Forecasters", *The Economic Journal*, Vol. 118, 1107-1127.

[2] Boero, G., Smith, J. and Wallis, F. (2008), "Uncertainty and Disagreement in Economic Forecasting", *Finance and Economics Discussion Series Federal Reserve Board*, No.56

[3] Bowles, C., Friz, R., Genre, V., Kenny, G., Meyler, A. and Rautanen, T. (2007), "The ECB Survey of Professional Forecasters (SPF). A Review after eight years' experience", Occasional Paper Series - ECB, No.59.

[4] Carlson, J. and Parkin, M. (1975), "Inflation Expectations", *Economica*, No.166, 123-138.

[5] Carruth, A., Dickerson, A. and Henley, A. (2000), "What do we know about investment under uncertainty?", *Journal of Economic Surveys*, No.14(2), 119-153.

[6] Clements, M.P. (2007), "Internal Consistency of Survey Respondents' Forecasts: Evidence based on the Survey of Professional Forecasters", Mimeo, Department of Economics, University of Warwick.

[7] Clements, M.P. (2008), "Consensus and Uncertainty: Using Forecast Probabilities of Output Declines", *International Journal of Forecasting*, No.24, 76-86.

[8] D'Amico, S. and Orphanides, A. (2008), "Uncertainty and Disagreement in Economic Prediction: The Bank of England Survey of External Forecasters", *The Economic Journal*, Vol. 118, 1107-1127.

[9] Diebold, F. X., Tay, A. S., and Wallis, K. F. (1999), "Evaluating Density Forecasts of Inflation: The Survey of Professional Forecasters", in Engle, R. F., and White, H. (eds.), Cointegration, Causality and Forecasting: A Festschrift in Honour of Clive Granger, pp. 76-90, Oxford: Oxford University Press.

[10] Engelberg, J., Manski, C.F. and Williams J. (*forthcoming*), "Comparing the Point Predictions and Subjective Probability Distributions of Professional Forecasters", *Journal of Business and Economic Statistics*.

[11] European Central Bank , "Results of a special questionnaire for participants in the ECB Survey of Professional Forecasters"", ECB Special Questionnaire, Autumn 2008.

[12] Genest, C. and Zidek, J.V. (1986), "Combining Probability Distributions: A critique and an Annotated Bibliography", *Statistical Science*, Vol.1, No.1, 114-148.

[13] Giordani, P. and Soderlind, P. (2003), "Inflation Forecast Uncertainty", *European Economic Review* , No.47, 1037-1059.

[14] Hall, S.G. and Mitchell, J.(2007),"Combining Density Forecasts", *International Journal of Forecasting*, Vol. 23, 1-13.

[15] Lahiri, K., and Sheng, X. (2009),"Measuring Forecast Uncertainty by Disagreement: The Missing Link", *Journal of Applied Econometrics*, *forthcoming*.

[16] Lahiri, K., and Wang, X. (2006),"Subjective probability Forecasts for Recessions. Evaluation and Guidelines for Use", *Business Economics*, 26-37.

[17] Mitchell, J., Mouratidis, K. and Weale, M. (2005),"Uncertainty in UK Manufacturing: Evidence from Qualitative Survey Data", *Economic Letters*, Vol. 94(2), 245-252.

[18] Mincer J. and Zarnowitz, V.(1969), "The Evaluation of Economic Forecasts", in: J. Mincer, ed., Economic Forecasts and Expectations (NBER).

[19] Newey, W.K and West, K.D. (1987),"A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix", *Econometrica*, Vol. 55(3), 703-708.

[20] Pesaran, M.H. and Weale, M. (2005),"Survey Expectations", CeSifo Working Paper No. 1599.

[21] Timmermann, A. (2005), "Forecast Combination", CEPR Discussion Paper Series No 5361.

[22] Zarnowitz, V. and Lambros, L. (1987),"Consensus and Uncertainty in Economic Prediction", *Journal of Political economy*, Vol. 95, 591-621.