# QUASI *EX-ANTE* INFLATION FORECAST UNCERTAINTY

## Extended abstract

WOJCIECH CHAREMZA*, CARLOS DÍAZ* AND SVETLANA MAKAROVA***

* Vistula University, Poland

** University of Leicester, UK

*** University College London, UK

February 2017

In this paper, we concentrate on the analysis of the distribution of the *ex-post* inflation forecast uncertainty and its relation to the *ex-ante* uncertainty. The *ex-post* forecast uncertainty is measurable at time when the realisation of the forecasted variable is known (time *t*). It is based on the results of comparing of such realisations with their forecasts made in the past, at time $t-h$, where *h* is the forecast horizon. The *ex-ante* uncertainty is a distributional characteristic (usually variance) of the forecast formulated at time $t-h$ for time *t*. It can be argued that under the conditions of stationarity and ergodicity of the sequence of forecast errors, perfect model specification, and the absence of structural breaks in the forecasted period, the *ex-post* and *ex-ante* uncertainty should be identical. The fact that they are not the same has been frequently observed and interpreted in various ways (*e.g.* Dowd, 2007, Clements, 2014). There are two main reasons for this. The first one can be attributed to less than perfect way the *ex-ante* uncertainty is usually measured. It is often evaluated using data (individual forecasts) in surveys of professional forecasters or consensus forecasts (for a critique and modifications of these approaches see *e.g.* Andrade and Bihan, 2013; Lahiri, Peng and Sheng, 2014; Öztürk and Sheng, 2016). For international comparison, such data might not be available for a number of countries, or not directly comparable, due to different ways of constructing the surveys. The second reason is related to the fact that the ergodicity assumption of the distribution of forecast errors used for computing the *ex-post* uncertainty might not be valid, particularly for long series of data, as the uncertainty might depend on of the phase of the business cycle. Suppose, however, that both *ex-post* and *ex-ante* uncertainties are measured perfectly. In this case, they should be identical but only if there is no effective monetary policy action undertaken at time $t-h$ affecting the distributions for which measures of such uncertainties are computed. Otherwise, that is, if the policy makers' action is efficient to a degree, then the *ex-post* uncertainty should usually be smaller than the *ex-ante* uncertainty, as the efficient monetary policy stabilize inflation.

Evidently, it is easier and less expensive to compute the *ex-post* rather than *ex-ante* uncertainty, as the former does not require access to well-constructed and time-consistent surveys. With this in mind, we suggest a measure that approximates the *ex-ante* uncertainty from data on the past forecast errors, that is, data usually used for computing the *ex-post* uncertainty. The approximation is made by removing the approximated effects of the monetary policy onto the distribution of forecast errors. Therefore, we refer to it as the *quasi ex-ante* uncertainty.

Following Clements (2014), we define the *ex-post* inflation forecast uncertainty as the mean of squared forecast errors. Suppose that, for each forecast horizon *h*, these forecast errors observed at time *t* constitute a stationary and ergodic sequence $e_{t|t-h}$, $t = t_0,\ t_0+1, \ldots, T-h, h = 1,2,\ldots,H$. Charemza *et al*. (2016) show that the empirical distribution of $e_{t|t-h}$ is, for each forecast horizon, well approximated by the distribution of a random variable $U$, expressed as:

$$U = X + \alpha \cdot Y \cdot I_{Y>\bar{m}} + \beta \cdot Y \cdot I_{Y<\bar{k}} \quad ,$$

where $(X,Y) \sim N\left(\begin{bmatrix}0\\0\end{bmatrix}, \begin{bmatrix}\sigma^2 & \rho\sigma^2\\ \rho\sigma^2 & \sigma^2\end{bmatrix}\right)$, with $|\rho| < 1$ ,

$I_{\{\bullet\}}$ is the indicator function of a set $\{\bullet\}$, $\alpha, \beta, \bar{k} < \bar{m} \in \mathbb{R}$, $\sigma^2, \in \mathbb{R}^+$. This distribution is called the *weighted skew normal* and denoted as $U \sim \mathrm{WSN}_\sigma\,(\alpha, \beta, \bar{m}, \bar{k}, \rho)$.

For an economy conducting inflation-stabilization policy, suggested interpretation of the WSN distribution implies that the parameters $\alpha$ and $\beta$ represent the effects of, respectively, contractionary and output-stimulating polices on the distribution of the *ex-post* forecast errors and $\rho$ describes the specific knowledge (in addition to the commonly available information) of the inflation forecasters delivering forecasts signals to an inflation-controlling body (usually a central bank). The random variable describing such forecasts is *Y*. On the basis of such forecast signals the decision-makers (central bankers) make their decisions. If the signals suggests 'large' deviations from the common-knowledge forecast, that is if either $Y < \bar{k}$ or $Y > \bar{m}$, a policy action is undertaken aimed at reducing inflation uncertainty at forecast horizon *h*.

In order to derive the *quasi-ex-ante* measure of uncertainty, we extract the non-predictable component in *U* as:

$$V = U - E(X \mid Y) = U - \rho Y \quad .$$

It can be shown that the distribution of *V* also belongs to the WSN family as

$$\frac{1}{\sigma\sqrt{1-\rho^2}} V \sim \mathrm{WSN}_1\left(\frac{\alpha}{\sqrt{1-\rho^2}}, \frac{\beta}{\sqrt{1-\rho^2}}, \frac{\bar{m}}{\sigma}, \frac{\bar{k}}{\sigma}, 0\right) \quad .$$

Comparison of the variance of *V*, denoted as $\sigma_V^2$, with the mean squared error of *U*, denoted as $MSE_U$, provides an approximation for the relative influence that policy decisions might have on the distribution of inflation forecasts. Although observations on *V* are not available, it is possible to evaluate the *uncertainty ratio* UR using the estimated parameters of WSN, as:

$$\mathrm{UR} \overset{def}{=} \frac{\sigma_V^2}{MSE_U} = 1 + 2\rho \frac{-(\alpha D_m + \beta D_k) - \rho/2}{MSE_{U^*}} - \frac{\left[E(U^*)\right]^2}{MSE_{U^*}} \quad ,$$

where $U^* \sim \mathrm{WSN}_1(\alpha, \beta, m, k, \rho)$, $m = \bar{m}/\sigma$, $k = \bar{k}/\sigma$, $E(U^*) = \alpha \cdot \varphi(m) - \beta \cdot \varphi(k)$, and

$$D_a = \int_{|a|}^{+\infty} t^2 \varphi(t)\,dt = 1 - \Phi(|a|) + |a|\varphi(a) \quad .$$

Under the symmetry, that is when $\alpha = \beta$ and $m = -k$, UR increases above unity with the increase in the compound strength, $\alpha D_m + \beta D_k$, and is also affected by the effects of the central bankers' forecasts (through $\rho$). Note that as $\alpha$ and $\beta$ reflect the marginal intensity of monetary policy actions, and $D_m$, $D_k$ the frequency of such actions. The magnitude of UR can be negatively affected by a possible asymmetry, resulting in $E(U^*) \neq 0$.

It is shown that the maximum of UR for a given $\rho$ and $k = -m$ is

$$\mathrm{UR}_{\max}(\rho) = 1 + \frac{4\rho}{\rho(1-4D)/D + 2\sqrt{2(1-\rho^2)/D + \rho^2/(4D^2)}} \quad ,$$

where $D = D_m = D_k$, achieved when $\alpha = \beta = -\left(\rho + \sqrt{8D(1-\rho^2) + \rho^2}\right)/(4D)$.

To assess the practical relevance of our results and confirm, to an extent, the rationale of the assumptions imposed, we have used data on inflation forecast errors for 38 countries that are for 32 OECD countries, 5 BRICS countries (Brazil, China, India, South Africa and the Russian Federation) and Indonesia. The monthly series of CPI inflation are of various lengths for different countries and all end at January or February 2013. The longest series, starting in January 1949, is for Canada (770 observations), and two shortest are for Estonia (182 observations) and China (242 observations).

Foe reach forecast horizon *h*, observations on $U$ have been recovered as:

$$e_{t|t-h} = (\pi_t - \hat{\pi}_{t|t-h}) / (s_{t|t-h} / s_h) \qquad t = t_0,\ t_0 + 1, \dots, T - h \quad , \quad h = 1, 2, \dots, H$$

where $\hat{\pi}_{t|t-h}$, $s_{t|t-h}$ and $s_h$ are respectively the ARMA-GARCH(1,1) *h*-steps ahead point forecasts of mean of inflation, the conditional and unconditional standard deviations of the residuals. The estimation has been made in the pseudo out-of-sample way (see Stock and Watson, 2007; for further development see Inoue *et al*., 2014), that is by computing predictions recursively for a certain period within the observed sample, re-estimating the model each time, and then computing forecast errors. The ARIMA-GARCH(1,1) models have been estimated by the quasi-maximum likelihood (QML) method (see Francq and Zakoïan, 2012), and the parameters of WSN have been computed by the simulated minimum distance estimation method. Forecasts have been made for up to 24 periods (months) ahead. For each country, for the first recursion we have used first 20% of observations if the number of these observations was greater than 80; otherwise, we have used first 80 observations. It has been found that the WSN distributions fits better than the two-piece normal distribution in 85% cases and better than the generalized beta distribution in 90% cases.

The rationale of UR has been verified by relating it to the measures of central banks' independence. Usually it is hypothesised that there should be a positive relationship between the effects the monetary policy onto inflation uncertainty and the degree of central banks' independence. We have used the Dincer and Eichengreen (2014) and the Bodea and Hicks (2015) measures of such independence, and related them to UR's and the compound strength defined above. For 23 countries with independent central banks the Spearman's rank correlation coefficients between the banks' independence measures and the UR's computed separately for each forecast horizon, are predominantly positive but insignificant. At the first sight, it seems that we do not confirm the hypothesis that central banks' independence is beneficial. However, we have found much stronger evidence of the existence of a relationship between the compound strength and central banks independence measures, if the countries are split into two regimes: (1) where $\mathrm{UR} < \mathrm{UR}_{\max}$ (13 countries) and (2) $\mathrm{UR} > \mathrm{UR}_{\max}$ (10 countries). This can be explained by the fact that, with the increase in UR, the compound monetary policy strength is initially increasing, up to the point of $\mathrm{UR}_{\max}$, and then decreasing.

Our results are in line with some earlier findings that a high degree of central banks' independence can sometimes be sub-optimal (see e.g. Hefeker and Zimmer, 2012; Hielscher and Markwardt, 2012; Charemza and Ladley, 2016). Not surprisingly, for central banks' for all 38 countries and not only those conducting inflation targeting, the evidence of the nonlinear relationship between the strength of monetary policy and central banks' independence is much weaker.

We conclude that we suggest a *pseudo ex-ante* measure of forecast uncertainty using past forecast errors that might be used as an alternative (or substitute) to purely *ex-ante* uncertainty measures, which are more difficult to construct. Usually, past forecast errors are sued for constructing measures of the *ex-post* uncertainty. However, such measures do not fully reflect the *ex-ante* uncertainty the agents' face at the moment of undertaking decisions who do not know the possible effects of monetary policy. The *pseudo ex-ante* measure proposed here requires knowledge of the *ex-post* forecast errors and parameters of the weighted skew-normal distribution fitted to them. This measure, which is, to an extent, free from the potentially predictable element (and, consequently, of the effects of policy decisions), could also be of interest to the policy makers, who does not want the picture of uncertainty be blurred by outcomes of their own decisions made in the past. Instead, they could rather be interested in answering the question of 'what would the uncertainty be if we do not carry out the policy we actually want to implement?'. The comparison of both measures: *pseudo ex-ante* and *ex-post* provides a useful indicator of a possible room for improvement regarding the possibility of further reduction in the inflation forecast uncertainty.

## References

Andrade P, and H. Le Bihan (2013), 'Inattentive professional forecasters', *Journal of Monetary Economics* **60**, 967-982. DOI: 10.1016/j.jmoneco.2013.08.005

Bodea C, and R. Hicks (2015), 'Price stability and central bank independence: discipline, credibility, and democratic institutions, *International Organization* **69**, 35-61 DOI: 10.1017/S0020818314000277

Charemza W, Díaz C, Makarova S. (2016), 'Weighted skew-normal distribution as an approximation to forecast errors', presented at the CFE conference, Seville.

Charemza, W. and D. Ladley (2016), 'Central banks' forecasts and their bias: Evidence, effects and explanation', *International Journal of Forecasting* **32**,804–817.

Clements M P. (2014), 'Forecast uncertainty – ex ante and ex post: US inflation and output growth', *Journal of Business and Economic Statistics* **32**: 206-216. DOI: 10.1080/07350015.2013.859618

Dincer N N, and Eichengreen B. (2014), Central bank transparency and independence: updates and new measures, *International Journal of Central Banking* **10**: 189-253. http://www.ijcb.org/journal/ijcb14q1a6.htm (Accessed May 2016).

Dowd K. (2007), Too good to be true? The (In)credibility of the UK inflation fan chart, *Journal of Macroeconomics* **29**, 91-102. DOI: 10.1016/j.jmacro.2005.04.003

Francq C, and J-M. Zakoïan (2012), 'QML estimation of a class of multivariate asymmetric GARCH models', *Econometric Theory* **28**: 179-206. DOI: 10.1017/S0266466611000156

Hefeker C, and B. Zimmer (2011), 'The optimal choice of central bank independence and conservatism under uncertainty' *Journal of Macroeconomics* **33,** 595-606. DOI: 10.1016/j.jmacro.2011.09.005

Hielscher K, and G. Markwardt (2012) 'The role of political institutions for the effectiveness of central bank independence', *European Journal of Political Economy* **28**, 286-301. DOI: 10.1016/j.ejpoleco.2011.08.004

Inoue A, L. Jin and B. Rossi (2014), 'Window selection for out of sample forecasting with time-varying parameters', Barcelona GSE Working Paper Series Working Paper no 768. http://www.barcelonagse.eu/sites/default/files/working_paper_pdfs/768.pdf

Lahiri K, H. Peng and Sheng X. (2014), Measuring uncertainty of a combined forecast', Presented at the workshop 'Uncertainty and Economic Forecasting', UCL, London.

Öztürk, E.O. and X.S. Sheng (2016), 'Measuring global and country-specific uncertainty', https://editorialexpress.com/cgi-bin/conference/download.cgi?db_name=IAAE2016&paper_id=635/

Stock J H, and M.W. Watson (2007), 'Why has US inflation become harder to forecast?' *Journal of Money, Credit and Banking* **39** (Supplement): 3-33. DOI: 10.1111/j.1538-4616.2007.00014.x