Box 3.1

Inflation Uncertainty Measures

Inflation uncertainty is an important indicator for price stability and social welfare. In periods of heightened inflation uncertainty real financing costs increase, investment plans are distorted, and pricing behavior deteriorates. In addition, indicators on inflation uncertainty are perceived as the hallmark of achieving the price stability objective. Hence, central banks pay close attention to movements in inflation uncertainty.

This box derives alternative measures to monitor inflation uncertainty for the case of Turkish economy. In this context, various uncertainty measures are constructed using the CBRT's Survey of Expectations and their movements are interpreted.

Survey-Based Inflation Uncertainty

In the economic literature, conventional inflation uncertainty measures are constructed using either model-based or survey-based approaches. Model-based indicators employs the degree of predictability for inflation time series, while survey-based measures focus on the information embedded in forecasts of survey participants. This study used survey-based measures to construct measures of inflation uncertainty. This approach is preferred, because it yields a direct estimate of uncertainty perceived by the economic agents with a forward-looking perspective, and hence, is considered more relevant in terms of inflation dynamics and social welfare.

In the economic literature, the survey-based inflation uncertainty measures typically adopt three alternative approaches: (i) Disagreement in point forecasts among survey participants (ii) Indicators derived from probability distributions, which reveals the likelihood that participants attribute to the different outcomes for inflation (iii) A combination of the first two measures.[1]

The concept of "disagreement" shows how dispersed are the forecasts of survey participants at any given time, which is mostly measured by cross sectional standard deviation of point forecasts. The advantage of disagreement is that it can be easily calculated for almost all type of surveys. The main disadvantage is that, this measure can give misleading results after a short-term shock if participants update their forecasts at different times. For example, consider a favorable disinflation shock. If some respondents updated their forecasts rapidly, whereas the others are slower to update, this may lead to an increase in disagreement, which will give the impression that uncertainty is increasing despite declining inflation risks.[2]

Uncertainty measures derived from individual level density forecasts are used as a benchmark for uncertainty in the central banking and academic literature since they reflect subjective uncertainty perceived directly by individual respondents.[3] The indicator is computed mostly based on the standard deviation of individual density forecasts. The advantage of this indicator is that it shows a direct measure of perceived individual uncertainty around the point forecasts at the micro-level, and thus it is closer to the true notion of uncertainty. The disadvantage is that in many countries' surveys of expectations, micro level probability distribution forecasts are not available and therefore the calculation of this measure is often not possible.

[1] Hülagü and Şahinöz (2012) use inflation expectation errors (inflation surprises) calculated from the CBRT's Survey of Expectations as an indicator of uncertainty. However, in this approach, month *t* value of the inflation surprise can be calculate only when inflation is announced at month *t + 1*. Therefore, this indicator is not included in this Box since the aim is to derive timely measures to guide decision-makers.

[2] See Mankiw et al. (2003), Zarnowitz and Lambros (1987) for a detailed discussion on disagreement.

[3] See Rich and Tracy (2010).

The third approach for inflation uncertainty focuses on measures incorporating both disagreement and individual level uncertainty. This measure is constructed by aggregating individual density forecasts and calculating some measure of dispersion for this distribution.

Economic literature often uses standard deviation as a benchmark uncertainty indicator. On the other hand, some studies employ the concept of "entropy" from information theory. Entropy is a reasonable candidate as an alternative uncertainty indicator since it measures the degree of concentration of a probability distribution.[4] The advantage of this measure is that it provides more robust results than the standard deviation metric when the individual probability distributions are bi-modal or non-normal.

Measures of Inflation Uncertainty for Turkey

For the case of Turkey, the particular design of the Expectations Survey (the Survey) compiled by the Statistics Department of the CBRT, which is published monthly on the official website, allows for a proper construction of the above-mentioned uncertainty measures. The availability of individual level density forecasts for 12-month ahead inflation expectations in the survey since 2013 permits measurement of inflation risk perceived by individual respondents.

In the Survey, each month around 100 professionals provide forecasts on indicators such as inflation, output growth, the Turkish lira exchange rate, interest rates and current account for different maturities. Survey participants are asked not only to report their 12-month and 24-month ahead inflation forecasts but also density forecasts in the form of histograms. Survey participants provide density forecasts in two steps. First, the on-line survey asks the respondents to provide their point forecasts on a digital menu. Once the point forecast is received, the system automatically creates intervals and asks participants to distribute probabilities as multiples of 10% for each interval.[5] The chart below is an example of the screen shot that shows the density forecast filled out by a hypothetic participant whose point estimation is 9.7% for one-year ahead inflation (Chart 1).

Chart 1: The Screen Shot of Probability Forecasts

Source: CBRT.

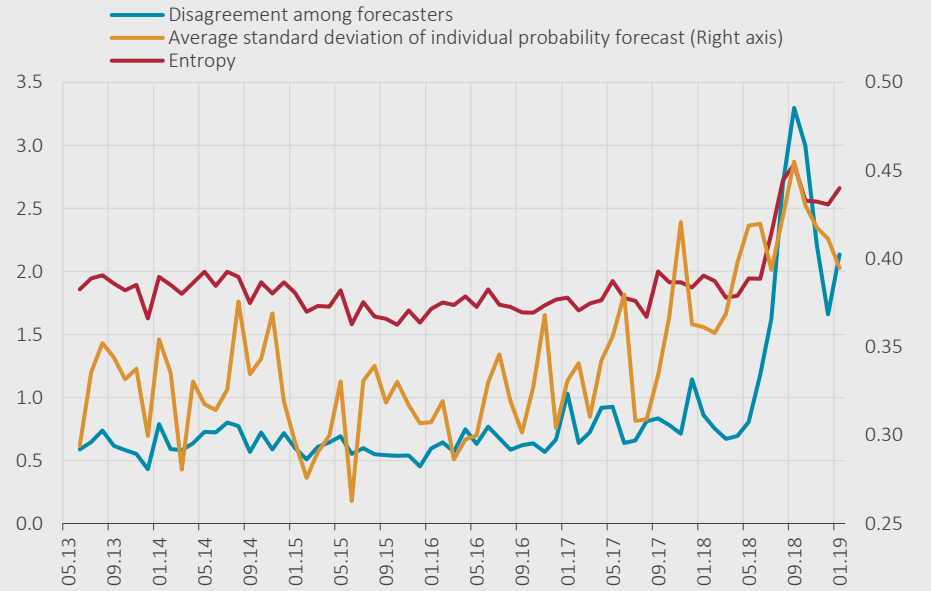
[4] See Harris (2006) for a more comprehensive assessment of the concept of entropy.

[5] Although the number of participants who provide density forecasts is lower than the number of respondents providing point forecasts, approximately 40 participants share their density forecasts each month during the sample period.

Using individual level data, we construct alternative uncertainty measures based on the approaches proposed in the previous section. In this context, three different measures are introduced. The first indicator measures the cross-sectional dispersion across participants' point forecasts and is calculated as the standard deviation of survey participants' point forecasts. The second indicator is the average of the standard deviation of individual density forecasts across survey participants. The third measure is constructed by using the entropy of the aggregated individual density forecasts.[6]

Accordingly, uncertainty measures calculated using the data on one-year ahead inflation expectations are shown in Chart 2.

Chart 2: Inflation Uncertainty Measures Implied by 12-Month Ahead Expectations



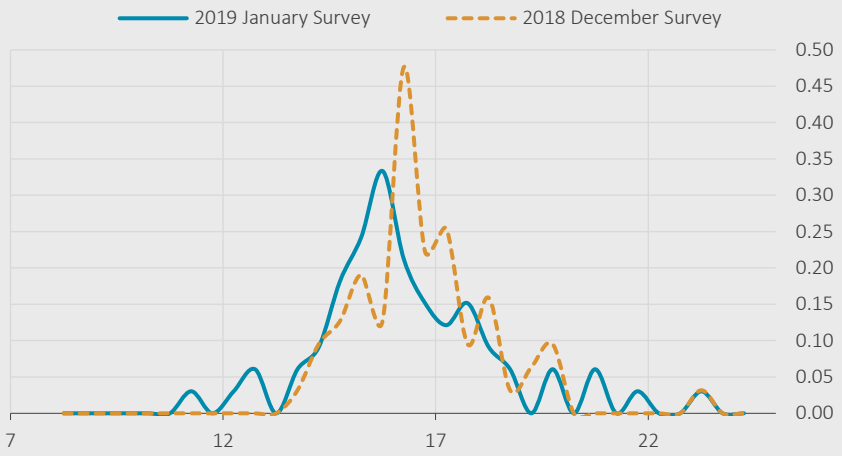
Source: Gülşen and Kara (2019).

All uncertainty measures show that inflation uncertainty has started to increase slightly since 2017, and displayed a much sharper upside movement until September in 2018. Although inflation uncertainty declined significantly after September, it still hovers at elevated levels compared to historical averages.

Although uncertainty measures mostly show similar patterns, they exhibit some differences in certain periods. The indicator calculated from the individual density forecasts, which measures the direct perception of uncertainty, shows a slow but continuous decline after September. Yet, the entropy indicator, which measures whether the distribution is concentrated on certain intervals or distributed across many intervals, has not shown a significant improvement in recent period. Meanwhile, the rapid recovery in the disagreement since September 2018 seems to reverse in January 2019. To explore further the recent upsurge of the disagreement measure, we compare the cross sectional distribution of point forecasts in January with that of the previous month (Chart 3).

[6] The uncertainty measures used in this box are based on Gülşen and Kara (2019). Following Rich and Tracy (2010), the entropy measure is calculated as follows: $entropy_t = -\left(\sum_{b=1}^{n} p_{b,t}\left[\ln\left(p_{b,t}\right)\right]\right)$ where *n* shows the total number of intervals of the probability distribution shown in Chart 1; *b* is the number of interval and $p_{b,t}$ shows the probability assigned to the b^{th} interval at time *t*.

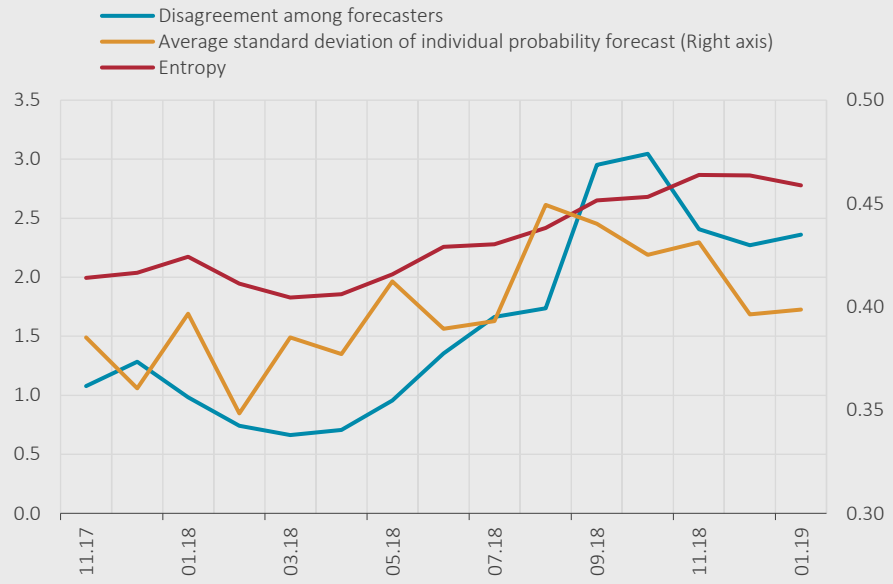
Chart 3: Cross Sectional Distribution of Point Forecasts from 2018 December and 2019 January Survey of Expectations (12-Month Ahead Inflation Expectations)



Source: CBRT.

Chart 3 shows that from December to January many participants have lowered their inflation forecasts (the distribution shifts to left), while a small number of participants increase their forecasts. Despite the decline in the average of the inflation forecasts, the standard deviation rises because a few number of participants update their inflation forecasts to extreme levels. This confirms that, consistent with the economic literature, the disagreement measure may not be an adequate proxy for inflation uncertainty. Still, the disagreement measure should not be ignored and their behavior should be monitored, because the behavior of outlier respondents may reveal some important signal.

Chart 4: Inflation Uncertainty Measures Implied by 24-month Ahead Expectations



Source: Gülşen and Kara (2019).

We also compute the inflation uncertainty measures for two-year ahead inflation expectations (Chart 4).[7] Similarly, all of the inflation uncertainty indicators edge up in 2018, before easing considerably after September 2018. However, the level reached in January is still elevated compared to historical averages. In other words, economic agents do not perceive the recent decline in inflation as an improvement in medium-term inflation outlook.

Academic literature on the determinants of inflation uncertainty argues that the level of inflation is the key determinant of uncertainty.[8] In line with the literature, inflation level in Turkey is strongly significant in all models explaining the uncertainty measures derived in this study.[9] The tight relationship between inflation and inflation uncertainty underscores the key role of price stability in supporting long-term balanced growth and welfare improvement. Inflation uncertainty, which increases in periods of high inflation, hampers economic activity through higher real interest rates and delayed investments, distorting long-term plans and the pricing behavior.[10]

To sum up, monitoring and interpreting inflation uncertainty measures constructed using survey data have the potential to be complementary for forward-looking analysis of inflation dynamics and pricing behavior.

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[7] Since the probability distribution of two-year ahead inflation expectations is available at fixed intervals from November 2017, for methodological consistency the uncertainty indicators are shown from this period.

[8] Carvalho and Minella (2012) find that for the case of Brazil, disagreement on the point forecasts can be largely explained by inflation and sovereign risk premium. However, the authors do not include alternative uncertainty indicators in their analysis.

[9] Detailed empirical results can be found in Gülşen and Kara (2019).

[10] Ball (1992) describes the economic reasons for the relationship between inflation level and inflation uncertainty.