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THE NATIONAL BANK OF ROMANIA INFLATION FORECASTS BASED ON ECONOMETRIC MODELS ARE MORE ACCURATE THAN THE TARGET INFLATION

Abstract. *The objective of this research is to show that National Bank of Romania follow the international pattern by providing inflation rate forecasts based on its own model better than the target inflation. Starting from quarterly values for the annual inflation, for 2012 the forecasts based on the institution macro-econometric models were more accurate than the annual target fixed for each quarter.The accuracy of inflation targets made for 2013 was evaluated in ex-ante variant, choosing as benchmark forecasts those provided by NBR and the na?ve ones.This study introduces as a novelty in literature some measures of accuracy and it proposes the evaluation of accuracy for uncertainty intervals using only the lower, respectively the upper limit of each forecast interval. Only with some exceptions the errors based on the inferior limit of uncertainty intervals proposed by NBR are smaller than those computed using the superior boundaries as point forecasts. In ex-ante variant, for 2013 the targets for this year and the NBR forecasts based on econometric models were chosen as possible realizations. If the targeted inflation is considered as the real value of inflation in the first two quarters of 2013 the upper limits of intervals are recommended to be chosen unlike the inferior boundaries for the third and the fourth quarters from 2013.This paper is an original research not only for assessing NBR forecasts accuracy, but also for the proposal of new methods of evaluating the accuracy for point forecasts and uncertainty intervals.*

Key words: *forecasts, econometric models, inflation target, inflation rate, measures of forecasts accuracy, uncertainty intervals.*

JEL classification: *C53, E17, E59*

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ПРОГНОЗЫ УРОВНЯ ИНФЛЯЦИИ НАЦИОНАЛЬНОГО БАНКА РУМЫНИИ, ОСНОВАННЫЕ НА ЭКОНОМЕТРИЧЕСКИХ МОДЕЛЯХ, БОЛЕЕ ТОЧНЫ, ЧЕМ ТАРГЕТИНГ ИНФЛЯЦИИ

Аннотация. В статье показано, что прогнозы уровня инфляции, осуществляемые Национальным банком Румынии (НБР) в соответствии с международным стандартом, который базируется на институциональных макроэкономических моделях, являются более точными, чем метод таргетинга инфляции, который применяется правительством. Авторами предложены новые способы измерения и оценки точности прогнозирования для интервалов неопределенности с использованием нижних значений границ каждого интервала прогнозирования. Прогнозируемый НБР на основе эконометрической модели уровень инфляции на 2013 год сравнивается с расчетами в рамках модели таргетинга и оценивается их точность. Предложены также новые методы оценки правильности прогнозов в фиксированных точках и интервалах неопределенности.

Ключевые слова: прогнозы, эконометрические модели, таргетинг инфляции, уровень инфляции, измерение точности прогнозирования, интервалы неопределенности.

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ПРОГНОЗИ РІВНЯ ІНФЛЯЦІЇ НАЦІОНАЛЬНОГО БАНКУ РУМУНІЇ, ЗАСНОВАНІ НА ЕКОНОМЕТРИЧНИХ МОДЕЛЯХ, ТОЧНІШІ, НІЖ ТАРГЕТИНГ ІНФЛЯЦІЇ

Анотація. У статті показано, що прогнози рівня інфляції, здійснювані Національним банком Румунії (НБР) відповідно до міжнародного стандарту, що базується на інституціональних макроекономічних моделях, є більш точними, ніж метод таргетингу інфляції, що застосовується урядом. Авторами запропоновано нові способи виміру та оцінки точності прогнозування для інтервалів невизначеності із використанням нижніх значень границь кожного інтервалу прогнозування. Прогнозований НБР на основі економетричної моделі рівень інфляції на 2013 рік порівнюється із розрахунками в рамках моделі таргетингу й оцінюється їхня точність. Запропоновано також нові методи оцінки правильності прогнозів у фіксованих точках та інтервалах невизначеності.

Ключові слова: прогнози, економетричні моделі, таргетинг інфляції, рівень інфляції, вимір точності прогнозування, інтервали невизначеності.

Introduction. The forecasting process should not be separated by the assessment of the predictions accuracy. Many forecasts could be provided for the same variable on the same horizon, but we have to identify which of them will be closer to reality. Actually, there are two techniques of evaluating the forecasts accuracy: ex-post variant (when we already have the real registered values) and ex-ante one (when we do not know which will be the real value, but we may choose a particular forecast as reference).

In this article, we presented the most important statistical measures used to assess the forecasts accuracy and we also introduce some new measures. We refer to a problem that has not been discussed yet in literature: the evaluation of accuracy for forecast intervals. Therefore, we associated to each interval point forecasts represented by the lower and the upper limits of the intervals and we used the classical measures of accuracy.

The targets proposed by the National Bank of Romania (NBR) are quite far from the reality, the prognosis based on the own econometric models giving better results. So, we consider a better choice the use of NBR predictions as benchmarks for assessing ex-ante accuracy of the inflation forecasts proposed for 2013.

Research objective. The accuracy of some inflation rate predictions published by the National Bank of Romania, checking the assumption previously established in literature: the target inflation is less accurate than that of predictions made by the Central Bank.

Brief Literature Review. The assessment of forecasts accuracy in literature. The forecasts evaluation using accuracy measures should be done for all the predictions that are used in decisional process. Some of the forecasts might be acceptable, some of them might be very far from the reality. We do not know which of the forecast will be the best, but we know the historical accuracy of past forecasts. This is a good indicative for the future accuracy of predictions, especially for short run anticipations. The recent performance of an institution in forecasts accuracy is an important information for choosing the best prediction and consequently for improving the decisional process. On the other hand, the accuracy evaluation will help in improving the model used to build the forecast. In the context of the current crisis, the need of providing more accurate forecasts becomes more important.

The forecasts accuracy evaluation is one of the current concerns of many researchers. One purpose of this assessment is related to the need of improving the predictions. The current economic and financial crisis emphasized the struggles of uncertainty reduction. The forecasts accuracy is a very large domain of research, an exhaustive presentation of it being impossible. But, some of the recent results will be described.

To assess the forecast accuracy, as well as their ordering, statisticians have developed several measures of accuracy. For comparisons between the MSE indicators of forecasts, *Granger* and *Newbold* proposed a statistic. Another statistic is presented by *Diebold* and *Mariano* for comparison of other quantitative measures of errors [3]. *Diebold* and *Mariano* test proposed in 1995 a test to compare the accuracy of two forecasts under the null hypothesis that assumes no differences in accuracy. The test proposed by them was later improved by *Ashley* and *Harvey,* who developed a new statistic based on a bootstrap inference. Subsequently, *Diebold* and *Christoffersen* have developed a new way of measuring the accuracy while preserving the co-integration relation between variables.

Meese and *Rogoff's* paper, «Empirical exchange rate models of the seventies», remains the starting point for many researches on the comparing of accuracy and bias. Recent studies target accuracy analysis using as comparison criterion different models used in making predictions or the analysis of forecasted values for the same macroeconomic indicators registered in several countries.

Allan obtained a good accuracy for the OECD forecasts combined with outturn values of GDP growth for G7 countries between 1984 and 2010. The same author mentioned two groups of accuracy techniques used in assessing the predictions: quantitative forecasts accuracy statistics and qualitative accuracy methods [2].

Dovern and *Weisser* used a broad set of individual forecasts to analyze four macroeconomic variables in G7 countries. Analyzing accuracy, bias and forecasts efficiency, resulted large discrepancies between countries and also in the same country for different variables [4].

Most international institutions provide their own macroeconomic forecasts. It is interesting that many researchers compare the predictions of those institutions (*Melander* for European Commission, Vogel for OECD, *Timmermann* for IMF) with registered values and those of other international organizations, but it is omitted the comparison with official predictions of government.

Abreu evaluated the performance of macroeconomic forecasts made by IMF, European Commission and OECD and two private institutions (Consensus Economics and The Economist). The author analized the directional accuracy and the ability of predicting an eventual economic crisis [1].

In Netherlands, experts made predictions starting from the macroeconomic model used by the Netherlands Bureau for Economic Policy Analysis (CPB). For the period 1997–2008 was reconstructed the model of the experts macroeconomic variables evolution and it was compared with the base model. The conclusions of *Franses, Kranendonk* and *Lanser* were that the CPB model forecasts are in general biased and with a higher degree of accuracy [6].

Gorr showed that the univariate method of prediction is suitable for normal conditions of forecasting while using conventional measures for accuracy, but multivariate models are recommended for predicting exceptional conditions when ROC curve is used to measure accuracy [7].

Ruth, using the empirical studies, obtained forecasts with a higher degree of accuracy for European macroeconomic variables by combining specific sub-groups predictions in comparison with forecasts based on a single model for the whole Union [11].

Heilemann and *Stekler* explain why macroeconomic forecast accuracy in the last 50 years in G7 has not improved [9]. The first explanation refers to the critic brought to macro-econometrics models and to forecasting models, and the second one is related to the unrealistic expectations of forecast accuracy. Problems related to the forecasts bias, data quality, the forecast process, predicted indicators, the relationship between forecast accuracy and forecast horizon are analyzed.

For a variable X, that is predicted, the error is computed as the difference between the real value and the forecasted one of the indicator. It will be denoted by *«e»*. Some of the measures of predictions accuracy are presented below (n is the length of the forecast horizon):

1. Mean error (ME)

$$ME = \frac{1}{n}\sum_{j=1}^{n} e_X$$

2. Mean absolute error (MAE)

$$MAE = \frac{1}{n}\sum_{j=1}^{n} |\ e_X|$$

3. Root Mean Squared Error (RMSE)

$$RMSE = \sqrt{\frac{1}{n}\sum_{j=1}^{n} e_X^2}$$

4. U1 Theil's statistic

r – the real values;

f – the forecasted values.

$$U_1 = \frac{\sqrt{\sum_{t=1}^{n}(r_t - f_t)^2}}{\sqrt{\sum_{t=1}^{n} r_t^2} + \sqrt{\sum_{t=1}^{n} f_t^2}}$$

A higher accuracy implies a value closer to zero for U1 statistic.

5. U2 Theil's statistic

$$U_2 = \sqrt{\frac{\sum_{t=1}^{n-1}\left(\frac{f_{t+1}-r_{t+1}}{r_t}\right)^2}{\sum_{t=1}^{n-1}\left(\frac{r_{t+1}-r_t}{r_t}\right)^2}}$$

A value less than 1 for U2 indicates the superiority of the forecast that is compared, while a value greater than 1 confirms the higher accuracy for the benchmark forecast.

6. Bias

We also compute the means difference or the bias (difference between the mean of registered values on the forecasting horizon and the mean of forecasted values) as $md = \bar{a} - \bar{p}$.

We propose the introduction of new measures of accuracy:

- Radical of order n of the mean of squared errors:

$$RnMSE = \sqrt[n]{\frac{1}{n}\sum_{j=1}^{n} e_X^2(T_0 + j, k)}$$

- The mean for the difference between each predicted value and the mean of the effective values on the forecasting horizon: $\bar{a} = mean(p_t - \bar{a})$.
- For comparisons with the naive forecasts a new indicator is computed: ratio of radicals of sum of squared errors (RRSSE).

$$\text{RRSSE} = \frac{\sqrt[n]{\sum_{t=1}^{n} e_t^2}}{\sqrt[n-1]{\sum_{i=2}^{n}(x_i - x_{i-1})^2}}.$$

The significance of this indicator is similar to U1 coefficient one.

Hall and *Jaaskela* compared the accuracy of inflation forecasts for countries organized in two groups: inflation targeting countries and non-inflation targeting ones. The authors got smaller errors for predictions made by non-targeting countries [8]. *Flamini* compared the targeted and non-targeted inflation made by the Central Bank for England, showing the superiority of domestic predictions [5].

Lungaram, Sethapramot and *Sirisettaapa* arrived to the same conclusion: predicted inflation based on the Central Bank models outperforms the target [10].

Woglom recommended the optimal forecasts for inflation rate because of the higher degree of accuracy. The information related to the GDP gap is useful in predicting better the accuracy [12].

Results. The assessment of NBR inflation forecasts. The objective of our research is to assess the accuracy of two types of forecasts: those provided by National Bank of Romania, which are based on its own econometric model and those presented as target. The targeted inflation is established in accordance with the convergence criteria of the Central European Bank (CEB). Practically, the NBR fixes the target taking into account two limitations: the target required by CEB and the economy possibility to adjust to CEB expectations. The target fixed for a certain year is reached slowly, in previous years being proposed larger values that will diminish in time.

In Romania the strategy of monetary policy is the inflation targeting. It was adoped in August 2005 after the preparation process that supposed the accomplish of criteria that condition the strategy efficiency. These criteria consist in: 1) Getting an annual inflation rate under 10%; 2) The NBR assurance of a credibility gain; 3) The strength of NBR independence; 4) The flexibility of exchange rate; 5) The reduction of fiscal domination; 6) The growth of banking intermediates.

The projection of monetary policy is oriented through the realization of the conditions necessary to get an inflation rate inside the target interval. The Central Bank struggles to orient the anticipations regarding the inflation to a dynamic that is convergent to the fixed target. The persistence of uncertainty related to the sustenance of sovereign debts for some countries from euro area, the future economic growth, the adjustment of European banking system generated adverse effects regarding the maintenance of macroeconomic equilibrium in Romania. The risks associated to the forecasting process of inflation are provided by the volatility of administrated prices and the growths of food prices. The investments consolidation is expected for 2013, fact that determines a positive economic growth and a lower value for the inflation rate. The mix of policies proposed by World Bank, International Monetary Fund and European Union for Romania are taken into consideration in the estimation of future inflation. All these factors determine adjustment of the inflation prognosis made by NBR and also for the target whose evaluation is made at the request of CEB. The volatile prices of foods, the depreciation in currency and the increases in international prices of raw materials determined a higher inflation rate than the projections in 2012 in Romania.

The quarterly forecasting process is implemented by the assurance of two main activities: the data base administration and the development of prognosis models for the main macroeconomic variables. Three types of forecasts are made by NBR for inflation rate, for each of them utilizing a different econometric model. A model that is estimated empirically is used to make short-run predictions for the inflation rate. In this econometric model the inflation is the dependent variables and the factors are: the exchange rate variation, the oil price, the interest rates and the real wage. For the quarterly inflation prognosis (medium run forecasts) used in our study the bank a central model. In this case the inflation is analyzed according to the hypothesis regarding the rational behavior of representative economic agents (firms, households, financial institutions, central bank and extern sector). The satellite models complete the previous forecasts.

Actually, the projection is not the result of automatically application of an econometric model. The experts' opinions contribute to the adjustment of predictions.

We utilized the quarterly values of the annual inflation published by NBR for 2012. These values are computed using the econometric models utilized by the institution in forecasting aims. Another type of predictions is represented by the targets fixed by the bank. The National Bank of Romania utilized an econometric model for short and medium term predictions, but the institution does not provide details regarding the form of the model, the considered variables or other details.

The NBR implements the monetary policy taking into account the direct inflation targeting. The evolution of the inflation targets supposes the following:

- The need to emphasize the disinflation and viable annual inflation on medium run implies to have descending targets on a forecasting horizon of 2 years as annual values for December;
- The pass to a continuous target on long run in accordance with the definition of prices stability shown by CEB.

The main assumption in literature is that the forecasts based on Bank model are more accurate than the targeted inflation. This assumption is also check for Romanian inflation rate.

For the targeted inflation and for that based on the econometric model some accuracy measures were computed and the forecasts were compared from this point of view. Two types of evaluations were made for the accuracy using two techniques: ex-post one when the real values of the inflation rate are known and ex-ante known, when the registered values for the analyzed indicator are not known, other values being considered as referential. In the final part of the research some accuracy measures were proposed for the uncertainty intervals built by NBR *(table 1).*

The NBR's forecasts are more accurate than those given by the target inflation, according to all indicators excepting the mean percentage error and two of our proposed measures of accuracy. This shows that on the forecasting horizon 2012 Q1: 2012 Q4 the error increased in average with 31.37% for the NBR projections unlike the value of 24.13% for the target. However, the two types of predictions are better than the naïve ones. A lower value of U1 for NBR forecasts (0.2007) implies a superior degree of accuracy compared with the fixed target for 2012. For comparisons between forecasts we may utilize the RRSSE, which has a lower value for NBR predictions and consequently implies better forecasts on the forecasting horizon.

The results obtained for quarterly values of forecasts inflation made us to consider the NBR predictions as benchmark for the targeted inflation. In a second case the naïve forecasts will

be chosen as reference. A modified U1 statistic will be calculated in the first situation as:

Where NBR_f – the forecast provided by NBR;

$target$ – the targeted inflation.

$$U_1 = \frac{\sqrt{\sum_{t=1}^{n}(NBR\_f_t - target_t)^2}}{\sqrt{\sum_{t=1}^{n} NBR\_f_t^2} + \sqrt{\sum_{t=1}^{n} target_t^2}}$$

This accuracy assessment corresponds to the ex-ante evaluation of forecasts accuracy for 2013 *(table 2)*.

All the accuracy indicators show that a higher degree of accuracy will be registered if NBR forecasts are considered as benchmark, the conclusion being a proxy of the results registered for 2012.

The NBR provided some uncertainty intervals for the inflation rate. The lower and the upper limits will be considered as point forecasts in order to introduce new measures of forecasts accuracy for forecast intervals. It is interesting that in literature accuracy measures have not been introduced yet for prediction intervals.

Table 1

The forecasts accuracy measures for the forecasts provided by NBR and for the target inflation for annual inflation in 2012 quarters

Accuracy indicator	NBR forecasts	Inflation target
ME	0.9575	0.7250
MAE	1.1575	1.5250
MPE	0.3137	0.2413
RMSE	1.3770	1.6948
U1	0.2007	0.2412
U2	0.5966	0.7795
RnMSE	1.1735	1.3019
Md	2.7675	3.0000
$\bar{d}$	-0.9575	-0.7250
RRSSE	1.3043	1.4470

Source: own computations using Excel

The error computed as the difference between the effective value and the predicted one and this absolute error are computed for forecasts based on uncertainty intervals.

For 2013 the ex-ante errors are anticipated considering that the target, respectively the NBR point forecasts will be registered *(table 3)*.

Excepting the second quarter of 2012, the errors computed starting from the lower limits of the uncertainty forecasts provided by NBR are more accurate. For the first two quarters of 2012 these predictions were overestimated. If the targeted inflation rate is considered as realization for 2013 and the errors are calculated starting from the inferior limit, only the last two uncertainty intervals are better than the case when superior boundaries are taken into consideration. If the point NBR forecasts are utilized as effective values it is indicated to assess the accuracy using the lower limits of the quarterly intervals for 2013.

The results of our research is in accordance with the findings in literature, one of them belonging to *Flamini,* that shows the superiority of domestic inflation compared to the one targeted by the Central Bank of England [5]. *Hall* and *Jaaskela* also got a better prediction for non-targeted inflation for more countries [8]. *Lungaram, Sethapramot* and *Sirisettaapa* concluded also that the forecasts based on Central Bank models are better than the targeted inflation [10].

Conclusions. The NBR developed a good system of forecasting starting from its own econometric models and continuing with the targets used in monetary policy, but there has not been any interest to assess the accuracy of those alternative forecasts.

The results for quarterly inflation predicted for 2012 put in evidence the superiority of the forecasts based on the econometric model unlike the target which is mostly based on subjective appreciations. Our finding are in accordance with the international results obtained for countries like England, Germany and Thailand or for countries in South Africa or Economic and Monetary Union of the European Union.

Table 2

The accuracy measures of ex-ante forecasts of the quarterly targeted annual inflation for 2013

Accuracy indicator	Naïve forecasts as benchmark	NBR forecasts as benchmark
ME	2.2000	**1.5250**
MAE	2.2000	**1.5250**
MPE	0.4211	**0.3674**
RMSE	2.2000	**1.7486**
U1	0.2683	**0.2299**

Source: own computations using Excel

The uncertainty intervals should also be accompanied by some measures of accuracy, a simple solution being the consideration as point forecasts the lower and the upper limits of intervals. However, this method does not take into consideration all the values in the intervals.

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Table 3

Accuracy measures of point forecasts based on uncertainty intervals

Quarter	Error according to lower limit		Error according to upper limit	
	simple error	absolute error	simple error	absolute error
2012 Q1	**-0.12**	**0.12**	0.97	0.97
2012 Q2	-1.44	1.44	**0.65**	**0.65**
2012 Q3	**0.1**	**0.1**	2.84	2.84
2012 Q4	**0.27**	**0.27**	3.63	3.63
2013 Q1*	-1.98	1.98	***1.66***	***1.66***
2013 Q2*	-1.98	1.98	***1.96***	***1.96***
2013 Q3*	***-1.77***	***1.77***	2.38	2.38
2013 Q4*	***-2.18***	***2.18***	2.19	2.19
2013 Q1**	***0.12***	***0.12***	3.76	3.76
2013 Q2**	***0.62***	***0.62***	4.56	4.56
2013 Q3**	***-0.87***	***0.87***	3.28	3.28
2013 Q4**	***-1.68***	***1.68***	2.69	2.69

Source: own computations using Excel

*considering the target as realization

** considering the point NBR forecast as realization