Forecast Intervals for Inflation Rate and Unemployment Rate in Romania

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Abstract: The main objective of this research is to construct forecast intervals for inflation and unemployment rate in Romania. Two types of techniques were employed: bootstrap technique (t-percentile method) and historical error technique (root mean square error method- RMSE). The forecast intervals based on point forecasts of National Bank of Romania (NBR) include more actual values of quarterly inflation rate during Q1:2011-Q4:2013. The proposed prediction intervals for quarterly inflation and unemployment rate contain the registered values. Considering as constant the error from previous year, we will build forecast intervals for annual inflation and unemployment rate based predictions provided by two anonymous experts on the horizon 2004-2015.All the forecast intervals for inflation rate based on first expert expectations included the actual values during 2004-2013.

Keywords: forecast intervals; point prediction; inflation rate; unemployment rate

JEL Classification: C51; C53

1 Introduction

The point forecasts did not provide any information regarding the degree of accuracy. On the other hand, the forecast intervals allow the evaluation of future uncertainty and the comparison between the forecasting methods, indicating the strategies to be applied for desired results.

The main aim of this paper is to construct forecast intervals for inflation and unemployment rate in Romania. Excepting some forecast intervals proposed by (Bratu, 2012, p. 146), in Romania prediction intervals for macroeconomic variables were not proposed. The most frequently used method for constructing forecast intervals is the historical errors method that supposes keeping constant an accuracy measure. The bootstrap method is also used when the distribution type of the sample is unknown.

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A grid bootstrap was used to compute the median without bias by (Gospodinov, 2002, p. 86), but the evolution of the events should be characterized by a high persistence. The main disadvantage is the high volume of computations. (Guan, 2003, p. 79).

The sieve bootstrap technique allows for consistent estimators of conditional repartition in the case of non-parametric prediction intervals (Alonso, Pena and Romo, 2003, p. 182). In Romania there is a strong correlation between inflation and money, making us to believe if the money earning went too far (Croitoru, 2013, p. 6). Therefore, the inflation forecasting should be taken under control.

In this paper we used as forecasting methods to build prediction intervals the historical errors method and the bootstrap technique.

It would be necessary to continue the research and build some Bayesian forecast intervals and to compare the results with those obtained using usual methods. The paper continues with the methodological framework, providing different types of quarterly and annual forecast intervals for the two variables. Moreover, the intervals are constructed using as point forecasts the anticipations of two forecasters during 2004-2015. It seems that first expert generated better inflation forecast intervals than the second one.

2. Methodology

The prediction interval that uses the historical errors method considers that errors follow a normal distribution of zero mean and standard deviation that equals the root mean squared error (RMSE) of the histrorical forecasts. Given a certain level of significance (α), the forecast intervals are built as it follows:

$$[\hat{y}_f - RMSE(k) \cdot z_{\left(\frac{\alpha}{2}\right)}; \hat{y}_f + RMSE(k) \cdot z_{\left(\frac{\alpha}{2}\right)}] \quad (1)$$

$\hat{y}_f -$ the point prediction of the variable Y given at time t for the period (t+k)

$z_{\left(\frac{\alpha}{2}\right)}$- quantile α/2 of normal distribution of zero mean and standard deviation equalled to1

The following multiple linear regression is considered:

$$Y = X\beta + u \quad (1)$$

Y- vector (length: nx1)

X- matrix (length: nxp)

β- vector of parameters (length: px1)

u- vector of error terms (length: nx1)

$\hat{u}$- residuals ($\hat{u}$=Y-X$\hat{\beta}$)

$\hat{\beta}$- parameter estimator ($\hat{\beta} = (X^T X)^{-1} X^T Y$)

The form of bootstrap model is:

$$Y^* = X\hat{\beta} + u^* \quad (2)$$

Y*- vector (length: nx1)

X*- matrix (lenth: nxp)

$\hat{\beta}$- parameter estimator ($\hat{\beta} = (X^T X)^{-1} X^T Y$)

u^* −random element

The selected sample is: $\{y_i^*\}_{i=1}^n$. The random term from theoretical bootstrap process uses modified residuals:

$$\tilde{u}_i = \frac{\hat{u}_i}{\sqrt{1-h_i}} - \frac{1}{n}\sum_{s=1}^{n} \frac{\hat{u}_s}{\sqrt{1-h_s}} \quad (3)$$

The theoretical process is computed as:

$$y_i^*(b) = X_i\hat{\beta} + \tilde{u}_i^*(b) \quad (4)$$

i=1,2,..,n

b-order of iteration

$\tilde{u}_i^*(b)$- resampled from $\tilde{u}_i$

Given the random variable z_j ($z_j = \frac{\beta_j - \beta_j}{s(\hat{\beta}_j)}$), the interval for β_j considers that z_j has Student distribution (n-p degrees of freedom). For a level of confidence of (1-2α) the interval is:

$$[\ddot{\beta}_j - s(\ddot{\beta}_j)t_{(1-\alpha),n-p}; \ddot{\beta}_j - s(\ddot{\beta}_j)t_{(\alpha),n-p}] \quad (5)$$

$$[\hat{\beta}_j^*(\alpha B); \hat{\beta}_j^*((1-\alpha)B)] \quad (6)$$

The percentile-t bootstrap method is based on $z_j$estimation. We build a bootstrap table, the values of z_j^* are:

$$z_j^* = \frac{\beta_j^* - \beta_j}{s^*(\hat{\beta}_j^*)} \qquad (7)$$

The percentile-t forecast interval for β_j is:

$$[\ddot{\beta}_j - s(\ddot{\beta}_j)\hat{t}^{(1-\alpha)}; \ddot{\beta}_j - s(\ddot{\beta}_j)\hat{t}^{(\alpha)}] \qquad (8)$$

For the observation with number f of the exogenous variable X, the prediction is calculated using the model (Y- dependent variable): $\hat{y}_f = X_f\ddot{\beta}$. Having a normal distribution of the errors and the confidence interval (1-2α), the standard prediction interval is:

$$[\hat{y}_f - s_f \cdot t_{(1-\alpha),n-p}; \hat{y}_f + s_f \cdot t_{(1-\alpha),n-p}] \qquad (9)$$

A prediction interval for y_f is based on forecast error $e_f = \hat{y}_f - y_f$. The future value y_f^*:

$$y_f^* = X_f\hat{\beta} + \tilde{u}_f^* \qquad (10)$$

It is based on a retrieval of an empirical distribution of the modified residuals. For replication b, the prediction error is:

$$\hat{y}_f^*(b) = X_f\hat{\beta}^*(b) \qquad (11)$$

$$e_f^*(b) = \hat{y}_f^*(b) - y_f^*(b) \qquad (12)$$

The bootstrap forecast error is:

$$e_f^* = \hat{y}_f^* - \hat{y}_f - \tilde{u}_f^* \qquad (13)$$

Given the empirical distribution of e_f^* (G^*), the percentiles are employed to determine the bootstrap prediction intervals $(G^{*-1}(1-\alpha) and\ G^{*-1}(\alpha))$. The percentile prediction interval is:

$$[\hat{y}_f - G^{*-1}(1-\alpha); \hat{y}_f - G^{*-1}(\alpha)] \qquad (14)$$

For percentile-t prediction interval, standard deviation estimator (s^*) is :

$$s_f^* = s^* \cdot \sqrt{(1+h_f} \qquad (15)$$

$$h_f = X_f(X^TX)^{-1}X_f^T \qquad (16)$$

The statistic z_f^* is determined:

$$z_f^* = \frac{e_f^*}{s_f^*} = \frac{\hat{y}_f^* - \hat{y}_f - \hat{u}_f^*}{s_f^*} \quad (17)$$

The percentile-t prediction interval has the form:

$$[\hat{y}_f - s_f \cdot z^*_{f(1-\alpha)}; \hat{y}_f - s_f \cdot z^*_{f(\alpha)}] \quad (18)$$

3. Forecast Intervals

Using the quarter point forecasts and the prediction intervals provided by the National Bank of Romania, we built some forecast intervals based on historical errors methods by keeping constant the root mean square error (RMSE) of the previous 4 quarter. The horizon is 2011:Q1-2015:Q4.

Table 1. Forecast intervals for the inflation rate predicted by National Bank of Romania (2011:Q1-2015:Q4)

Quarter	Forecast interval		Forecast historical method	interval-error	Point forecast	Actual values
	Lower limit	Upper limit	Lower limit	Upper limit		
T1:2011	7.48	7.95	**-2.96**	**17.96**	7.5	1.013
T2:2011	7.93	8.05	**-0.73**	**16.59**	7.93	1.005
T3:2011	3.45	3.58	**-1.69**	**8.59**	3.45	0.990
T4:2011	3.14	3.25	**-0.99**	**7.27**	3.14	1.012
T1:2012	1.43	2.52	**-3.01**	**7.81**	2.40	1.010
T2:2012	1.35	3.44	**-5.02**	**9.10**	2.04	1.002
T3:2012	2.46	5.20	**-3.40**	**14.06**	5.33	1.022
T4:2012	1.57	4.93	**-4.42**	**14.32**	4.95	1.009
T1:2013	1.34	5.33	**-3.78**	**14.16**	5.19	1.003
T2:2013	1.04	5.98	**-2.91**	**14.69**	5.89	1.003
T3:2013	**0.62**	**4.77**	**-4.04**	**11.06**	3.51	0.988
T4:2013	**0.81**	**5.18**	**-2.18**	**9.20**	3.51	1.006
T1:2014	1.02	7.93	-1.24	6.60	2.68	
T2:2014	1.5	3.5	-1.14	6.70	2.78	
T3:2014	1.5	3.5	-0.84	7.00	3.08	
T4:2014	1.5	3.5	-0.73	7.11	3.19	
T1:2015	1.5	3.5	-1.72	6.12	2.2	
T2:2015	1.5	3.5	-2.12	5.72	1.8	

T3:2015	1.5	3.5	-1.32	6.52	2.6
T4:2015	1.5	3.5	-1.12	6.72	2.8

Source: own computations

In the period from 2011 to 2013 only two forecast intervals of NBR include the actual values of inflation rate. The prediction intervals based on historical RMSE contain all the actual values during 2011-2013.

The variables with quarterly data that are used are: index of consumer prices that will be used in computing inflation rate, real exchange rate and unemployment rate on the period 2000:Q-2014:Q4. The quarterly forecasts will be made for 2011-2014, after the aggregation of data for obtaining annual values. The Tramo/Seats method was applied to get seasonally adjusted data. The logarithm was applied for the index of consumer prices. The data in first difference was computed for unemployment rate and exchange rate (d_ur and d_er).

The seasonally adjusted and stationarized index of consumer prices is denoted by log_ip. The following valid model was obtained:

$\log\_ip_t = 0{,}119 - 0{,}026 \cdot d\_er$ (19)

(std. error=0,08) (std. error=0,02)

(t-calc.=13.62) (t-calc.=-11.24)

According to Breusch-Godfrey test for the first lag, the errors are independent. The hypothesis of errors normal distrbution is checked using Jarque-Bera test and we do not have enought evidence to reject the normal repartition. According to White test, he errors are homoskedastic. The results of the application of these test are presented in Appendix 1.

For the seasonally adjusted and first differentiated quarterly unemployment rate (ur) an autoregressive model of order 1 is built, for which the errors are independent, homoskedastic and they follow a normal repartition (Appendix 2).

$\Delta ur_t = 0{,}005 + 0{,}309 \cdot \Delta ur_{t-1}$ (20)

Table 2. Point forecasts and bootstraped forecast intervals using the linear regression model for inflation rate (%) (percentile-t method) (horizon: 2011:Q1-2015:Q4)

Quarter	Point forecasts	Forecast intervals for inflation rate Intervals limits		Actual values
Q1:2011	1.0114	**0.0245**	**1.9983**	1.013
Q2:2011	1.0088	**0.0219**	**1.9957**	1.005
Q3:2011	1.0059	**0.0190**	**1.9928**	0.990

Q4:2011	1.0075	**0.0206**	**1.9944**	1.012
Q1:2012	1.0044	**0.0175**	**1.9913**	1.010
Q2:2012	1.0032	**0.0163**	**1.9901**	1.002
Q3:2012	1.0012	**0.0143**	**1.9881**	1.022
Q4:2012	1.0047	**0.0178**	**1.9916**	1.009
Q1:2013	1.0035	**0.0166**	**1.9904**	1.003
Q2:2013	1.0029	**0.0160**	**1.9898**	1.003
Q3:2013	1.0031	**0.0162**	**1.9900**	0.988
Q4:2013	1.0032	**0.0163**	**1.9901**	1.006
Q3:2014	1.0034	0.0165	1.9903	
Q4:2014	1.0033	0.0164	1.9902	
Q3:2014	1.002	0.0151	1.9889	
Q4:2014	1.0021	0.0152	1.9890	
Q3:2015	1.002	0.0151	1.9889	
Q4:2015	1.0013	0.0144	1.9882	
Q3:2015	1.0012	0.0143	1.9881	
Q4:2015	1.001	0.0141	1.9879	

Source: authors' computations

As we can see in the table above, the inferior and superior limits of the bootstrap intrvals have ranges with low variations. The results are close of the desired monetary policy in Romania, but the intervals are too narrow and the registered inflation rate for inflation is located out of these intervals. The reasons for this fact are related to the underestimated point forecasts for inflation based on linear regression model. All the forecast intervala based on percentile-t method include the actual values of inflation rate.

Table 3. Point forecasts and bootstraped forecast intervals using the linear regression model for unemployment rate (%) (percentile-t method) (horizon: 2011:Q1-2015:Q4)

Quarter	**Point forecasts**	**Forecast intervals for inflation rate Intervals limits**		**Actual values**
Q1:2011	7.21	**5.46**	**8.95**	7.20
Q2:2011	7.27	**5.52**	**9.01**	7.40
Q3:2011	7.41	**5.66**	**9.15**	7.40
Q4:2011	7.41	**5.66**	**9.15**	7.40
Q1:2012	7.37	**5.63**	**9.12**	7.30
Q2:2012	7.21	**5.47**	**8.96**	7.00
Q3:2012	7.04	**5.29**	**8.78**	7.10
Q4:2012	7.07	**5.33**	**8.82**	7.00
Q1:2013	7.07	**5.32**	**8.81**	7.20
Q2:2013	7.24	**5.49**	**8.98**	7.30
Q3:2013	7.31	**5.56**	**9.05**	7.30
Q4:2013	7.31	**5.56**	**9.05**	7.30

Q1:2014	7.33	**5.59**	**9.07**	7.20
Q2:2014	7.4	**5.66**	**9.14**	7.20
Q3:2014	7.41	5.67	9.15	
Q4:2014	7.43	5.69	9.17	
Q1:2015	7.45	5.71	9.19	
Q2:2015	7.45	5.71	9.19	
Q3:2015	7.5	5.76	9.24	
Q4:2015	7.53	5.79	9.27	

Source: authors' computations

Starting with 2013, the unemployment rate has a slow tendency of increase. The variations of range for forecast intervals for unemployment rate are rather small, because the differencies between predicted unemployment are low from a quarter to another. All the forecast intervals based on percentile-t method include the actual values of unemployment rate.

Table 4. Point forecasts and forecast intervals for qurterly inflation rate and unemployment rate (%) based on historical error methods (horizon: 2011:Q1-2015:Q4)

Quarter	Forecast intervals of inflation rate based on historical RMSE of the previous 4 quarters		Forecast intervals of unemployment rate based on historical RMSE of the previous 4 quarters	
	Intervals limits		Intervals limits	
Q1:2011	-9.448	11.471	6.86	7.55
Q2:2011	-7.655	9.673	6.93	7.60
Q3:2011	-4.130	6.142	7.03	7.78
Q4:2011	-3.121	5.136	6.92	7.89
Q1:2012	-4.407	6.415	6.83	7.91
Q2:2012	-6.057	8.063	6.65	7.77
Q3:2012	-7.731	9.734	6.46	7.61
Q4:2012	-8.365	10.375	6.58	7.57
Q1:2013	-7.963	9.970	6.58	7.55
Q2:2013	-7.799	9.805	6.79	7.68
Q3:2013	-6.551	8.557	6.91	7.70
Q4:2013	-4.687	6.694	6.95	7.66
Q1:2014	-2.917	4.923	7.10	7.56
Q2:2014	-2.917	4.923	7.09	7.71
Q3:2014	-2.918	4.922	7.03	7.79
Q4:2014	-2.919	4.920	7.00	7.86
Q1:2015	-2.921	4.917	6.96	7.94
Q2:2015	-2.923	4.915	7.05	7.67
Q3:2015	-2.928	4.912	7.34	7.87
Q4:2015	-2.929	4.911	7.56	7.96

Source: authors' computations

Forecasts of inflation and unemployment rate provided by this method seem reasonable,the lenght of intervals being rather big. However, if we go in time, these intervals become narrower. All the forecast intervala based on historical error method include the actual values of inflation and unemployment rate.

Considering constant the error from previous year, we will build forecast intervals for inflation and unemployment rate based on two experts' predictions on the horizon 2004-2015. Some point forecasts are provided by (Dobrescu, 2013, p. 10).

Table 5. Prediction intervals for annual inflation rate (%) based on historical errors method (horizon: 2004-2015)

Year	Forecast intervals based on first expert forecasts		Forecast intervals based on second expert predictions		Actual inflation rate
2004	**3.99**	**18.97**	**5.24**	**18.56**	15.3
2005	**10.13**	**17.35**	**3.32**	**14.68**	11.9
2006	**7.82**	**9.38**	**3.08**	**10.92**	9
2007	**3.90**	**7.42**	**9.4**	**8.06**	6.56
2008	**1.33**	**15.67**	6.03	11.7	4.84
2009	**1.19**	**10.01**	7.93	11.07	7.85
2010	**4.81**	**7.99**	**5.00**	**7.40**	5.59
2011	**3.17**	**7.04**	8.29	9.931	6.09
2012	**2.15**	**6.85**	5.37	10.263	3.3
2013	**-3.19**	**12.93**	-4.58	2.13	3.98
2014	-3.194	4.806	-07.18	2.10	
2015	-3.628	5.638	-8.18	2.2201	

Source: authors' computations

The intervals range for inflation rate is extremly variable in the period 2004-2012. The range is larger during 2013-2015. All the forecast intervals based on first expert anticipations include the actual values of inflation rate while only 5 out of 10 intervals on the horizon 2004-2013 contain the second expert prognosis.

Table 6.Forecast intervals for annual unemployment rate (%) based on historical errors method (horizon: 2004-2015)

Year	Forecast intervals based on first expert forecasts		Forecast intervals based on second expert predictions		Actual unemployment rate
2004	**6.808**	**7.592**	**6.8240**	**9.1760**	7.4
2005	**4.754**	**11.066**	**4.7640**	**11.0360**	6.3
2006	**4.748**	**9.452**	**4.0760**	**11.5240**	5.9
2007	**1.638**	**11.282**	**0.5440**	**14.6560**	4
2008	**3.536**	**7.064**	**1.5200**	**13.2800**	4.4
2009	**3.400**	**13.200**	**3.3040**	**13.4960**	5.8

2010	**6.636**	**10.164**	**7.2040**	**7.5960**	7.5
2011	**6.604**	**7.812**	**6.3240**	**8.6760**	6.9
2012	**4.748**	**9.452**	**4.2680**	**10.9320**	5.9
2013	3.136	6.664	3.4320	6.5680	7.3
2014	5.836	9.364	5.4320	8.5680	
2015	5.945	9.567	5.4734	8.5834	

Source: authors' computations

In 2007 the highest range for prediction intervals was obtained for both experts. 9 out of 10 forecast intervals based on first expert anticipations and the second one predictions include the actual values of inflation rate during 2004-2013. For the last year in the horizon both forecasters anticipated lower unemployment rates.

4. Conclusion

The forecast intervals are a way to reflect the uncertainty that affects the forecasting process. For inflation rate and unemployment rate point predictions forecast intervals were built for Romania, providing a better framework for establishing the decision making process. The annual inflation rate forecasts of the first expert anticipation generated precise prediction intervals when bootstrapping and historical errors methods are applied during 2004-2013. However, the intervals are quite large. A future direction of research would be the construction of forecast intervals using Bayesian method.

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APPENDIX 1. Linear regression model for quarterly index of consumer prices

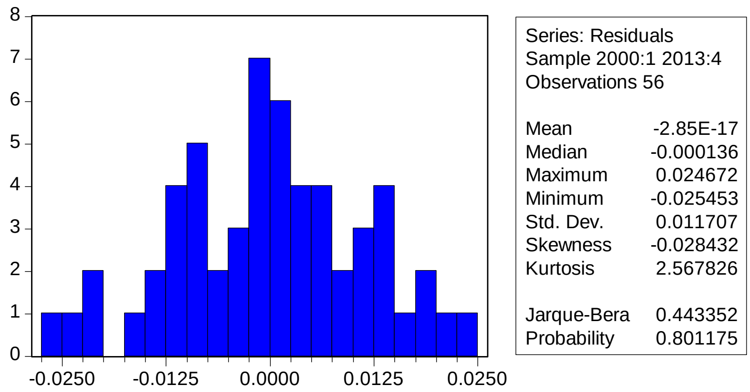
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.119341	0.008761	13.62264	0.0000
Curs_schimb__SA	-0.026202	0.002331	-11.24136	0.0000
R-squared	0.700613	Mean dependent var		0.022474
Adjusted R-squared	0.695068	S.D. dependent var		0.021395
S.E. of regression	0.011814	Akaike info criterion		-6.003922
Sum squared resid	0.007537	Schwarz criterion		-5.931588
Log likelihood	170.1098	F-statistic		126.3683
Durbin-Watson stat	1.032398	Prob(F-statistic)		0.000000

White Heteroskedasticity Test:

F-statistic	1.284795	Probability	0.285184
Obs*R-squared	2.589492	Probability	0.273967

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	6.08290	Probability	0.191
Obs*R-squared	3.03713	Probability	0.305



APPENDIX 2. Autoregressive model for quarterly unemployment rate

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.005242	0.042195	0.124224	0.9016
U(-1)	0.309934	0.131379	2.359076	0.0221

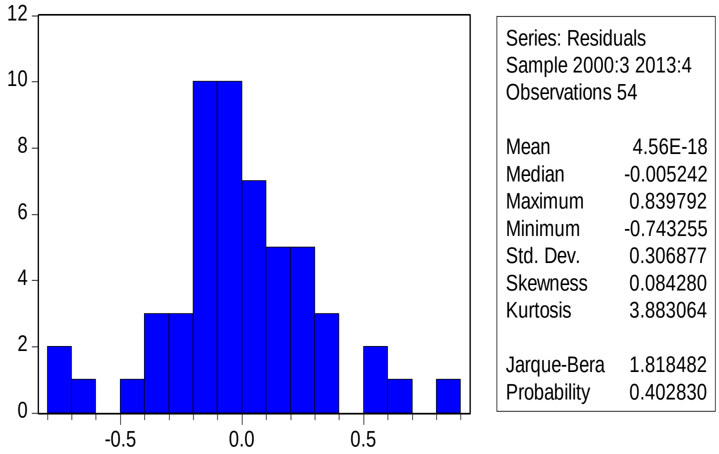
R-squared	0.096677	Mean dependent var	0.009259
Adjusted R-squared	0.079305	S.D. dependent var	0.322881
S.E. of regression	0.309814	Akaike info criterion	0.530642
Sum squared resid	4.991194	Schwarz criterion	0.604308
Log likelihood	-12.32734	F-statistic	5.565238
Durbin-Watson stat	1.894308	Prob(F-statistic)	0.022112

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.422747	Probability	0.238472
Obs*R-squared	1.465554	Probability	0.226049

White Heteroskedasticity Test:

F-statistic	0.352616	Probability	0.704547
Obs*R-squared	0.736532	Probability	0.691933


12
10
8
6
4
2
0
-0.5
0.0
0.5
Series: Residuals
Sample 2000:3 2013:4
Observations 54
Mean 4.56E-18
Median -0.005242
Maximum 0.839792
Minimum -0.743255
Std. Dev. 0.306877
Skewness 0.084280
Kurtosis 3.883064
Jarque-Bera 1.818482
Probability 0.402830