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The Accuracy of Forecasts Made for the Structure of Consumer Basket: A Comparative Analysis between Euro Area and Romania

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ABSTRACT

In this study, the Markov chain method was used to predict the structure of consumer basket for euro zone and Romania, a country that tries to fulfill the entrance conditions in euro area, by using the same methodology for the determination of harmonized index of consumer prices (HICP). The *ex-post* assessment of forecasts for 2010-2012 evidences the superiority of forecasts accuracy for euro area based on this method. The highest degree of accuracy in each territorial unit is registered for services weights, according to U Theil's statistic, even if the absolute indicators for accuracy are lower for other weights predictions. It is anticipated that for 2013 the Markov chain method will predict the best for each consumer basket the food weights forecasts for euro area and the services weights predictions for Romania.

Keywords: forecasts; Markov chains; accuracy indicators; consumer basket; harmonized index of consumer prices.
JEL classification: E31; E37.
MSC2010: 62M05.

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La exactitud de las predicciones para la estructura de cesta del consumo: un análisis comparativo entre la zona euro y Rumanía

RESUMEN

En este estudio se aplica el método de las cadenas de Markov para predecir la estructura de la cesta de consumo para la zona euro y para Rumanía, un país que trata de cumplir las condiciones de entrada en la zona euro. En ambos casos, se sigue la misma metodología para la determinación del índice armonizado de precios al consumo (IPCA). La evaluación *ex-post* de las previsiones para el período 2010-2012 pone de manifiesto la mejora de la precisión de las previsiones para la zona euro al usar este método. El mayor grado de precisión en cada unidad territorial se ha registrado para los pesos de los servicios, de acuerdo con el estadístico U de Theil, aunque los indicadores absolutos de precisión son más bajos para otras predicciones de pesos. Se considera que las predicciones para el año 2013 por el método de las cadenas de Markov serán más precisas para cada cesta de consumo en las previsiones de los pesos para los alimentos para la zona euro y para las de los pesos de los servicios para Rumanía.

Palabras clave: previsiones; cadenas de Markov; indicadores de precisión; cesta del consumo; índice de precios al consumo armonizado (IPCA).
Clasificación JEL: E31; E37.
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1. INTRODUCTION

The harmonized index of consumer prices (HICP) is one of the macroeconomic indicators whose evolution presents a considerable interest, especially from the point of the calculation of inflation rate and from that of the realisation of stability of prices. The inflation rate forecasting is presented in many studies, without any methodological details regarding its computation. Moreover, other indicators that are used in calculating the HICP (the weights of the consumer basket components and the individual indexes of prices for the components) can be separately predicted.

Markov chain method is one of the quantitative methods used when forecasting economic variables. It is also used in the prediction of the structure of consumer basket that is considered for the calculation of HICP. The objective of this study is to make predictions using this quantitative method and to compare the forecasts accuracy for two regions: the euro area and Romania, a country not still in the euro zone that wants to become a part of the area. In our research, the structure of consumer basket was predicted using Markov chains for both the euro area and Romania, and comparisons of accuracy were respectively made. Actually, we have to see why the forecasts of one region are better and consequently we have to adopt the strategy to make predictions.

The comparison between the euro zone and Romania is relevant, because the two regions use the same methodology, although they are not part of the same economy yet. On the other hand, the Markov chain method gives better results for the forecasts related to the structure of consumer basket, because this structure changes each two years. It gives better results in forecasting process because the classical econometric models need large data sets, while the Markow chain require fewer data.

2. FORECAST ACCURACY

Meese and Rogoff (1983) established the fundamentals for the improvement of the quality of economic predictions. The random walk process used by them, even if it is a simple one, succeeded in outperforming the forecasts based on complex and structural models. There, the error is computed as the difference between the registered value and the forecasted one, and obviously a negative error shows that the prediction is higher than registered value.

In literature there are many measures for assessing the accuracy; Hyndman and Koehler (2005) provided a rather detailed classification. Some of these measures were selected to be used in this study:

a. Root Mean Squared Error (RMSE):

$$RMSE = \sqrt{\frac{1}{n}\sum_{j=1}^{n} e_t^2(T_0 + j, k)}$$

where t represents the time, e_t stands for the error, n is the number of periods, T_0 is the origin of the prediction, k count the horizon lenght and j is the index for moving the origin.

b. Mean error (ME):

$$ME = \frac{1}{n}\sum_{j=1}^{n} e_t(T_0 + j, k)$$

c. Mean absolute error (MAE):

$$MAE = \frac{1}{n}\sum_{j=1}^{n} \left| \; e_t(T_0 + j, k) \; \right|$$

d. U Theil's statistics (U_1 and U_2):

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

where a stand for the actual values and p for the predicted values.

As in the previous measures, a value of U_1 that is closer to zero indicates a better accuracy.

$$U_2 = \sqrt{\frac{\sum_{t=1}^{n-1}\left(\frac{p_{t+1} - a_{t+1}}{a_t}\right)^2}{\sum_{t=1}^{n-1}\left(\frac{a_{t+1} - a_t}{a_t}\right)^2}}$$

The values less than 1 for U_2 show that the forecast is better than the benchmark.

Spircu and Ciumara (2007) offer details regarding other formulae for the computation of Theil's statistics, when the prediction is based on an econometric model denoted by "mod":

$$U = \sqrt{\frac{MSE(\text{mod.})}{MSE(random\_walk)}} = \frac{RMSE(\text{mod.})}{RMSE(random\_walk)}$$

Instead of a random walk, we can choose a model with good results in a certain phase of the research. In general, a value less than or equal to 0.55 for U coefficient shows a good choice of the model.

Many articles refer to the comparison of accuracy measures: Leitch and Tanner (1991), Martin and Witt (2002), Hyndman (2006), Makridakis and Hibon (1979), Koehler (2001); some others to the comparison of different prediction methods: Makridakis (1993), Yokum and Armstrong (1995), Tashman (2000), D'Agostino, Gambetti, and Giannone (2010), Dovern and Weisser (2011), Abreu (2011), Kocięcki, Kolasa, and Rubaszek (2012), Österholm (2012), for example.

In recent literature, the preferences are distributed in two directions: comparative analysis of the accuracy for predictions based on different methods or the comparative study of forecasts performance for the same variable, but registered in more countries. Allan (2012) 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 when assessing the predictions: quantitative forecasts accuracy statistics and qualitative accuracy methods. In our study, we are interested in the first category of techniques that is used to evaluate the accuracy of an institution or to compare the accuracy of different predictions.

Franses, McAleer, and Legerstee (2012) evaluated two forecasts based on different econometric models: the one is based on an econometric model and the other uses a model and also the intuition; indeed, both forecasts are the result of econometric models and intuition. Deschamps and Bianchi (2012) concluded that there are large differences between macroeconomic forecasts for China regarding the accuracy measures for consumption and investment, GDP, and inflation. The slow adjustment to structural shocks generated biased predictions, the information being utilized relatively inefficient. And Bratu (2012) assessed the accuracy of more macroeconomic forecasts for the USA, proposing some empirical strategies to improve the accuracy. These papers used some of the accuracy measures utilized by us in this research.

Heilemann and Stekler (2010), studying the inflation and GDP rate forecasts in 1967-2008 for Germany, concluded that the values of errors are similar with those of the USA and England, the absolute errors being in decrease. On the other hand, Strauch (2009) assessed the accuracy of SGP forecasts for budget balance and GDP rate on the forecasting horizon 1991-2004. In our research, we used a different forecasting method: Markov chains, that is specific for small sets of data that reflect the structure of an indicator.

3. PREDICTIONS BASED ON MARKOV CHAINS

Markov chains were introduced by Andrei Andreevich Markov who showed that, for a Markov chain with numerical states and positive transition probabilities, the outcomes' average converges to the expected value of the limiting repartition. The methodology of constructing predictions using Markov chains is presented by many researchers, like Kemeny and Snell (1976), which utilized the Theory of Finite Markov Chains, while Jerrum and Sinclair (1989) used the Markov Chain Monte Carlo Method as an approach to approximate counting and integration. The Markov chains method is used in predicting structural changes of macroeconomic indicators (the structure of an indicator for financial performance, the structure of employeed people according to branches, the structure of branches for the GDP formation, etc.). The Markov methods may use two types of information: complete information (for proper Markov chains) or partial information (hidden Markov chains). An introduction on Markov chains methodology is made by Meyn and Tweedie (1993), while the general presentation of the technique is attributed to authors like Doob (1953), Chung (1960), Feller (1970, 1971), Billingsley (1995), and others. However, a more detailed description is made by Nummelin (1984), Revuz (1984), Resnick (1994), Norris (1997), Robert and Casella (2000), Lee and Shin (2009), and others.

The application of Markov chains is useful when data regarding the causes of the phenomenon are not known. The probability of a phenomenon to pass from state i to state j is usually denoted by p_{ij}. The Markov chain is a combination composed by the initial state and the stochastic matrix of passing probabilities. After n successive steps we have the probability known as Chapmann-Kolmogorow relation, which is equal to the passing matrix after n steps:

$$p_{ij}^{(n+m)} = p_{ik}^{(n)} \cdot p_{kj}^{(m)}$$

If $m=1$, the relationship becomes:

$$p_{ij}^{(n+1)} = p_{ik}^{(n)} \cdot p_{kj}^{(1)}$$

The stochastic matrix is finite and countable, with non-negative elements and the sum of values on each row is 1.

Let us see some specific applications. Hsu and Chiao (2012) started from predictions based on Markov chain for firms' earnings and they evaluated the evolution in time of the relative accuracy established by experts. Sakamoto (2012) used the Markov chain method to predict indicators for the Japanese industry, showing the equivalence of the method with a VAR(1) method. Lee and Shin (2009) showed that a double hidden Markov chain generated better predictions than a simple one for reserves of stock market. Zhang D. and Zhang X. (2009) obtained a better accuracy for forecasts of stock market trend by using Markov chain. Leslie (2008) showed that Markov chains method improved the forecasts accuracy in certain conditions unlike other forecasting methods. In general, Markov chains, after Avery and Henderson (1999), can be successfully used to model the space discrete series in the context of log-linear models.

Starting from the consumer basket structure (foods, non-foods, and services) considered when computing the harmonized index of consumer prices (HICP) from 2006, 2008, and 2010 for euro area and Romania, we made predictions by using Markov chains for the structure in 2012. The data are available on the web-site that contains the Central European Bank data base (http://sdw.ecb.europa.eu/).

In the following Table 1, the weights of foods, non-foods, and services are presented for the euro area. We can see an increase of non-services weights in 2008 with respect to 2006 (by 1.808%), while in the following years successive decreases of services weights can be observed.

Table 1. Structure of consumer basket utilized in computing HICP in euro area

Years	Foods (%) (A)	Non-foods products (%) (B)	Services (%) (C)
2006	19.275	39.941	40.784
2008	19.501	39.602	40.897
2010	19.167	38.854	41.979
2012	19.071	39.459	41.47

Source: http://sdw.ecb.europa.eu/

The application of this method implies several steps. Firstly, these will be presented for euro area:

1. The transition matrix presentation (this type of matrix shows the changes in the consumer basket structure in 2008 in comparison with 2006 and then in 2010 with respect to 2008). Actually, we compute how many times the values in a specific year changed compared to a previous year. The next table is obtained by putting the structural indicators in each column and then the rest of the cells are completed as to have the sum of elements on each line equalled to 100 and the sum of elements on each column equalled to 100.

	A	B	C	2006
A	19.501			19.501
B	0.8487	39.602		40.4507
C	0.277		40.897	41.174
2008	20.6267	39.602	40.897	100

The foods weight grew in 2008 in comparison with 2006 (by 1.1725%), while non-food products decreased by 0.8487% and services by 0.277%.

	A	B	C	2008
A	19.167		1.7127	20.8797
B		38.854	1.8887	40.7427
C			41.979	41.979
2010	19.167	38.854	45.5804	100

The weight of foods decreased in 2010 with respect to 2008 (by 1.7127%), the weight of non-food product by 1.8887%, while services weight increased by 2.6456%.

2. The presentation of total transition matrix obtained by summing up the values from the two above matrices.

	A	B	C	
A	38.668	0.000	1.713	40.381
B	0.849	78.456	0.000	81.193
C	0.277	0.000	82.876	83.153
	39.794	78.456	86.477	200.000

3. The presentation of the matrix of transition probabilities (each value of total transition matrix is divided by the total on its corresponding row).

$$\begin{pmatrix} 0.958 & 0 & 0.042 \\ 0.021 & 1.943 & 0 \\ 0.007 & 0 & 0.997 \end{pmatrix}$$

4. The computation of predicted weights for 2012 (multiplying the vector that contains the structure of last known year by the transposed matrix of transition probabilities).

$$\begin{pmatrix} 0.958 & 0 & 0.042 \\ 0.021 & 1.943 & 0 \\ 0.007 & 0 & 0.997 \end{pmatrix} \cdot \begin{pmatrix} 19.071 \\ 39.459 \\ 41.47 \end{pmatrix} = \begin{pmatrix} 20.1345 \\ 37.8948 \\ 41.9706 \end{pmatrix}$$

For 2012 the Markov chain method anticipates a growth of foods weight and a slow decrease of non-foods products and services weights. In reality, the weights of foods and services decreased, but that of non-foods products grew.

In this present research, the data were processed using MARKOV program and forecasts were made for 2010, 2011, and 2013 (see Table 2).

Table 2. Predicted structure of consumer basket in euro area (forecasting method: Markov chains; forecasting horizon: 2010-2013)

Years	Foods (%) (A)	Non-foods products (%) (B)	Services (%) (C)
2010	19.285	37.568	43.147
2011	19.654	37.765	42.581
2012	20.134	37.894	41.97
2013	20.637	38.023	41.34

Source: own calculations by using MARKOV program.

On the other hand, the evaluation of forecasts accuracy for consumer basket components weights of HICP is made on the forecasting horizon 2010-2012 (see Table 3).

Table 3. Accuracy of predictions for the structure of consumer basket in euro zone on the forecasting horizon 2010-2012

Accuracy indicator	Forecasts for foods weights (A)	Forecasts for non-foods products weights (B)	Forecasts for services weights (C)
ME	-0.5123	1.4523	-0.9393
MAE	0.5123	1.4523	0.9393
RMSE	0.6508	1.4573	0.9894
U_1	0.0167	0.0189	0.0118
U_2	0.3742	0.2519	0.4774

Source: own calculations by using Excel.

According to U_1 statistic values, the highest accuracy of predictions based on Markov chains was registered for services weights. But, in absolute terms of accuracy, some indicators (*ME*, *MAE*, and *RMSE*) indicate the presence of lower errors. Anyway, all predictions are superior to those based on random walk.

Considering that the values of weights registered in 2012 are constant in 2013, the accuracy of predictions was assessed in *ex-ante* variant for 2013 (see Table 4).

Table 4. Accuracy of forecasts for the structure of consumer basket in euro area in 2013

Accuracy indicator	Forecasts of foods weight (A)	Forecasts of non-food products weight (B)	Forecasts of services weight (C)
Error	-1.566	1.436	0.13
U_1	2.0719	3.8059	4.1343

Source: own calculations by using Excel.

The *ex-ante* accuracy of forecasts for 2013 is rather low, anticipating an overestimation of foods weight. The overestimation is explained by the fact that the predicted value is higher than the one registered in 2012.

This quantitative method is applied also when forecasting the structure of consumer basket of HICP for Romania. By comparison with euro area, in Romania the weight of merchandise is higher, but in decrease from one year to another (see Table 5).

Table 5. Predicted structure of consumer basket in Romania (forecasting method: Markov chains; forecasting horizon: 2010-2013)

Years	Foods (%) (A)	Non-foods products (%) (B)	Services (%) (C)
2006	38.472	45.082	16.446
2008	36.899	46.068	17.033
2010	34.956	47.943	17.101
2012	31.012	45.77	23.218

Source: http://sdw.ecb.europa.eu/

The Markov chains method is applied now for the Romanian case.

1. Transition matrices:

	A	B	C	2006
A	36.899	2.1871	3.5692	42.6553
B		46.068		46.068
C			17.033	17.033
2008	36.899	48.2551	20.6022	100

The weight of foods decreased in 2008 in comparison with 2006 (by 4.0886%), while the non-food products ones increased by 2.1871%, and that of services increased by 3.5692%.

	A	B	C	2008
A	34.956	4.07	0.3992	39.4252
B		47.943		47.943
C			17.101	17.101
2010	34.956	52.013	17.5002	100

The weight of foods decreased by 5.2657% in 2010 compared to 2008, the weight of non-foods grew by 4.07%, while the services one increased by 0.3992%.

2. Total transition matrix:

	A	B	C	
A	71.855	6.2571	3.9684	82.0805
B	0	94.011	0	94.011
C	0	0	34.134	34.134
	71.855	100.2681	38.1024	200

3. Matrix of transition probabilities:

$$\begin{pmatrix} 0.8754 & 0.0762 & 0.0483 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

4. Computation of predicted weights for 2012:

$$\begin{pmatrix} 0.8754 & 0.0762 & 0.0483 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 34.956 \\ 47.943 \\ 17.101 \end{pmatrix} = \begin{pmatrix} 35.0827 \\ 47.943 \\ 17.101 \end{pmatrix}$$

The predicted weights for 2012 by using the Markov chain method are the same as those for 2010 (see Table 6).

Table 6. Predicted structure of consumer basket in Romania (forecasting method: Markov chains; horizon: 2010-2012)

Years	Foods (%) (A)	Non-foods products (%) (B)	Services (%) (C)
2010	19.022	36.899	44.079
2011	19.392	37.253	43.355
2012	20.134	37.894	41.97
2013	20.468	37.945	41.587

Source: own calculations by using MARKOV program.

For 2010-2012 the forecasts accuracy is evaluated in *ex-post* variant, then separately in *ex-ante* technique the prediction for 2013, when the real value to be registered is not known.

The U_1 statistic of Theil identifies the forecasts for services weights as the ones with highest accuracy on the horizon 2010-2012. However, the *ME*, *MAE*, and *RMSE* have the lowest values for foods weights. The predictions for the euro area are more accurate than those for Romania, when Markov chains method is used. For both regions, the forecasts are overestimated, because of the negative values for mean absolute error. The cause of these values too large in average is related to the fact that different shocks were not taken into consideration.

Table 7. Accuracy of forecasts for weights of HICP consumer basket components from Romania for 2010-2012

Accuracy indicator	Forecasts for foods weights (A)	Forecasts for non-foods products weights (B)	Forecasts for services weights (C)
ME	-0.4503	-3.5440	3.9950
MAE	2.506333	3.5440	3.9950
RMSE	2.5509	4.2584	4.0017
U_1	0.0657	0.0598	0.0443
U_2	1.4476	0.6752	0.4530

Source: own calculations by using Excel.

Table 8. Accuracy of forecasts for the structure of consumer basket in Romania in 2013

Accuracy indicator	Forecasts for foods weights (A)	Forecasts for non-foods products weights (B)	Forecasts for services weights (C)
Error	2.75	-6.933	4.183
U_1	0.0629	0.1005	0.0479

Source: own calculations by using Excel.

The prediction for services weight from 2013 will be more accurate, being underestimated, than that of foods. The value is underestimated because the error has a positive value, the prediction being greater than the actual value.

4. CONCLUSION

The Markov chains method was used for the realisation of forecasts regarding the forecasts of consumer basket structure utilized in calculating the HICP. The accuracy was assessed for the predictions realized on the horizon 2010-2013 for euro area and Romania. Although the indicators for evaluating the accuracy, in absolute terms, registered lower values for other weights, for euro zone and Romania on the forecasting horizon, the services weights have more accurate forecasts, these being better for euro area. The predictions for all weights of Romania consumer basket are less accurate than predicted for euro area. So, the Markov chains method provided better results for euro area compared to Romanian case. For 2013, and for the prediction based on the same method, a higher accuracy is anticipated for the expectations of foods from euro area and services in Romania.

The methodology could be applied to other countries included in euro zone or not. Actually, the Markov chain method is relevant for any country that uses a similar methodology as that of euro area. The comparison was made with Romania as a candidate for euro zone. The differences in accuracy are not significant, so the Markov chain is a good forecast method for both regions. The predictions do not always underestimate or overestimate the real value. It depends on the type of data series. The identified tendency could change in time. In fact, a rule regarding the tendency could not be established.

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