MODELS FOR FORECASTING THE PRICE OF WHEAT AND MAIZE IN SERBIA

MODELI ZA PROCENU CENE PŠENICE I KUKURUZI U SRBIJI

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ABSTRACT

This paper examines the annual average price of two basic and economically most important cereals in Serbia: wheat and maize. The purpose of this research is to predict the future pricing trends on the basis of the wheat and maize price analysis over a longer period of time.

Firstly, the average annual prices expressed in dinars per ton were converted into the prices expressed in EUR. Subsequently, the prices thus obtained were processed using descriptive statistics, and utilized to make predictions for the next five years (2018-22). The predictions were made using the ARIMA model.

The forecast obtained indicates that the prices of maize will not be as stable as those of wheat. In the forecast period, the maize price will range from EUR 127.5 to 134 per ton. In the last two years of the period under consideration, the price of maize will stabilize at around EUR 132 per ton.

Key words: wheat, maize, prices, prediction, Serbia.

REZIME

Predmet istraživanja u ovom radu su prosečne godišnje cene dve osnovne i ekonomski najvažnije žitarice u Srbiji: pšenice i kukuruza. Cilj istraživanja je da se na bazi analize cena pšenice i kukuruza u dužem vremenskom periodu predvidi njihovo kretanje u budućnosti. U prvom koraku, prosečne godišnje cene koje su izražene u dinarima po toni, prevedene su u cene izražene u evrima. Podaci o prosečnim cenama dobijeni su iz statističkih publikacija, a podaci o prosečnoj vrednosti evra u period od 2002. do 2017. godine od Narodne banke Srbije. Ovako izražene cene prvo su obrađene na osnovu deskriptivne statistike, a zatim su predviđene njihove vrednosti za narednih pet godina (2018-22). Predviđanje je sprovedeno pomoću ARIMA modela. Kada je u pitanju cena pšenice, deskriptivna analiza je pokazala da je prosečna cena pšenice iznosila 135,30 evra/toni, a po godinama se kretala u interval od 90,50 (2005.godine) do 190,85 evra/toni (2012). Cena pšenice pokazuje tendenciju porasta u analiziranom period (2002-17) po prosečnoj godišnjoj stopi od 1,34%. Predviđanje pokazuje relativno stabilnu cenu pšenice koja će se kretati oko 139 evra po toni. Deskriptivna analiza cene kukuruza je pokazala da je prosečna godišnja cena kukuruza iznosila 123,90 evra/t. Po godinama analiziranog perioda kretala se u interval od 77,84 (2006.godine) do 184,04 evra/t (2012). I cena kukuruza pokazuje tendenciju porasta po prosečnoj godišnjoj stopi od 2,53%. Predviđanje pokazuje da cena kukuruza nije stabilna kao cena pšenice. U predikcionom period ona se kreće u intervalu od 127,5 do 134 evra/toni. U poslednje dve godine cena kukuruza će se stabilizovati na nivou od oko 132 evra/toni.

Cljučne reči: pšenica, kukuruz, cene, predviđanje, Srbija.

INTRODUCTION

This paper examines the annual average price of two basic and economically most important cereals in Serbia: wheat and maize. The purpose of this research is to predict the future pricing trends on the basis of the wheat and maize price analysis over a longer period of time.

The models for forecasting prices and their parity have been analyzed by a number of authors. Novković *et al.* (2006) analyzed the time series of wheat price/mineral fertilizers using the ARIMA model to predict the movement of parity in the future period. Mutavdzic *et al.* (2007) analyzed trends to predict the movement of parity prices for fattening pigs and mercantile maize. Moreover, Mutavdzic *et al.* (2010) encompassed the prediction of the parity prices of basic crop products based on time series analysis and the application of the ARIMA model. Novković and Mutavdžić (2016) analyzed the prices of beans in Serbia using descriptive statistics and the appropriate ARIMA model and predicted the movement of beans prices in the

forthcoming period. Novković *et al.* (2016) analyzed and predicted the price of cabbage in Serbia, whereas Mutavdžić *et al.* (2017) analyzed the quarterly movement of wheat and maize prices in Serbia and the Republic of Srpska in the period 2010-2015. The results of the method of relation to the general quarterly average indicate that the prices of cereals in the Republic of Srpska are at a higher level. Furthermore, Mutavdžić *et al.* (2017a) analyzed monthly fluctuations in the prices of cereals in Serbia. Ivanisevic *et al.* (2015) performed an analysis of the movement of tomato prices in Serbia using the method of descriptive statistics, and subsequently predicted their future values on the basis of the time series analysis.

MATERIAL AND METHOD

First of all, the average annual prices expressed in dinars per ton were translated into the prices expressed in euros. The data on the average prices were obtained from statistical publications and the data on the average EUR value in the period 2002-2017 from the National Bank of Serbia.

The prices thus expressed were first processed using descriptive statistics, and then their values for the next five years were predicted (2018-22). The average annual prices of wheat and maize were obtained from the Statistical Office of Serbia.

The average annual rate of change (r) in a descriptive statistical analysis is calculated according to the following formula:

$$G = \left(\frac{Y_n}{Y_1} \right)^{\frac{1}{n-1}}$$

and the average rate of change:

$$r = (G - 1)$$

where

r is the average annual rate of change,

G is the average annual index of change,

Y_1 is the absolute value of the first member of the time series,

Y_n is the value of the last number of the time series, n is the length of the series (number of years).

The autoregressive moving average (ARMA) models were used for the forecast purposes. The general model introduced by *Box and Jenkins (1976)* include both autoregressive and moving average parameters, as well as the explicit differentiation in the formulation of the model. Specifically, the following three types of parameters are included in the model: the autoregressive parameters (p), the number of differencing passes (d), and moving average parameters (q). In the notation introduced by *Box and Jenkins*, the models were summarized as ARIMA (p, d, q), which means that a model described as (0, 1, 2) contains 0 (zero) and autoregressive (p) parameters as well as 2 moving average (q) parameters.

The input series for ARIMA needs to be stationary, i.e. it should have a constant mean, variance, and autocorrelation through time. Therefore, the series usually needs to be differenced until it is stationary (this also often requires log transforming the data to stabilize the variance). The number of times series needs to be differenced to achieve stationarity, which is reflected in the d parameter (see the previous paragraph). In order to determine the necessary level of differencing, one should examine the plot of the data and autocorrelogram. Significant changes in levels (strong upward or downward changes) usually require the first order non-seasonal (lag=1) differencing; strong changes of slope usually require the second order non-seasonal differencing. Seasonal patterns require respective seasonal differencing (see below). If the estimated autocorrelation coefficients decline slowly at longer lags, the first order differencing is usually needed. However, one should keep in mind that some time series may require little or no differencing, and that *overdifferenced* series produce less stable coefficient estimates.

At this stage (which is usually called the *identification* phase, see below) we also need to decide how many autoregressive (p) and moving average (q) parameters are necessary to yield an effective but still *parsimonious* model of the process (*parsimonious* means that it has the fewest parameters and greatest number of degrees of freedom among all the models that fit the data). In practice, the numbers of the p or q parameters very rarely need to be greater than 2 (see below for more specific recommendations).

At the next step (*Estimation*), the parameters are estimated using function minimization procedures (see below for more information on minimization procedures; see also Nonlinear Estimation), so that the sum of squared residuals is minimized. The estimates of the parameters are used in the last stage (*Forecasting*) to calculate new values of the series (beyond those included in the input data set) and confidence intervals for those predicted values. The estimation process is performed on transformed (differenced) data; before the forecasts are generated, the series needs to be *integrated* (integration is the inverse of differencing) so that the forecasts are expressed in values compatible with the input data. This automatic integration feature is represented by the letter I in the name of the methodology (ARIMA = Auto-Regressive Integrated Moving Average) (the statistical software Statistica 13.5, 2019).

For the purpose of the present study, the average annual prices of wheat and corn were obtained from the official publications of the Serbian Statistical Office.

RESULTS AND DISCUSSION

The results of descriptive statistics on the trend in the average annual wheat and maize prices in Serbia in the period 2002/17 are presented in Table 1.

Table 1. Descriptive statistics of the prices of wheat and corn (2002/17)

Cereal	Average value euro/ton	Interval of Variation		Coefficient of Variation (%)	Annual rate (%)
		Minimum euro/ton	Maximum euro/ton		
Wheat	135.3	90.5	190.8	23.0	1.34
Maize	123.9	77.8	184.0	23.2	2.53

The descriptive statistical analysis performed showed that the average price of wheat was 9.2 % higher than the average price of maize in the period under consideration. The minimum price of wheat (achieved in 2005) was 1/3 lower than the average price, whereas the maximum price of wheat (achieved in 2012) was higher by more than 40 %. The price of wheat shows a slightly increasing trend.

The descriptive statistical analysis performed showed that the average price of maize varied at an interval similar to that of wheat. This is also indicated by a slightly higher coefficient of variation, which is significant in both cereals. The minimum price of maize (achieved in 2006) was 37 % lower than the average price, whereas the maximum price of maize (achieved in 2012) was higher by more than 48 %. The maize price also shows an increasing trend, but by almost 90 % more than the price of wheat. In the analyzed period, the average annual price of maize was higher than the price of wheat in only three years: 2004, 2010 and 2016. In 2004, the price difference was very significant, 28.34 euro/ton or 29.6 %. In 2010, the price difference was 11.16 euro/ton (9.3 %), whereas the corn price was slightly higher in 2016 (0.65 euro/ton).

Table 2. Model parameters for predicting wheat prices

Parameter	Input: Wheat					
	Transformations: D(1)					
	Model: (1,1,1) MS Residual = 1038,4					
	Param.	Asympt. Std.Err.	Asympt. t (13)	p	Lower 95% Conf	Upper 95% Conf
p(1)	0,360467	0,391018	0,921866	0,373391	-0,484277	1,205210
q(1)	0,855897	0,224339	3,815187	0,002145	0,371241	1,340553

The forecast value of wheat prices in the period 2018-2022 (Table 3) showed the trend of relative wheat price stability, which will approximate 139 euro per ton. The estimated price of wheat in 2022 is 3 % higher than the average price in the period under consideration.

Table 3. Predicted values of wheat prices (euro/ton) in the period 2018-2022

Forecast period	Forecasts; Model (1,1,1)			
	Input: Wheat			
	Start of origin: 1 End of origin: 16			
	Forecast	Lower 95%	Upper 95%	Std. Err.
2018	138,93	69,31	208,54	32,22
2019	139,18	61,21	217,16	36,09
2020	139,28	58,06	220,49	37,59
2021	139,31	56,08	222,54	38,53
2022	139,32	54,45	224,19	39,28

The movement of wheat prices in the analyzed period and the prediction period are shown in Fig. 1. The graph shows the fluctuation of wheat prices in previous years and a very stable movement of forecast prices in the future period.

Fig 1. Movement of wheat prices

The estimated model for analyzing and forecasting maize prices (Table 4) shows that the level of prices in the previous two years had a statistically significant influence on the level of corn prices in the current year.

Table 4. Model parameters for forecasting corn prices

Para.	Input: Maize					
	Transformations: D(1)					
	Model: (2,1,1) MS Residual = 626,20					
	Param.	Asympt. Std.Err.	Asympt. t (13)	p	Lower 95% Conf	Upper 95% Conf
P(1)	-0,077508	0,221716	0,34958	0,732249	-0,55650	0,401480
P(2)	-0,646581	0,221777	-2,91546	0,012045	-1,12570	-0,167462

The Forecast of maize prices in the prediction period (Table 5) showed that maize prices were not stable as wheat prices. The maize prices ranged from 127.5 to 134 euros per ton. In the last two years of the period under consideration, the prices of maize will stabilize at approximately 132 Euro/ton. The estimated price

of corn in 2022 is 6.2 % higher than the average price in the analyzed period.

Table 5. Predicted values of corn (euro /ton) prices in the period 2018-2022

Forecast period	Forecasts; Model (2,1,0)			
	Input: Maize			
	Start of origin: 1 End of origin: 16			
	Forecast	Lower 95%	Upper 95%	Std. Err.
2018	134,40	80,34	188,47	25,02
2019	127,57	54,02	201,12	34,05
2020	127,47	52,35	202,58	34,77
2021	131,90	54,00	209,79	36,06
2022	131,62	42,83	220,40	41,10

The movements of the maize prices in the analyzed period and the forecast period are shown in Fig. 2.

Fig 2. Movement of maize prices

The graph shows that the maize price fluctuations recorded in previous years will continue in the future period with a slightly increasing trend.

CONCLUSION

The comparative analysis of wheat and maize prices in Serbia in the period 2002-2017 indicates the following:

- The average annual price of wheat was 135.30 euro/ton, ranging from 90.50 (2005) to 190.85 EUR/ton (2012).
- The prices of wheat showed an increasing trend at an average annual rate of 1.34 %.
- The forecast showed relatively stable wheat prices that will approximate 139 euro per ton in the prediction period (2018-22).
- The average annual price of maize was 123.90 euro/ton, ranging from 77.84 (2006) to 184.04 EUR/ton (2012).
- Maize prices showed an upward trend, but at a significantly higher average annual rate of 2.53%.
- The forecast showed that the prices of maize are not stable as wheat prices.
- In the last two years, the prices of maize will stabilize at approximately 132 euro/ton.
- In the period under consideration, the average annual price of maize was higher than wheat prices in only three years. The

price difference was very significant in 2004 (28.34 euro/ton or 29.6 %), followed by 11.16 euro per ton in 2010 and 0.65 euro/ton in 2016.

The difference in the prices of wheat and maize will be reduced in the future.

ACKNOWLEDGEMENT: *This paper is a result of the research within the project III 46012 supported by the Ministry of Education, Science and Technology, Republic of Serbia.*

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Received: 19. 03. 2019.

Accepted: 09. 09. 2019.