FORECASTING TOMATO PRICES ON MARKETS IN THE REPUBLIC OF SERBIA USING THE ARIMA MODEL

Mladen PETROVIĆ[1], Svjetlana JANKOVIĆ ŠOJA[2], Bojan SAVIĆ[2], Vedran TOMIĆ[1], Vojin CVIJANOVIĆ[1], Nataša PEROVIĆ[3]

[1]Institute for Science Application in Agriculture, Belgrade, Serbia
[2]Faculty of Agriculture, University of Belgrade, Serbia
[3]Faculty of Business Economics and Law Bar, University of Adriatik, Bar, Montenegro
*Corresponding author: mpetrovic@ipn.bg.ac.rs

Abstract

Vegetable production is a highly intensive and profitable branch of agriculture, which can have a significant effect on the development of the agricultural sector. In the Republic of Serbia, tomatoes are grown in open fields and in different forms of protected areas (plastic and glass greenhouses). Tomatoes are grown worldwide on over 5,000,000 ha, and in the Republic of Serbia, according to the data retrieved from the National Statistical Office (RZS), tomatoes are grown on about 8.000 ha, being the most commonly grown vegetable crop (together with potatoes and peppers), with an average yield of almost 15 t/ha and total production of 111,639 metric tons (FAOSTAT). Tomato prices differ over quarters in a year, and those discrepancies are not small. Tomato prices are therefore twice/twice and a half times lower in summer than in winter, primarily due to the way of production, based on which it can be concluded that the production season significantly affects the price of this agricultural commodity. Apart from the way and technology of production, the price is greatly affected by the market, and in this case by the import from the neighboring countries. The goal of this paper is the tomato prices' forecast by quarters of 2021, based on the prices from the markets in the Republic of Serbia in the period 2014-2020, recorded and kept within the Market Information System of Serbian Agriculture (STIPS), and by using the ARIMA modelling. Moreover, this analyzes can be used to project the prices for other agricultural commodities and such analyzes can help greatly in current global crisis caused not only by the COVID-19 pandemic, but also by the current war situation in Ukraine.

Keywords: *ARIMA, price, tomato, market, Serbia.*

Introduction

Vegetable production is carried out in almost all regions of the Republic of Serbia, with various crops grown. It is a very intensive and profitable branch of agricultural production (Novković et al., 2012). As such, it can have a significant impact on the development of the agricultural sector, but this production also depends significantly on the level of overall economic development (Paunović, 2016). The tomato (Solanum lycopersicum L.) is one of the most common vegetable crop on the global level, being also one of the most profitable one (Cvijanović et al., 2021). The production of tomatoes, along with peppers is one of the most profitable vegetable productions, of those most represented in the Republic of Serbia (Petrović et al., 2021). Concerning the protected areas in Serbia, , tomatoes occupy the largest area in the structure of production, with a share of over 70% (Zdravković et al., 2012), which has a positive effect on the increase in yields

and overall production. The paper used the time series analysis, more precisely ARIMA modeling, in order to forecast the prices for the quarters in 2021, and based on the data of the tomato quarterly prices on the markets in the Republic of Serbia for the 2014-2020 period. The time series means an ordered sequence of observations. Editing is usually done in relation to time in equal time intervals. Forecasting time series, i.e. determining the future course, is one of the most important, if not the most important, goal of time series analysis (Lipovina-Božović, 2014.). Since most of our time series are non-stationary, the model that best describes them is the ARIMA model (which reduces the series to a stationary one by differentiating) which, combined with the arithmetic mean and expert correction, gives the best "recipe" for a quality forecast (Korović, 2015).

Materials and methods

For the purposes of this paper, data on tomato prices on markets in the Republic of Serbia collected through the Market Information System of Serbian Agriculture (STIPS) were analyzed. Prices are collected on a weekly basis, which are used to calculate prices on a monthly and annual basis. Based on the monthly tomato prices on the markets in the Republic of Serbia, the average prices at the quarter level were calculated. The data were processed in a statistical program “SPSS Statistics“.

The main goals in time series analysis are to describe, explain and predict - forecast the time series. In the process of forecasting, the authors had a time series for which data are known up to the moment h, X=(X1,....,Xh), and it is necessary to determine the future values for ℓ steps forward, i.e. Xh+ℓ where $\ell \geq 1$. Value ℓ is called a forecast horizon (Ilić et al., 2014). For monthly time series it is good to forecast three steps ahead (next three months), for quarterly times series to forecast one (or two) quarters, and for daily time series to forecast for longer periods (days, even months), but it is questionable how precise these forecasts are. Beyond the aforementioned limitations, these would not be forecasts but projections (Dabetić, 2016). Projections require further considerations and some additional factors and research (Joksimović et al., 2020). Seasonal ARIMA models, like non-seasonal ones, take into consideration interdependence of consecutive observation of a time series, e.g. interdependence of observations of consecutive months (quarters) within a year. However, unlike non-seasonal time series, seasonal ones at the same time take into consideration interdependence of observations of the same months (quarters) in consecutive years (Mutavdžić et al., 2014).

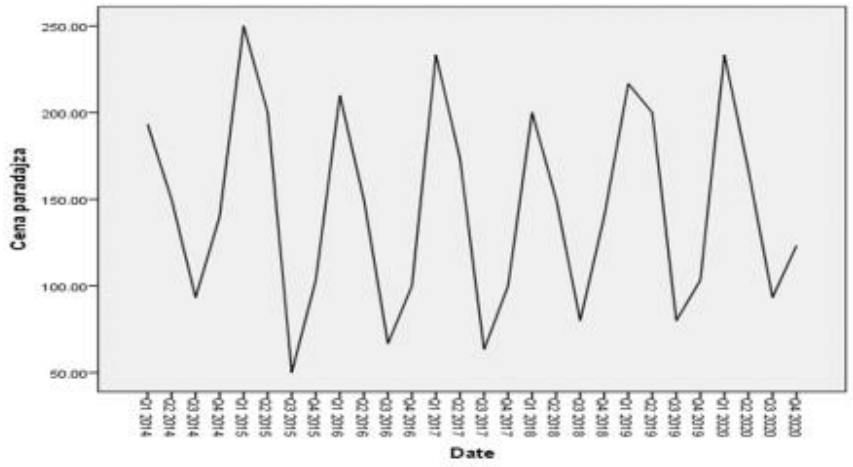
The seasonal ARIMA model for time series {Xt, tϵT} has the following form (Mladenović and Nojković, 2015):

$$\phi(B)(1-B)^{d}(1-B^{s})^{D}X_{t}=\theta(B)\varepsilon_{t},$$

where the operators of seasonal and non-seasonal time differencing are applied d, i.e. D times, respectively. When making a seasonal ARIMA model, an interactive approach of Box and Jenkins model (Mladenović and Nojković, 2015) should be applied.

Results and discussion

Before analyzing the data on the tomato prices on markets in the Republic of Serbia, it was checked whether the data follow a normal distribution by applying two tests: the Kolmogorov-Smirnov and Shapiro-Wilk tests. Based on both tests, it was concluded that the data follow a normal distribution, which enables a further data analysis based on ARIMA modeling.



Source: Authors' calculation in the"SPSS Statistics", based on the STIPS data

Graph 1: Quarterly tomato prices at the markets in the Republic of Serbia in the 2014-2020 period

From the Graph 1, one can conclude that the data do not follow one trend (constant increase or constant decrease in prices), but there is a notable fluctuation in prices, based on which it can be concluded it is a stationary time series. During data modelling, based on the auto correlational and partial correlation function of a time series, several models were chosen to describe the price movements at the markets in the Republic of Serbia. The performances of the chosen model were tested and the authors came to conclusion that the most suitable ARIMA model (1,0,0)x(1,1,2) is the one with the parameters shown in Table 1.

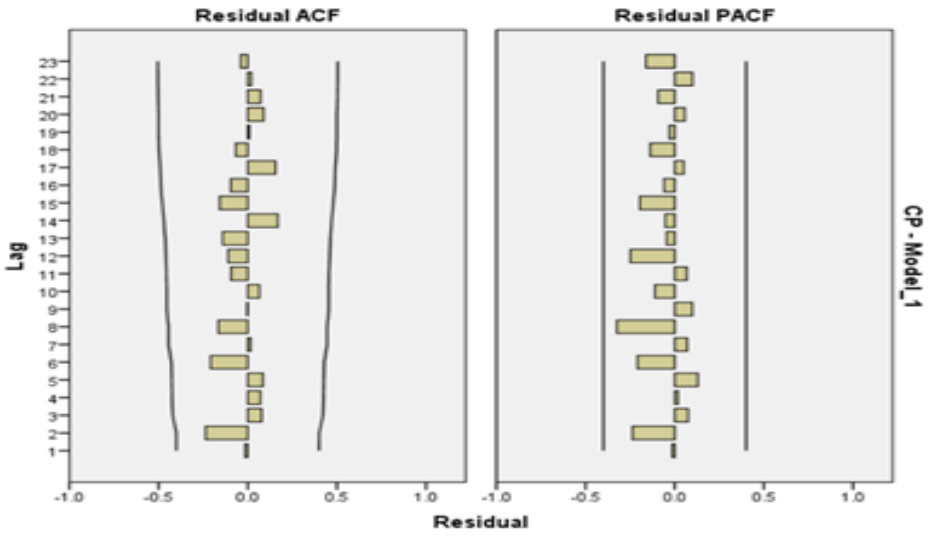
Table 1. Estimated parameters of the ARIMA (1,0,0)x(1,1,2) model

Variable		Estimates	Standard error	t	p-value
Constant		1.473	2.069	0.712	0.485
AR	First lag	0.286	0.226	1.265	0.221
AR, seasonal	First lag	-0.986	0.154	-6.416	0.000
MA, seasonal	First lag	0.136	94.623	0.001	0.999
	Second lag	0.860	82.364	0.010	0.992

Source: Authors' calculation in the "SPSS Statistics", based on the STIPS data

In general, if seasonal variations are assumed to change over time in a multiplicative manner, then a model in the following form is used (Mladenović and Nojković, 2015):

$$\left(1-\phi_1 L-\phi_2 L^2-\cdots-\phi_p L^p\right)\left(1-\Phi_1 L^s-\Phi_2 L^{2s}-\cdots-\Phi_P L^{Ps}\right)(1-L)^d\left(1-L^s\right)^D X_t =$$
$$\left(1-\theta_1 L-\theta_2 L^2-\cdots-\theta_q L^q\right)\left(1-\Theta_1 L^s-\Theta_2 L^{2s}-\cdots-\Theta_Q L^{Qs}\right)e_t$$



Source: Authors' calculation in the "SPSS Statistics", based on the STIPS data

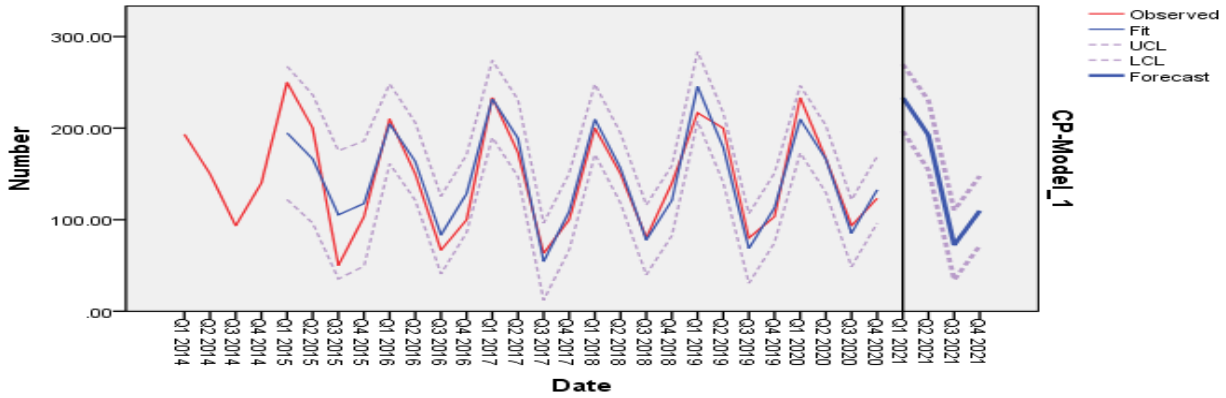
Graph 2: Correlogram results for the residuals of the estimated model

Based on the Graph 2, it can be concluded that the residuals do not contain any significant correlations on any of the lags, i.e. that the residuals follow the pattern of white noise.

Table 2: Estimated tomato prices at the markets of the Republic of Serbia based on the ARIMA model (1,0,0)x(1,1,2)

Quarters	Estimated prices	Confidence interval of 90% of the estimated prices		Real prices
		Lower bound	Higher bound	
I quarter of 2021	233.17	196.66	269.68	166.67
II quarter of 2021	192.16	154.19	230.13	183.33
III quarter of 2021	72.3	34.22	110.38	93.33
IV quarter of 2021	109.8	71.76	147.83	150.00

Source: Authors' calculation in the "SPSS Statistics", based on the STIPS data



Source: Authors' calculation in the "SPSS Statistics", based on the STIPS data

Graph 3: Quarterly tomato prices in the 2014-2020 period and the ARIMA-model estimated prices at markets in the Republic of Serbia

Based on Graph 3, it can be concluded that there is a deviation from the real prices and the ARIMA-model forecast prices for 2014 and 3rd quarter of 2015, while from the 4th quarter of 2015 onwards the forecast prices from the proposed model almost overlapped with real tomato prices at markets in the Republic of Serbia. The tomato price has a seasonal character and therefore constantly varies depending on the season, being lower in the summer than in the other quarters of the year. Moreover, the data obtained from the ARIMA model for the quarters of 2021 follow the same trend. Nevertheless, although the tomato price has been increasing worldwide (as forecast by the ARIMA model for the quarters of 2021), in the Republic of Serbia it has decreased for about 15% from the same period last year (STIPS data). The forecast price for the 1st quarter of 2021 was 233.17 RSD/kg, while the real price was considerably lower, amounting to 166.67 RSD/kg. Based on the STIPS data, however, in 2nd quarter of 2021 the tomato price at markets was 183.33 RSD/kg, while the forecast price was 192.16 RSD/kg. In the 3rd quarter the real price was about 20 RSD/kg higher than the price forecast by the ARIMA model. A considerably higher price than the forecast one can due to lower yields as a result of climate conditions during the summer production, that have happened in the Republic of Serbia mostly in an open field during that period of a year. Moreover, in 4th quarter of 2021 the real price was higher than the forecast one, almost completely overlapped with the higher bound of the forecast price. In that quarter it has happened a considerable increase in real tomato price at markets, and one of the reasons was dissatisfaction of tomato growers with the price in the previous quarter, which led to the lower production in the last quarter of 2021. At the same time, due to insufficient imports, the tomato price has been significantly increased in the last quarter. A great impact on price growth and such discrepancies from the forecast prices had the global crises caused by the COVID-19 pandemic, which has led to the growth of prices in general, including the price for inputs necessary for agricultural production and also the labor price, resulting consequently in the increase of prices for agricultural commodities.

Conclusion

Having analyzed the tendencies in price movement at markets in the Republic of Serbia, it can be concluded that a seasonal character prevails, i.e. greatly affects the tomato price. Apart from the seasonal character, tomato prices are greatly affected by the market, supply and demand, as well as the imports from the neighboring countries which are big producers of this vegetable crop and consequently offers tomatoes at lower prices (Greece, Albania, North Macedonia, etc.). Furthermore, in this case, given the analysis for 2021, the prices were greatly affected by the global crises caused by the COVID-19 pandemic. Studying the tendency of tomato price movements in the analyzed period (2014-2020), and prices forecast by using the ARIMA model, it can be concluded that due to numerous factors, the forecast prices do not differ from the real market prices. Therefore, the model can be considered reliable, since the real and forecast prices do not differ significantly, especially in 2nd quarter of 2021, whereas in 3rd and 4th quarter due to the dependence of the production on climate conditions and imports there was some discrepancies from the forecast prices, which implies the seasonal character of the production and its impact on the commodity prices.

Acknowledgement

The paper is a result of the researching financed by The Ministry of Education, Science and Technology Development of the Republic of Serbia No. 451-03-68/2022-14/ 200045

References

Cvijanović, V., Petrović, M., Momirović, N., Tomić, V., Ljiljanić, N. (2021): Challenges in tomato growing in organic production, Zbornik radova: Biotehnologija i savremeni pristup u gajenju i oplemenjivanju bilja, COBISS.SR-ID 52862729, pp.77-84, Institut za povrtarstvo, Smederevska Palanka.

Dabetić, S. (2016): Primena matematičko-statističkih metoda u istraživanju ponude i tražnje mesa, doktorska disertacija, Fakultet za ekonomiju i inženjerski menadžment, Univerzitet Privredna akademija, Novi Sad.

Food and Agriculture Organization of the United Nations (FAOSTAT), https://www.fao.org/faostat/en/#data, retrieved on 15.07.2022.

Ilić, I., Jovanović, S., Janković-Milić, V. (2016): Forecasting Corn Production in Serbia Using Arima Model, Economics of Agriculture, no. 4, pp. 1141 – 1156, Belgrade.

Joksimović, M., Ivanović, S., Janković-Šoja, S. (2020): Production and Tendency in Milk Processing in Montenegro, Economics of Agriculture, Year 67, No. 2, 2020, (pp. 391-404), Belgrade.

Korović, P. (2016): Prognoziranje vremenskih serija – Modeli i izbor modela, master rad, Matematički fakultet, Univerzitet u Beogradu.

Lipovina-Božović, M. (2014): Ekonometrijski modeli za prognozu makroekonomskih indikatora na primjeru Crne Gore, doktorska disertacija, Ekonomski fakultet, Univerzitet Crne Gore, Podgorica.

Mladenović, Z., Nojković, A. (2015): Primenjena analiza vremenskih serija, Centar za izdavačku delatnost, Ekonomski fakultet, Beograd.

Mutavdžić, B., Drinić, Lj., Novković, N., Ostojić, A., Roković, G. (2014): Forecasting of Vegetable Production in Republic of Srpska, The Central European Journal of Regional Development and Tourism, Vol.6 Issue 1.

Novković, N., Mutavdžić, B., Šomođi, Š. (2010): Models for Forecasting in Vegetable Production, Škola biznisa, br3/2010, UDC 635.1/.8:005.521(497.113).

Paunović, T. (2016): Modeli za optimizaciju strukture proizvodnje povrća na porodičnim gazdinstvima, doktorska disertacija, Poljoprivredni fakultet, Beograd.

Petrović, M., Savić, B., Cvijanović, V. (2021): Financial Aspects of Pepper (*Capsicum annuum L*) Production on Family Farms in Serbia, Economics of Agriculture, Year 68, No. 4, 2021, doi: 10.5937/ekoPolj2104015P, (pp. 1015 – 1028), Belgrade.

Serbian agriculture market information system (STIPS), https://www.stips.minpolj.gov.rs/srl/node/21519 , retrieved on 15.07.2022.

Statistical Office of the Republic of Serbia (RZS), https://data.stat.gov.rs/Home/Result/130102?languageCode=sr-Cyrl, retrieved on 15.07.2022.

Zdravković, J., Pavlović, R., Marković, Ž., Zdravković, M. (2012). Paradajz, Monografija. Univerzitet u Kragujevcu, Agronomski fakultet u Čačku, Institut za povrtarstvo, Smederevska Palanka.