ANALYSING AND FORECASTING TRENDS IN THE APPLE PRODUCTION IN SERBIA

ANALIZA I PREDVIĐANJE KRETANJA PROIZVODNJE JABUKE U SRBIJI

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ABSTRAKT

This paper examines quantitative changes in the capacity and actual volume of the Serbian apple production in the period 1980-2016. On the basis of the analysis, forecast and comparison performed, the condition and development prospects of the Serbian apple production were assessed. An analysis of the production parameters observed was based on descriptive statistics, whereas ARIMA models were employed for forecast purposes.

Based on the forecast values obtained, increasing trends in the parameters observed are expected in the forecast period. At the end of the forecast period, the total number of productive apple trees will approximate to 25 million, whereas the expected volume of apple production will approximate to 340,000 tonnes.

Key words: apple, production, condition analysis, forecast, Serbia

REZIME

U radu su analizirane kvantitativne promene u kapacitetima i ostvarenoj proizvodnji jabuke u Srbiji, u periodu 1980-2016. godine. Na osnovu analize, predviđanja i poređenja date su ocene stanja i perspektive razvoja proizvodnje jabuke u Srbiji. Analiza proizvodnih parametara jabuke u posmatranom periodu izvedena je na osnovu deskriptivne statistike, dok su za predviđanje korišćeni ARIMA modeli.

U proseku za analizirani period (1980-2016) ukupan broj rodnih stabala jabuke u Srbiji je iznosio 16 miliona i ispoljava tendenciju povećanja (stopa promene 2,20%). Slična tendencija kretanja ukupnih rodnih stabala jabuke je uočena i u kraćim vremenskim periodima, s napomenom, da je intenzitet povećanja rodnih stabala najizraženiji u periodu 2005-2016. godine (stopa promene 1,58%).Učešće jabuke u ukupnim rodnim stablima u Srbiji se povećava sa 13,7% u 1980. godini, na 30,2% u poslednjoj analiziranoj godini. U ispitivanom periodu, ukupna proizvodnja jabuke iznosila je 247.753 tone sa tendencijom povećanja po prosečnoj godišnjoj stopi promene od 1,20%. Posmatrano po kraćim vremenskim periodima, proizvodnju jabuke u Srbiji karakteriše nešto veća varijabilnost i različite tendencije u pojedinim periodima. Učešće jabuke u ukupnoj proizvodnji voća u Srbiji se povećava sa 20,3% u 1980. godini, na 28,5% u poslednjoj analiziranoj godini.

Predviđene vrednosti pokazuju da će se tendencija povećanja posmatranih pojava iz analiziranog perioda nastaviti i u periodu predviđanja. Na kraju predikcionog perioda, ukupan broj rodnih stabala biće na nivou od oko 25 miliona, a očekivana proizvodnja jabuke oko 340.000 tona.

Ključne reči: jabuka, proizvodnja, analiza stanja, predviđanje, Srbija.

INTRODUCTION

The fruit production in Serbia has been characterised by obsolete cultivar assortments, semi-intensive and extensive plantations with inadequate planting materials, low levels of cultural and pomological practices, inferior and non-uniform quality of fruits, and the lack of proper storage capacities. Over the past years, intensive fruit plantations have been established, featuring contemporary cultivar assortments and high-performance production technology. Furthermore, quality planting materials have been produced in domestic nurseries and the number of modern cold storages and new processing facilities is constantly increasing (*Keserović and Magazin, 2014*). The most significant improvements have been recorded in the application of apple-growing technologies. Contemporary standards in apple production require more intensive plantations with dense plant populations, irrigation systems and hail netting, accompanied by the introduction of quality assurance (*Keserović et al., 2007*). Such plantations ought to incorporate fruit cultivar assortments based on market demands (e.g. 'Golden Delicious', 'Red Delicious' and 'Granny Smith' cultivars). Consequently, the yield per hectare would range from 50 to 70 tonnes on average with high investments per unit area *(Milić et al., 2005; Lukač Bulatović, 2014)*.

Under market conditions, a successful production depends on analysing and forecasting both the results and most important factors of production. Forecasting the future is a principal component of planning *(Novković, 2003)*. Different quantitative models for forecasting trends in agricultural production have been developed: models for forecasting trends in apple production *(Sharma et al., 2014)*, models for forecasting trends in mango, avocado and guava production (Hamjah, 2014), models for forecasting trends in vegetable production *(Novković et al., 2010)*, models for forecasting trends in wheat production *(Falak and Eatzaz, 2008)*, models for forecasting trends in corn production *(Novković et al., 1992)*, models for forecasting trends in rice production *(Rahman, 2010; Awal and Siddique, 2011; Suleman and Sarpong, 2012)*, and models for forecasting trends in animal production *(Novković et al., 2006)*.

MATERIAL AND METHOD

The data used in this paper contain the results of Serbian apple production in the period 1980–2016. Time series of the parameters observed were completely excerpted from or newly

created on the basis of the publications issued by the Statistical Office of the Republic of Serbia. In addition to the official publications, the website of the Statistical Office of the Republic of Serbia was also utilised as a data source. For the purpose of defining some basic features of the parameters observed, the following descriptive statistical indicators were calculated: the mean value, the annual rate of change, the coefficient of variation and the basic index.

The autoregressive–moving-average (ARMA(p,q)) model was employed for the analysing and forecasting purposes in the present study. The ARMA model is a combination of the autoregressive (AR) part, which involves regressing the variable on its own legged (past) values, and the moving average (MA) part, which entails modelling the error term as a linear combination of error terms occurring at the same and different times in the past. Provided a time series is not stationary, the autoregressive–moving-average model for an integrated time series (ARIMA(p,d,q)) is used with an integrated (differential) time series $(1-L)^d = \Delta^d$, where d is the smallest number of differentiations required for reaching stationarity.

RESULTS AND DISCUSSION

In the period 1980-2016, the number of productive apple trees in Serbia amounted to 16 million on average (Table 1),

Table 1. Number of productive apple trees and the total volume of apple production in Serbia in the period 1980-2016

Period	Apples	
	Number of productive trees (000)	Production (t)
1980-1992		
Average	12,444.92	224,614.92
minimum	10,705.00	186,420.00
maximum	13,099.00	306,950.00
Annual Rate of Change (%)	1.43	-1.24
Coefficient of Variation (%)	6.50	16.93
1993-2004		
Average	13,933.58	182,258.92
minimum	12,829.00	95,584.00
maximum	14,889.00	246,138.00
Annual Rate of Change (%)	1.31	-0.75
Coefficient of Variation (%)	4.87	25.15
2005-2016		
Average	21,848.75	338,313.67
minimum	20,021.00	267,819.00
maximum	23,082.00	458,409.00
Annual Rate of Change (%)	1.58	1.24
Coefficient of Variation (%)	5.87	16.11
1980-2016		
Average	15,977.62	247,753.11
minimum	12,799.00	95,584.00
maximum	23,082.00	458,409.00
Annual Rate of Change (%)	2.20	1.40
Coefficient of Variation (%)	26.74	32.26

Source: Author's calculation based on the official data of the Statistical Office of the Republic of Serbia

indicating an increase in the total number of productive apple trees at a rate of change of 2.20 %. Over shorter periods of time, the number of productive apple trees increased from 12.5 million in the period 1980-1992 to 13.9 million in the period 1993-2004 and 21.9 million in the final subperiod under consideration. The average annual rates of change calculated confirm an increase in the number of productive apple trees. Notably the largest increase in the number of productive apple trees was recorded in the period 2005-2016 (a rate of change of 1.58 %).

In the period 1980-2016, the average production of apples in Serbia amounted to 247,753 t, varying annually from 95,584 t in 2002 to 458,409 t in 2013. The great annual variability in the volume of apple production is further argued by an absolute variation of 362,825 t recorded in the period under consideration. Over shorter periods of time, the actual volume of apple production decreased from 224,615 t in the period 1980-1992 to 182,259 t in the period 1993-2004, followed by an increase to 338,314 t in the final subperiod under consideration. The coefficients computed indicate variability in the volume of apple production, which is especially pronounced in the period 1993-2004 (CV = 25.15 %).

With 23.1 million productive trees in 2016, apples claim a share of 30.19 % in the total number of productive fruit trees in Serbia (Table 2).

Relative to the base year of 1980, the total number of productive apple trees in 2016 increased by 12.4 million, i.e. approximately twofold (216 index points). In 2016, the share of apples in the Serbian fruit plantation structure increased by 220 index points compared to that recorded in 1980.

With a volume production of 328,369 t in 2016, apples claim a share of 28.53 % in the total fruit production in Serbia. Relative to the base year of 1980, the total volume of apple production in Serbia in 2016 increased by 139,669 t (174 index points). In 2016, the share of apple production in the total fruit production in Serbia increased by 40.75 % compared to that recorded in 1980.

Under market conditions, a successful production depends on monitoring, analysing and forecasting both the results and most important factor of production. Condition analyses and forecasting can be based on an orderly sequence of data at equal

Table 2. Fruit production and the number of productive fruit trees in Serbia

Year	Apples	Other fruit species[1]	Total
1980			
Number of productive trees (000)	10,705	67,450	78,155
- Share (%)	*13.70*	*86.30*	*100.00*
Production (t)	188,700	742,193	930,893
- Share (%)	*20.27*	*79.73*	*100.00*
2016			
Number of productive trees (000)	23,082	53,366	76,448
Index 1980=100	*215.62*	*79.12*	*97.82*
- Share (%)	*30.19*	*69.81*	*100.00*
Index 1980=100	*220.43*	*80.89*	*/*
Production (t)	328,369	822,525	1,150,894
Index 1980=100	*174.02*	*110.82*	*123.63*
- Share (%)	*28.53*	*71.47*	*100.00*
Index 1980=100	*140.75*	*89.64*	*/*

Source: Author's calculation based on the official data of the Statistical Office of the Republic of Serbia

time intervals, i.e. the time series analysis of the parameters observed.

The Statistica 13.1 software package was used for data analysis. The program displays (in tables and plots) the chosen model, parameter estimates, root-mean-square error, mean absolute error, maximum absolute percentage error and maximum absolute error by exploring the residual autocorrelation function (ACF), partial autocorrelation function (PACF) and Ljung-Box statistics.

Using Statistica 13.1, ARIMA(0,1,1) models were employed for forecasting trends in the number of productive apple trees and the total volume of apple production in Serbia. The parameter estimates (Tab. 3) were found statistically non-

significant relative to the autoregressive part. However, the exclusion of the AR part from the model is not an option in Statistica 13.1. Furthermore, the model was utilised for computing the parameter estimates and the 95 % confidence interval. Upon analysing the residual autocorrelation function and partial autocorrelation function of the model assessed, it can be argued that the model is adequate.

The model assessed (Table 3) indicates that the prior year value greatly affects the current year value. The forecast values of the number of productive apple trees (Table 4; Fig. 1) show a constant annual increase, and the number of productive apple trees will approximate to 25 million at the end of the forecast period.

Table 3. Models for forecasting the number of productive apple trees and the total volume of apple production in Serbia

| Apples	Model	ARIMA Model Parameters						
		Parameters	Estimate	SE	t	p	Confidence interval (95 % Conf.)	
							Lower	Upper
Number of productive trees	(1,1,0)	Constant	344.32549	139.56105	2.46720	0.01881	60.70331	627.94766
		p (1)	-0.08084	0.17390	- 0.4649	0.64499	-0.43424	0.27256
Production	(0,1,1)	q (1)	0.55702	0.13019	4278187.00	0.00014	0.29270	0.82133

Number of productive trees – Residuals:
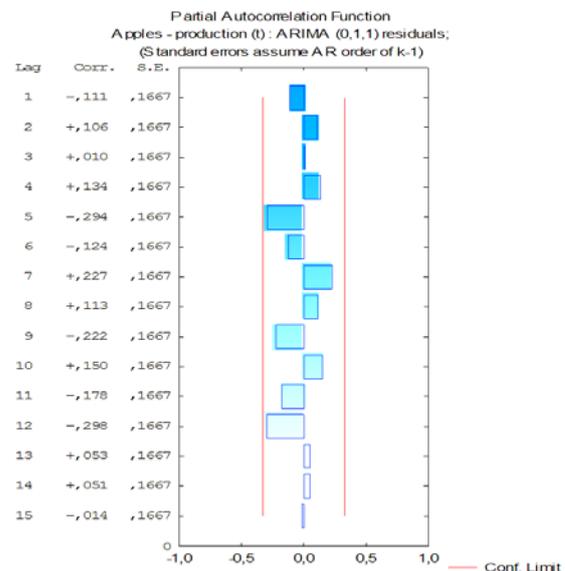ACF
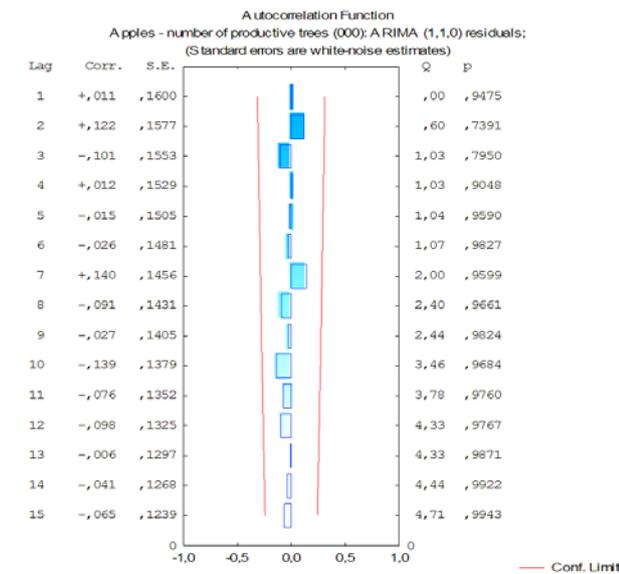
Production - Residuals:
ACF
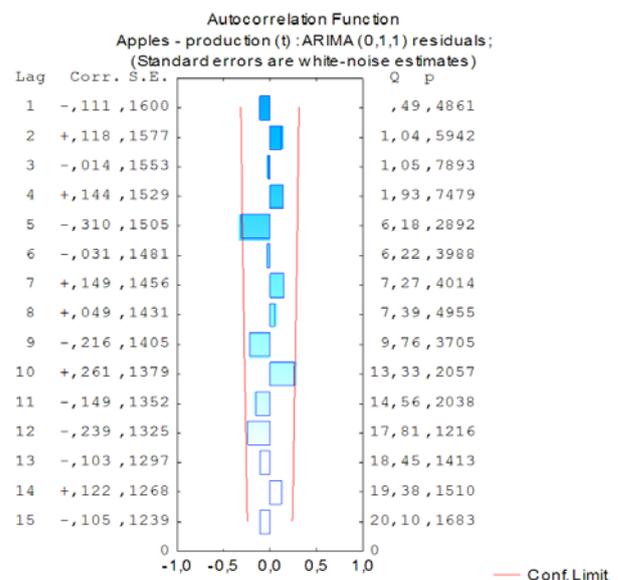
PACF
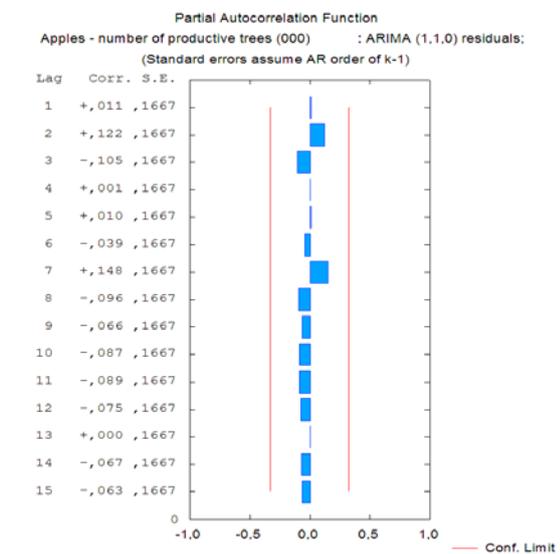
PACF

Table 4. Forecast of the number of productive apple trees and the total volume of apple production in Serbia (2018-2022)

Apples	Forecast				
	2018	2019	2020	2021	2022
Number of productive trees (000)	23,796.24	24,140.74	24,485.05	24,829.38	25,173.71
UCL	21,340.01	21,168.32	21,074.13	21,030.20	21,022.43
LCL	23,796.24	24,140.74	24,485.05	24,829.38	29,324.98
Production (t)	343,755.50	343,855.50	344,257.40	344,351.50	344,476.30
UCL	209,750.4	199,280.20	190,123.40	189,112.00	178,930.30
LCL	477,760.5	488,430.70	498,391.30	499,590.90	510,022.20
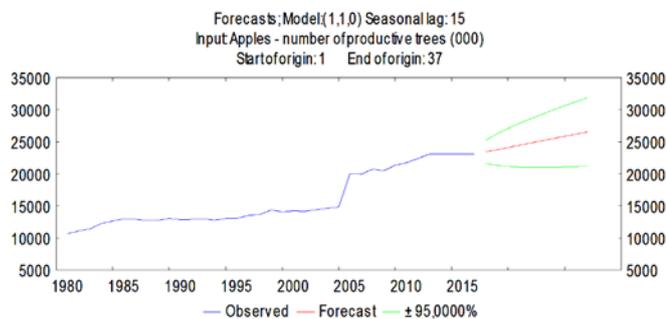
*Fig. 1. Forecast of the number
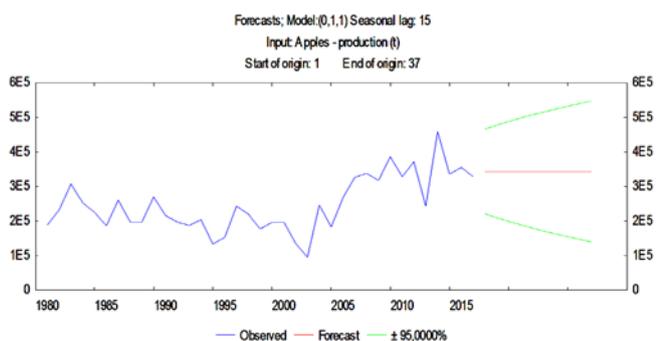of productive apple trees in Serbia (000)*

*Fig. 2. Forecast of the total volume of apple
production in Serbia (tonnes)*

The forecast trend values of the apple production in Serbia indicate a slight annual increase up to 2022 (Table 4; Fig. 2). At the end of the forecast period, the estimated apple production will approximate to 340,000 t, which is a increase of approximately 90,000 t in comparison with the average apple production in the period 1980-2016. production in Serbia (tonnes)

CONCLUSION

In the period under consideration (1980-2016), the total number of productive apple trees in Serbia amounted to 16 million on average, indicating an increasing trend with a rate of change of 2.20 %. Similar trends were noticed even over shorter periods of time, and the largest increase in the number of productive apple trees was recorded in the period 2005-2016 (a rate of change of 1.58 %). The share of productive apple trees in the total number of productive fruit trees in Serbia is constantly increasing (from 13.7 % in 1980 to 30.2 % in the final year of the period under consideration).

In the period under consideration, the total volume of apple production in Serbia amounted to 247,753 t, indicating an increase at an average annual rate of change of 1.20 %. Over shorter periods of time, the apple production in Serbia exhibits

greater variability and different trends. The share of apple production in the total fruit production in Serbia increased from 20.3 % in 1980 to 28.5 % in the final year of the period under consideration.

The forecast trend values of the number of productive apple trees in Serbia indicate a continuous increase up to 2022. At the end of the forecast period, the estimated number of productive apple trees will approximate to 25 million, which is a increase of 9 million compared to the average number of productive apple trees in the period 1980-2016. The forecast trend values of the apple production in Serbia indicate a slight increase throughout the entire forecast period. The forecast volume of apple production by the end of 2022 will approximate to 340,000 t, which is an increase of approximately 90,000 t compared to the average volume of apple production in the period 1980-2016.

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