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FORECAST OF PLANTING VINEYARDS WITH LOCAL GRAPEVINE VARIETIES IN THE REPUBLIC OF SERBIA USING THE ARIMA MODELS

ABSTRACT: Compared to the previous period, the vineyard area in the Republic of Serbia has decreased significantly. Although the planting of new vineyards is subsidized over a long period of time, not enough vineyards are planted to ensure self-sufficiency in domestic grapes, wine (wine products) and spirit drinks originating from grapes. This is especially case for vineyards with local grapevine varieties, which can be of great importance for the rural development and promotion. In this paper, utilized time series analysis, specifically Auto Regressive Integrated Moving Average (ARIMA) modeling was used to predict the dynamics of newly planted vineyard areas with all grapevine varieties and local grapevine varieties based on data from the previous 20 years (period from 2003 to 2022). The aim is to forecast the trends of newly planted vineyard areas, both for all grapevine varieties and vineyards with local grapevine varieties, for the period from 2023 to 2027. A time series refers to a structured sequence of observations. The structuring is frequently done in terms of time intervals. Forecasting time series data, or determining future trends, is one of the most crucial goals of time series analysis. Based on such analysis, it is possible to forecast the expansion of vineyard areas for the upcoming period. ARIMA models helped to determine five-year trends in data on newly planted vineyard areas. The forecast made in this paper showed that vineyard area of all grapevine varieties would be planted at an annual range of about 230 and 300 hectares over the next five years. The forecast for future annual planting for the same period (2023–2027) of vineyards with local grapevine varieties is in the range of only about 10 to 60 hectares. The obtained ARIMA forecast results, especially for the forecasts for planting vineyards with local grapevine varieties, show that it is necessary to pay special attention to this problem and to initiate numerous measures and activities in order to increase the area of vineyards with local grapevine varieties in the Republic of Serbia.

KEYWORDS: forecasting, vineyards, local grapevine varieties, ARIMA modeling

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INTRODUCTION

Planting vineyards has been a constant subject-matter of the agricultural policy of the Republic of Serbia; it has been limited in the European Union for several decades, and it has been also a topic when it comes to monitoring the tendencies in terms of vineyard areas by the International Organization for Vine and Wine (OIV). Given the importance of local grapevine varieties, they are given special attention in order to increase the vineyard areas with local varieties.

According to the OIV, the total vineyard area in the world in 2022 was 7.3 million hectares (OIV, 2022). Although the areas under vineyards in the world have been constantly decreasing since 2006, from 2017 onwards such areas have started to stabilize. The reason for this, however, lies in increasing the number of these areas in some countries (Russia, India, Brazil, France and others), at the expense of other countries in which the number of areas under vineyards have been decreased in recent years (Moldova, Turkey, Spain, Argentina and the USA) (OIV, 2022). Despite international varieties prevail in general, in some countries, there have been new vineyards with local varieties, as in Italy (Glera variety), Portugal (Touriga Franca, Touriga Nacional and Arinto) and other countries (OIV, 2017).

For a long time, in order to avoid the risk of oversupply of wine products and ensure the competitiveness, within the measures of the Common Market Organization (CMO) for the wine sector, the European Union has constricted the expansion of the existing vineyard areas, through the "planting rights" system. This "planting rights" has been changed after the EU passed a new common agricultural policy (Regulation [EU], No. 1308/2013). In 2016, the regulation introduced the system of authorization of planting vineyards, where each member state can increase vineyard areas, corresponding to no more than 1% of the total area actually planted with grapevines calculated on 31 July of the previous year. Such limitations and strict control of production can help avoid the risk of the wine oversupply on the market, but also the risk of devaluation of protected and renowned EU geographical indications.

In the Republic of Serbia, when it comes to the areas under vineyards and trends of planting new vineyards, the situation in the previous period has been completely opposite. Compared to 1955, when there were 135,000 ha of vineyards (Jakšić, 2019), in 2022 there were 19,973 fruitful vineyards (without data from AP Kosovo and Metohija) (Jeftić, 2023). According to the data from the Vineyard Registre, there are more than 6.5 thousand hectares of vineyards in Serbia for commercial production of grapes and wine (Jakšić, 2019). The Republic of Serbia currently does not have enough vineyard areas, and consequently, enough quantities of domestic grapes, wine (wine products) and spirit drinks originated from domestic grapes to ensure an adequate level of self-sufficiency. This is confirmed by data showing that in 2022 the total production of wine recorded in the Winery Registre was 25 million litres, 16.8 million of

which was made of domestic grapes and 8.2 million of imported, i.e. delivered raw material (Jeftić, 2023). According to the Serbian Statistical Office (RZS), the total imports of wine (excluding aromatic wine) in 2022 amounted to 22.9 million litres (Jeftić, 2023). Given such circumstances, there is a need for planting a considerable number of vineyards, and especially vineyards with local grapevine varieties that can have economic importance and they can also greatly affect the development of rural areas and promotion of Serbia or certain wine-growing areas/geographical indications. For that reason, the Serbian Ministry of Agriculture, Forestry and Water Management (MPŠV) has been encouraging the planting of new vineyards for more than two decades, giving some incentives for newly planted vineyards with local grapevine varieties (*Službeni glasnik RS*, No. 49/23). The calls from Certification of Planting Material and Clonal Selection Programme funded by the Serbian Ministry of Agriculture, Forestry and Water Management (MPŠV, 2019) until 2019 launched clonal selection of certain local grapevine varieties in Serbia. Nevertheless, except in 2008 and 2009, despite significant national and EU incentives, there have not been many newly planted vineyards in the last 20 years in Serbia (on average, 232 hectares per year). It is particularly true when it comes to newly planted vineyards with old autochthonous and regional/local grapevine varieties and there are 31 of them in Serbia (Jakšić et al., 2019). Namely, over the last 20 years, 53 hectares of vineyards with local varieties, on average, have been planted per year, and the largest area was planted in 2021.

Without going deep into the issue of lacking the certified clone planting material for local grapevine varieties, high costs of setting up and maintaining a vineyard, high price competition of wine from the neighbouring countries (Jakšić, 2019) and other problems that lead to planting less vineyards, there is a need for research and forecast planting of vineyards in the future period based on data on trends in vineyard planting in previous periods and based on using appropriate research methods. The goal of this paper was to predict vineyard planting (total vineyard areas with all grapevine varieties and with local grapevine varieties) based on the data on vineyard planting in previous years and using the ARIMA (Auto Regressive Integrated Moving) model.

MATERIALS AND METHODS

Methodology for predicting the planting of new vineyards using the ARIMA models

ARIMA models are the most widely used approaches to time series forecasting to provide complementary approaches to the problem. ARIMA models aim to describe the autocorrelations in the data (Hyndman and Athanasopoulos, 2021). The primary objectives of time series analysis include description,

explanation and prediction or forecasting of time series data. During the forecasting process, the authors work with a time series for which data are available up to a certain point in time, denoted as an "h", where "X = (X1, …, Xh)". The objective is to predict future values for "ℓ" periods in advance, represented as "Xh+ℓ", where "ℓ" is defined as the forecast horizon (Ilić et al., 2014). For annual time series, it is often appropriate to forecast three periods ahead, which corresponds to the next three years. For quarterly time series, the forecast horizon typically extends to one or two quarters. However, for daily time series, forecasts may extend over longer periods, encompassing days or even months. It is worth noting that the precision of such forecasts becomes increasingly questionable beyond the specified limitations. In such cases, these predictions are more accurately described as projections rather than forecasts (Dabetić, 2016). Projections require further consideration and additional factors and research (Joksimović et al., 2020). Seasonal ARIMA models, similar to their non-seasonal counterparts, consider the interdependence of consecutive observations within a time series, such as the relationship between observations of consecutive months (or quarters) within a year. However, unlike non-seasonal time series, seasonal time series models also account for the interdependence of observations for the same months (or quarters) in consecutive years (Mutavdžić et al., 2014).

The seasonal ARIMA model for a time series {Xt, tϵT} follows the structure (Mladenović and Nojković, 2015):

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

Both seasonal and non-seasonal differentiation operators are used in the definition of an ARIMA model, referred to as d- and D- times, respectively. To construct an ARIMA model effectively, it is advisable to follow the interactive approach proposed by Box and Jenkins (Mladenović and Nojković, 2015). The predictive analyzes using the ARIMA model were performed using SPSS statistical software.

Data used for the analysis

For the study, data on the dynamics of newly planted vineyards for the period 2003–2022 were used (Jakšić, 2019; Jeftić, 2023; internal interviews), including both planted areas (vineyard areas with all more than 251 grapevine varieties (Jeftić, 2023), as well as vineyard areas with just 31 local grapevine varieties). Based on the presented data, an analysis is performed to forecast the trends in newly planted vineyards with all grapevine varieties, as well as with local varieties for the next five years (2023–2027).

Table 1. Data on the areas of newly planted vineyards with all grapevine varieties and local varieties for the period 2003–2022

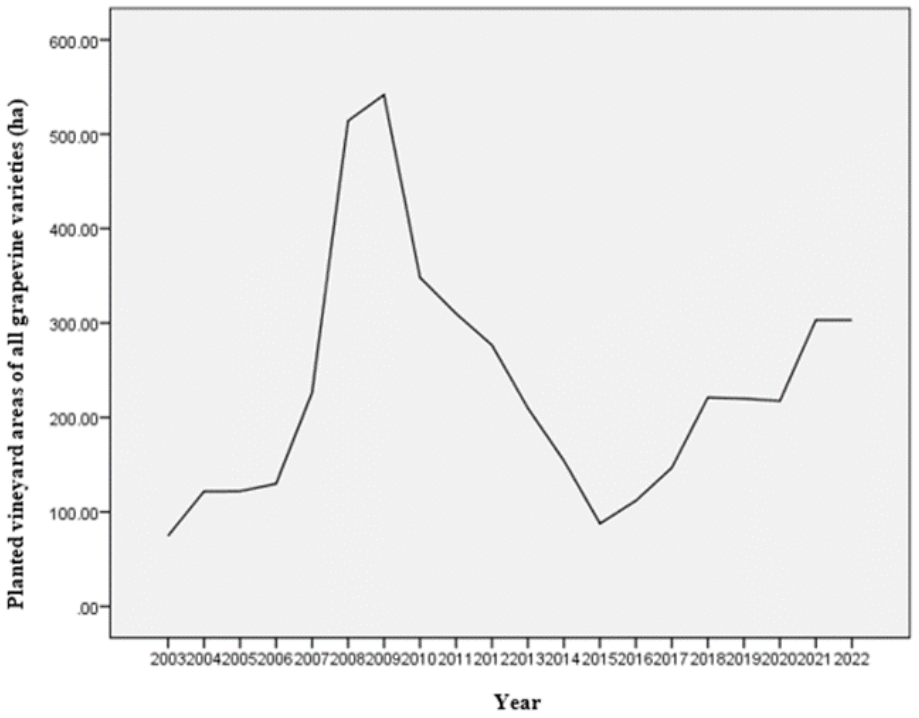
Year	Area of newly planted vineyards with all grapevine varieties (ha)	Areas of newly planted vineyards with local grapevine varieties (ha)
2003	74.709	32.405
2004	121.673	31.759
2005	121.949	28.102
2006	129.736	22.733
2007	226.078	29.288
2008	514.174	84.477
2009	541.603	79.903
2010	348.227	59.688
2011	310.088	65.110
2012	276.587	65.371
2013	209.782	64.931
2014	154.234	50.200
2015	87.645	23.885
2016	111.823	26.858
2017	146.865	44.444
2018	221.114	32.925
2019	219.933	42.010
2020	217.465	43.683
2021	303.102	122.164
2022	303.141	116.182
Average	231.996	53.306

Source: (Jakšić, 2019) and interviews of grape producers.

RESULTS AND DISCUSSION

Analysis of the forecast for planting vineyards with all grapevine varieties

Before analyzing the prediction of vineyard areas with all grapevine varieties, two tests were used to verify the data following a normal distribution: Kolmogorov-Smirnov and Shapiro-Wilk test. Based on both tests, the data were found to follow a normal distribution, allowing a further data analysis based on ARIMA modeling. Based on the data in Table 1, an analysis of the prediction of planting of vineyards with all grapevine varieties for the next five years, period 2023–2027, was performed.



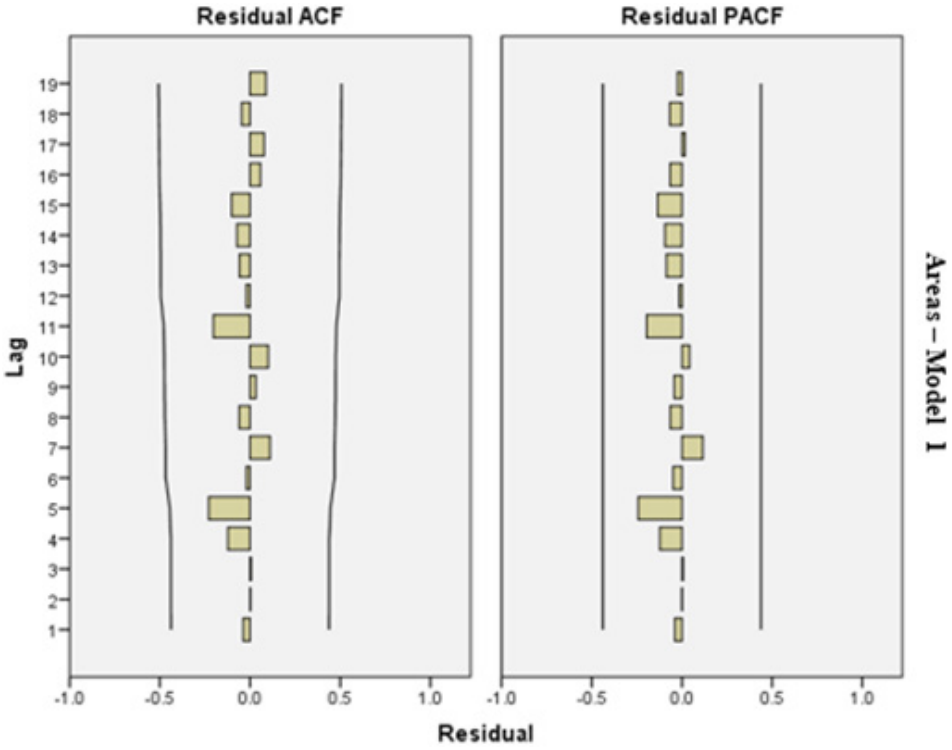
Graph 1. The trend of newly planted vineyard areas with all grapevine varieties in the period 2003–2022

From Graph 1, it can be concluded that the data do not follow one trend (a constant increase or a constant decrease in planted vineyard areas with all grapevine varieties), but there is a noticeable fluctuation in the amount of planted vineyard areas with all grapevine varieties, from which it can be concluded that it is a stationary time series. In the data modeling, based on the autocorrelation and partial correlation function of the time series, the following model (4,0,2) was chosen from several models to describe newly planted vineyards with all grapevine varieties in the Republic of Serbia.

Table 2. Estimated parameters of the ARIMA (4,0,2) model

Lag	Estimate	SE	t	Sig.
AR Lag 1	1.704	0.505	3.371	0.005
Lag 2	-1.455	0.964	-1.509	0.155
Lag 3	0.909	0.753	1.208	0.249
Lag 4	-0.494	0.281	-1.758	0.102
MA Lag 1	0.937	6.635	0.141	0.890
Lag 2	0.048	1.001	0.048	0.962

Source: Author's calculation in the SPSS program based on the data from Table 1



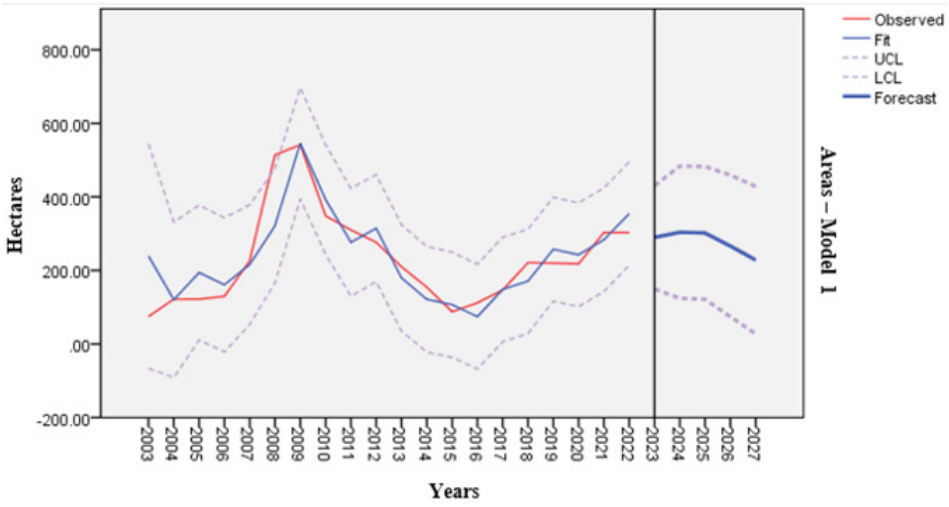
Graph 2. Correlogram results for the residuals of the estimated model 1

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

Table 3. Estimation of newly planting vineyards with all grapevine varieties in the Republic of Serbia based on the ARIMA model (4,0,2)

Years	Estimated newly planted vineyard areas	Confidence interval of 90% of the estimated newly planted vineyard areas	
		Lower bound	Higher bound
2023	290.02	149.73	430.30
2024	303.88	123.88	483.89
2025	301.94	121.47	482.42
2026	266.51	74.05	458.96
2027	228.05	27.83	428.27

Source: Author's calculation in the SPSS program based on the data from Table 1

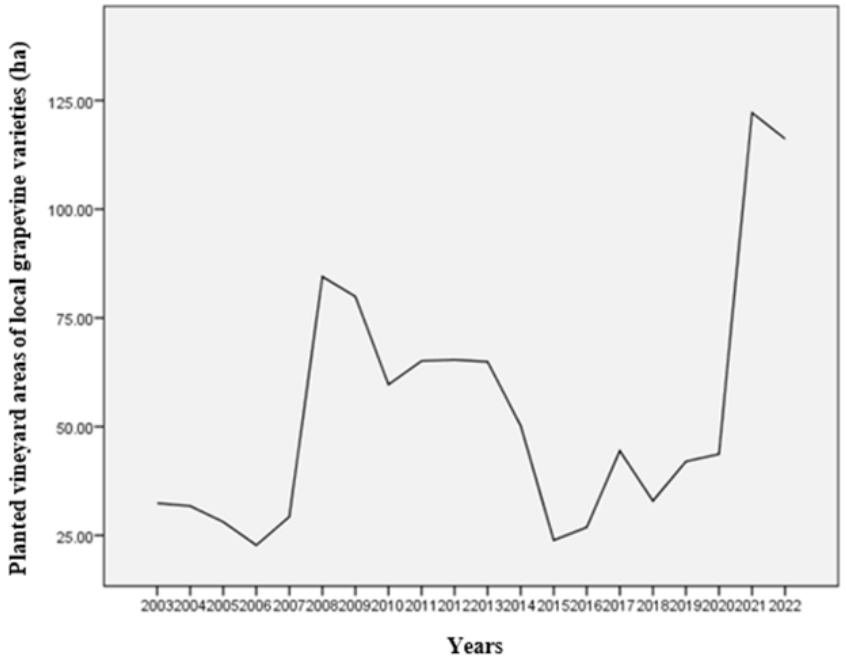


Graph 3. Newly planted vineyards with all grapevine varieties in the period 2003–2022 and the amounts estimated according to the ARIMA model for the next five years

Based on the defined ARIMA modeling, Graph 3 shows the trend of newly planted vineyard areas with all grapevine varieties in the period 2003–2022, as well as the trend of newly planted vineyard areas according to the ARIMA model. Based on the graphical representation, it can be inferred that the defined ARIMA model closely aligns with the actual figures of newly planted vineyard areas with all grape varieties, indicating that the defined model is reliable. Additionally, the defined ARIMA model forecasts the amount of newly planted vineyard areas with all grape varieties for the next five years (2023–2027). The forecast data obtained indicate that there will be no significant changes in terms of newly planted vineyard areas with all grapevine varieties, with the trend of planting remaining within the range of 230–300 hectares annually.

Analysis of the forecast for planting vineyards with local grapevine varieties

As in the above-mentioned case, before analyzing the prediction of vineyard areas with local grapevine varieties, two tests – the Kolmogorov-Smirnov and the Shapiro-Wilk tests were used to determine whether the data followed a normal distribution. Based on both tests, it was concluded that the data followed a normal distribution, enabling a further data analysis based on ARIMA modeling. Based on the data in Table 1, an analysis of the prediction of planting vineyards with local grapevine varieties for the next five years, period 2023–2027, was performed.



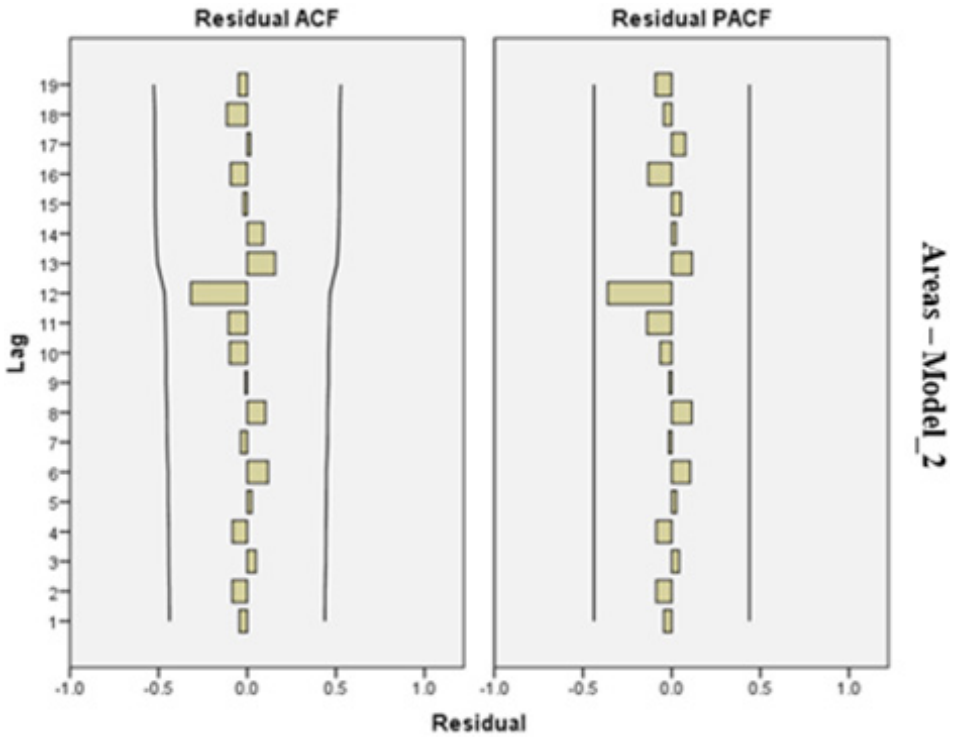
Graph 4. The trend of newly planted vineyard areas with local grapevine varieties in the period 2003–2022

From Graph 4 it can be concluded that the data do not follow one trend (a constant increase or a constant decrease in planted vineyard areas with local grapevine varieties), but there is a noticeable fluctuation in the amount of planted vineyard areas with local grapevine varieties, based on which it can be concluded that it is a stationary time series. As in the previous case, in the data modeling, based on the autocorrelation and partial correlation function of the time series, the following model (5,0,3) was chosen from several models to describe newly planted vineyards with local grapevine varieties.

Table 4. Estimated parameters of the ARIMA (5,0,3) model

Lag	Estimate	SE	t	Sig.
AR Lag 1	1.121	1.006	1.114	0.289
Lag 2	-0.590	1.977	-0.298	0.771
Lag 3	-0.368	2.095	-0.176	0.864
Lag 4	0.541	1.260	0.429	0.676
Lag 5	-0.588	0.602	-0.977	0.350
MA Lag 1	1.356	14.790	0.092	0.929
Lag 2	0.133	6.405	0.021	0.984
Lag 3	-0.573	9.493	-0.060	0.953

Source: Author's calculation in the SPSS program based on the data from Table 1



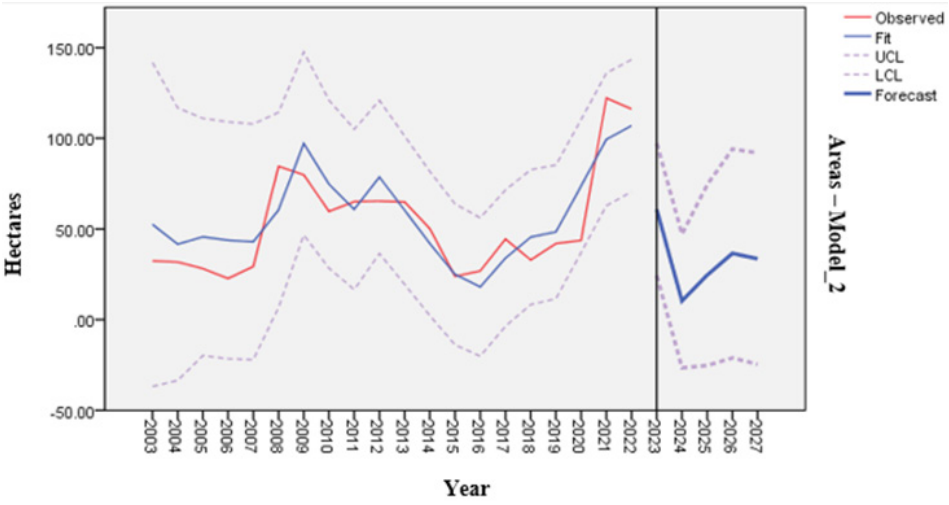
Graph 5. Correlogram results for the residuals of the estimated model 2

Based on Graph 5, it can be concluded that the residuals do not contain significant correlations on any of the lags, i.e. the residuals follow the pattern of white noise.

Table 5. Estimation of newly planted vineyards with local grape vine varieties in the Republic of Serbia based on the ARIMA model (5,0,3)

Years	Estimated newly planted vineyard areas	Confidence interval of 90% of the estimated newly planted vineyard areas	
		Lower bound	Higher bound
2023	60.76	24.29	97.24
2024	10.30	-26.56	47.15
2025	24.59	-25.27	74.45
2026	36.54	-21.05	94.14
2027	33.63	-24.68	91.93

Source: Author's calculation in the SPSS program based on the data from Table 1



Graph 6. Newly planted vineyards with local grapevine varieties in the period 2003–2022 and the amounts estimated according to the ARIMA model for the next five years

Based on the defined ARIMA modeling for the local grapevine varieties, Graph 6 shows the trend of newly planted vineyard areas with local grapevine varieties in the period 2003–2022, as well as the trend of newly planted vineyard areas according to the ARIMA model. Based on the graphical representation, it can be deduced that the defined ARIMA model aligns very well with the actual figures of newly planted vineyard areas with local grapevine varieties, indicating that the defined model is reliable. Moreover, the defined ARIMA model forecasts the amount of newly planted vineyard areas with local grapevine varieties for the next five years (2023–2027). The obtained forecasted data suggest that there will be no significant changes in terms of newly planted vineyard areas with local grapevine varieties, with the trend of planting remaining within the range of 10–60 hectares annually.

CONCLUSION

After a gradual decrease, vineyard areas in the world have been stabilized on around 7.3 million hectares. The European Union to a certain extent limits planting of new vineyards, to avoid oversupply of wine and to ensure the competitiveness of EU wine. In Serbia, a country that imports wine, the situation is quite different, where despite considerable government incentives, there have not been enough newly planted vineyards. It is particularly case when it comes to 31 old local varieties that could be important for rural development and for promoting wine-growing areas, and geographical indications of the Republic of Serbia.

The ARIMA models forecasted the dynamics of planting new vineyards for the next five years (period 2023–2027). These models determined that the trend of planting new vineyards with all grapevine varieties would range 230–300 hectares annually. Although the models showed there would be a mild decrease in planting of new vineyards, the forecasted hectares were somewhat higher than the overall average for the last twenty-year period (2003–2022).

Based on the trend of planting vineyards in the previous period, the forecast was also made for the dynamics of planting new vineyards with local grapevine varieties for the next five years (period 2023–2027). The ARIMA models forecasted that newly planted vineyards with local varieties would increase the area for only 10–60 hectares annually. Such values are within the overall average for vineyards with local varieties in the previous twenty-year period (2003–2022).

Presuming that the circumstances affecting the trend in planting vineyards in the last twenty years (2003–2022) would remain the same or similar, the forecasts of the dynamics of planting vineyards with all grapevine varieties and with local varieties by using ARIMA modeling indicates\ that hectares of future newly planted vineyards in Serbia will not be enough to obtain a proper self-sufficiency in terms of grapes, wine (wine products) and spirit drinks originating from grapes. It is particularly true when it comes to vineyards with local grapevine varieties, and it is therefore necessary to pay special attention to this matter and launch numerous measures and activities to increase hectares under vineyards with local grapevine varieties.

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ПРЕДВИЂАЊЕ ПОДИЗАЊА ВИНОГРАДА СА ЛОКАЛНИМ СОРТАМА ВИНОВЕ ЛОЗЕ У РЕПУБЛИЦИ СРБИЈИ КОРИШЋЕЊЕМ „ARIMA" МОДЕЛА

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РЕЗИМЕ: У односу на претходни период, површине винограда у Републици Србији су значајно смањене. Иако се садња нових винограда субвенционише дужи временски период, ипак се не сади довољно винограда како би се обезбедиле довољне количине домаћег грожђа, вина (производа од вина) и алкохолних пића пореклом од грожђа. Ово посебно важи за винограде са локалним сортама винове лозе, које могу бити од великог значаја за рурални развој и промоцију. У овом раду је коришћена анализа временских серија, конкретно моделовање ауторегресивног интегрисаног покретног просека (ARIMA) за предвиђање динамике новозасађених површина винограда са свим сортама винове лозе и локалним сортама винове лозе на основу података из претходних 20 година (период од 2003. до 2022. године). Циљ је да се прогнозирају трендови новозасађених површина винограда, како за све сорте винове лозе, тако и за површине винограда са локалним сортама винове лозе, за период од 2023. до 2027. године. Временска серија се односи на структурирани низ посматрања. Често се структурирање врши у смислу временских интервала. Предвиђање података временских серија, или одређивање будућих трендова, један је од најважнијих циљева анализе временских серија. На основу такве анализе могуће је предвидети обим површина винограда за наредни период. ARIMA модели могу помоћи да се утврди петогодишњи тренд за податке о новозасађеним површинама винограда. Прогноза у овом раду показала је да ће се нове површине винограда са свим сортама винове лозе кретати у интервалу од око 230 до 300 хектара годишње у наредних пет година. Прогноза будуће годишње садње за исти период (2023–2027) винограда са локалним сортама винове лозе креће се у распону од свега 10 до 60 хектара. Добијени прогнозирани резултати на основу ARIMA моделовања, посебно за прогнозе засада винограда са локалним сортама винове лозе, показују да је овом проблему потребно посветити посебну пажњу и покренути бројне мере и активности како би се повећале површине винограда са локалним сортама винове лозе у Републици Србији.

КЉУЧНЕ РЕЧИ: предвиђање, виногради, локалне сорте винове лозе, ARIMA моделовање