Journal of Agricultural Sciences (Belgrade)
Vol. 69, No. 4, 2024
Pages 409-426
https://doi.org/10.2298/JAS2404409G
UDC: 631.153:634.1/.8"2012/2022"
338.435:634.1/.8
Original scientific paper

VALUE OF PERMANENT CROPS IN THE GROSS VALUE ADDED IN AGRICULTURE

Biljana Lj. Grujić Vučkovski*, Ksenija R. Vukićević and Dragana D. Stevanović

Tamiš Research and Development Institute, Pančevo, Serbia

Abstract: The aim of the research is to analyze the impact of the value of the production of permanent crops (fruit and viticulture sector) on the realized gross value added (GVA) in agriculture in Serbia and the EU from 2012 to 2022. The results were obtained by applying a multiple regression model where the dependent variable is the GVA in agriculture, and the independent variables represent the production values of the fruit and viticulture sector (in EUR mln). The coefficients of the model were tested using the t-test, and the model was verified using the F-test at a significance level of 0.05. The value of the standardized beta coefficient shows that the fruit-growing sector had a greater influence on the realized GVA of agriculture in Serbia and the EU (0.532 vs. 0.852), the t-values for Serbia belonged to the critical area in both sectors, while the t-values for the viticulture sector in the EU did not belong to the critical area. The F-test values show that the fitted model was significant at the 0.05 level for both observation areas. An analysis of the presence of multicollinearity in the independent variables was also conducted, and the results showed that there was a weak multicollinearity originating from the value of viticulture production.

Key words: gross domestic product (GDP), gross value added (GVA), intermediate consumption, agricultural output, permanent crops.

Introduction

The economic categories GDP and GVA are very important because they measure the economic strength of the state and the economic sector. We have explained the difference between these economic categories as follows: GVA represents the value added for the improvement of certain product indicators, while GDP expresses the total amount of products produced in a country (Sahu and Gartia, 2022).

Agricultural production is a very important activity for Serbia and the Serbian economy (Užar and Radojević, 2019; Grujić et al., 2022). It also plays a significant role in total exports and employment (Nikolić et al., 2017; FAO, 2020a; Volk et al.,

*Corresponding author: e-mail: grujic@institut-tamis.rs

2019; Grujić et al., 2021). Its specificity is contained in the fact that it achieves a high gross value added (GVA), which results in a high participation in the GDP structure. Agricultural production in Serbia generates a high value for agricultural output, which includes the value of so-called intermediary consumption. Specifically, the value of agricultural output includes the values of taxes, subsidies, and intermediary consumption in the total agricultural output (Užar and Radojević, 2019; Popescu et al., 2021a). Serbia achieves a constant increase in the value of agricultural production and GVA, even though agricultural production is characterized by different levels of regional development. According to Brankov and Matkovski (2022), agriculture contributes considerably to the development of GVA, which is higher in Western Balkan countries than in the EU. A group of authors (Grujić et al., 2022) applied the multiple linear regression method to determine the impact of different areas of agricultural production on the GVA of agriculture in Serbia, finding that crop production, especially grain production, significantly contributes to the creation of the GVA of agriculture. The aforementioned research also showed the significant participation of the fruit-growing and viticultural sectors in the creation of GVA agriculture, while Dašić et al. (2022) believe that fruits and grapes from Serbia are recognizable on the markets of other countries, achieve a high price and are more competitive compared to products from other countries.

If we look at the EU level, we conclude that the GVA of agriculture in the EU records a significant share in the total GDP of the EU (Popescu et al., 2021a; Popescu et al., 2021b). Furthermore, agricultural production in the EU (as a whole) has a significant impact on the global agricultural market (Popescu et al., 2021a; Pawlak et al., 2021), despite the fact that member countries have varying levels of economic growth (Baer-Nawrocka, 2016). The EU should provide enough food for its population and market, but also create surpluses for export to the markets of non-EU countries (Megyesiova, 2021). The production process should also ensure quality-controlled food, which is implemented under the umbrella of the Common Agricultural Policy (CAP) (FAO, 2020b). The CAP reforms aim to make agricultural production more market-oriented (Giannakis and Bruggeman, 2015). In Romania, the participation of GVA of agriculture in the creation of GDP is weak. In 2022, it was about 4.6% (Ionitescu, 2023). Lithuania records a constant increase in agricultural output and GVA in agriculture (Kriščiukaitienė and Baležentis, 2011).

Agriculture is also an important economic sector in other non-EU countries of the world. Teshome and Lupi (2018) point out that agriculture in Ethiopia has great importance for the country's economy, especially in terms of employment. In Nigeria, the importance of agriculture is reflected in the reduction of poverty and the increase in income, as the share of agricultural GVA in total GDP is steadily increasing. Matthew and Mordecai (2016) have applied the multiple linear regression method to determine whether per capita income in agriculture in Nigeria is more influenced by the value of agricultural output or public agricultural expenditure and found that both predictors have a significant impact. About 70% of the population lives in the rural areas of Bangladesh, where the agricultural sector accounts for 14.23% of GDP (2015), which shows that agriculture is the main source of income (Dey, 2022). According to the same source, it was determined that the analyzed predictors (rice, jute, wheat, potato, and sugarcane), as areas of plant production, described 97.4% of the total variations of the dependent variable (value added in agriculture) in the set model. During 2022, the share of GVA in agriculture, forestry and fisheries (abbreviated as AFF) and rural population in the total population decreased in Bangladesh (11.2% versus 60%) (FAOSTAT, 2024). The success of the economy in India is based predominantly on the results achieved in the agricultural sector. In 2014, women outnumbered men (60:40) in this sector (Reddy and Dutta, 2018). In this country, the state provides significant subsidies for agricultural inputs (pesticides, seeds, fertilizers). Therefore, these authors used multiple regressions to analyze the impact of certain agricultural inputs on the GVA of agriculture (in %). They have found that seeds and pesticides have a significant impact, while the influence of fertilizers has no significant impact on the GVA of agriculture.

Since the study covered a number of the previously specified economic categories, mathematical equations were used in the following sections to illustrate them. Užar and Radojević (2019) set up the equation as follows (Equation 1):

$$GDP = PV + T - Sb - IC \quad (1)$$

where *PV – production value, T – taxes, Sb – subsidies, IC – intermediate consumption.* The initial formula can be further used to calculate other economic categories relevant to this research (Equations 2 and 3).

$$GVA = PV + IC \quad (2)$$

$$GDP = GVA + T - Sb \quad (3)$$

We can further use the mathematical equations set in this way to calculate the value of intermediate consumption, and its form was presented by Albu et al. (2020). With this formula, we obtain the value of intermediate consumption in a simple way (Equation 4).

$$IC = AOV - GVA \quad (4)$$

where *AOV – agricultural output value.*

Equation 4 was used to set up a mathematical form that can be used to easily calculate the value of final consumption or the so-called direct GVA (Albu et al., 2020) and is shown in Equation (5).

$$AOV - IC = \text{direct } GVA \text{ (final consumption)} \quad (5)$$

The theoretical frameworks of the exhibited components of the national accounts, articulated by mathematical equations, were examined in the subsequent phase of the research, while the results were given in tabular or graphical format. Their modifications were accompanied by sufficient annotations.

Table 1 shows the average annual rate of change (abbreviated as AARC) of GDP and GVA (at current prices) in Serbia and the EU from 2012 to 2022. The values are expressed in percentages.

Table 1. AARC of GDP and GVA in AFF in Serbia and the EU, 2012–2022 (in %).

Territory	AARC of GDP	AARC of GVA
Serbia	7.1	7.3
EU	3.4	3.6

Source: Calculation of the authors based on EUROSTAT and SORS databases.

According to the data shown in Table 1, we can see that from 2012 to 2022 Serbia's average annual GDP increased by 7.1%, and GVA in AFF by 7.3%. In the territory of the EU, a positive AARC was also recorded for the observed indicators, but the value was twice as low. The fact that the AARC of GVA in AFF in Serbia is twice as large can be explained by the fact that in Serbia the agricultural sector is more important for the development of the economy than in the case of EU countries, as well as that the agricultural sector is more represented in Serbia compared to the area of the EU member states.

Table 2 shows the structure of the participation of GVA of AFF in total GDP according to the observed areas.

Table 2. The share of GVA of AFF activity in GDP in Serbia and the EU, 2012–2022 (in %).

Variables	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Average*
Share of GVA in AFF in total GDP *in Serbia*	7.5	7.9	7.7	6.7	6.8	6.0	6.3	6.0	6.3	6.3	6.5	6.7
Percentage of GVA in AFF in total GDP *in the EU*	1.7	1.7	1.7	1.6	1.6	1.7	1.6	1.6	1.6	1.6	1.7	1.6

Source: EUROSTAT and SORS. *Note: Calculation of the authors based on EUROSTAT and SORS databases.

When analyzing the participation of GVA in the AFF in total GDP, we notice that Serbia also recorded almost four times higher average annual participation in this respect compared to the EU (Table 2). Megyesiova (2021) states that the lower contribution of GVA in agriculture is characteristic of developed countries, and vice versa, in less developed countries, the participation of GVA in agriculture is higher in the total GDP of the country.

Table 3 provides a comparative overview of the realized values of agricultural production and GVA in agriculture for 2012 and 2022 for Serbia and the EU. We observe that in Serbia the value of agricultural production increased on average by 4.9% per year, reaching a 61.3 higher value in 2022 compared to 2012. When we look at the EU, we see that the AARC agricultural output and the rate of change recorded lower growth compared to Serbia. More precisely, the calculated AARC of agricultural output value in the EU showed a growth of 3.3% per year on average and a positive rate of change of 38.6% in 2022 compared to 2012, and from 2010 to 2015 (Zsarnóczai and Zéman, 2019) the output value of agriculture in the EU increased by 8.6%.

Table 3. Agricultural output value and GVA in Serbia and the EU, 2012 and 2022.

Territory	Agricultural output value				GVA in agriculture				Average GVA in agriculture , in EUR mln (2012–2022)	Share of GVA in agriculture in agricultural output value, in %*	
	2012, in EUR mln	2022, in EUR mln	Rate of change, in %	AARC, in %	2012, in EUR mln	2022, in EUR mln	Rate of change, in %	AARC, in %		2012	2022
Serbia	4,443.5	7,165.8	161.3	4.9	1,930.1	3,903.5	202.2	7.3	2,646.916	43.4	54.5
EU	369,514.6	511,975.5	138.6	3.3	152,030.5	215,599.1	141.8	3.6	169,974.639	41.1	42.1

Source: EUROSTAT and SORS. *Note: Calculation of the authors based on EUROSTAT and SORS databases.

If we look at the realized values of GVA in agriculture, we see that Serbia doubled the realized GVA in 2022 compared to 2012 (+102.2%). Both Serbia and the EU recorded positive changes in the realized value of GVA in agriculture, and the increase in this value in 2022 compared to 2012, expressed by the rate of change, was 41.8%.

As we can see in Table 3 and according to Equations 4 and 5, GVA in agriculture represents only a part of the total realized agricultural value. Accordingly, we can say that in the EU, the share of the value of the intermediate consumption was higher (around 60%) than in Serbia (45–55%). We also concluded that intermediate consumption in Serbia in 2022 was 29.8% higher than in 2012, while in the EU it was 36.3% higher.

Popescu et al. (2021a) analyzed individual EU countries and found that in 2020, compared to 2011, the largest increase in agricultural output value was recorded in France (18.3%), Germany (13.8%) and Italy (13%) and the largest GVA growth was achieved by Latvia (128.38%).

By further analysis of the ratio of realized values of GVA and intermediate consumption, we found that in Serbia, one euro spent on intermediate consumption increased from 0.8 euro (2012) to 1.2 euro (2022) of GVA for agriculture. In the EU, one euro spent on intermediate consumption produced about 0.7 euro of agricultural GVA and did not change significantly in the period 2012–2022.

After providing an overview of the total values of agricultural production, we now proceed to show the structure of these values. We know that the overall value of agricultural output is made up of the realized values of crop and livestock production, as well as agricultural services, and their respective shares are shown in Table 4.

Table 4. Share of the value of each agricultural sector in the total value of the production of agricultural goods and services (average for the period 2012–2022, in %).

Territory	Crop production	Animal production	Agricultural services
Serbia	68.4	29.1	2.5
EU	55.2	39.8	5.0

Source: Calculation of the authors based on EUROSTAT and SORS databases.

As can be seen in Table 4, plant production had a dominant share in generating the value of total agricultural production, both in Serbia and in the EU. However, agricultural production involvement was greater in Serbia than in the EU, although animal production participation was higher in the EU.

Since we have found that the value of plant production dominates the total value of agricultural production, we have decided to investigate the structure of the value of plant production by area and type of production (Figure 1).

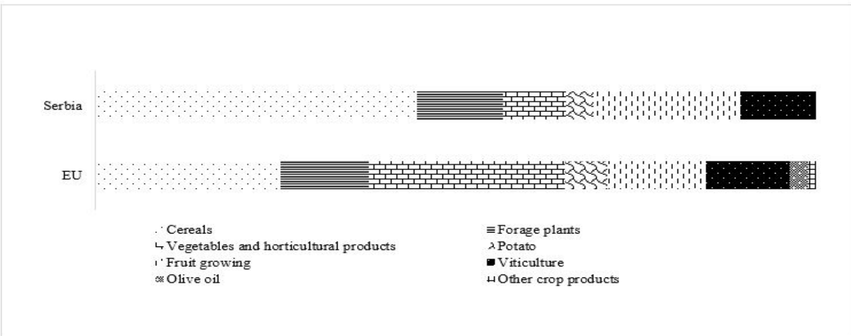

Figure 1. Structure of the value of vegetables and horticultural products in Serbia and the EU (average for the period 2012–2022, in %).

Figure 1 shows that the value of grain production had the largest average share in the realized value of plant production in Serbia (40%). In second place was the value of the production of the fruit sector (with 18.4%), followed by industrial and fodder plants, and the value of the production of the viticulture sector (with a 9.2% share) was in the fifth place.

In the EU, products from the group of vegetables and horticultural products accounted on average for the largest share of the value of plant production (24.7%), followed by grain, then by the fruit sector with 12.4%, and the value of the production of fodder plants, and in the fifth place was the value of the production of the viticulture sector (10.6%).

If we were to add up the share of the production value of the fruit and viticulture sector, which is the share of the value of the production of permanent plantations in the total value of agricultural production, we would arrive at a sum of 27.6% for Serbia and 23% for the EU. In other words, in Serbia and the EU, a quarter of the total realized value of agricultural production came from permanent plantings.

Table 5 presents three influential areas of crop production with their average values from 2012 to 2022, the rate of change (2022/2012) and the AARC for the period 2012–2022 in Serbia and the EU. The following areas were singled out: arable, fruit-growing and viticultural production. In our case, the value of crop production consisted of the value of the production of grain, industrial and fodder plants, vegetables and potatoes.

As seen in Table 5, agricultural production had the greatest average value of production in Serbia and the EU. The rates of change in the value of production reveal that permanent plants developed faster year after year. In Serbia, the increase in the production value of the viticulture sector by 216.4% and the fruit sector by 128.9% in 2022 compared to 2012 stood out. In the EU, the fruit sector recorded a growth rate of 46.7%, while the viticulture sector achieved a growth rate of 45.1%.

Table 5. Average value, rate of change and AARC for three areas of crop production in Serbia and the EU (2012–2022).

	Serbia		
	Average, in EUR mln	Rate of change (2022/2012), in %	AARC, in %
Crop farming	2,738.4	153.4	4.4
Fruit growing	663.9	228.9	8.6
Viticulture	334.4	316.4	12.2
	EU		
	Average, in EUR mln	Rate of change (2022/2012), in %	AARC, in %
Crop farming	161,705.5	140.9	3.5
Fruit growing	27,123.5	146.7	3.9
Viticulture	22,983.6	145.1	3.8

Source: Calculation of the authors.

Looking at the AARC, it can be seen that the value of agricultural production grew the slowest in both Serbia and the EU. Table 5 also shows that the value of Serbian fruit-growing sector production increased at an average yearly rate of 8.6% (4.4% in agriculture) and 12.2% in viticulture. In the EU area, there were no significant fluctuations in the AARC of certain crop production sectors (3.9% in fruit production and 3.8% in viticulture production).

Previous research has revealed that grain production accounts for a considerable portion of the total agricultural output value, but does not have a significant AARC, as is the case in the fruit and viticulture sectors. As a result, permanent plantations play a significant role in our research.

Material and Methods

The structure of the participation of each sector in the formation of the overall value of agricultural production revealed a considerable engagement in plant agricultural output, with permanent plantings also noted. Although agricultural production showed high average values, it cannot be said that it recorded high rates of change and AARC. Therefore, the research is focused on the analysis of the impact of production values originating from permanent plantings on the GVA of agriculture in Serbia and the EU in the period 2012–2022. The results were obtained using the multiple linear regression method. Permanent plantations included the sectors of fruit growing (i.e., the value of the fruit produced) and viticulture (i.e., the value of the wine produced).

At the beginning of the study, the results of the descriptive statistics of the value structure of plant production in Serbia and the EU were presented (coefficients of correlation and determination, standard error of regression, AARC, structures of indicators, etc.). The Durbin-Watson test *(d-test)* was used to determine the possible presence of autocorrelation between the variables in the set regression model (Akter, 2014). The results of this test lead to the conclusion that the predictors are significant for the set regression model.

The values of the coefficients of the *d-test* range from 0 to 4. If the obtained value is in the interval *from 0 to 2*, we consider that there is a positive first-order autocorrelation; if it is *from 2 to 4*, then we conclude that there is a negative first-order autocorrelation between the variables, but *if the value of this coefficient is 2* then we state that there is no autocorrelation between the variables. It is best when the d-test coefficient values are in the interval from 1.50 to 2.50 (Investopedia, 2024). The Durbin-Watson test (Chen, 2016) is calculated according to the following formula in Equation (6)

$$d = \frac{\sum_{i=2}^{n}(\hat{\varepsilon}_i - \hat{\varepsilon}_{i-1})^2}{\sum_{i=1}^{n}\hat{\varepsilon}_i^2} \quad (6)$$

where n – sample size, i – number of elements (i = 1, 2, …, n), $\hat{\varepsilon}_i$ – prediction error.

This was followed by an analysis of the impact of the realized value of fruit and viticulture production on the GVA of agriculture in Serbia and the EU in order to see which group of permanent plantations contributed more and had a greater influence on the realized value of the GVA of agriculture. In order to examine the influence of the independent variables on the dependent variable, the authors used a multiple linear regression model, and the SPSS software package was used for the analysis. The fitted multiple regression model is shown in Equations (7) and (8). The meaning of the individual variables can be found in Table 6.

$$\beta_1 L_1 + \beta_2 N_1 + \beta_0 = C_1 \quad (7)$$

$$\beta_1 L_2 + \beta_2 N_2 + \beta_0 = C_2 \quad (8)$$

Table 6. Explanation of the variables.

Variables	Description	Unit of measure	Source	Type of variable
C_1	GVA in agriculture in Serbia	Current prices, in RSD* mln	SORS, Statistical yearbook	Dependent
C_2	GVA in agriculture in the EU	Production value at producer price, in EUR mln	EUROSTAT	Dependent
L_1	The production value of the fruit-growing sector in Serbia	Producer prices of the current year, in RSD* mln	SORS, Statistical yearbook	Independent
L_2	The production value of the fruit-growing sector in the EU	Production value at producer price, in EUR mln	EUROSTAT	Independent
N_1	Production value of the viticulture sector in Serbia	Producer prices of the current year, in RSD* mln	SORS, Statistical yearbook	Independent
N_2	Production value of the viticulture sector in the EU	Production value at producer price, in EUR mln	EUROSTAT	Independent
β_1, β_2, and β_0	Model coefficients	-	SPSS program report	Regression parameters

Source: Author's view. * Given that the data for Serbia were expressed in local currency (RSD), it was necessary to convert them into EUR to ensure data comparability. Converting values from RSD to EUR was carried out using the average annual exchange rate available on the website of the National Bank of Serbia (abbreviated as NBS). The average annual mean exchange rate of RSD against foreign currencies represents the arithmetic mean of the mean exchange rates calculated during working days.

The research included the testing of β coefficients using the t-test and the set model using the F-test. The defined null and alternative hypotheses are presented in tabular form (Table 7).

Table 7. Hypotheses of the research.

*Testing of the β coefficients – **t-test***	
The null hypothesis H_0: coefficient β_i=0 means that the observed coefficient is not statistically significant.	*An alternative hypothesis Ha:* coefficient β_i≠0 means that the observed coefficient is statistically significant.
*Testing of the established model – **F-test***	
The null hypothesis H_0: The model is not statistically significant at the 0.05 significance level.	*An alternative hypothesis Ha:* The model is statistically significant at the 0.05 significance level.

Source: Author's view.

First, a matrix form of the centralized data values was formed by Equation (9).

$$Y^* = X^* \beta^* \varepsilon^* \quad (9)$$

where $Y*$ – vector of the dependent variable (GVA in Serbia and the EU), X – matrix of independent variables (realized value of production of the fruit-growing and viticulture sector in Serbia and the EU), β – the vector of coefficients, ε – error of the model. The estimation of the unknown coefficients β_i was performed, where i takes the values 1 and 2 (Equation 10), as well as the rating of the coefficient β_0 (Equation 11).

$$\beta^* = (X^{*'} X^*)^{-1} X^{*'} Y^* \quad (10)$$

$$b_0 = \bar{Y}_n - b_1 \bar{x}_{1n} - \cdots - b_k \bar{x}_{kn} \quad (11)$$

where $\bar{Y}_n, \bar{x}_{1n}, \ldots, \bar{x}_{kn}$ are the arithmetic means of the corresponding data.

The indicators of the possible presence of multicollinearity in the observed variables were also analyzed in the research. The verification of the appearance of multicollinearity was carried out by evaluating the values obtained for the tolerance level, the VIF coefficient and the Eigenvalues. Mathematical formulas for their calculation were presented by Adeboye et al. (2014).

According to the set regression model, the downloaded report from the SPSS program showed the predictive values of the indicators of descriptive statistics, including the limits at which the values should move.

In addition to the above-mentioned methods of descriptive statistics and multiple linear regression, the methods of induction and deduction were used during the research when drawing appropriate conclusions. The methods of analysis and synthesis were also used in the interpretation of statistical data. All results, whether presented tabularly or graphically, are accompanied by appropriate comments by the author.

The research is based on the analysis of literature that includes the results of previous studies on the same or a similar topic by domestic and foreign authors.

The statistical analysis of the secondary data was carried out using the SPSS software package.

Results and Discussion

Since the research results reported in the introductory section have demonstrated that crop production dominates the value structure of overall agricultural output, the research will be continued using inputs from this type of production in Serbia and the EU. To support this, Table 8 presents the basic results of the descriptive data for various crop producing areas.

Table 8. Descriptive statistics of plant production in Serbia and the EU from 2012 to 2022 (in EUR mln).

Serbia									
	Cereals	Industrial crops	Forage plants	Vegetables and horticultural products	Potato	Fruit growing	Viticulture	Olive oil	Other crop products
Average	1,431.6	537.0	375.3	270.9	123.6	663.9	334.4	0.0	4.6
Min	937.6	401.7	145.4	220.7	96.3	476.7	167.3	0.0	3.9
Max	1,921.1	757.3	1,914.7	329.6	207.1	1,091.4	529.3	0.0	5.2
Std. dev.	290.8	117.2	513.5	34.7	33.5	192.7	108.6	0.0	0.3
Cv, in %	20.3	21.8	136.8	12.8	27.1	29.0	32.5	0.0	7.5
EU									
	Cereals	Industrial crops	Forage plants	Vegetables and horticultural products	Potato	Fruit growing	Viticulture	Olive oil	Other crop products
Average	51,374.2	20,725.0	24,001.5	53,933.9	11,670.9	27,123.5	22,983.6	4,964.1	2,181.4
Min	40,077.6	17,801.8	22,157.0	46,735.9	9,022.5	21,892.0	18,484.4	3,255.7	1,894.4
Max	80,187.5	30,685.3	26,189.5	65,747.3	15,390.0	32,117.5	27,392.1	6,699.0	2,563.1
Std. dev.	11,505.7	3,766.0	1,268.4	6,093.0	2,042.2	3,306.1	2,443.6	1,006.3	224.1
Cv, in %	22.4	18.2	5.3	11.3	17.5	12.2	10.6	20.3	10.3

Source: Calculation of the authors.

Table 8 shows that Serbia had the largest percentage deviation from the average value in the production of fodder plants, which reached 136.8%. There were no major fluctuations in the other crops. As for the EU, there were no significant deviations from the arithmetic mean and the values were around the average values.

Table 9 shows the statistical indicators of the set regression model for Serbia and the EU. More precisely, the variability of the assumed model of the dependent variable *Y* from the independent variable *X* is presented.

Table 9. Statistical indicators of the set model.

Model	R	R square	Adjusted R square	Std. error of the estimate	Durbin-Watson (d-test)	Type of autocorrelation	Sig. F change
Serbia	.950	.902	.877	182.1481	2.622	Negative	.000
EU	.840	.706	.632	11,397.4244	1.970	Positive	.007

Source: Calculation of the authors. Output from the SPSS program.

The correlation coefficient shows us that there was a strong positive relationship between the predictors, which was greater in Serbia. The coefficient of determination shows that 90.2% of variations in the GVA of Serbian agriculture can be explained by the influence of the fruit and viticulture sector, and 70.6% of the variations in the EU. The corrected coefficient of determination shows that 87.7% for Serbia, or 63.2% of the variability of agricultural VAT for the EU, depended on the value of production created by the fruit and viticulture sector. With these results, we have shown that permanent plantings occupy a significant place in the GVA structure of agriculture in Serbia and the EU because they describe more than half of the changes under whose influence the GVA structure changes. The values of the *d-test* were in the optimal intervals. Finally, we can conclude that the set model was significant (sig. value), whereby the significance for Serbia was higher than for the EU.

According to the report of the SPSS program, we obtained the scores of the coefficients β_1, β_2, and β_0, as well as indicators of the possible presence of multicollinearity between the predictors (Table 10).

Table 10. Results of the estimated regression model.

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.	Collinearity statistics	
		B	Std. error	Beta			Tolerance	VIF
Serbia	(constant)	940.211	208.343		4.513	.002		
	Fruit growing	1.437	.495	.532	2.902	.020	.364	2.746
	Viticulture	2.250	.879	.469	2.560	.034	.364	2.746
EU	(constant)	41,382.844	34554.679		1.198	.265		
	Fruit growing	4.847	1.685	.852	2.876	.021	.419	2.389
	Viticulture	-.125	2.280	-.016	-.055	.958	.419	2.389

Source: Calculation of the authors. Output from the SPSS program.

According to the results shown in Table 10, the set regression model was given a new form, which is shown in Equations 12 and 13.

$$1.437 * L_1 + 2.250 * N_1 + 940.211 = C_1 \quad (12)$$

$$4.847 * L_2 - 0.125 * N_2 + 41{,}382.844 = C_2 \quad (13)$$

Table 10 shows that, in Serbia and the EU, the fruit-growing sector had a greater influence on the realized GVA of agriculture than the viticulture sector. This conclusion was drawn based on the observed higher value of the standardized beta coefficient in the fruit-growing sector than in the viticulture sector. The obtained results for the unstandardized beta coefficients, depending on the area of observation, can be interpreted as follows: "If the value of fruit production increases by EUR 1 mln, then the GVA value of agriculture in Serbia increases by EUR 1,437 mln, and in the EU by EUR 4,847 mln". Therefore, if we were to increase the GVA value of agriculture, then the production value of the fruit-growing sector would also have to increase.

Furthermore, the null hypothesis H_0 was tested, coefficient $\beta_i = 0$ (the observed coefficient was not statistically significant), against the alternative hypothesis H_1, coefficient $\beta_i \neq 0$ (coefficient was statistically significant), with the index i assuming the values 1 and 2. Testing was performed using the t-test, and the realized values of the test statistic for the regression coefficients are given in Table 11. The t-statistic was distributed according to the Student's-distribution, provided that the null hypothesis was true, with 8 degrees of freedom, and its theoretical value amounted to $t(0.05; 8) = 2{,}306$.

If we look at the level of Serbia, we find that the values of the coefficients β_1 and β_2 belonged to the critical area, therefore we accept the corresponding alternative hypotheses for the observed coefficients. (t_{β_1} = 2.902 and t_{β_2} = 2.560) at a significance level of 0.05 (Table 11).

Table 11. Realized test statistic values for the regression coefficients in the set regression model for Serbia and the EU.

	Serbia		
Coefficients	Estimate	t-value	*p*
(Intercept)	940.211	4.513	0.002
β_1	1.437	2.902	0.020
β_2	2.250	2.560	0.034
	EU		
(Intercept)	41382.844	1.198	0.265
β_1	4.847	2.876	0.021
β_2	-0.125	-0.055	0.958

Source: Calculation of the authors. Output from the SPSS program.

If we look at the EU level, we can see that the realized t-value for the coefficient β_1 p belonged to the critical area. Thus, we accept the appropriate alternative hypothesis for the observed coefficient (t_{β_1} = 2.876) at a significance level of 0.05. Therefore, the t-value for the coefficient β_2 was not in the critical area, was not significant at the 0.05 significance level, because $t_{\beta_2} = -0.055$ and we accept a null hypothesis.

Using the F-test, the entire model was tested (H_0: the model was not statistically significant; H_1: the model was statistically significant), and the obtained results show that the model was statistically significant, at a significance level of 0.05, which can be seen in Table 12.

Table 12. The F-statistic values at the significance level of 0.05.

Territory	*F*	F (0.05,2,8)	*p*
Serbia	36.813	4.459	0.000
EU	9.600	4.459	0.007

Source: Calculation of the author. Output from the SPSS program.

According to the results shown in Table 12, we can conclude that the regression model set for the level of Serbia was more significant than that for the EU, because p = 0.000 < p = 0.007.

The rest of the paper analyzes the indicators of the possible presence of multicollinearity in the variables. The basis for the conclusions is presented in Tables 10 and 13.

Table 13. Results of the multicollinearity check of the variables.

Serbia						
Model	Dimension	Eigenvalue	Condition index	Variance of proportions		
				(constant)	Fruit growing	Viticulture
1	1	2.935	1.000	.01	.00	.00
	2	.049	7.726	.93	.05	.17
	3	.016	13.675	.07	.95	.83
EU						
Model	Dimension	Eigenvalue	Condition index	Variance of proportions		
				(constant)	Fruit growing	Viticulture
1	1	2.990	1.000	.00	.00	.00
	2	.007	20.526	.89	.24	.04
	3	.003	33.442	.11	.76	.96

Source: Calculation of the author. Output from the SPSS program.

The values in the *Tolerance* column (0.364 for Serbia and 0.419 for the EU) and *VIF* (2.746 for Serbia and 2.389 for the EU) shown in Table 10 indicate a weak presence of multicollinearity. The set regression model was valid, so we conclude that fruit and wine production were only weakly collinear. In Table 13, the

Eigenvalues show the degree of closeness between the variables. When the Eigenvalues are close to zero, then the condition index achieves a very high value. For example, a high value of the β_2 coefficient, which represents the viticulture sector, influenced the presence of multicollinearity in the set model (13.675 for Serbia and 33.442 for the EU).

Finally, the results of the SPSS program provided the potential predictive values of the observed variables, primarily the parameters of descriptive statistics. The results are tabulated in Table 14.

Table 14. Prediction values of the set model.

	Serbia			
	Minimum	Maximum	Mean	Std. deviation
Predicted value	2,001.789	3,699.854	2,646.927	494.2450
	EU			
	Minimum	Maximum	Mean	Std. deviation
Predicted value	145,180.531	193,701.109	169,974.639	15,792.4216

Source: Calculation of the authors. Output from the SPSS program.

Based on the given data for Serbia, the statistical program SPSS showed the expected predicted mean value of GVA of EUR 2,646,927 mln, which was EUR 0.011 mln higher than the mean value of the analyzed period.

When it comes to the EU, the expected mean value of GVA would be unchanged at EUR 169,974 mln compared to the average of the observed period.

Conclusion

According to the findings, Serbia had a higher average yearly proportion of GVA in agriculture in total GDP (6.7%) than the EU (1.6%) for the study period (2012–2022), whereas the EU had a higher share of intermediate consumption.

In Serbia and in the EU, plant production contributed significantly more than livestock production to the creation of GVA for agriculture. Within crop production, the value of production under permanent plantings stood out, principally due to greater AARCs than for cereal production and crop farming.

The *d-test* values show that there was an autocorrelation between the predictors. Using the multiple regression method, the authors found that GVA in agriculture in Serbia and in the EU had a greater influence on the production value of the fruit-growing sector (sig. = 0.020 and sig. = 0.021, respectively), and the set model was statistically significant at the significance level of 0.05. The test of the analyzed predictors shows that they were significant for Serbia, while for the EU the value of viticulture production did not fall within the critical area ($t_{\beta_2} =$

-0.055). In the set model, a weak multicollinearity between the fruit-growing and viticulture sectors was observed, and the multicollinearity originated from the viticulture sector.

The results of this research reveal that permanent crops, which have a greater AARC output value than grain, have contributed considerably to the development of GVA in agriculture in Serbia and the EU between 2012 and 2022.

Acknowledgements

The paper is a part of a research work financed by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia and approved by decision no. 451-03-66/2024-03/200054 and research results of the project U 01/2023 Green economy in the era of digitalization, Faculty of Finance, Banking, and Auditing, Alpha BK University in Belgrade, Republic of Serbia.

References

Adeboye, N.O., Fagoyinbo, I.S., & Olatayo, T.O. (2014). Estimation of the effect of multicollinearity on the standard error for regression coefficients. *Journal of Mathematics*, *10* (4), 16-20.

Akter, J. (2014). Bootstrapped Durbin–Watson test of autocorrelation for small samples. *ABC Journal of Advanced Research*, *3* (2), 137-142.

Albu, N., Zubrzycki, K., Scholz, R., Ostwald, D.A., Somweber K., & Haut, S. (2020). The Direct Gross Value Added Calculation Method – case study, Basel/Berlin/Darmstadt, September 2020. https://www.wifor.com/uploads/2021/04/Case_Study_Novartis_WifOR_Direct_Gross_Value_Added.pdf

Baer-Nawrocka, A. (2016). The role of agriculture in the national economy of EU countries. *Journal of Agribusiness and Rural Development*, *2016 (42),* 501-510.

Brankov, T., & Matkovski, B. (2022). Is a Food Shortage Coming to the Western Balkans? *Foods*, *11* (22), 3672.

Chen, Y. (2016). Spatial autocorrelation approaches to testing residuals from least squares regression. *PloS one*, *11* (1), e0146865,

Dašić, D., Stanić, T., & Živković, D. (2022). Market of agricultural and food products in the Republic of Serbia: possibilities and implications. *Economic of agriculture*, *69* (1), 57-74. doi:10.5937/ekoPolj2201057D

Dey, S. (2022). Impacts of major crop production on the agricultural sector in Bangladesh: a time series analysis. *International Journal of Sustainable Agricultural Research*, *9* (1), 10-17.

FAO (2020a). *Smallholders and family farms in Serbia. County study report. 2019.* Budapest. Food and Agriculture Organization of the United Nations Budapest, 2020. https://doi.org/10.4060/ca7449en

FAO (2020b) International Telecommunication Union. Food and Agriculture Organization of the United Nations. Status of Digital Agriculture in 18 Countries of Europe and Central Asia, Geneva, Switzerland: FAO.

FAOSTAT (2024). Eletronic database, https://www.fao.org/faostat/en/#data/OA (accessed: 10 July 2024).

Giannakis, E., & Bruggeman, A. (2015). The highly variable economic performance of European agriculture. *Land use policy*, *45*, 26-35. https://doi.org/10.1016/j.landusepol.2014.12.009.

Grujić, B., Simonović, Z., & Ćurčić, N. (2021). Importance of agriculture and food industry in the economy of the Republic of Serbia. In L. Chivu, V. Ioan-Franc, G. Georgescu & A. Jean-Vasile

(Eds.), *Harnessing Tangible and Intangible Assets in the context of European Integration and Globalization. Challenges ahead*, Volume 2, (pp. 971-982). National Institute for Economic Research, Bucharest, Romania, Peter Lang, Berlin.

Grujić Vučkovski, B., Paraušić, V., Jovanović Todorović, M., Joksimović, M., & Marina, I. (2022). Analysis of influence of value indicators agricultural production on gross value added in Serbian agriculture. *Custos e Agronegocio*, *18* (4), 349-372.

Investopedia (2024). Durbin Watson Test: What It Is in Statistics, With Examples, https://www.investopedia.com/terms/d/durbin-watson-statistic.asp (accessed: 10 July 2024)

Ionitescu, S. (2023). The role of agriculture in Romania's economy in the period 2013-2022. *Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development*, *23* (4), 407-418.

Kriščiukaitienė, I., & Baležentis, T. (2011). Efficiency of the Lithuanian agricultural sector: return on fixed assets, output, and value added. *Management Theory & Studies for Rural Business & Infrastructure Development*, *28* (4), 66-74.

Matthew, A., & Mordecai, D.B. (2016). The impact of agricultural output on economic development in Nigeria (1986-2014). *Archives of Current Research International*, *4* (1), 1-10.

Megyesiova, S. (2021). Production, employment and productivity of agricultural sector in the European Union. *Bulgarian Journal of Agricultural Science*, *27* (5), 846-858.

National Bank of Serbia (NBS), 2024. Average exchange rate, https://nbs.rs/en/finansijsko_trziste/medjubankarsko-devizno-trziste/kursna-lista/prosecni-kursevi/index.html (accessed: 02 July 2024)

Nikolić, R., Fedajev, A., Stefanović, V., & Ilić, S. (2017). *The Agriculture Sector in Western Balkans–Some Characteristics of Development.* Economic of agriculture, 64 (1), 275-293.

Popescu, A., Dinu, T.A., Stoian, E., & Serban, V. (2021a). Efficiency of labor force use in the European Union's agriculture in the period 2011-2020. *Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development"*, *21* (3), 659-672.

Popescu, A. (2021b). Romania's contribution to the European Union's agriculture in the period 2010-2020. *Annals of Academy of Romanian Scientists, 10*, (1), 88-106.

Pawlak, K., Smutka, L., & Kotyza, P. (2021). Agricultural potential of the EU countries: how far are they from the USA? *Agriculture*, *11* (4), 282.

Reddy, T.K., & Dutta, M. (2018). Impact of agricultural inputs on agricultural GDP in Indian economy. *Theoretical Economics Letters*, *8* (10), 1840.

Sahu, P., & Gartia, R. (2022). Sectorwise gross value added (GVA) in Odisha: A statistical analysis. *International Journal of Statistics and Applied Mathematics*, *7* (4), 128-135.

Teshome, A., & Lupi, A. (2018). Determinants of agricultural gross domestic product in Ethiopia. *International Journal of Research Studies in Agricultural Sciences* (IJRSAS), *4* (2), 12-20.

Užar, D., & Radojević, V. (2019). The importance of agriculture in forming gross value added in Serbia in the period of 2008-2017. *Economic of Agriculture*, *66* (4), 1091-1105.

Volk, T., Rednak, M., Erjavec, E., Rac, I., Zhllima, E., Gjeci, G., Bajramović, S., Vaško, Ž., Kerolli-Mustafa, M., Gjokaj, E., Hoxha, B., Dimitrievski, D., Kotevska, A., Janeska Stamenkovska, I., Konjevic, D., Spahic, M., Bogdanov, N., & Stevović, (2019). *Agricultural policy developments and EU approximation process in the Western Balkan countries.* Luxembourg: Publications Office of the European Union.

Zsarnóczai, J.S., & Zéman, Z. (2019). Output value and productivity of agricultural industry in Central-East Europe. *Agricultural Economics/Zemědělská Ekonomika*, *65* (4), 185-193.

Received: August 15, 2024
Accepted: October 30, 2024

VREDNOST STALNIH ZASADA U BRUTO DODATOJ VREDNOSTI POLJOPRIVREDE

Biljana Lj. Grujić Vučkovski*, Ksenija R. Vukićević i Dragana D. Stevanović

Istraživačko-razvojni institut Tamiš, Pančevo, Srbija

R e z i m e

Cilj istraživanja je analiza uticaja vrednosti proizvodnje stalnih zasada (voćarskog i vinogradarskog sektora) na ostvarenu bruto dodatu vrednost (skr. BDV) u poljoprivredi Srbije i EU od 2012. do 2022. Rezultati su dobijeni primenom modela višestruke regresije gde je zavisna promenljiva BDV u poljoprivredi, a nezavisne promenljive predstavljaju vrednosti proizvodnje voćarskog i vinogradarskog sektora (u mil. EUR). Pomoću t-testa testirani su koeficijenti modela, a primenom F-testa izvršena je provera postavljenog modela na nivou značajnosti od 0,05. Vrednost standardizovanog beta koeficijenta pokazala je da veći uticaj na ostvarenu BDV poljoprivrede u Srbiji i EU ima sektor voćarstva (0,532 prema 0,852), t-vrednosti za Srbiju pripadaju kritičnoj oblasti u oba sektora, dok u EU t-vrednosti za vinogradarski sektor ne pripadaju kritičnoj oblasti. Vrednosti F-testa pokazale su da je postavljeni model značajan na nivou značajnosti od 0,05 za oba područja posmatranja. Sprovedena je i analiza na prisustvo multikolinearnosti kod nezavisnih varijabli, a rezultati su pokazali da postoji slaba multikolinearnost koja potiče od vrednosti vinogradarske proizvodnje.

Ključne reči: bruto domaći proizvod (BDP), bruto dodata vrednost (BDV), međupotrošnja, proizvodnja poljoprivrednih dobara i usluga, stalni zasadi.

Primljeno: 15. avgusta 2024.
Odobreno: 30. oktobra 2024.

*Autor za kontakt: e-mail: grujic@institut-tamis.rs