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LONG-RUN AND SHORT-RUN RELATIONSHIP BETWEEN AGRICULTURAL VALUE ADDED AND ECONOMIC GROWTH: EMPIRICAL EVIDENCE FROM SERBIA

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Abstract

The aim of this paper is to empirically examine the short-run and long-run relationships between agricultural value added and real GDP growth in Serbia from 1995 to 2023, using the ARDL approach. The results of the empirical analysis based on the ARDL bounds testing procedure indicate the existence of cointegration between the examined variables. The findings reveal that, in the long run, there is a statistically significant and positive relationship between agricultural value added and economic growth, while the short-run relationship is also positive but of lower intensity. The negative and statistically significant error correction coefficient in the ECM model confirms that a substantial portion of short-run deviations in real GDP growth is corrected within one year, indicating the existence of a stable long-run equilibrium among the analyzed variables. These empirical results suggest that designing and implementing policies that stimulate agricultural production could make a significant contribution to achieving long-term sustainable economic growth in Serbia.

Key words: *Agricultural value added, economic growth, ARDL approach, coitegration, ECM, Serbia*

JEL Classification: *Q10, O47, C32, C52*

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1. Introduction

Agriculture is a primary economic activity with wide-ranging importance to a country's economy. As a source of food, industrial raw materials, and employment in rural areas, agriculture not only satisfies the basic needs of the population but also plays a crucial role in promoting economic growth (Dowrick and Gemmell 1991).

In recent decades, the global economy has undergone significant structural changes, reflected, among other things, in the declining relative share of value added from the agricultural sector in gross domestic product (GDP). According to World Bank data, during the 1960s, agriculture accounted for more than 10% of global GDP on average, whereas by the 2020s this share had declined to less than 4% (World Bank 2025).

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In the case of Serbia, the agricultural sector accounted for 3.8% of GDP in 2023 (World Bank 2025), which is higher than in most European countries and indicates that the sector still plays a relatively significant role in the national economy.

The available literature shows that the number of empirical studies examining the relationship between agricultural value added and GDP growth remains limited, especially in transition economies. In the case of Serbia, several previous studies (Novaković et al. 2024; Mitrović, Mitrović and Cogoljević 2017; Atanasijević and Danon 2014) highlight the importance of agriculture in the structure of GDP. However, a quantitative analysis of the relationship between agricultural value added and GDP growth has not yet been conducted. In this context, this study seeks to address the following key research question: Is the growth of agricultural value added associated with GDP growth in Serbia, and how stable is this relationship? To address this question, this study is to empirically examine the short-run and long-run relationships between agricultural value added and real GDP growth in Serbia using time-series econometric analysis.

This research makes a significant contribution to the academic literature. Primarily, it focuses on analyzing the relationship between agricultural value added and economic growth, thereby enriching the existing literature on growth structures in countries where agriculture plays an important role. Furthermore, given that previous studies on the impact of agriculture on economic growth have yielded inconclusive and highly context-dependent results, this paper contributes to a better understanding of this relationship within the specific context of Serbia. Considering that Serbia is still undergoing structural transformation and aligning its economy with the standards of developed market economies, analyzing the contribution of agriculture to economic growth is of particular importance. It provides deeper insight into the transitional challenges and developmental potential of the agricultural sector.

In addition to its academic contribution, this research also has clear practical implications. By establishing the long-run and short-run relationships between agricultural value added and economic growth, the study provides a foundation for formulating economic policies aimed at enhancing the agricultural sector and fostering sustainable growth. The findings may serve as a basis for developing recommendations related to rural development, increasing agricultural productivity, and promoting more efficient resource utilization, which are issues of particular importance for developing and transitional economies such as Serbia.

The paper is structured into five sections. Following the introduction, Section 2 provides a review of previous research. Section 3 describes the data and the methodological framework, while Section 4 presents and interprets the research findings. Finally, Section 5 contains the key conclusions, policy implications, and directions for future research.

2. Literature review

The study of the relationship between the sectoral structure of GDP and economic growth represents a significant segment of contemporary theoretical discussions and empirical research. Traditionally, agriculture is perceived as the primary sector that stimulates economic growth, particularly in the early stages of national economic development (Johnston and Mellor 1961). In this context, Mackie (1964) emphasizes that in low-income countries with slow growth rates, the underdevelopment of the agricultural sector can constitute a major obstacle to overall economic development. Conversely, in rapidly growing economies, the role of agriculture becomes more important, as this sector may play a key role in generating the initial momentum for sustainable economic progress. A similar position is taken by Nyiwul and Koirala (2022), who underscore that the primary sector is of fundamental importance in growth and sustainable development in developing countries.

Some authors point out that the contribution of agriculture to overall economic growth gradually declines as countries advance in their development. In developing countries, such as those in the Sub-Saharan African region, agriculture plays a significant role in poverty reduction and in fostering economic growth (Christiaensen, Demery, and Kuhl 2011). In contrast, in developed economies, the relative contribution of agriculture to GDP decreases, with the industrial and service sectors assuming a dominant role (Gollin 2010). This trend is consistent with the theory of structural transformation, which posits that, as economies develop, production and employment gradually shift from the primary to the secondary and eventually to the tertiary sector, as a result of productivity gains and technological progress (Kuznets 1973). Similarly, Gollin (2023) examines the key role of agricultural productivity growth in the process of structural transformation, emphasizing that improving efficiency in this sector represents a fundamental prerequisite for long-term economic growth, particularly in low-income countries. Empirical confirmation of the differentiated roles of the agricultural sector across various stages of economic development is provided by a study conducted by Los and Gardebroek (2015), based on a sample of 55 African countries over the period from 1961 to 2010. By applying panel cointegration techniques and the Granger causality test, their study shows that food production growth plays a key developmental role in low-income countries, while in upper-middle-income countries, the decisive factor is the pace of labor force transition from agriculture to more productive sectors.

Timmer, deVries, and de Vries (2014) emphasize that developing countries undergo specific patterns of structural change that differ from the earlier experiences of developed economies. In this process, although the share of agriculture in GDP and total employment declines, the agricultural sector continues to play a crucial role in securing income and employment, particularly in rural areas. Deininger, Jin, and Ma (2022) further emphasize that in low- and middle-income countries, the pace and form of agricultural transformation vary significantly, depending on policy, land structure, and the dynamics of labor shifting to more productive sectors. In addition, Wang, Zhang, and Guo (2024) show that in large modern economies, such as China, agricultural transformation involves farm modernization, technological innovations, and the reorganization of production chains, confirming that the process is not limited to traditional patterns but reflects contemporary development trends. In this context, Liu et al. (2024) highlight that the digital economy serves as a key contemporary driver of agricultural transformation, shaping the sector by enhancing productivity, improving market integration, and facilitating the transition toward high-quality development.

One of the earliest empirical studies examining the relationship between agricultural value added per worker and GDP per capita was conducted by Gardner (2003), using data from 85 countries. Building on his findings, Tiffin and Irz (2006) applied the Granger causality test to the same sample of countries and demonstrated that agriculture acts as a driver of economic growth in developing countries, whereas this relationship is less pronounced in developed economies. The causal relationship between agricultural value added per worker and GDP *per capita* was also examined using data from 14 of the oldest European Union member states (EU-15, excluding Luxembourg). The results indicate that the direction of causality varies across countries: in some, agriculture drives economic growth, while in others, a reverse or a bidirectional relationship is observed (Apostolidou et al. 2014). Despite the absence of unambiguous findings, the main conclusion highlights the role of agriculture as a potential stabilizing factor during times of economic crisis. This underscores the need for greater recognition of agriculture within economic policy frameworks, despite its declining share in the European Union's GDP. Similar conclusions are confirmed by Beckman and Countryman (2021), who analyze the role of agriculture in different regions around the world during the COVID-19 pandemic and indicate that this sector had a stabilizing effect on overall macroeconomic performance, mitigating the negative impacts of the crisis on GDP and employment. A study conducted on a sample of nine developing and transition countries from Sub-Saharan Africa, Asia, and Latin America confirms the existence of a long-run relationship between agriculture and economic growth, with the direction of causality also varying across countries (Awokuse and Xie 2015).

Similar findings are confirmed by a study conducted by Mbotiji, Oumar, and Egwu (2023) on a sample of Central African countries covering the period from 1990 to 2020, in which fixed effects panel models, random effects panel models, and the generalized least squares (GLS) method were applied. The results indicate that agricultural value added has a positive and statistically significant impact on economic growth in the observed region. A study conducted by Maiga (2024), based on a sample of five African countries (Tanzania, Ghana, Kenya, Morocco, and South Africa), using a multiple linear regression model, revealed that agricultural productivity contributes significantly to economic growth, although the effect was relatively weaker in Morocco and South Africa.

In the context of transition economies, Lerman (2001) emphasizes that differences in the approach to reforms in Eastern European countries and the Commonwealth of Independent States, particularly regarding private land ownership and the restructuring of the agricultural sector, have led to significant disparities in economic outcomes. According to his findings, Eastern European countries achieved greater progress in terms of GDP growth and agricultural productivity. However, Radlińska (2025) notes that the agricultural sectors of most Central and Eastern European countries still differ in many respects from those of other European Union member states.

Additional insights into the relationship between agriculture and economic growth are provided by country-level analyses, which allow for the identification of specific patterns and dynamics of this relationship while accounting for the context of each individual country. Using the Johansen cointegration approach and the Granger causality test, it has been established that agriculture makes a significant contribution to long-term economic growth in Tunisia, whereas its short-term effect is considerably weaker (Chebbi 2010). By applying the ARDL model to Algeria for the period from 1991 to 2022, it has been documented that both agricultural value added and agricultural employment contribute to increased overall output (Mostefai 2024). In the case of Italy, it has been shown that improved efficiency and sustainability of agricultural production, achieved through the implementation of modern technologies, significantly contribute to economic growth (Finco et al. 2021). According to a study by Petre and Ion (2019), investments in agriculture in Romania, particularly following the country's accession to the European Union in 2007, have significantly contributed to GDP growth in rural areas. Additionally, Kumar (2025), examining the economic significance of agriculture in the state of Bihar, India, over the period 2000–2024, highlighted that agriculture, particularly through crop cultivation and livestock production, continues to play a key role in economic growth, with a special importance for rural areas.

Although numerous studies confirm the positive impact of agriculture on economic growth and poverty reduction (Thirtle, Lin, and Piesse 2003), certain findings suggest that these conclusions may not be universally applicable. Rupasingha (2009), analyzing agricultural processing enterprises at the county level in the United States, found no compelling empirical evidence for their significant contribution to income growth, employment, or poverty reduction. Similarly, some analyses indicate that agriculture may have a negligible or even negative effect on economic growth, while other studies fail to establish a clear causal relationship between the agricultural sector and GDP (Khan et al. 2022; Emam 2022; Ullah 2021; Tahamipour and Mahmoudi 2018; Matsuyama 1992).

Considering the findings of the aforementioned studies, it is evident that the contribution of agriculture to economic growth is not universally determined. Diversity among countries in terms of natural resources, cultural heritage, and historical context precludes the existence of a single definition of the role that agriculture should play in the economic growth process (Johnston and Mellor 1961). Further variability in empirical findings arises from differences in the choice of indicators used to measure agricultural sector development, the periods analyzed, and the methodologies applied, even when examining the same countries.

Therefore, the existing theoretical and empirical literature does not allow for a clear conclusion regarding the nature and importance of the relationship between agriculture and economic growth. This inconsistency in findings indicates that the issue remains open and requires further research that would take into account specific national conditions and development contexts.

3. Data and metodology

The empirical analysis in this paper is based on a set of macroeconomic variables selected in accordance with relevant studies that examine the relationship between agriculture and economic growth. The dependent variable is the annual growth rate of real GDP, as it is most commonly used as a primary indicator of overall economic performance and the dynamics of economic growth. The value added in agriculture (including forestry and fisheries), measured as a percentage of GDP, is used as the independent variable (Adebayo et al. 2024; Sertoglu, Ugural, and Bekun 2017). This variable shows the relative contribution of the agricultural sector to the overall economic activity and reflects its structural importance, i.e., how prominent agriculture is in the overall economy compared to other sectors.

To control for the impact of other potential determinants of economic growth, three additional variables are included in the analysis. First, capital investment, measured by the share of gross fixed capital formation in GDP, is introduced as a control variable, as investments in physical infrastructure, equipment, and technology represent one of the fundamental factors influencing the expansion of productive capacities and long-term economic development (FAO 2021). Second, trade openness (Los and Gardebroek 2015), measured as the ratio of the sum of exports and imports to GDP, allows for the control of the impact of foreign trade activities on economic growth. Finally, the inflation rate is included to control for nominal effects within the economy, and it is frequently used in the literature as an indicator of macroeconomic stability (Asom and Ijirshar 2016; Bassanini, Scarpetta, and Hemming 2001).

The time series data analysis on an annual basis covers the period from 1995 to 2023. The selection of this time frame is determined by data availability. Moreover, this period coincides with the beginning of the transition to a market-oriented economy, following the abandonment of the self-management socialist model. The research relies on secondary data obtained from the World Bank database (World Bank 2025), which represents a reliable source of internationally comparable and methodologically consistent statistical series, frequently used in empirical research.

Table 1. Summary of Variables Included in the Analysis

Explanation	Abbreviation	Transformation
Real GDP Growth Rate (annual %, proxy for Economic Growth)	EG	Original
Agricultural Value Added (as a percentage of GDP)	*ln*AVA	Natural Logarithm
Gross Fixed Capital Formation (as a percentage of GDP)	*ln*INV	Natural Logarithm
Trade Openness (export + import as a percentage of GDP)	*ln*TO	Natural Logarithm
Inflation, Consumer Prices (annual %)	INF	Original
Agricultural Value Added per Worker (used for robustness check)	lnAVAPW	Natural Logarithm

Note: ln denotes natural logarithm.

Due to the nature of the data, the model employs a combination of logarithmic and non-logarithmic variables. The GDP growth rate series is not log-transformed because it contains negative values. Since the inflation rate series is already expressed as a relative change, a logarithmic transformation is also not applied; instead, the variable is included in the model in its original form. The remaining variables have positive values and are log-transformed in order to mitigate heteroskedasticity. Table 1 provides an overview of variables used in the analysis, along with their corresponding abbreviations and information on the applied transformations. The table also includes an additional variable, agricultural value added per worker, expressed in constant 2015 prices, which is used for robustness testing. This indicator measures labor productivity in agriculture and is commonly used in the literature as an alternative measure of the importance of the agricultural sector, as it allows for a more accurate assessment of the sector's actual efficiency and performance (Gollin, Lagakos, and Waugh 2014; Apostolidou et al. 2014).

Based on the variables defined above, the following functional form of the baseline model is specified:

$$\mathrm{EG}_t = f(ln\mathrm{AVA}_t, ln\mathrm{INV}_t, ln\mathrm{TO}_t, \mathrm{INF}_t) \tag{1}$$

To examine cointegration, that is, the long-run equilibrium relationship between the dependent and independent variables in the model, the Autoregressive Distributed Lag (ARDL) bounds testing approach to cointegration analysis is applied. This method, which has been widely used in macroeconomic time series analysis, was developed by Pesaran and Shin (1998) and later extended by Pesaran, Shin, and Smith (2001). The choice of the ARDL bounds testing approach is based on its advantages over conventional cointegration techniques, such as the two-step residual-based procedure (Engle and Granger 1987) and the full maximum likelihood test (Johansen 1988; Johansen and Juselius 1990).

First and foremost, the ARDL bounds testing approach allows for the inclusion of variables with different orders of integration in the model. This means that it can be applied regardless of whether the time series is integrated of order zero, that is, stationary in levels, integrated of order one, that is, stationary after first differencing, or fractionally integrated (Pesaran, Shin, and Smith 2001, p. 290). This represents the most significant advantage of the bounds testing approach over other cointegration methods (Halil Arıç and Taştan 2018, p. 70). However, time series integrated of order two should not be included in the ARDL model, as such a level of integration renders the F-statistic invalid, along with all critical values, which are defined only for series integrated of order zero and/or one (Menegaki 2019, p. 2).

In economic analyses, where the endogeneity of regressors is a common issue, the ARDL model proves to be particularly useful, as it allows for obtaining unbiased and reliable parameter estimates. An additional advantage of the ARDL methodology lies in the fact that it requires the formulation of only a single regression equation (Bayer and Hanck 2013), unlike alternative approaches that involve the simultaneous estimation of a system of multiple equations.

Another important feature of this method is its ability to simultaneously estimate both long-run and short-run coefficients (Özen, Hodžić, and Yildirim 2022). Moreover, the ARDL approach allows individual variables to have different lag structures. The results obtained using this method remain consistent and robust even in the context of a limited sample size (Dewi et al. 2018).

Based on the functional form of the model presented in Equation (1), the ARDL model is specified to examine the long-run equilibrium relationship among the observed variables. Accordingly, the following equation is used to perform the bounds testing procedure:

$$\Delta EG_t = \alpha_0 + \sum_{i=1}^{m} \delta_i \, \Delta EG_{t-i} + \sum_{i=0}^{n} \gamma_i \, \Delta lnAVA_{t-i} + \sum_{i=0}^{p} \tau_i \, \Delta lnKAP_{t-i} + \sum_{i=0}^{q} \varphi_i \, \Delta lnTO_{t-i} + \sum_{i=0}^{r} \theta_i \, INF_{t-i} + \mu_1 EG_{t-1} + \mu_2 lnAVA_{t-1} + \mu_3 lnKAP_{t-1} + \mu_4 lnTO_{t-1} + \mu_5 INF_{t-1} + \varepsilon_t \quad (2)$$

where α_0 and ε_t are the intercept and random error terms, respectively, while Δ is the first difference operator. The short-run relationships are measured by δ, γ, τ and φ, while long-run relationships are by μs. The parameters *m*, *n*, *p*, *q* and *r* indicate the optimal lag length for the corresponding variables in the model.

Based on Equation (2), the existence of cointegration among the variables is tested using the F-test. The test is based on the null hypothesis H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = 0$, which implies that no cointegrating relationship exists among the variables. In contrast, the alternative hypothesis H_1: $\mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4 \neq \mu_5 \neq 0$ suggests the presence of cointegration. The calculated F-statistic is compared with the critical values provided by Pesaran, Shin, and Smith (2001), which include two sets of bounds: a lower bound (I(0)) and an upper bound (I(1)). If the F-statistic exceeds the upper bound, the null hypothesis is rejected at the chosen level of significance, indicating that a cointegrating relationship exists among the variables. Conversely, if the F-statistic falls below the lower bound, the null hypothesis cannot be rejected, suggesting the absence of cointegration. If the F-statistic lies between the lower and upper bounds, the test result is inconclusive, and no definitive conclusion regarding the existence of cointegration can be drawn.

If the ARDL model indicates the existence of a cointegrating relationship, the estimation of the long-run coefficients is conducted based on the following equation:

$$EG_t = \alpha_t + \mu_1 EG_{t-1} + \mu_2 AVA_{t-1} + \mu_3 INV_{t-1} + \mu_4 TO_{t-1} + \mu_5 INF_{t-1} + \varepsilon_t \quad (3)$$

Subsequently, in order to identify the short-run relationships among the variables, an error correction model (ECM) is specified based on the ARDL framework. In accordance with the ARDL model defined in Equation (2), the ECM can be expressed as follows:

$$\Delta EG_t = \alpha_0 + \sum_{i=1}^{m} \delta_i \, \Delta EG_{t-i} + \sum_{i=0}^{n} \gamma_i \, \Delta lnAVA_{t-i} + \sum_{i=0}^{p} \tau_i \, \Delta lnINV_{t-i} + \sum_{i=0}^{q} \varphi_i \, \Delta lnTO_{t-i} + \sum_{i=0}^{r} \theta_i \, INF_{t-i} + \lambda ECM_{t-1} + \varepsilon_t \quad (4)$$

where ECM_{t-1} is error correction term, that is, the component of the model that captures the short-run dynamics of the system and represents the speed of adjustment or the system's corrective response. ECM_{t-1} indicates the proportion of the deviation from equilibrium that is corrected, that is, the extent to which the deviation of the dependent variable in the previous period is adjusted in the current period. The coefficient associated with ECM_{t-1} should be negative and statistically significant, as this indicates an adjustment of the dependent variable toward its long-run equilibrium. If the estimated coefficient λ = -1, the adjustment in the current period is complete, whereas λ = 0 suggests no adjustment and implies that the assertion of a long-run relationship is invalid (Nkoro and Uko 2016, p. 85).

Following the estimation of the coefficients in the above equations, it is necessary to conduct diagnostic tests to identify potential issues such as serial correlation, heteroskedasticity, model misspecification, non-normality of residuals, and parameter instability.

To verify the robustness of the obtained results, an additional analysis is conducted in which the main independent variable, lnAVA, from the baseline model (Model 1) is replaced with an alternative indicator, lnAVAPW. All other elements of the model, including the control variables, lag selection, and diagnostic tests, remain identical. This parallel specification and testing of the alternative model (Model 2) make it possible to assess whether the results remain consistent when agricultural labor productivity is considered instead of the sector's relative contribution to GDP.

4. Results and discussion

As previously noted, the ARDL bounds testing approach permits the inclusion of variables with mixed orders of integration, provided that none of the variables are integrated of order two. Therefore, the first step in the analysis is to test the stationarity of the observed time series. The results of the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller 1979) and the Phillips-Perron (PP) test (Phillips and Perron 1988), presented in Table 2, indicate a mixed order of integration among the analyzed time series.

Table 2. Results of ADF and PP unit root tests

Levels	ADF test	PP test
EG	-4.698048*	-4.672857*
*ln*AVA	-1.695524	-1.695524
*ln*INV	-3896832**	-1.919353
*ln*TO	-7.570453*	-4.870333*
INF	-3.270402	-2.990406
lnAVAPW	-2.407061	-2.154494
1st differences	ADF test	PP test
Δ*ln*AVA	-4.466837*	-4.460573*
Δ*ln*INV	-3.929803**	-3.810837**
ΔINF	-6.672230*	-7.949988*
lnAVAPW	-4.524774*	-7.153027*

Note: Trend and intercept are included in the test equation for all variables; * and ** indicate significance at the 1% and 5% levels, respectively.

Source: Authors' own calculations

The growth rate of real GDP (EG) and trade openness (*ln*TO) are stationary at levels. Similarly, the capital investment series, according to the ADF test, exhibits stationarity at levels, although the PP test does not confirm this finding, indicating the need for further testing. On the other hand, the series representing the share of agricultural value added in GDP (lnAVA), the inflation rate (INF), and agricultural value added per worker (lnAVAPW) are not stationary at levels. However, when these series are transformed into first differences (ΔlnAVA, ΔlnINV, ΔINF, and ΔlnAVAPW), they become stationary, indicating that they are integrated of order one, I(1).

Considering the established orders of integration of the observed time series, it is possible to specify the ARDL model, given that none of the series are integrated of order two (I(2)), which would undermine the validity of the ARDL bounds testing approach.

To identify the optimal lag length for the further specification of the baseline and alternative ARDL (m, n, p, q, r) models, standard information criteria were applied for selecting the maximum lag length. Based on the values presented in Table 3 (Panel A and Panel B), it can be observed that all relevant criteria indicate that the optimal lag length is equal to 2 for both models.

After specifying the baseline ARDL model (Model 1), an F-test was applied to equation (2) to determine whether a cointegration relationship exists among the examined variables. According to the data presented in Table 4, Panel A, the F-statistic for the baseline model is 15.816. When this value is compared with the critical bounds of I(0) and I(1) at different significance levels, it is evident that the F-statistic exceeds the upper I(1) bound at all levels of significance. Accordingly, the null hypothesis (H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = 0$) is rejected, indicating the existence of a statistically significant long-run equilibrium relationship between the dependent and independent variables in the baseline model.

Table 3. Lag Selection for ARDL Models

Panel A: Model 1					
Lag	LR	FPE	AIC	SC	HQ
0	NA	0.512726	13.52120	13.76117	13.59256
1	120.8192	0.010760	9.619760	11.05958	10.04789
2	67.75888*	0.001229*	7.236682*	9.876350*	8.021594*
Panel B (Model 2)					
Lag	LR	FPE	AIC	SC	HQ
0	NA	0.002199	8.069594	8.309564	8.140950
1	101.1874	0.000118	5.102999	6.542818	5.531133
2	55.69383*	2.001150*	3.473987*	6.113654*	4.258898*

Notes: (1) Model 1 represents the baseline specification with lnAVA as the main independent variable, while Model 2 uses lnAVAPW as an alternative indicator. (2) The selected lag order, according to the criterion, is indicated by an asterisk (*). The LR test statistic, which is a sequentially modified likelihood ratio test, is performed at a significance level of 5%. FPE refers to the Final Prediction Error, while AIC stands for the Akaike Information Criterion. The abbreviation SC denotes the Schwarz Information Criterion, and HQ corresponds to the Hannan-Quinn Information Criterion.

Source: Authors' own calculations

Table 4. Bounds Test Results for the ARDL Models

Panel A: Model 1					
Estimated equity: EG=f(*ln*AVA, *ln*INV, *ln*TO, INF)					
Optimal lag: (1,1,1,0,2)					
Test Statistic	Value	k	Significant	I(0) Bound	I(1) Bound
F-statistic	15.816	4	10% 5% 2.5% 1%	2.45 2.86 3.25 3.74	3.52 4.01 4.49 5.06
Panel B: Model 2					
Estimated equity: EG=f(lnAVPW, lnINV, lnTO, INF)					
Optimal lag: (1,0,0,1,0)					
Test Statistic	Value	k	Significant	I(0) Bound	I(1) Bound
F-statistic	10.440	4	10% 5% 2.5% 1%	2.45 2.86 3.25 3.74	3.52 4.01 4.49 5.06

Source: Authors' own calculations

For the alternative model (Model 2), in which the primary independent variable lnAVA is replaced by the indicator lnAVAPW, the F-statistic amounts to 10.440 (Table 4, Panel B). This value also exceeds the upper I(1) bounds at all standard significance levels, confirming the presence of a long-run cointegration relationship in the alternative model as well. The result suggests that changing the main independent variable does not affect the fundamental conclusion regarding the long-run equilibrium among the examined variables.

Given the existence of a cointegration relationship among the variables in the examined models, the long-run coefficients were estimated using equation (3). The results for Model 1, presented in Table 5, Panel A, indicate that changes in the share of agricultural value added in GDP (lnAVA) are positively correlated with the growth rate of real GDP (EG). Specifically, in the long run, a 1% increase in lnAVA corresponds to an approximate 0.17 percentage point higher growth rate of real GDP, *ceteris paribus*. A similar result is confirmed in Model 2 (Table 5, Panel B), where a 1% increase in agricultural value added per worker (lnAVAPW) corresponds to a long-run increase in the real GDP growth rate of approximately 0.26 percentage points.

Estimates of the other long-run coefficients

Table 5. Estimated Long-run Coefficients in ARDL Models

Panel A: Model 1				
Dependent Variable: EG				
Regressor	Coefficient	Std. error	t-statistic	Probability
C	8.345	1.272	6.560	0.000
*ln*AVA	0.173	0.049	3.527	0.002
*ln*INV	0.171	0.024	6.840	0.000
*ln*TO	0.034	0.014	2.441	0.025
INF	-0.001	0.057	-0.031	0.975
Panel B: Model 2				
Dependent Variable: EG				
Regressor	Coefficient	Std. error	t-statistic	Probability
C	5.144	2.241	2.295	0.031
lnAVAPW	0.261	0.135	1.933	0.054
lnINV	0.617	0.201	3.069	0.005
lnTO	0.832	2.622	0.317	0.753
INF	0.036	0.033	1.090	0.296

Source: Authors' own calculations

indicate a positive and statistically significant relationship between the share of capital investments in GDP (lnINV) and the economic growth rate in both models. In Model 1, a positive and statistically significant relationship is also found between trade openness (lnTO) and economic growth, whereas in Model 2 this relationship is not statistically significant. The relationship between inflation (INF) and economic growth in the long run is statistically insignificant in both models.

These results suggest the existence of statistically significant relationships between long-run changes in the independent variables and GDP growth, highlighting the absolute importance of agriculture for economic growth, as well as its relative significance compared to the other variables considered.

The short-run coefficients in the ECM specified in equation (4) were subsequently estimated. The results, presented in Table 6, represent the estimates of the short-run coefficients within the ARDL(1,1,1,0,2) model (Model 1). The findings indicate that a 1% increase in the share of agricultural value added in GDP (ΔlnAVA) is associated with an increase in the real GDP growth rate of approximately 0.09 percentage points, *ceteris paribus*. This result is statistically significant at the 10% level, indicating a positive, though less robust, short-run effect.

A 1% increase in the share of capital investments in GDP (ΔlnINV) corresponds to an increase in the real GDP growth rate of about 0.22 percentage points. This result is highly statistically significant, suggesting that investments play a key role in stimulating economic growth in the short run, *ceteris paribus*. An increase of 1% in trade openness (ΔlnTO) is associated with a 0.06 percentage point rise in the real GDP growth rate. The change in the inflation rate in the current period (ΔINF) is not statistically significant, whereas inflation from the previous period (ΔINF(-1)) is negatively associated with the real GDP growth rate at the 10% significance level, which may indicate a delayed negative impact of inflation on economic growth.

The error correction coefficient is negative (ECM(-1) = -0.66) and statistically significant at the 1% level. A negative and statistically significant ECM coefficient confirms that the system adjusts toward long-run equilibrium following short-run deviations. Specifically, approximately 66% of the deviation of the real GDP growth rate from its long-run equilibrium in the previous period is corrected in the current period. This implies that the system returns to equilibrium within approximately 1.5 years (1/0.66), given that the coefficient lies within the interval between 0 and -1.

As shown in Table 6, the high coefficient of determination (R-squared = 0.857) indicates that Model 1 explains 85.7% of the total variability in the real GDP growth rate, thereby confirming its adequacy.

The results presented in Table 7 refer to the estimation of the short-run coefficients within the ARDL(1,0,0,1,0) model (Model 2). The findings indicate patterns similar to those observed in Model 1. Specifically, a 1% increase in agricultural value added per worker (ΔlnAVAPW) is associated with an increase in the real GDP growth rate of approximately 0.07 percentage points, and this effect is statistically significant at the 10% level. Although the magnitude of the effect is slightly lower than in Model 1, the sign and significance of the coefficient confirm that the agricultural sector has a positive, yet moderate, short-run relationship with economic growth.

As in the previous model, an increase in capital investments (ΔlnINV) shows a positive and statistically significant relationship with the economic growth rate, again highlighting the key role of investments in

Table 6. ARDL(1,1,1,0,2) Error Correction Model Estimation Results (Model 1)

Dependent Variable: ΔEG				
Regressor	Coefficient	Std. error	t-statistic	Probability
Δ*ln*AVA	0.095	0.051	1.759	0.098
Δ*ln*INV	0.223	0.044	5.068	0.000
Δ*ln*TO	0.057	0.024	2.375	0.033
ΔINF	0.003	0.041	0.073	0.942
ΔINF(-1)	-0.065	0.033	-1.969	0.068
ECM(-1)	-0.66	0.065	-10.153	0.000
Model Statistics				
R-squared	0.857		Akaike criterion	5.053
Adj. R-squared	0.781		Schwarz criterion	5.533
F-statistic	11.348		Hannan-Quinn criterion	5.196
Prob(F-statistic)	0.000		Durbin-Watson statistic	1.682

Source: Authors' own calculations

Table 7. ARDL(1,0,0,0,1) Error Correction Model Estimation Results (Model 2)

Dependent Variable: ΔEG				
Regressor	Coefficient	Std. error	t-statistic	Probability
Δ*ln*AVA	0.067	0.038	1.763	0.091
Δ*ln*INV	0.841	0.285	2.955	0.007
Δ*ln*TO	0.069	0.037	1.865	0.077
ΔINF	-0.035	0.047	-0.745	0.464
ECM(-1)	-0.56	0.075	-7.466	0.000
Model Statistics				
R-squared	0.673		Akaike criterion	5.270
Adj. R-squared	0.500		Schwarz criterion	5.750
F-statistic	3.895		Hannan-Quinn criterion	5.413
Prob(F-statistic)	0.007		Durbin-Watson statistic	1.947

Source: Authors' own calculations

sustaining short-run economic activity. Trade openness (ΔlnTO) also exhibits a positive relationship with economic growth, but at the 10% significance level. The change in the inflation rate (ΔINF) remains statistically insignificant, consistent with the findings from Model 1.

The error correction coefficient (ECM(-1) = -0.56) is negative and statistically significant, confirming the existence of a stable long-run equilibrium among the examined variables in this model as well. The negative sign of the ECM coefficient implies that approximately 56% of the deviation from the long-run equilibrium is corrected within the current period, indicating that the system returns to equilibrium over roughly 1.8 years (1/0.56).

The coefficient of determination (R-squared = 0.673) shows that Model 2 explains approximately 67.3% of the variability in the real GDP growth rate, which is lower compared to Model 1 (R-squared = 0.857). This difference is understandable given that Model 2 uses agricultural value added per worker, which measures sectoral productivity rather than its relative contribution to the economy, and therefore naturally accounts for a smaller portion of the variation in overall economic growth.

After presenting the key results, diagnostic tests were conducted for both models to verify the main econometric assumptions, including the absence of autocorrelation, the normality of residuals, the absence of heteroskedasticity, and the correct functional form specification.

The results of the diagnostic tests for Model 1 are presented in Table 8, Panel A. The presence of serial correlation was examined using the Breusch-Godfrey

Tabela 8. Diagnostic Tests

Panel A: Model 1				
Test	Specification	Test statistic	d.f.	Probability
Serial correlation	Breusch-Godfrey LM Test	1.40	(2,15)	0.277
Normality	Jarque-Bera	1.988	2	0.369
Heteroscedasticity	Breusch-Pagan-Godfrey ARCH	1.163 0.117	2 1	0.375 0.734
Functional form	Ramsey RESET Test	3.596	(1,12)	0.076
Panel B: Model 2				
Test	Specification	Test statistic	d.f.	Probability
Serial correlation	Breusch-Godfrey LM Test	1.21	(2,19)	0.317
Normality	Jarque-Bera	0.639	2	0.726
Heteroscedasticity	Breusch-Pagan-Godfrey ARCH	1.41 0.385	2 1	0.254 0.540
Functional form	Ramsey RESET Test	2.715	(1,16)	0.118

Source: Authors' own calculations

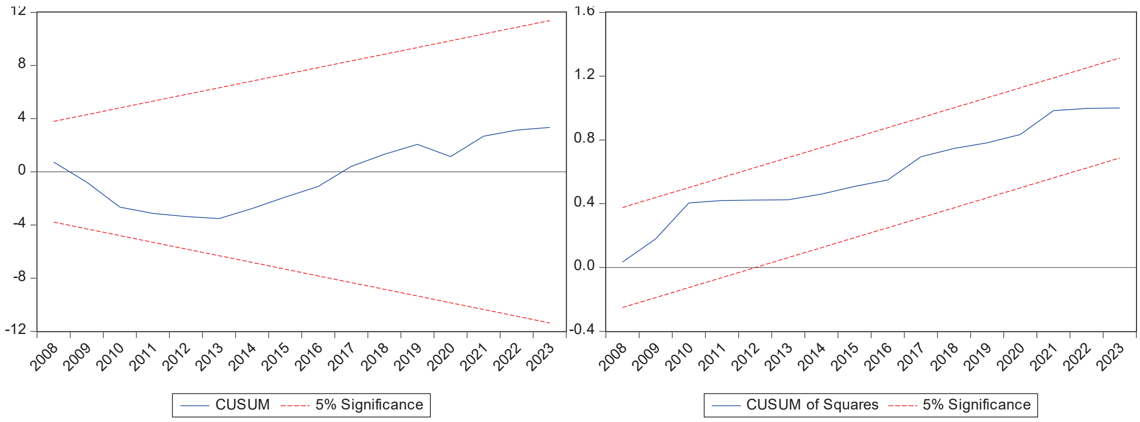
LM test. The test result, with a probability greater than 5%, indicates that serial correlation is not present in the model. The Jarque-Bera test was employed to assess the normality assumption of the residuals. A p-value greater than 5% confirms that the residuals are normally distributed. The Breusch-Pagan-Godfrey and Auto-Regressive Conditional Heteroskedasticity (ARCH) tests were applied to detect heteroskedasticity. Given that the p-values of both tests exceed 5%, it can be concluded that heteroskedasticity is not an issue in the model. The Ramsey RESET test was used to verify the correctness of the model specification. The test result, also with a probability above 5%, suggests that there are no specification errors in the model.

The diagnostic test results for Model 2 are presented in Table 8, Panel B. The results confirm that this model also satisfies the assumptions regarding autocorrelation, heteroskedasticity, and normality. The Ramsey RESET test, with a p-value of 0.118, indicates that the model's functional form is not problematic. Overall, the diagnostic results confirm that Model 2, as an alternative linear specification, provides robust support for the findings of Model 1, thereby increasing the reliability of the estimated effects.

The stability of the estimated parameters in Model 1 and Model 2 was examined using the Cumulative Sum (CUSUM) test and the Cumulative Sum of Squares (CUSUMSQ) test. The CUSUM and CUSUMSQ test plots for Model 1 are presented in Figure 1. The lower and upper dashed lines represent the 95% confidence bounds, while the solid lines denote the estimated parameters. Since the estimated parameters in both plots remain within the confidence bounds, it can be concluded that the parameters in Model 1 satisfy the stability condition at the 5% significance level over the observed period.

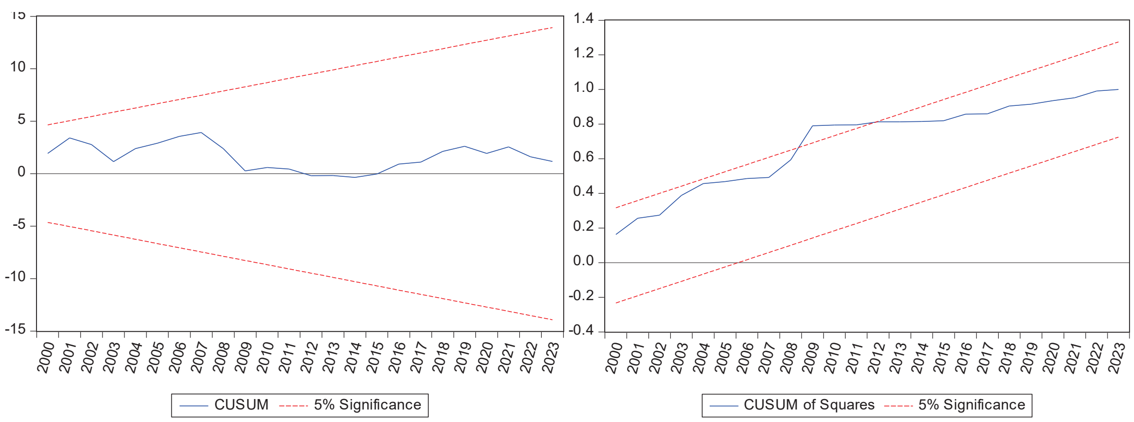
For Model 2, as shown in Figure 2, the parameter estimates in the CUSUM test remain within the confidence bounds. On the other hand, the CUSUM of Squares test shows a slight exceedance of the upper

Figure 1. Plots of CUSUM and CUSUM of Squares Tests (Model 1)



Source: Authors' own draft, 2025

Figure 2. Plots of CUSUM and CUSUM of Squares Tests (Model 2)



Source: Authors' own draft, 2025

critical bound around the middle of the sample, indicating a short period of parameter instability. Since this represents only a temporary fluctuation, Model 2 can be considered stable overall.

Considering that the short-run effect of agriculture is weaker and statistically less reliable, the findings suggest that agriculture primarily has a long-term significance for economic growth in Serbia. Although there are contextual differences, the results of this study are consistent with previous research (Mostefai 2024; Finco et al. 2021; Chebbi 2010) conducted for individual countries, which also confirm the long-term contribution of the agricultural sector to growth.

It is important to note, however, that the estimated short-run coefficients from the ECM model and the long-run coefficients derived from the ARDL model in this study indicate statistical associations between variables in both short-run and long-run dynamics, but do not imply causal relationships in a strict econometric sense. Establishing causality would require additional testing (e.g., the Granger causality test), which goes beyond the scope of this research.

5. Conclusion

This study aimed to examine the long-run and short-run relationships between agricultural value added and economic growth in Serbia. The growth rate of real GDP was used as the dependent variable, while gross agricultural value added, expressed as a percentage of GDP, served as the main explanatory variable. Control variables included capital investment (as a percentage of GDP), trade openness, and the inflation rate. The analysis of annual time-series data was conducted for the period 1995–2023 using the ARDL model. The results of the ARDL bounds test confirmed the existence of a long-run relationship among the variables. The analysis revealed that the association between the share of agricultural value added in GDP and the real GDP growth rate is positive and statistically significant, even as the agricultural sector's share gradually declines in overall GDP. Additionally, both capital investment and trade openness exhibit a positive and statistically significant long-run relationship with economic growth.

The short-run dynamics among the variables were examined using an ECM model based on the ARDL approach. The results indicate a positive and statistically significant relationship between the share of agricultural value added in GDP and economic growth in the short run. However, this finding is less robust, as significance is confirmed at the 10% level. In the short run, capital investment and trade openness also display positive and statistically significant relationships with economic growth. The negative and statistically significant error correction coefficient indicates that more than half of the short-term deviation in the real GDP growth rate is corrected within one year, confirming the existence of a stable long-run equilibrium among the observed variables.

To check the robustness of the results, an additional analysis was conducted in which agricultural value added per worker was used instead of the share of agricultural value added in GDP. The results of the alternative ARDL/ECM model showed similar signs and levels of statistical significance for the main coefficients, while the error correction coefficient remained negative and statistically significant, confirming the existence of a long-run relationship.

Comparison of the results from the baseline and alternative models indicates that changes in the measurement of agricultural activity do not significantly affect the main findings, further confirming the robustness of the results.

The findings have important implications for economic policy in Serbia. Given that agricultural value added is positively and statistically significantly associated with economic growth in both the short and long run, sectoral policies should be designed to promote improvements in the productivity and sustainability of the agricultural sector. Particular attention should be directed toward the efficient use of underutilized resources and the adoption of modern technologies in agriculture, supported by appropriate financial support mechanisms provided by the government. Addressing climate change and environmental degradation poses additional challenges that complicate strategic planning and require integrated approaches encompassing ecological, economic, and social dimensions of agricultural development. Furthermore, it is essential that agricultural sector policy be aligned with other sectoral policies in order to achieve synergistic effects. This is particularly important considering that there is currently no active agricultural development strategy, as the previous Strategy for Agriculture and Rural Development covered the period from 2014 to 2024.

This study has certain limitations that may serve as a basis for future research. First, the obtained results should be interpreted with caution, given that agricultural value added is expressed as a share of GDP, which raises the possibility of endogeneity and a denominator effect. In other words, changes in non-agricultural sectors can mechanically affect this share even when agricultural output remains unchanged. However, as noted earlier, the robustness of the findings was verified through an alternative model specification using agricultural value added per worker. In this case, the results were consistent, confirming the stability of the main findings. Furthermore, although a long-term relationship between agricultural value added and economic growth has been confirmed, this study does not establish causality. The results indicate the presence of a correlation, but not the direction of causal influence.

One of the limitations relates to the potential for bias due to omitted variables, given that the number of available observations in the sample is relatively small. Therefore, it would be beneficial to consider additional variables, such as employment in agriculture, the share of the rural population in total population, agricultural exports, as well as subsidies and public investments in agriculture. A new study incorporating a broader set of variables and a longer time horizon would provide an opportunity for a more precise assessment of the impact of agricultural production on the dynamics of overall economic activity in Serbia.

Furthermore, the use of aggregate macroeconomic data does not allow for an insight into regional disparities and the specific characteristics of different subsectors within agriculture, which may obscure significant variations in the contribution of various parts of the agricultural sector to economic growth. For this reason, one of the future research directions could be a micro-level analysis, aimed at examining the effects of individual agricultural subsectors or types of production on economic growth. In addition, a comparative analysis of Serbia with countries that share a similar economic structure could reveal further specificities and offer guidance for a more effective design of development policies in the agricultural sector.

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