AGRICULTURE AND ECONOMIC GROWTH: THE EU 27 RECORD FROM 2002 TO 2021

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ABSTRACT

The aim of this paper is to analyze the contribution of the agricultural sector to the European Union member states' economic growth in the period from 2002 to 2021. This paper makes an attempt to answer the question of whether the agricultural sector contributes to the economic growth of the European Union countries, in terms of incentives that their governments give to the agricultural sector. For this purpose, a multiple regression model is developed with one dependent and several independent variables, and the obtained research results show a positive influence of the agricultural sector, expressed through agricultural production, on economic growth rate of EU 27 countries in the analyzed period.

Introduction

The agricultural sector represents an important economic segment of many countries. Its contribution to economic growth and development is not the same in all countries. It largely depends on country's level of economic growth. In this regard, numerous theories of economic growth have been created, which look at economic growth, i.e. economic growth factors, from different standpoints. The past thirty years have seen radical changes in the agricultural sector, where the application of technological innovations and the concept of sustainable development occupy a significant place. What is more, the relationship between agriculture and economic growth has been the subject of a large number of studies. The focus of these studies are the countries of Asia and Africa, as well as some European countries. However, there are no comprehensive studies that would include the countries of the European Union. In order to fill this research niche, this paper tries to analyze the relationship between agriculture and the economic growth of

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the European Union countries in the period from 2002 to 2021. The paper is divided into two parts. The first part gives an overview of literature covering theoretical-empirical research on the relationship between agriculture and economic growth. It summarizes the results of the most significant studies dealing with this issue. Proceeding from the identified research gap, the second part develops research methodology, hypotheses and sample, which includes EU27 countries. A multiple regression model is developed, with one independent and several dependent variables. The model also includes the effect of the COVID 19 pandemic crisis. The obtained research results show the positive impact of the agricultural sector on the economic growth of the EU27 countries.

Literature review

The importance of agriculture in economic development varies from country to country. In other words, the role of agriculture in economic development depends on a country's level of economic growth. Thus, for underdeveloped countries in initial development stages, agriculture is of great importance. The population and labor force structure in underdeveloped countries prove this, given the high share of agricultural population and agricultural labor force. Agriculture is becoming the dominant form of production in these countries (Božić et al., 2011).

Therefore, the relationship between agriculture and economic growth has been the subject of a large number of studies, which differ from each other in terms of methodology, content, as well as standpoints and recommendations for further research. Bearing in mind the previously presented economic growth models, studying this relationship attracted and attracts economists wishing to identify the factors and perspectives of economic growth and development (Humphries & Knowles, 1998). All this points to the fact that the agricultural sector had and still has a key place in global economic development. From a historical point of view, pre-industrial economies had a large share of agriculture in total active population, and this population is characterized by low labor productivity. In this context, Lewis (1955) points to the presence of surplus labor as a prerequisite for the growth of other economic sectors. In this way, as he says, the agricultural sector is a source of labor (and capital) that can be redirected to other economic sectors in order to stimulate their production growth. Based on these research results, further research indicates that the transfer of labor force from the American agricultural sector to other more productive sectors, after World War II, was the main factor in the US economic growth until the 1970s (Denison, 1985). Similar results come from research related to Japan (Ōkawa & Rosovsky, 1973) and Europe (Johnson, 1997). Furthermore, a large number of authors come to the conclusion that high productivity growth in agriculture is a fundamental factor to achieve economic development in many countries (Johnston & Mellor, 1961; Rostow, 1959). Johnston (1991) estimates that the average rate of labor productivity growth in industrial countries in the post-war period up to 1980 was 4.3% per year, compared to 2.6% in other economic sectors.

Given that previous studies point to the importance of productivity boost in agriculture, all subsequent studies focus on the factors that generate technical changes

in agriculture, which ultimately lead to higher productivity. Thus, Hayami & Ruttan (1971) and Binswanger & Ruttan (1978) develop the concept of the so-called induced technical change, where the higher cost of labor in the rest of the economy encourages the development of labor-saving technology in agriculture. These authors specifically identify the importance of technology in agriculture, which, on the other hand, depends on resources some countries have. Thus, Dimitri et al. (2005) analyze these tendencies looking at the US agricultural sector. In 1900, 41% of the total labor force worked in the agricultural sector, and this share decreased to 16% in 1945 and 4% in 1970. Total factor productivity in US agriculture grew at an average annual rate of 1.5% from 1948 to 2008, which is four times higher than productivity growth in the rest of the economy.

As we can see, all these studies primarily analyze productivity in the agricultural sector, which should lead to economic growth. Furthermore, a large number of researchers, analyzing the relationship between agriculture and economic growth, focus on developing countries, i.e. the countries of Asia and Africa, where, by nature, agriculture is one of the most important economic sectors.

So, Phiri et al. (2020) conclude that despite the positive impact of agriculture on Zambia's economic growth, it faces enormous challenges. First of all, this refers to the migration of the labor force, especially the educated people, towards the increasingly important service sectors. On the other hand, this has led to a decrease in the share of agriculture in GDP, and, thus, to overall economic growth. An additional challenge facing the agricultural sector in Zambia, according to this group of authors, relates to the impact of droughts and adverse weather conditions on agriculture. This study has shown that, with the enormous potential of agriculture in Zambia, its economic and social benefits to the country and the region as a whole can be more significant. Steenkamp et al. (2020) conclude that agriculture plays an important role in solving the problem of unemployment and economic growth in the countries of South Africa. Through the analysis of international best practices, these authors provide insight into how the government can support the agricultural sector by implementing various measures, such as: financial assistance, adequate agricultural insurance, improving the advisory role for farmers, as well as investing in the implementation of various innovative solutions in agriculture.

Agriculture is the driver of India's economic development, as theoretical and empirical studies show (Khan et al., 2019). However, the share of agriculture has been declining since 2000. Despite the decline in the share of agriculture in GDP and expenditure on agriculture, cereal production has seen impressive growth in India. In particular, research has shown that agriculture has a long-term relationship with the industrial and service sectors, that is, that the growth of the agricultural sector leads to the growth of other sectors and the overall economy.

Similar research was conducted in Nigeria, and results show that certain sub-sectors of agriculture, such as fisheries, forestry, livestock and grain production, have a significant impact on economic growth (Agboola et al., 2022). The results highlight the importance

of agricultural development in order to achieve long-term sustainable economic growth. The relationship between agriculture and economic growth has also been studied in Pakistan (Nadia et al., 2020), where the focus was on value added in production, value added in agriculture and economic growth. To conclude, if economic policy measures are aimed at value added in production and value added in agriculture, it will have positive effects on long-term economic growth. Also, the relationship between agriculture and economic growth was studied in Tunisia (Abdelhafidh & Bakari, 2019), but in terms of investment in agriculture. Research results show that investments in agriculture are a fundamental and strong source of economic growth in Tunisia, which is why the state should implement various measures to further encourage investments in agricultural sector. Such conclusions also come from the study on the relationship between agriculture and economic growth of sub-Saharan African countries (Runganga & Mhaka, 2021). The results of this study show that agriculture is the driver of economic growth, in the short term, and that it should be supported by macroeconomic policy measures in order to bring long-term economic growth.

The previous overview of studies on the relationship between agriculture and economic growth confirms the previously stated thesis that this relationship was mainly analyzed in different African and Asian countries. A small number of researchers have dealt with the issue of this relationship in developed countries (Awokuse & Xie, 2015), especially the EU countries. In this way, the research question is whether the agricultural sector contributes to EU countries' economic growth, in terms of incentives that their governments give to the agricultural sector.

Research methodology, hypotheses and data

Taking into account the result of theoretic and empirical research, the research question relates to whether agriculture production in the EU27 has an adequate contribution to the dynamics of economic growth? In accordance with this research question, null and alternative hypotheses have been formed. The null hypothesis is – H0: Agriculture production in the EU27 has no positive impact on the dynamics of economic growth. Alternative hypothesis H1: Agriculture production in the EU27 has a positive impact on the dynamics of economic growth. To give an answer to this research question, it is necessary to define the timeframe of analysis, select the research methods and parameters to be observed. The aim is to observe the EU27 countries in the period from 2002 to 2021. This twenty-year period is sufficiently long to provide for valid observation results, and also represents a period in which there was an expansion and contraction of the level of economic activity, so that it takes into account the reality of the cyclical nature of economic activity.

As regards the research method, multiple regression is chosen. Multiple linear regression is the most common form of linear regression analysis. As a predictive analysis, the multiple linear regression is used to explain the relationship between one continuous dependent variable and two or more independent variables. Parameters to be observed in the defined time period have been adjusted to the research question. In this regard, the dynamics of economic activity is analyzed using the real GDP growth rate, as a significant aggregate macroeconomic indicator. This value will, in this study, stand for the dependent variable.

On the other hand, the independent variable will be the one that represents the agriculture production in the selected countries. This is undoubtedly agriculture production as a % GDP. Besides the dependent and independent variables, multiple regression also requires the control variables. This study focuses on the two such variables, which, without any doubt, have an impact on the dynamics of economic activity, namely the real economic growth rate.

The first control variable is final consumption expenditure of general government % GDP. The choice of this control variable is the result of the fact that, final consumption expenditure of general government are close correlated with economic activities in agriculture sector. At the same time final consumption expenditure of general government during observation period were topic of critics for unsustainable government budget deficits in EU countries and main constrain for further economic growth. The second control variable is the Gross fixed capital formation (investments) %GDP. The third control variable is COVID-19 crisis that occurred in the period analyzed, whose omission would reduce the validity of the findings in this study. The COVID-19 is constructed as an artificial binary variable (dummy). 2020 year is marked as the crisis years. In this year, in the countries studied, the dummy variable value is 1, while in other years, when there was no financial crisis, the value of this variable is 0. All data is taken from Eurostat and presented in the annex to this work. We emphasize that we are focus on COVID-19 crisis as variable.

As already mentioned, multiple regression model will be used to analyze the 27 EU countries, so the number of countries shall be presented as $i = 1, ...27$. These countries are observed over a period of 20 years, $t = 1, ...20$. The regression model is as follows:

$$y_{it} = \alpha + x_{it}'\beta + c_i + u_{it} \quad (1)$$

where y_{it} is the dependent variable, α is the constant, x_{it}' is K-dimensional row vector which is related to the independent and control variables, β is K-dimensional column vector of parameters with the independent and control variables, c_i is the effect of the specificity of the observed economy and u_{it} represents the residual. If the number of years analyzed is 20, then T = 20, so all observations for each country are summarized by the following matrix:

Dependent variable y_i is presented by using the following matrix:

$$y_i = \begin{bmatrix} y_{i1} \\ . \\ . \\ y_{i5} \\ . \\ . \\ y_{i20} \end{bmatrix}, \; y_i = [20 \times 1]$$

For independent and control variables X_i, the matrix is as follows:

$$X_i = \begin{bmatrix} \acute{x}_{i1} \\ . \\ . \\ \acute{x}_{i5} \\ . \\ . \\ \acute{x}_{i20} \end{bmatrix}, \; X_i = [20 \times 4]$$, as the focus of analysis is on 4 variables

(one independent and three control) in the regression model, so the number of K dimensions in this case is 4.

The matrix of residual in the analyzed model is:

$$u_i = \begin{bmatrix} u_{i1} \\ . \\ . \\ u_{i5} \\ . \\ . \\ u_{i20} \end{bmatrix}, \quad u_i = [20 \times 1]$$

If the last of the countries analyzed *i* is marked by $N, and \; (N = 27)$ and the last year analyzed *t* is marked by $T, and \; (T = 20)$, then NT will mark all observations in all countries over the entire observation period, namely: dependent variable *y* is presented in the form of the matrix

$$y = \begin{bmatrix} y_1 \\ . \\ . \\ y_i \\ : \\ y_{27} \end{bmatrix}, \text{of order } y = [NT \times 1]$$

Independent and control variables X are presented in the form of the matrix:

$$X = \begin{bmatrix} X_1 \\ . \\ . \\ X_i \\ : \\ X_{27} \end{bmatrix}, \text{ of order } X = [NT \times K].$$

Residual u_i is presented in the form of the matrix:

$$u = \begin{bmatrix} u_1 \\ . \\ . \\ u_3 \\ : \\ u_{20} \end{bmatrix}, \text{of order } u = [20 \times 1]$$

.

The question that arises in the model shown in equation (1) is whether there is correlation between the residual u_{it} (containing the specific effect of the observed country c_i), on one side, and independent and control variables, on the other side. Speaking in mathematical terms, the question is whether $E = (u_{it}|X_i, c_i) = 0$, when there is no correlation, or $E = (u_{it}|X_i, c_i) \neq 0$, when there is correlation.

In theoretical terms, this is a multiple regression model with random or fixed effects (Schmidheiny, 2015). Multiple random-effect model in this particular case would imply that the specificity of the observed country marked by c_i is not correlated with the independent and control variables, and that it changes over time independently of the country. This is an extremely rigorous assumption that is very rarely applied by economists in such research. Multiple fixed-effect model implies that the specificity of the observed country can be correlated with the independent and control variables, and that it does not change with the passage of time, i.e. that it reflects the specifics of business and system environment, characteristic of each country. This assumption is much more realistic and more prevalent in macroeconomic research. In the present study, multiple fixed-effect model has been chosen, with the implementation of adequate statistical tests to check its validity in relation to the random-effect model.

Results and discussion

The analysis starts by descriptive statistics, in order to assess the connection between the analyzed variables. Results of descriptive statistics are shown in Table 1.

Table 1. Descriptive statistics and names of variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
Real GDP growth rate	540	.0219333	.0390993	-.177	.252
Agriculture production as % GDP	540	.0411168	.0272961	0	.21467
Final consumption expenditure of general government % GDP	540	.1970587	.0338316	.1122844	.27935
Gross fixed capital formation (investments) %GDP	540	.2140759	.0423539	.106	.536
Dummy	540	.05	.218147	0	1

Source: Authors' calculations

The results show that, among the 27 countries surveyed in the eight-year period, there is a significant standard deviation of the real economic growth rate, several times the average value. On the other hand, the case with independent variable is opposite. This fact has been a further research challenge to prove the importance of agriculture production for economic growth in the countries studied. What follows is the presentation of the correlation matrix between dependent, independent, and control variables.

Table 2. Correlation matrix between independent variable and predictors

Variable	Real GDP growth rate	Agriculture production as % GDP	Final consumption expenditure of general government % GDP	Gross fixed capital formation (investments) %GDP	Dummy
Real GDP growth rate	1.0000				
Agriculture production as % GDP	0.1280	1.0000			
Final consumption expenditure of general government % GDP	-0.2759	-0.3598	1.0000		
Gross fixed capital formation (investments) %GDP	0.2983	0.0847	-0.1753	1.0000	
Dummy	-0.4042	-0.0449	0.0884	0.0496	1.0000

Source: Authors' calculations

Results in Table 2 show that among the variables there is no significant correlation, which is extremely important for the application of multiple regression model. It is interesting that between the dependent and independent variables there is a very weak correlation, which further complicates the research question, but also confirms the proper approach in choosing the research method. The results of the selected research method, multiple regression with fixed effect, are shown in the following table.

Table 3. Multiple regression using fixed effect model

Fixed-effects (within) regression	Number of obs 540
R-sq: within =0.2982	Number of groups= 27
between=0.3759	Obs per group: min=20
overall=0.2534	avg=20
	max=20
	F (3,509)=54,06
corr (u_i, Xb)= -0.5623	Prob > F= 0.0000

Real GDP growth rate	**Coef.**	**Std. Err.**	**t**	**P > | t |**	**[95% Conf. Interval**	
Agriculture production as % GDP	.2474049	.1230462	2.01	0.045	.005664	.4891458
Final consumption expenditure of general government % GDP	-.4793007	.1096693	-4.37	0.000	-.6947608	-.2638405
Gross fixed capital formation (investments) %GDP	.2564649	.0423044	6.06	0.000	.1733521	.3395776
Dummy	-.0669529	.0065413	-10.24	0.000	-.0798042	-.0541016
_cons	.0546559	.0268875	2.03	0.043	.0018317	.10748
sigma_u	.01646069					
sigma_e	.03192857					
rho	.209979	(fraction of variation due to u_i)				
F test that all u_i=0: F(26, 509) = 2.18 Prob > F = 0.0008						

Source: Authors' calculations

The results in Table 3 show that independent and control variables in the model are statistically significant. F test statistics has an adequate level of probability, which shows that all coefficients of variables are different from zero, and have an impact on the dependent variable (in this case, real economic growth rate). It should also be noted that the correlation between variables (independent and control) and residual is different from zero, in this case -0.5623. Its negative value shows that the variables were properly introduced into the constructed model. More specifically, if the independent and control variables effectively determine the value of the dependent variable, then the value of residual (statistical error) is less. Based on the above, it can be concluded that the econometric model is adequate, and reads:

$$(Real\ GDP growth\ rate)_{it} = 0{,}247(Agriculture\ production\ as\ \%\ GDP)_{it} - 0{,}479(Final\ consumption\ expenditure\ of\ general\ government\ \%\ GDP) 0{,}256\ (Gross\ fixed\ capital\ formation\ (investments)\ \%GDP)_{it} - 0{,}067(Dummy)_{it} + 0{,}546 + c_i + u_{it} \quad (2)$$

The results of the model shown in equation 2 point to the conclusion that, by applying *ceteris paribus* clause (with other circumstances unchanged), if a country in the EU27 in one year increases the agriculture production as a % of GDP for one percentage point, it causes increase in real economic growth rate in that year by 24,7 percentage points. The present model is in line with theoretical postulates and the starting hypothesis. The presented model has a coefficient of determination R = 0.3759, which means that it is valid in 37.59% of observations in the EU27 in the period from 2002 to 2021. This has unequivocally confirmed the alternative hypothesis H1.

Hausman test for Endogeneity of the Model

The constructed multiple regression model has started from the assumption that there is a correlation between the residual u_{it} (containing the specific effect of the observed country c_i), on one side, and the independent and control variables, on the other side. Speaking in mathematical terms, $E = (u_{it}|X_i, c_i) \neq 0$. More specifically, multiple regression model with fixed effect has been designed. This means that the specificities of the observed countries have an endogenous character, i.e. represent the internal determinant of real economic growth rate, and are correlated with the independent and control variables. To verify the validity of this assumption, and, therefore, the constructed econometric model, Hausman test is applied. The null hypothesis in this test states that there is no correlation between the residual u_{it} (containing the specific effect of the observed country c_i), on one side, and the independent and control variables, on the other side. In other words, random-effect model should be used. An alternative hypothesis is that the correlation does exist, and that it is a fixed-effect model that is adequate. For this purpose, the random-effect model has been constructed (Table 4), and the test results are presented in Table 5.

Table 4. Regression using random effect

Fixed-effects (within) regression			Number of obs=540			
R-sq: within=0.2982			Number of groups=27			
between=0.3759			Obs per group: min=20			
overall=0.2534			avg=20			
			max=20			
			F (3,509)=54,06			
corr (u_i, Xb)= -0.5623			Prob > F= 0.0000			
Real GDP growth rate	**Coef.**	**Std. Err.**	**z**	**P > | z |**	**[95% Conf. Interval**	
Agriculture production as % GDP	.0504913	.0693423	0.73	0.467	-.0854172	.1863997
Final consumption expenditure of general government % GDP	-.2400944	.0575645	-4.17	0.000	-.3529187	-.1272701

Gross fixed capital formation (investments) %GDP	.2663691	.0366096	7.28	0.000	.1946157	.3381225
Dummy	-.0714343	.0064126	-11.14	0.000	-.0840028	-.0588658
_cons	.0137185	.016016	0.86	0.392	-.0176722	.0451092
sigma_u	.00692184					
sigma_e	.03192857					
rho	.04488886	(fraction of variation due to u_i)				

Source: Authors' calculations

Table 5. Hausman test result

	- Coeficients -			
	(b) fixed	(B) random	(b-B) Difference	Sqrt (diag (V_b-V_B)) S.E.
Agriculture production as % GDP	.2474049	.0504913	.1969136	.1016465
Final consumption expenditure of general government % GDP	-.4793007	-.2400944	-.2392063	.0933471
Gross fixed capital formation (investments) %GDP	.2564649	.2663691	-.0099042	.0211992
Dummy	-.0669529	-.0714343	.0044814	.0012912
b = consistend under Ho and Ha; obrained from xtreg **B = incosistent under Ha, efficient under Ho; obrained from xtreb** **Test: Ho: difference in coefficients not systematic** **chi2 (4) = (b-B) ` [(V_b-V_B) ^ (-1)] (b-B) = 10.72** **Prob>chi2 = 0.0298** **(V_b-V_B is positive definite)**				

Source: Authors' calculations

The result of Hausman test with a probability of 97,2% rejects the null hypothesis, based on which the random-effect model is more appropriate. This clearly suggests that the alternative hypothesis is confirmed. More specifically, there is a correlation between the residual u_{it} (containing the specific effect of the observed country c_i), on one side, and the independent and control variables, on the other side. Speaking in mathematical terms, $E = (u_{it}|X_i, c_i) \neq 0$. This means that the constructed multiple regression fixed-effect model is entirely acceptable.

The research carried out clearly suggests that the increase economic activities in agriculture sector has a significant positive impact on the real rate of economic growth in the EU27 countries from 2002 to 2021.

Conclusion

Research on the relationship between agriculture and economic growth attracted and still attracts a large number of researchers. Agriculture itself occupies a significant

place in the economies of a number of countries, and its contribution to the economy is conditioned by the achieved level of economic growth. In this regard, a large number of economic growth theories have been developed. The fact of particular interest is that in recent years agriculture itself has experienced significant changes as a direct consequence of technological innovations and the concept of sustainable development. Thus, more and more people are talking about multi-functional agriculture. As research on the relationship between agriculture and economic growth mainly focuses on the countries of Asia and Africa, as well as some European countries, note that no comprehensive research has been conducted that would include the EU countries. In order to fill this research niche, the aim of this paper was to analyze the relationship between agriculture and economic growth in EU27 countries, for the time period from 2002 to 2021. This reflects the scientific contribution of this paper. The paper gave a theoretical analysis of the most significant studies on the relationship between agriculture and economic growth. The second part of the paper developed an exploratory multiple regression model with dependent and independent variables, with a focus on EU27 data. The results showed a positive influence of agriculture on the economic growth of the EU27 countries in the analyzed time period. However, this research also has certain limitations that primarily relate to the time period, which could be broader, as well as the inclusion of dependent variables.

Conflict of interests

The authors of this study have no conflict of interest.

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