Research of Factors of Development of Agriculture In Ukraine: Methodical Approach on The Basis of Econometric Modeling

Yuriy Danko[1,*], Olena Nifatova[2], Volodymyr Orel[3], Valeryy Zhmailov[3] and Tetiana Lutska[4]

[1]*Research department, Sumy National Agrarian University, Ukraine.*
[2]*Barselona Economic Analysis Team, Universitat de Barcelona, Spain.*
[3]*Department of Marketing and Logistics, Sumy National Agrarian University, Ukraine.*
[4]*Economics and Law Departmen, National university of food technologies, Ukraine.*

Abstract: The article examines the factors of agricultural development in Ukraine. The study of agricultural production growth reserves was carried out using the production function as a basis for modeling economic development. Considering that the income of the industry is formed under the influence of a combination of factors of extensive and intensive growth, we conducted a correlation and regression analysis of the impact of groups of selected factors on the economic growth of agricultural production.

The result of the decomposition of the general variation of the real output of agricultural products of Ukraine into factors made it possible to draw the following conclusion: the potential for extensive growth of agricultural production by attracting additional land and human resources is exhausted. At the present stage of development of agriculture in Ukraine, the main factor in the growth of real agricultural output is to increase productivity

Keywords: Agriculture, development factors, modeling.

INTRODUCTION

In order to fully meet domestic needs in the main types of food products and simultaneously increase the presence of Ukrainian agricultural products on the world market, the only and unalterable condition is to ensure sufficient growth rates of real agricultural production. At present, the actual pace of such growth does not allow for the achievement of two essentially contradictory goals. The average annual growth rate of real agricultural production over the past 20 years is 116%. The absolute value of the average annual growth rate of real agricultural production is UAH 43,2 billion. Thus, to meet the domestic needs of the population in scarce foods (meat and meat products, milk and dairy products, fish and fish products, fruits, berries and grapes), the absolute value of the average annual growth rate of real agricultural production should increase at least 2,4 times - up to UAH 102,9 billion. (59,07 (billion UAH) + 43,2 (billion UAH).

Issues of sustainable development of agricultural production have always been relevant and studied by many scientists. The prevailing view of many researchers is that the goal of economic growth for the agricultural sector can be achieved by stimulating three main factors: capital, labour and total productivity of capital and labour [1-6]. In addition to these factors, some researchers agree that agricultural policy focuses on sustainable food security, increasing agricultural productivity, import substitution and income diversification [7, 8], which in turn expands the range of economic factors. development of the agricultural sector. Within this point of view, diversified agricultural systems become a model that includes factors that make diverse rural systems economically attractive [8-10]. Today scientific research of modelling of quantitative parameters of influence of key factors of growth of agricultural production become actual.

*Address correspondence to this author at the Research department, Sumy National Agrarian University, Ukraine. E-mail: yuriy.i.danko@gmail.com

RESEARCH METHODOLOGY

The study of reserves for the growth of agricultural production should be based on a proven methodology that will ensure the formation of sound conclusions. In our opinion, such a technique is a production function. After all, the production function is the simplest model of economic growth.

The production function is the dependence of the final output or its value on the use of various factors of production, specific types of resources and costs, presented in mathematical form [11].

The convenience of the production function is that it can be used at all economic levels - from macroeconomic, where it reflects of total production on available factors of production, to the mesoeconomic and up to the microeconomic level, where each firm has its own, different from others business entities, production function. It also means that the production function can be applied to certain sectors of the economy and industries [12].

In the analytical format, the most common type of production function is as follows:

$$Q = f(K, L) \quad (1),$$

Table 1 Initial Data for Econometric Modeling of Dependence of Change of Real Volumes of Agricultural Production of Ukraine on Change of Extensive and Intensive Factors.

Year	Y	x_1	x_2	x_3	x_4
	The Real Issue of Agriculture Products, UAH Million.	Employed in Agriculture. Production, Thousand People	Real Value of Fixed Assets, UAH million.	Sown areas of agriculture crops, thousand hectares	Labor productivity, agricultural production products per 1 employee, at constant prices in 2010; UAH.
2001	63607,6	4148,1	84747,7	27928	34566,8
2002	76546,9	4135,8	81853,8	27539	40719,7
2003	55225,5	4105,7	72069,3	25081	37991,5
2004	81566,7	3998,3	65435,4	26752	63369,9
2005	88362,6	4005,5	61268,3	26044	72621,9
2006	96830,1	4036,9	65718,9	25928	83878,9
2007	82631,2	3973,0	64314,3	26060	88576,1
2008	142527,7	3322,1	74325,6	27133	127372,5
2009	149611,8	3152,2	91640,3	26990	131332,0
2010	145671,5	3115,6	99725,6	26952	132680,4
2011	223138,2	3410,3	103344,1	27670	165229,0
2012	245044,0	3496,0	127444,4	27801	159679,0
2013	316166,8	3577,5	145573,3	28329	201216,9
2014	306699,1	3091,4	144333,9	27239	227753,4
2015	361675,1	2870,6	148002,2	26902	223309,9
2016	601439,4	2866,5	226181,9	27026	275317,8
2017	652333,6	2860,7	274613,4	27585	271491,4
2018	797777,7	2937,6	346209,7	27699	313627,3

where: *Q - production volume;*

K - amount of capital;

L - the amount of work.

This is a two-factor model in which the volume of production and income is a function of the amount of capital and labour.

The production function can be three-factor:

Q = E f(K, L) (2),

where: E is the factor of the level of basic technology.

In addition to the main sources of economic growth, multifactorial production functions take into account the influence of institutional, foreign economic and other factors.

In approaching the identification of quantitative parameters of the relationship of the production function of the agricultural sector with the existing factors of production, we take as a basis for the study the approach according to which industry income is formed under the influence of a combination of extensive and intensive factors.

Extensive growth factors of agricultural production form the group in which we have included:

1) x_1 – living labour costs (employed in agricultural production, thousand people);

2) x_2 – costs of materialized labour (real value of fixed assets in agriculture, UAH mln.);

3) x_3 – land costs (sown area of crops, thousand hectares).

Modelling the dependence of the level of capital adequacy on individual factors

Intensive factors of production are represented by one factor x_4 - labor productivity (production of agricultural products per 1 employee, UAH; at constant prices in 2010). As a function *(Y)* took the actual output of agricultural products (million UAH) (Table **1**).

Table 2. Decomposition of the General Variation of the Real Output of Agricultural Products of Ukraine into Factors.

Factor	Paired Coefficient Correlations, r_{yx_i}	β- Coefficient, β_{x_i}	Per cent, % ($r_{yx_i} \cdot \beta_{x_i} \cdot 100\%$)
The cost of living labor (x_1)	-0,053671857	0,006309511	-0,03
The cost of materialized labor (x_2)	0,43214531	0,424542242	18,35
Land costs (x_3)	0,45736732	0,131713809	6,02
Productivity (x_4)	0,73747645	0,746427146	55,05

Regression analysis showed a high, almost linear relationship between function and factors - R = 0,995467. However, correlation analysis revealed multicollinearity between regressors x_1 та x_2, x_1 and x_4, x_2 and x_4 here is a high degree of correlation [13] ($r_{x_i x_j} \to 1, i \neq j$), which distorts the studied relationship between function and factors and makes the regression model unstable.

In order to eliminate multicollinearity, we performed a series of calculations:

1) listed the actual values of the studied features and presented them as indicators of relative change (in% to the previous year). The construction of the correlation matrix revealed multi-collinearity - an excessive degree of connection between the regressors x_3 and x_4;

2) adopted the actual values of the studied features in 2001. for 100% and determined their relative changes in other periods, using 2001. as a basis for comparison. The construction of the correlation matrix revealed multicollinearity - an excessive degree of connection between all regressors;

3) for dynamic series of actual values of the functional feature and factors x_1, x_2 and x_3 we listed the actual values of the studied features and presented them as indicators of relative change (in% to the previous year); for factor x_4 we took the actual values of the studied features in 2001. 100% and determined their relative changes in other periods, using 2001 as a basis for comparison. The construction of the correlation matrix revealed multicollinearity - an excessive degree of connection between the regressors x_2 and x_4.

Finally, the following approach gave a positive result for the time series of actual values of the functional trait and factors x_1, x_2 and x_4 we listed the actual values of the studied traits and presented them as indicators of relative change (in% to the previous year); for factor x_3 we took the actual values of the studied features in 2001 for 100% and determined their relative changes in other periods, using 2001, as a basis for comparison.

We supplemented the correlation analysis with regression and obtained the following results

1) the correlation coefficient is 0,891, so the closeness of the connection is high;

2) the coefficient of determination is 0,794, therefore, the variability of the function by 79,4% is determined by the variability of the selected factors;

3) Fisher criterion: $F_ф$ = 11,552, $F_к$ = 3,259; $F_ф > F_к$, therefore, the null hypothesis that there is no relationship between the indicators is rejected - the model is adequate to reality;

4) Student criterion: $t_ф$ = 14,974, $t_к$ = 2,179; $t_ф > t_к$, therefore, the null hypothesis about the insignificance of the regression coefficient is rejected - it is statistically significant;

5) Darbin-Watson criterion: $DW_ф$ = 2,344, DW_1 = 0,78, DW_2 = 1,9; $DW_ф > DW_2$, therefore, the hypothesis of no autocorrelation of residues is accepted;

6) χ^2- Pearson criterion: $\chi^2_ф$ = 4,859, $\chi^2_к$= 12,592; $\chi^2_ф < \chi^2_к$, therefore, in the array of regressors multicollinearity is absent;

7) regression equation: $Y = -207{,}37 + 0{,}028x_1 + 0{,}712x_2 + 1{,}233x_3 + 1{,}097x_4 + e$.

To determine the weight fraction of the influence of each of the factors on the variability of the resultant trait, the decomposition of the general variation of the function into factors was performed (Table **2**).

The result of the decomposition of the general variation of the real output of agricultural products of Ukraine into factors allows us to draw an extremely valuable conclusion: the potential for extensive growth of agricultural production by attracting additional land and human resources is actually exhausted. As we can see, the main factor in the growth of real agricultural output, which provides more than 55% variation in the function is to increase productivity.

No less significant is the contribution of materialized labor - more than 18%. In our opinion, only a sufficient supply of capital allows us to fully use the growth potential of production by increasing labor productivity. These two factors account for 73,4% of the variability of the studied function.

Based on the presented set of data on the actual values of the function (production of agricultural products per 1 employee) and the argument (the value of fixed assets of agriculture per 1 employee), along with a graphical interpretation of the studied relationship (Fig. **1**), we derived its analytical form.

$Y = 7{,}3187 \cdot x^{0{,}9367}$, (3)

Thus, we found a mathematical formula for the coefficient of elasticity of labor productivity at the level of capital-labour ratio which shows how many hryvnias will change the actual volume of agricultural production per 1 employee when changing the real volume of fixed assets in agriculture per 1 employee per 1 UAH.

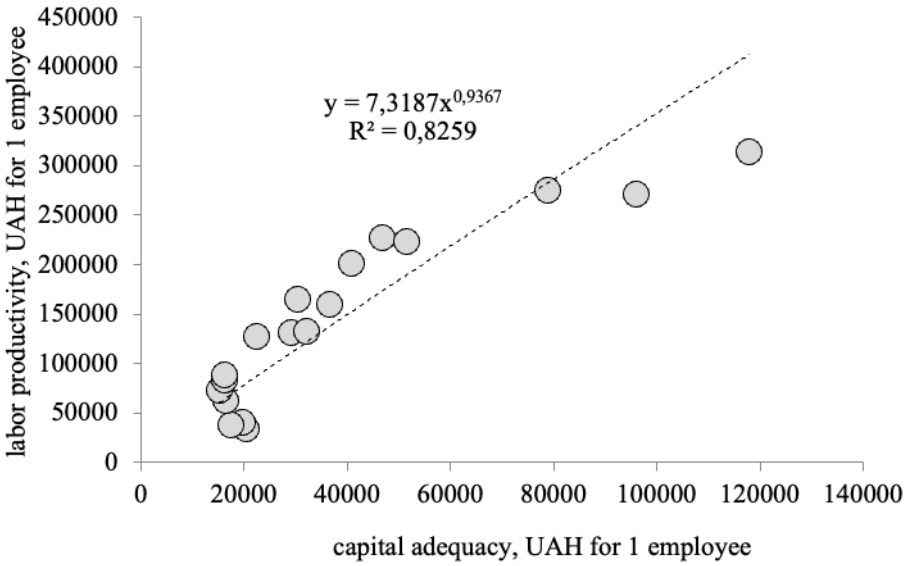

Fig. (1). Graphic model of the connection between changes in real capital and labor productivity in agricultural production, UAH per 1 employee, at constant prices*.

Thus, with each increase in the real volume of fixed assets in agriculture per 1 employee per 1000 UAH., The real volume of agricultural production per 1 employee increases by 936,7 UAH.

To achieve the targets of agri-food production to ensure the domestic market, labor productivity must increase at least twice. In 2018 this figure amounted to 313,6 thousand UAH. per 1 employee, therefore, its desired level should be not less than 630 thousand UAH. Given the actual level of real capital in 2018. (117,9 thousand UAH) and the calculated dependence (formula 3), the desired level of real capital should increase 5,7 times - up to 672,6 thousand UAH. And in the scale of all agricultural production, the real value of fixed assets should increase from 346,2 to 1973,3 million UAH.

The calculated capital deficit is not accidental and is explained by the deindustrialization of agricultural production, especially in the livestock industries - the reduction of the main herd of animals, the elimination of farms and livestock complexes, livestock mechanization, etc. caused a sharp reduction in the corresponding fixed assets. This conclusion is confirmed by a simple comparison: the value of fixed assets in agriculture in 2000 and 2018 is $ 17916,8 and $ 14688,2 million respectively. Therefore, without their restoration it is impossible to achieve the target indicators of productivity, production volumes and levels of consumption of products of animal origin.

Given the unalterable role of capital as a key factor in increasing labor productivity and real agricultural production, the next step in the study will be to determine the factors that affect its level. As an object of study, we took the interregional differentiation in the level of capital adequacy in agriculture (Table **3**).

When substantiating the factors of influence, it is necessary to make one remark - the most important and most obvious factor of capital adequacy is the level of investment in the relevant industry. Because of this, we did not take all investments in agriculture, but only those coming from abroad. In our opinion, such selectivity will allow us to find out to what extent foreign investments affect the level of capital adequacy in domestic agriculture. In a study of the regional structure of foreign investment, we also found that more than 70% of them come to one region - Kyiv. Therefore, we excluded the latter from the econometric model as one that distorts the relationships under study.

Y – capital adequacy, real value of fixed assets of agriculture per 1 employee, in% to the previous year;

x_1 - the region's share in the structure of foreign investment in agriculture, %;

x_2 - the region's share in financing applied and scientific and technical developments, %;

x_3 - the share of crop production in the structure of agricultural production, %;

x_4 - average monthly nominal wage of employees, UAH, in% to the national average;

x_5 – share of fixed assets in useful forms of capital (sowing machines, planting machines, machines for crop protection, etc.), in% to the national average.

Table 3. Initial Data for Econometric Modeling of the Dependence of the Level of Capital Armament on Individual Factors in Terms of Regions of Ukraine According to the Average Data of 2010-2018.*

Region	Y	x_1	x_2	x_3	x_4	x_5
	Capital –to-Labour-Ratio	The Share of the region in the Structure of Foreign Investment in Agriculture	The Share of the Region in the Financing of Applied and Scientific and Technical Developments	The Share of Crop Production in the Structure of Agricultural Production	Average Monthly Nominal Wages of Employees	The Share of Fixed Assets in Useful Forms of Capital
Vinnytsia	94,28	2,053	0,364	69,480	106,005	7,189
Volyn	70,24	6,497	0,158	56,921	83,852	1,362
Dnepropetrovsk	188,70	5,764	25,612	68,415	97,880	7,741
Donetsk	142,53	0,765	0,152	65,083	100,302	3,656
Zhytomyr	89,21	5,120	0,261	66,521	93,211	2,059
Transcarpathian	7,44	0,660	0,760	50,309	88,151	0,271
Zaporizhian	151,56	5,989	18,683	76,424	87,204	7,867
Ivano-Frankivsk	14,68	3,067	0,592	47,781	123,828	0,744
Kirovograd	197,31	10,383	1,328	81,709	95,115	8,362
Luhansk	243,62	2,386	0,460	75,786	95,982	3,804
Lviv	26,27	14,216	3,253	59,833	117,898	1,444
Mykolaiv	99,96	2,483	4,013	79,137	90,402	6,205
Odessa	118,90	7,672	2,609	80,129	75,417	7,717
Poltava	171,35	10,418	0,753	76,474	107,642	6,653
Rivne	39,72	4,379	0,182	65,170	80,887	0,923
Sumy	92,92	2,056	2,221	77,142	98,871	3,117
Ternopil	51,99	1,171	0,327	73,091	100,372	2,101
Kharkiv	111,06	3,692	35,044	75,912	96,853	6,932
Kherson	90,52	3,021	0,784	78,839	92,810	4,728
Khmelnitsky	71,47	4,613	0,087	72,103	101,942	3,193
Cherkasy	96,80	0,938	0,963	58,999	107,823	4,526
Chernivtsi	20,28	0,715	0,848	61,873	76,254	0,717
Chernihiv	109,19	1,943	0,547	76,081	101,719	3,204

Table 4. Correlation Matrix in Modeling the Dependence of the Change in the Real Level of Capital Adequacy in Agriculture of the Regions of Ukraine on the Change of Individual Factors*.

	Y	x_1	x_2	x_3	x_4	x_5
Y	1					
x1	0,19944	1				
x2	0,27694	0,09693	1			
x3	0,63068	0,16271	0,20053	1		
x4	-0,03334	0,15004	-0,05199	-0,24836	1	
x5	0,72219	0,27798	0,49200	0,69612	-0,05938	1

Table 5 Correlation Matrix in Modeling the Dependence of Changes in the Real Level of Capital Adequacy in Agriculture in the Regions of Ukraine on Changes in Individual Factors

	Y	x_1	x_2	x_3	x_4
Y	1				
x_1	0,19944	1			
x_2	0,27694	0,09693	1		
x_4	-0,03334	0,15004	-0,05199	1	
x_5	0,72220	0,27798	0,49200	-0,05938	1

Table 6 Decomposition of the General Variation of the Real Level of Capital Adequacy in Agriculture of the Regions of Ukraine into Factors.

Factor	Paired Coefficient Correlations, r_{yx_j}	β- Coefficient, β_{x_j}	Per cent, % ($r_{yx_j} \cdot \beta_{x_j} \cdot 100\%$)
The share of the region in the structure of foreign investment in agriculture (x1)	0,19943969	-0,007425476	-0,15
The share of the region in the financing of applied and scientific and technical developments (x2)	0,276935884	-0,103558956	-2,87
The average monthly nominal wage of employees (x4)	-0,033343574	0,008448842	-0,03
The share of fixed assets in useful forms of capital (x5)	0,722197566	0,77571472	56,02

Correlation analysis revealed multicollinearity [14-15] (Table **4**) between regressors x_3 and x_5? which distorts the studied relationship between function and factors and makes the regression model unstable.

In order to eliminate multicollinearity, we excluded regressor x3, from the model, as it has a lower pairwise correlation coefficient with the function than regressor x5. This approach gave a positive result - we obtained a correlation matrix in which there are no signs of multicoliarity (Table **5**).

We supplemented the correlation analysis with regression and obtained the following results:

1) the correlation coefficient is 0,728, so the closeness of the connection is high;

2) the coefficient of determination is 0,529, therefore, the variability of the function by 52,9% is determined by the variability of the selected factors;

3) Fisher criterion: Fф = 5,069, Fк = 2,928; Fф > Fк, therefore, the null hypothesis that there is no relationship between the indicators is rejected - the model is adequate to reality;

4) Student criterion: tф = 6,557, tк = 2,101; tф > tк, therefore, the null hypothesis about the insignificance of the regression coefficient is rejected - it is statistically significant;

5) χ2- Pearson criterion: χ2ф = 7,821, χ2к= 12,591; χ2ф < χ2к, therefore, in the array of regressors multicollinearity is absent;

7) regression equation: Y = 26,664 - 0,128x1 - 0,698x2 + 0,044x4 + 17,692x5 + e.

To determine the weight fraction of the influence of each of the factors on the variability of the resultant trait, the decomposition of the general variation of the function into factors was performed (Table **6**).

CONCLUSIONS

Thus, econometric modeling allowed us to draw a number of important conclusions about the factors of capital –to-labour-ratio adequacy in agriculture of Ukraine: factors x1, x2 and x4 do not affect the level of capital adequacy - foreign investment in agriculture in Ukraine is so small that does not significantly affect the capital –to-labour-ratio level.

A perspective way to solve this problem is the formation of favorable conditions for the creation of joint Ukrainian-foreign agricultural enterprises, the development of the institute of Ukrainian farmers from among foreign citizens. The key condition for the effectiveness of the proposed methods is impartial, clear and uncompromising protection of private property. This implies the absolute exclusion of raiding. This requires honest and effective work by law enforcement and the judiciary.

We must understand that the formation of Ukraine had many important stages. At each stage there have been structural changes in the growth of agriculture. First, the changes are related to global processes since Ukraine's agriculture is ex-

port oriented. So, changes in our product markets affect the processes in Ukraine.

A positive signal is that capital-to-labour-ratio is formed mainly through useful forms of capital. However, they are almost entirely concentrated in crop industries. The fixed assets of the livestock industries of agricultural enterprises are so insignificant that the State Statistics Service does not even provide relevant data. This is a very serious obstacle to the revival of livestock and pig farming, as it implies the need for significant initial investment in the construction of livestock complexes and the acquisition of highly productive breeding animals. Such investments have a long payback period - more than 5-8 years. This, in turn, increases business risks due to the unpredictability of landowners, the inefficiency of state agricultural policy in terms of guaranteeing minimum purchase prices for livestock products, inflation, which increases the cost of servicing bank loans, raiding.

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Received: Nov 14, 2022 Revised: Nov 25, 2022 Accepted: Dec 27, 2022