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REGRESSION RELATIONSHIP BETWEEN PRODUCTION AND FACTORS OF PRODUCTION IN POLISH AGRICULTURE

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Abstract

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Based on the functional dependence of net final output on the land, labour and fixed assets in agriculture in 2009 and 2010, it was determined that the growth rate of the value of the output was more than proportional.

The research revealed that labour (number of employed) reduced the relative growth of net final output in agriculture in 2009 and 2010 (-0.246). It transpired that the application of labour in relation to the gross value of total fixed assets was unfavourable, and that the employment of technical devices limited labour efficiency in agriculture.

The impact of agricultural land (land) on the relative growth of net final output exceeded 28%, and the impact of the gross value of total fixed assets was approximately 72%; the other factors of production in agriculture in 2009 and 2010 remained unchanged.

Key words: model, effect, resourses, elasticity
Abbreviations: JEL classification indices*:* C51, E23, Q16

Introduction

While studying the relationships between economical events, phenomena and processes one has to search for the explicitly determined best model. The best model is the one which meets the specified quality criterion. From this point of view it cannot be the best with regard to other quality criteria. It is enough to change the sequence of variables' selection in order to see that the best model is not achieved.

The net final output as the synthetic category being the endogenous variable can be the subject of the measurement of economic relationships in agriculture due to explanatory (endogenous) variables which are the resources of factors; they can be considered potential predictors of the aforementioned output category. In this meaning the potential model has the features of the full model (Aczel, 1989, 1993). Total productivity change distribution in agriculture in Slovenia in the years 1994-2003 did not change significantly on average. This was the result of the application of technological progress (Bojnec and Latruffe, 2009). This proves that technological progress contributes to output growth in agriculture.

Therefore, the construction of the model may be the subject of a specified set of collected empirical data (Berkum and Meijl, 2000). This is supported by the classical theory of statistics, which explains that the facts cannot be evaluated prior to the formulation of a theory (model) as this leads to erroneous conclusions (Maddala, 2001).

In the reference literature, based on the expected profit maximisation hypothesis it was proved that the explanatory (endogenous) variables are independent from the random component (Lichtenberg, 2001; Khuong Ninh et al., 2004). From the point of view of the estimation of function parameters in the model with standard and non-standard variables they have the features of exogenous variables. This way the

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model with variable parameters is created (Maddala, 2001).

The research aimed at the determination of the function relationship between net final output and land, labour and fixed assets in agriculture in 2009 and 2010.

Materials and Methods

Information included in the data from the Agricultural Yearbooks for years 2010 and 2011 were the subject of discovering the content of the research. It related to the empirical data in the provinces in Poland in 2009 and 2010, including the following: the level of the net final output and agricultural land, the number of employed, and the gross value of the total fix assets. The aggregation in the set of variables from 2009 and 2010 was performed in order to increase the number of the empirical data set.

From among the models of linear and curvilinear function, for research purposes the power (curvilinear) model was selected due to the higher coefficient of determination (R2). The function model parameters were estimated by the method of least squares, and the numerical calculations were performed with Statistica 9.0. software.

Research Results

The features of variables, like the arithmetic mean, range and coefficient of variation are included in Table 1. The net final output (Table 1) was the principal synthetic measure of the evaluation of agricultural production activity in the individual provinces in Poland as it presented the value of the real output in a given region designed for sale in 2009 and 2010. Among the studied variables, the net final output was most differentiated among the individual provinces (70%). Risk in economic activity is the result of uncertainty and not of probability level (Willet, 1951). While the central tendency of the net final output focused near the level of 3779.1 million PLN.

In the set of provinces, agricultural land was the least differentiated (45.9%), with concentration close to the average of 988.2 thousand hectares of agricultural land. Thus the dispersion related to the mean value was relatively low in relation to other variables. This indicates the relatively constant character of this variable and the fact that it does not bring significant information. It results from the technical combination of production factors that where the quantity of one factor is relatively constant and the quantity of the other factor changes the average product of the latter is maximum (optimum). This results from the law of diminishing returns (Rothbard, 2004). With regard to the substantive indispensability of the agricultural land area, in the model the resources of primary factors (land and labour) were separated with the estimation of parameters to two power models (Table 2).

The spread of the number of employed in agriculture in provinces was 1.4 times and by nearly 20 percentage points higher with relation to agricultural land. For this reason the role of the information provided by this variable was of high significance (Oughton et al., 2002).

The spread of gross value of the total fixed assets remained between the agricultural land variable and number of employed in provinces. Nevertheless, the mean gross value of the fixed assets was two times higher than the value of the net final output in a province, which indicates that the relative spread of the fixed assets provided significant information in the function parameter estimation procedure.

It results, for the theory of agricultural production function (Heady – Dillon, 1961), that the net final output (Y) depended on agricultural land (X1) and total fixed assets (X3), and in the second model –on labour (X2) and total fixed assets (X3). In both models the coefficient of determination (R2) was the highest; for this reason power (curvilinear) models were chosen for the research (Just and Pope, 2003).

As the number of explanatory variables was lower than the number of observations (provinces), the corrected value of R^2 approached the uncorrected value of the coefficient of determination (R2). R^2 is R2 corrected by the number of degrees of freedom (Maddala, 2001). For this reason the quality of the multiple regression model was estimated on the basis of R2. The number of data in the set was not high, and the model included several explanatory variables which brought significant explanation (R2) of the net final output; therefore it vas advantageous to separate explanatory variables into two

Table 1

Statistical characteristics of variables in agriculture in 2009 and 2010 (current prices)

No.	Specification	Symbol	Unit of measurement	Arithmetic mean	Range min.- max.	Coefficient of variation %
	Net final output	Y	million PLN	3779.1	1289.5-10815.3	69.8
2.	Agricultural land (AL)	X1	thousand hectares	988.2	447.0-2089.3	45.9
3.	Labour (employed)	X2	thousand persons	137.6	23.9-316.4	65.2
4.	Total fixed assets (gross value)	X3	million PLN	7735.6	2672.7-17230.0	52.1

Source: Agricultural statistical yearbook, CSO, Warsaw 2010 and 2011. Author's own calculations

Table 2

Exponential regression of net final output (Y) on agricultural land (X1), labour (X2) and total fixed assets (X3) in agriculture in 2009 and 2010

a a*	regression coefficient**			Standard error				t test				R^2
	X1	X2	X3	a	X1	X2	X3	a	X1	X2	X3	
-2.067 (0.127)	-0.348		0.878	0.48	0.14		0.13	-4.3	2.5		6.7	0.92
-1.947 (0.143)		-0.246	1.454	0.52		0.06	0.07	3.8		-4.41	6.8	0.94

Source: Agricultural statistical yearbook, CSO, Warsaw 2010 and 2011. Author's own calculations
*constant of equation (delogarithmed).
** significance level of individual parameters within the range 0.00 – 0.02

models with the aim of explaining the same dependent variable (Lissits and Balmann, 2003).

The randomness test of the random component distribution was performed by graphical analysis and the number series test, at 0.05 significance level. The graphical analysis and number series test confirmed the verification of the hypothesis assuming the accuracy of the choice of analytical form of these models (Table 2). The random component normality was checked with the Kolmogorow-Liliefors test. The achieved values, compared with critical values at 0.05 significance level, did not substantiate the rejection of the hypothesis that the random component distribution was normal. Autocorrelation, checked with the Durbin-Watson test, proved the absence of random component correlation at 0.05 significance level. The hypothesis of random component homoscedasticity was verified with the Goldfeld-Quandt test. Assuming that the significance level was 0.05, the obtained critical values of Snedecor's F distribution were higher than the calculated ones; therefore, there was no reason to reject the hypothesis of the homoscedasticity of random components. Application of the significance tests of the multiple regression model parameter evaluation presented by Aczel (1989, 1993).

The tabular presentation of the discussed model (Table 2) includes parameters and their statistical evaluations which express the relationship between the net final output value (Y), agricultural land (X1) and total fixed assets (X3), as well as between labour (X2) and total fixed assets (X3). Explanatory variables like agricultural land and total fixed assets explained the variability of the net final output value to 92% (R2), while the explanatory variables like labour and total fixed assets in the second equation explained the variability of the net final output value to 94% (R2). The remaining unexplained variability of the net final output value in both models was caused by other factors which were not considered in these function models. Nevertheless, in both function models the obtained explanation of the total variability of the net final output value was very high. Moreover, the obtained adjustment of the regression line to empirical data was also very high. The power of the relationship expressed by the correlation coefficient (R) between the net final output value and agricultural land area and gross value of the total fixed assets was 96% ($\sqrt{R^2} = R$); whereas the same power of the relationship between the net final output value and labour and gross value of the total fixed assets was 97%. Standard errors of regression parameters (regression coefficients) in both function equations were lower than 50% of their absolute values, while the t test values were several times higher than the values of regression coefficients (parameters), and the significance level remained in the range of 0.00 – 0.02. The aforementioned statistical evaluation of regression coefficients (parameters) indicates the possibility of their application in the econometric analysis of the net final output value in agriculture in 2009 and 2010.

Regression coefficients, function parameters at X1, X2 and X3, indicate the elasticity of the net final output in relation to agricultural land and total fixed assets, and in relation to labour and total fixed assets (correlation). The regression coefficients (parameters) are elasticity coefficients expressing the relative correlation. In the power function (Table 2), exponents at explanatory variables are interpreted as the elasticity of the endogenous variable in relation to respective factors: X1, X2 and X3. As Solow explains (1956), they are elasticities of Y in relation to X1, X2 and X3, while according to the marginal productivity theory of distribution by J. B. Clark they are percentages of the input of these factors (X1, X2 and X3) in the product (in the net final output).

The elasticity coefficient shows the average percentage change (increase or decrease) in the dependent variable when the Xj growth factor increases by 1%, on the assumption that the remaining factors remain unchanged. In the multiple regression model we can speak about the total impact of X1, X2 and X3 on Y an partial impact of X1 or X2 and X3 on Y (Maddala, 2001), after the impact of the remaining explanatory variables has been eliminated.

The net final output elasticity was higher in relation to total fixed assets than to agricultural land (Table 2). It results from the relationship of regression coefficients (elasticity) that the net final output value was over 2.5 times lower in relation to agricultural land than to total fixed assets. It results from the total of elasticity coefficients (powers) higher than unity (1.226) that the growth of the net final output in relation to the total impact of agricultural land and total fixed assets at the constant level of remaining factors was more than proportional. The simultaneous increase in agricultural land and total fixed assets by 10% contributed to the increase in net final output value by 12.26%, at the constant level of the remaining factors. It results from the percentage of impact (total elasticity = 100%) that the impact on the growth of agricultural land net final output (AL) was 28.38% and on the growth of total fixed assets – 71.62%. The proportions of the impact on the growth of agricultural land and of the total fixed assets net final output were generally 1: 2.5. The net final output elasticity at the impact of labour was over 1.66 higher in relation to total fixed assets in the second model than in the first model (Table 2). The impact of labour, however, decreased the relative growth of the net final output (-0.246). It results from the total of elasticity coefficients (powers) higher than unity (1.208) in the second model that as the result of the combined impact of labour and total fixed assets the value of the net final output also grew more than proportionally. The simultaneous increase in labour and fixed assets by 10% at the constant level of the remaining factors contributed to the increase in net final output value by 12.1% with its decrease due to irrational labour allocation in Polish agriculture in 2009 and 2010.

Summary and Conclusions

Based on the relative analysis of multiple regressions the following conclusions can be formulated:

Agricultural land and fixed assets, as well as labour and fixed assets, explained the variability of the net final output value in agriculture in 2009 and 2010 at 92% and 94%. Therefore, a high explanation of the variability of the net final output value in agriculture was obtained. The power of the relationship measured by the correlation coefficient between the net final output and agricultural land, labour and total fixed assets in the first and second model was 96% and 97%, respectively.

The total impact of agricultural land and fixed assets, as well as labour and fixed assets (by 10%) at the constant level of remaining factors increased the net final output value by 12.26% and 12.08%, respectively. In both regression models the growth of the net final output value was more than proportional.

The research proved that the impact of labour (in the second model) decreased the relative growth of the net final output value (-0.246). This indicates that the labour application in relation to the gross value of the fixed assets was unfavourable, and the employment of technical devices limited labour efficiency in agriculture in 2009 and 2010.

The impact on the growth of the agricultural land net final output was 28.38%, and of the total fixed assets – 71.62% at the unchanged level of the remaining factors in agriculture in 2009 and 2010. This indicates indirectly that the decrease in the number of employed (point 3) with the increase in the gross value of the total fixed assets would increase the employment of technical devices in land and labour, and would contribute to the increase in labour efficiency in Polish agriculture.

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