Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 16, Issue 4, 2016
PRINT ISSN 2284-7995, E-ISSN 2285-3952

IDENTIFICATION OF THE RELATIONSHIP BETWEEN STRUCTURAL VARIABLES AND TOTAL FACTOR PRODUCTIVITY AT REGIONAL LEVEL IN ROMANIA

Ioan STETCO

University of Agronomic Sciences and Veterinary Medicine Bucharest, 59 Marasti Boulevard, District 1, 011464, Bucharest, Romania

Corresponding author:istetco57@yahoo.com

Abstract

The present paper aims to assess the relation between the main structural variables and total factor productivity (TFP) based on Malmquist indices at the regional level in Romania. In order to set up this paper, there were used the data for the period 2007-2013 which were processed using Win4DEAP Program. The main results of our research revealed the necessity to increase the farms size and the share of farms with 50-100 ha and over 100 ha in order to improve the agricultural productivity. Also the results pointed out that the regions with a more developed vegetal sector have a higher TFP.

Key words**:** *farms, total factor productivity, productivity elasticity*

INTRODUCTION

Efficiency was for a long time assimilated with the concept of productivity, respectively through the capacity of a firm to transform inputs into outputs in production process. Among the first studies regarding productivity we mention the ones of Barton & Cooper [4]and Loomis & Barton [14], but there are a lot of studies starting from the sixties (like Kendrick [11]) which introduced the concept of total productivity factors (TFP) based on linear programming and input prices. In the same period others authors studied the relationship between Cobb-Douglas production function and inputs (Domar [8]; Chandler [6] and Lave [13]) or contested the use of this indicator (Abramovitz [1]; Solow [16]).

Only after2000 concerns regarding identifying the determinants of the increase / decrease productivity expanded. The paper of Alvarez-Cuadrado [2] demonstrates that the growth of productivity in agriculture led to a reallocation of resources from agriculture to other economic sectors and to an increase of aggregated output. The study of Fuglie *et al* [9] specifies that the growth of agriculture output decreased in developed countries over decades, especially due to a reduction of agriculture share in economy. According with Trostle *et al.* [17] and Choises [7] this phenomenon is also due to the increase of agricultural prices, the process of production concentration and the increase of competition for resources (land, water, energy, etc.). On this background, Martín-Retortillo [15] establish at European level three model of TFP growth: West European countries model characterized by TFP growth and an increase of utilized capital; Central and Eastern European countries model characterized by capital investments but lower growth in TFP; Mediterranean and Nordic European countries model characterized by higher capital investments.

Assessment studies of structural change in the agriculture of Central and Eastern European countries (Čechura *et al.* [5]) demonstrate that exists major gaps regarding productivity. However, in 2015, Hamulczuk [10] concludes that these countries prove a real convergence towards a higher level of productivity. In this context, Jitea and Pocol [12] prove that in Romania the CAP subsidies didn't raise the TFP, the growth of inputs being higher that the growth of agricultural output. They point out the orientation of support towards big farms and the ineligibility of the majority of farms (subsistence and semi-subsistence

farms) like the major causes for a low total factor productivity.

MATERIALS AND METHODS

Agricultural productivity analysis through the change in total factor productivity of production (TFP) is based on Malmquist indices. They are: TEFch - technical efficiency change; TECHch - technological change; PEch - pure technical efficiency change; SEche - scale efficiency change; TFPch - change in total factor productivity. TFP scores above 1, generated by an input orientation method under CRS assumption, emphasize the rational use of inputs, while the values below 1 emphasize an overuse of inputs.

We realized the evaluation of Total Factor Productivity with Win4Deap Program which permits the generation of Malmquist index. The Malmquist model oriented on input can be described as following [3]:

$$TFPch(x^{t+1}, y^{t+1}, x^t, y^t) = TEFch(x^{t+1}, y^{t+1}) \cdot TECHch(x^{t+1}, y^{t+1}, x^t, y^t) \cdot SEch(x^t, y^{t+1}, y^t) \cdot PEch(x^{t+1}, x^t, y^{t+1}) \quad (1)$$

or

$$TFPch = \frac{D^t(x^t, y^t)}{D^t(x^{t+1}, y^{t+1})}$$

where:

x= inputs

y = outputs

$$TEFch = \text{technical efficience change} = \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^{t+1}, y^{t+1})}$$

$$TECHch = \text{technical change} = \frac{D^t(x^t, y^t)}{D^{t+1}(x^{t+1}, y^{t+1})}$$

$$SEch = \text{scale efficience change} = \frac{SE^t(x^t, y^{t+1})}{SE^t(x^t, y^t)}$$

$$PEch = \text{overall } (pure)\text{efficiency change} = \frac{SE^t(x^{t+1}, y^{t+1})}{SE^t(x^t, y^{t+1})}$$

Technical efficiency change (TECHch), under input orientation approach, outlines the modification of inputs from t to *t+1*periodfor a given level of outputs. SEch is calculated based on scale efficiency scores through which the productivity given by an input and output mix is evaluated compared with technical optimum scale. PEch measures the modification of production frontiers when the level of inputs changes at a given level of outputs.

The assessment of the relation between agricultural structural change and total factor productivity was accomplished by linear multiple regression models:

$$Y = A\, x_1^{\beta_1}\, x_2^{\beta_2} \dots x_n^{\beta_n}$$

where: x_i- exogenous variable

A –exp. (intercept)

βi = parameters for measuring the TFP elasticity.

By logarithmic transformation we obtain the following regression model:

$$lnY = ln\alpha + \beta_1 lnx_1 + \beta_2 lnx_2 + \cdots + \beta_n lnx_n + \varepsilon$$

where:

-if $\sum_1^2 \beta_i < 1$ we have decreasing returns of scale (an increase of x_i generates a smaller increase of Y);

-if $\sum_1^2 \beta_i = 1$ we have constant returns of scale (an increase of x_i generates the same increase of Y);

-if $\sum_1^2 \beta_i > 1$ we have increasing returns of scale (an increase of x_i generates a higher increase of Y).

RESULTS AND DISCUSSIONS

Regarding the evolution of productivity in Romanian agriculture, in 2007-2013 periods, we may observe in South-East and West Regions an effect of catching-up which dominate the production frontier (Table 1).

Table 1. Malmquist indices – regional average values in 2007-2013 periods

	TEFch	TECHch	PEch	SEch	TFPch
South-East	1.048	1.108	1	1.048	1.161
West	1.033	1.171	1	1.033	1.21
South	1.077	1.045	1.004	1.072	1.125
Center	1	1.036	1	1	1.036
North-West	1	1.069	1	1	1.069
South-West	1	1.025	1	1	1.025
North-Est	1.03	1.026	1	1.03	1.057
Average 2007-2013	1.026	1.067	1.001	1.026	1.096

Source: own calculation with Win4Deap 2

In these regions we have a better managerial efficiency than scale efficiency. Also they have higher TFP values those other regions which indicate a more rational use of inputs relative to outputs and a real capacity to

optimize the volume of activities. The growth of technical efficiency of 10.8% in South-East Region and 17.1% in West Region reflects a bigger dimension of farms and higher incomes.

In South Region the managerial efficiency was lower suggesting that even we have an efficient utilization of inputs, those weren't adapted to the structural evolution of agriculture or activities volume. Also the capital investments doesn't reflect in outputs, the increase of productivity (with 12.5%) being due to the scale economies. The small productivity changes in Center, North-West and South-West are due to technological progress (an increase in invested capital) and to the efficient use of inputs. In North-East Region the catching-up effect dominate the production frontier curve proving that this region managed to optimize their volume of operations and that the economies of scale influence on productivity is higher than the influence of managerial efficiency (technical efficiency of inputs and outputs use) which led to a higher agricultural productivity index.

The TFP had major growths in the South-East in the 2007-2010 periods and in West Region in 2008-2010 periods but these remain the most performant regions in the 2007-2013 periods (Table 2). However at actual level of technology (inputs and outputs) we identify major impairments regarding agricultural productivity in Center and South-West regions, a positive evolution in North-West, North-East and South regions and a growth stagnation in South-East and West regions (they reached an optimum level of structural organization).

Table 2. Malmquist indices – Total Factor Productivity (TFP) in 2007-2013 periods

	South-East	West	South	Center	North-West	South-West	North-Est
2007-2008	1.462	1.012	1.268	0.937	0.925	0.991	1.105
2008-2009	0.871	1.407	1.105	0.855	1.05	0.933	1.211
2009-2010	1.578	1.985	1.211	1.355	1.124	1.032	1.09
2010-2011	1.094	1.074	1.151	1.09	1.039	1.343	0.977
2011-2012	1.053	1.027	0.897	0.977	1.096	0.943	1.199
2012-2013	1.059	1.007	1.157	1.07	1.199	0.959	1.113
Average 2007-2013	1.161	1.21	1.125	1.036	1.069	1.025	1.057

Source: own calculation with Win4Deap 2

Further we correlate the TFP scores with the farm size (ha/farm) (X_1), the share of farms with 50-100 ha in total farms UAA (X_2), share of farms with over 100 ha in total farms UAA (X_3) and number of cattle per farms (X_4) (Table 3):

Table 3. Farm structure variables and TFP_{REG} - average 2007-2013

	X_1	X_2	X_3	X_4	TFP_{REG}
South-East	5.5	0.4	0.9	4	1.161
West	6.2	0.4	0.6	3.8	1.210
South	3.5	0.2	0.4	2.5	1.125
Center	4.8	0.4	0.5	4.6	1.036
North-West	3.7	0.2	0.2	3	1.069
South-West	2.8	0.1	0.2	2.4	1.025
North-Est	2.6	0.1	0.2	2.3	1.057

Source: own calculation with Win4Deap 2

The regression model is statistically significant ($p=0.027<0.05$) and explain 98.62% of TFP_{REG} variation (Table 4). The intercept was very high suggesting that there are other factors which have a major influence on TFP_{REG} evolution.

The model reveals that the productivity growth is directly influenced (positively) by the share of farms with 50-100 ha in total farms UAA and negatively by the physical dimension of cattle farms.

Table 4. Regression model – farm structure variables and TFP_{REG} (average 2007-2013)

$TFP_{REG} = 1{,}184 + 0{,}041\ X_1 + 0{,}749\ X_2 + 0{,}018\ X_3 - 0{,}141\ X_4$			
Multiple R			0.99306
R^2 (R Square)			0.986169
Adjusted R^2			0.958507
Standard Error			0.014146
F			35.65099118
Significance F (p)			0.02747
	Coefficient	*t Stat*	*P*
Intercept	1.184358	14.62163	0.004644875
X_1	0.040708	2.067503	0.174619535
X_2	0.748602	1.898482	0.198048037
X_3	0.017593	0.341632	0.765183976
X_4	-0.14126	-4.49401	0.046116332

Source: own calculation Excel – Data Analysis

But what is the real influence of structural variable on productivity? To respond at this question we constructed a linear multiple regression models based on logarithmic transformation of previously used variables (Table 5).

Table 5. Farm structure variables and TFP_{REG} - average 2007-2013 values expressed in natural logarithms

	$LN(TFP_{REG})$	$LN(X_1)$	$LN(X_2)$	$LN(X_3)$	$LN(X_4)$
SE	0.1493	1.7047	-0.9163	-0.1054	1.3863
V	0.1906	1.8245	-0.9163	-0.5108	1.3350
S	0.1178	1.2528	-1.6094	-0.9163	0.9163
C	0.0354	1.5686	-0.9163	-0.6931	1.5261
NV	0.0667	1.3083	-1.6094	-1.6094	1.0986
SV	0.0247	1.0296	-2.3026	-1.6094	0.8755
NE	0.0554	0.9555	-2.3026	-1.6094	0.8329

Source: own calculation Excel – Data Analysis

The model in basically a Cobb-Douglas function, statistically insignificant ($p=0.078>0.05$) and explains 96.0% of TFP_{REG} variation:

Table 6. Regression model – farm structure variables and TFP_{REG} (average 2007-2013 values expressed in natural logarithms)

$TFP_{REG} = 1.0609 * X_1^{0,319} * X_2^{0,006} * X_3^{0,029} * X_4^{-0.324}$ where: $e^{0,0591} = 1,0609$ (the proportionality coefficient between factors)			
Multiple R			0.979793
R^2 (R Square)			0.959993
Adjusted R^2			0.87998
Standard Error			0.021627
F			11.99794
Significance F (p)			0.078413
COEFICIENTS			
	Coefficient	*t Stat*	*P*
Intercept	0.059105	0.202139	0.858504
X_1	0.318791	2.994126	0.095789
X_2	0.005942	0.07753	0.94526
X_3	0.028862	0.889668	0.467514
X_4	-0.32392	-3.49314	0.073083

Source: own calculation Excel – Data Analysis

We may observe that the parameters sum is very small and sub unitary (0.0297) which means that the productivity grows more slowly than the growth of others variables (decreasing efficiencies of scale). The TFP elasticity is negative reported to the size of cattle farm, while a change of 1% in the overall size of farms (ha per farm) leads to an increase of 0.319% of the TFP. In these conditions we may conclude that we have to increase the vegetal farm size and the share of farms with over 100 ha with 1% to obtain an increase with 0.348% of agricultural productivity.

CONCLUSIONS

In the 2007-2013 periods the Total Factor Productivity increased with 9.6% and the catching-up effect (+2,6%) shows that the higher level of TFP is due to changes of production frontier form and to a real convergence to optimum. Bu also we observed that the growth of TFP was mainly due to technological changes (managerial decisions) than to catching-up effects (scale economies). This means that the inputs remain higher compared with the outputs which point out real problems in costs control and income maximization. Also at regional level the productivity may increase with 0.354% if we increase with 1% the farm size, the share of farms with 50-100 ha and with over 100 ha in total farms UAA.

REFERENCES

[1]Abramovitz, M., 1956. Resource and output trends în the United States Since 1870, American Economic Review, Vol. 46 (1): 5-23

[2]Alvarez-Cuadrado, F., 2005, A quantitative exploration of the golden age of European growth: structural change, public investment, the Marshall plan and intra-European trade (No. UWEC-2004-15)

[3]Balk, B.M, 2001, Scale Efficiency and Productivity Change, Journal of Productivity Analysis, 2001, 15, 159-83

[4]Barton, G.T., Cooper, M.R., 1948, Relation of agricultural production to inputs. The Review of Economics and Statistics, pp.117-126.

[5]Čechura, L. Grau, A., Hockmann, H., Kroupová, Z., Levkovych, I., 2014, Total Factor Productivity în European Agricultural Production (No. 9). Compete Working Paper

[6]Chandler, C., 1962, The relative contribution of capital intensity and productivity to changes în output and income, Journal of Farm Economics, Vol 44 (2), pg. 335-348

[7]Choices, 2009. Agricultural productivity and food security în the long run. 24(4) 4thQuarter

[8]Domar, E., 1961, On the measurement of technological Change. Economic Journal, vol. 71, pg. 709-729

[9]Fuglie, K.O., Wang, S.L., Ball, V.E., eds., 2012. Productivity growth in agriculture: an international perspective. CABI.

[10]Hamulczuk, M., 2015, Total factor productivity convergence in the EU agriculture. Competitiveness of Agro-Food and Environmental Economy, p.34.

[11]Kendrick, J.W., 1961, Productivity trends in the United States, Princeton University Press

[12]Jitea, I.M., Pocol, C.B., 2014, The Common

Agricultural Policy and productivity gains in Romanian agriculture: is there any evidence of convergence to the Western European realities?. Studies in Agricultural Economics, 116(3), pp.165-167
[13]Lave, L.B., 1964, Technological change în US agriculture: The aggregation problem, Journal of Farm Economics, Vol. 46 (1):200-217
[14] Loomis, R.A., Barton, G.T., 1961, Productivity In Agriculture, Technical Bulletin No. 1238, Washington
[15] Martín-Retortillo, M., 2013, Patterns and causes of growth of European agricultural production 1990-2005, Seminar Paper 89
[16]Solow, R.M., 1957, Technical Change and the aggregate production function, Review of Economics and Statistics, Vol. 39, 313-320
[17]Trostle, R., Marti, D., Rosen, S., Westcott, P., 2011, Why have food commodity prices risen again? Outlook Report WRS-1103, U.S. Department of Agriculture, Washington