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Assessment of the Agricultural Performance in Central and Eastern European Countries

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Abstract

Based on selected individual data acquired from Farm Accountancy Data Network database the output efficiency of agriculture in Central and Eastern European countries at national level is evaluated. Moreover, the output oriented constant returns to scale Data Envelopment Analysis approach is applied in order of Malmquist productivity index calculation. Analysis includes two output variables and six input variables. The data were provided on request from Farm Accountancy Data Network for ten Central and Eastern European Countries and period 2004-2012 (in case of Bulgaria and Romania 2007-2012). Based on the results, the average Total Factor Productivity growth in Central and Eastern European region over the period 2004-2012 was 1.99%. Moreover, it can be concluded that the Total Factor Productivity growth was mainly the result of Technological Change.

Keywords

Central and Eastern European countries, Farm Accountancy Data Network, Data Envelopment Analysis, Malmquist productivity indices, total factor productivity.

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Introduction

Central and East European countries (CEEc) have undergone the process of transformation that affected their production structures (Ciaian, et al., 2009). Some CEEc are dominated by family farms (Poland, Slovenia) while in others there are prevalent transformed cooperatives (Slovakia, Czech Republic). Mixture of large transformed cooperatives and family farms can be observed in Hungary or Romania. There are also differences with respect to the application of the Common Agricultural Policy (CAP) at national levels as well as with the date of European Union (EU) accession, which had a tremendous impact on national economy in general and on agriculture in particular including the level of support (Pokrivcak et al., 2006). Gross Domestic Product (GDP) per capita and the level of development also differ between the countries, whereby Slovenia, the Czech Republic are among the most developed of CEECs and Romania or Bulgaria lag behind. The level of development is reflected in the functioning of land market as well as all other upstream and downstream markets.

All these differences between the countries might be reflected in the efficiency and productivity of agricultural sectors in different countries. The motivation to conduct this research was to calculate the productivity of agriculture in CEEc in order to find out, which countries use their limited resources in efficient way. We can find researches which took into account the analysis of one country (Coelli, 2006; Fogarasi, 2006) or the analysis of tens countries (Nowak et al., 2015; Domanska et al., 2014; Coelli and Rao, 2003). We took into account the countries situated in CEE region and the analysis was applied in a range of 9 years interval (2004 – 2012). The countries included are as follows: Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovakia and Slovenia. The novelty of the paper is reflected by the fact that our paper includes individual farm data, the analysis is performed for each country separately and the assessment of the performance of individual farms (58,929 observations in total) and their development during 9 years interval is analysed. Subsequently, the results are unified at country level.

To calculate the efficiency and productivity, different approaches have been used. In our paper, to express the efficiency, the Data Envelopment Analysis (DEA) and Malmquist productivity indices are used. Moreover, by applying Malmquist productivity indices, the change of the Total Factor Productivity (TFP) is decomposed into Technical and Technological efficiency change.

The objective of the paper is to examine the data acquired from Farm Accountancy Data Network (FADN) in order of asses the agricultural performance of CEE countries.

The paper consists of several parts. The following part consists of the literature review according to efficiency analysis and the determinants of efficiency. Data and methodology used are inherited by the second part of the paper. The third, and most important part of the paper, is the results and discussion, which consists of the efficiency analysis of the agricultural sector in selected countries. The last part deals with a summary of the results of previous sections.

There have been several papers which have measured the performance of agriculture in individual countries using indicators TE (technical efficiency) and TFP. Serrão (2003) examined the sources of productivity growth and the productivity differences among countries and regions over the period 1980-1998 covering 15 EU countries and 4 East European countries. The study was based on data collected from the Food and Agriculture Organisation (FAO) of the United Nations (UN). An approach based on DEA was used to provide the values of TE and to derive the Malmquist productivity indices. According to the author, average annual growth of TFP over that period reached 2.2%, where a major contributing factor was the technological change (TCH). Negative growth in technical efficiency change (TECH) was observed in a couple of years. France, Belgium and Luxembourg posted the most spectacular performance, with an average annual growth of 3.6% of TFP in case of France over the observed period. Turning to the performance of the five European regions defined in authors' research work, the Eastern European region (consisting of Romania, Bulgaria, Poland and Hungary) was the best performer, with an annual TFP growth of 2.6%.

Akande (2012) measured the TE and TFP growth of agricultural holdings in the EU-15 over the 11 years period by DEA approach. Author observed an average TE of 87% for the EU-15 region as a whole. The paper divided the EU-15 region into four regional groups. Western European Region was the most efficient with the highest average TE of 95% while Central European Region shared the same TE level of 85% with Southern European Region. Meanwhile, the Northern European region was the least technically efficient (84%). The annual average of 3% and 4% TFP growth rate was observed for all the regions in the EU-15. Study observed that TFP growth rate in the four regional groups were being driven by TCH and a decline in TECH particularly between the years 1999 and 2002. Subsequently up till 2005, the growth rate was driven by catch-up (TECH) while there seem to be technological regression.

Fogarasi (2006) analysed the efficiency and TFP in Hungarian sugar beet production. For the years 2004 and 2005, the TE and TFP were calculated by DEA and by a Malmquist index, respectively. Between 2004 and 2005 the average TE was very stable, around 0.80 for CRS efficiency and 0.87 for VRS efficiency. Between years TFP increased by 9%. The main reason for the observed TFP increase was TCH of 8%, while TECH efficiency played a limited role in improving the performance of sugar beet production.

Coelli et al. (2006) obtained detailed information on the TFP growth of arable farms in Belgium over a 16 years period (1987 – 2002). The TFP measures were calculated using a Malmquist indices and DEA approach. The results indicated an average annual rate of TFP change of 1% per year, with most of this being due to TCH. An inspection of the TFP change indices before and after the two CAP reforms (in 1992 and 2000) indicated that these reforms had had no discernible effect upon TFP trends.

Measurement of the TE of agricultural sector in the 27 European Union countries in 2010 was provided by Nowak et al. (2015). The research was conducted based on the output-oriented VRS DEA approach. Authors claimed that across the 27 EU Member States, the level of the TE of agricultural sector was diverse and the difference between the countries with the highest and the lowest efficiency was 40%. The countries situated in the western and southern part of the EU were identified as the countries with the thoroughly technically efficient agriculture. In turn, the least technically efficient agriculture was observed for the Central and North-East EU countries.

Domanska et al. (2014) measured the agricultural TFP change in 27 EU countries (2007-2011). The research was conducted based on Malmquist productivity index. The study demonstrated a small increase in agricultural TFP for the whole sample of 27 EU countries over the examined period. The reason of this increase was mainly the changes in technical efficiency. An effect of TCH was in turn relatively low and of negative character.

Rizov et al. (2013) investigated the impact of the CAP subsidies on farm TFP in the 15 EU countries based on FADN data. Authors employed a structural semi-parametric estimation algorithm directly incorporating the effect of subsidies into a model of unobserved productivity. Authors found negative impact of subsidies on farm productivity in the period before the decoupling reform was implemented.

Based on the above mentioned researches, we can conclude the increase of the level of TFP in the EU region (Serrão, 2003; Akande, 2012; Fogarasi, 2006; Coelli et al., 2006; Domanska et al., 2014). This increase was mainly caused by the increase of technological change, while the impact of technical efficiency change had just marginal (Fogarasi, 2006; Akande 2012) or even negative impact (Serrão, 2003). In our research, the methodology of DEA and data applied by Akande (2012) has been used. The methodology of Malmquist index used by Domanska et al. (2014) has been employed in order to find the impact of TCH and TECH on TFP growth.

Materials and methods

Model works with two output variables – crop output (total value of output of crops and crop products [EUR], sales + farm use + farm house consumption) and animal output (the total value of output livestock and livestock products [EUR] livestock production + change in livestock value + animal products). These outputs are produced as a result of six inputs. Total labour in form of annual working units (AWU), the total utilized agricultural area (hectares), buildings (buildings and fixed equipment [EUR]), machinery (machines, tractors, cars and lorries, irrigation equipment [EUR]), cost of materials (total specific cost, total farming overheads, machinery and building current costs [EUR]) and total livestock units [livestock units, LU] are considered while calculating TE and TFP.

The data were provided on request from FADN for 10 CEEc and period 2004-2012 (in case of Bulgaria and Romania 2007-2012). The database was adjusted for the farms not appearing in each observed year and for negative outputs (the conventional DEA model is used, which doesn't work with negative data points). Monetary expressed data were deflated from nominal euro to constant euro based on a fixed base year using the Agricultural Price Index (API) obtained from the statistical office of the European Union (EUROSTAT) in order to eliminate the impact of inflation over time. Crop output adjustment is based on API crops, animal output adjustment is based on API animal and the adjustment of inputs is based on API total inputs with a base year 2005. It must be noted, that results represent efficiency scores for individual countries which are based on farm data. For the purposes of the calculation of Malmquist index the Stata 12.0 statistical program was used.

Technical efficiency

Efficiency can be simply defined as the ratio of output to input. More output per unit of input reflects relatively greater efficiency. If the greatest possible output per unit of input is achieved, a state of absolute or optimum efficiency has been achieved and it is not possible to become more efficient without new technology or other changes in the production process (Sherman and Zhu, 2006).

Technical efficiency is one of the three components of overall efficiency, while the others are allocative efficiency and economic efficiency (Farrell, 1957). Technical efficiency is related to the ability of the decision making unit (DMU) to produce maximum output from given inputs or the minimum feasible amounts of inputs to produce a given level of output. The first part of the definition refers to output-oriented TE, while the second refer to input-oriented TE (Watkins, 2013). The allocative efficiency refers to the ability to use the set of inputs in optimal proportions, given their pertinent prices (Farrell, 1957). Economic efficiency is then calculated as the ratio of the minimum possible costs and the actual observed costs for a DMU and is the reflection of both efficiencies.

Data Envelopment Analysis

The one of the most widely used technique to obtain technical efficiency is DEA. DEA is a linear programming non-parametric technique developed in the work of Charnes, Cooper and Rhodes (1978). The original idea behind DEA was to provide a methodology whereby, within a set of comparable decision making units (DMUs), those exhibiting best practice could be identified, and would form an efficient frontier[1]. Furthermore, the methodology enables one to measure the level of efficiency of non-frontier units, and to identify

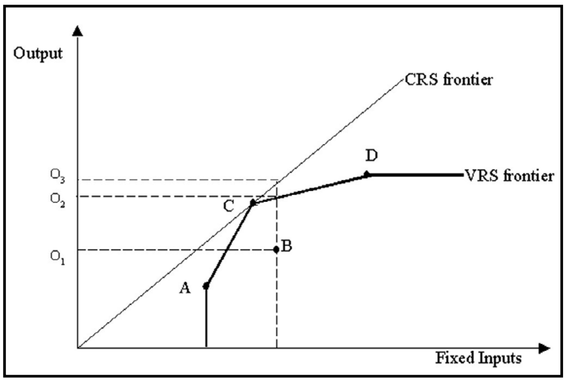
[1] An envelopment surface or efficient frontier is a frontier consisting of the "best practice" units (DMUs).

benchmarks against which such inefficient units can be compared (Cook and Seiford, 2009).

Returns to scale

The envelopment surface will differ depending on the scale assumptions that underpin the model. Two scale assumptions are generally employed: Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS). CRS reflects the fact that output will change by the same proportion as inputs are changed (e.g. a doubling of all inputs will double output); VRS reflects the fact that production technology may exhibit increasing, constant and decreasing returns to scale (Lestari, 2015).

The effect of the scale assumption on the measure of capacity utilization is demonstrated in Figure 1. Four data points (A, B, C, and D) are used to estimate the efficient frontier and the level of capacity utilization under both scale assumptions. Note that only fixed inputs are considered in Figure 1. The frontier defines the full capacity output given the level of fixed inputs. With constant returns to scale, the frontier is defined by point C for all points along the frontier, with all other points falling below the frontier (hence indicating capacity underutilization). With variable returns to scale, the frontier is defined by points A, C and D, and only point B lies below the frontier i.e. exhibits capacity underutilization. The capacity output corresponding to variable returns to scale is lower than the capacity output corresponding to constant returns to scale (Food and Agriculture Organization of the United Nations (FAO), 2003).



Source: FAO (2003)

Figure 1: The effect of the scale assumption on the measure of capacity utilization.

Input and output orientation

A range of DEA models have been developed to measure efficiency and capacity in different ways. These largely fall into the categories of being either input-oriented or output-oriented models (FAO, 2003).

Input-oriented models refer to the amount by which all inputs could be proportionally reduced without a reduction in output (e g. the input efficiency is 0.80 or 80%, which means that the selected DMU lags behind the best performer DMU, then the inputs should be reduced by 0.20 or 20% to become efficient) while output-oriented models answer the question by how much can be output quantities proportionally expanded without altering the input quantities (e g. the output efficiency is 1.30 or 130% compared to the best performer DMU, then the outputs should be proportionally expanded by 0.30 or 30% to become efficient) (Coelli, 1995). Uses of input or output oriented model provide similar values under constant return to scale but are unequal when variable return to scale is assumed.

In the case of efficiency we employ output-oriented model with CSR in form:

$$max_{\varphi,\lambda\varphi}$$

$$-\varphi y_i + Y\lambda \geq 0 \qquad (1)$$

$$x_i - X\lambda \geq 0$$

$$\lambda \geq 0$$

Where φ is efficiency rate for each decision-making unit (DMU, CEE state in this case), λ refers to linear combination of inputs and outputs, Y is vector of outputs and X vector of inputs. The condition $\lambda \geq 0$ indicates CSR. For the further information about DEA please see the following materials: Cook and Seiford (2009), Sherman and Zhu (2006) or Cooper et al. (2011).

Malmquist productivity index

The Malmquist index measures the TFP change between two adjacent periods by calculating the ratio of the distance of each data point relative to a common technological frontier. The Malmquist index can be greater, equal to or less than 1 if productivity grows; is stagnant or declines between the two periods. It can be decomposed into TECH and TCH.

Malmquist productivity index is a geometric mean of two production functions based on the distance functions, as follows:

$$M_0(y_{t+1}x_{t+1}y_tx_t) = [\frac{d_0^t(y_{t+1},x_{t+1})}{d_0^t(y_t,x_t)} \times \frac{d_0^{t+1}(y_{t+1},x_{t+1})}{d_0^{t+1}(y_t,x_t)}]^{1/2} \qquad (1)$$

$$M_0(y_{t+1}x_{t+1}y_tx_t) = \frac{d_0^{t+1}(y_{t+1},x_{t+1})}{d_0^t(y_t,x_t)}[\frac{d_0^t(y_{t+1},x_{t+1})}{d_0^{t+1}(y_{t+1},x_{t+1})} \times \frac{d_0^t(y_t,x_t)}{d_0^{t+1}(y_t,x_t)}]^{1/2} \qquad (2)$$

Where the outputs and inputs are y_t, x_t in the basic period, y_{t+1}, x_{t+1} are output and output in the next period. Notation d_0^t and $d_0^{(t+1)}$ represents distance of the DMU in the basic and next period.

Technical efficiency change measures technical efficiency change between period *t* and *t+1*. If the value is greater than 1, the production unit moves closer to the frontier, in other words, the DMU is catching up to the production frontier by improving efficiency. A value of less than 1 indicates efficiency regress.

Technological change represents the shift in technology of selected DMU, which means that if the value is higher than 1, then the DMU experienced technology progress and, on the other hand, the value lower than 1 means that the country experienced technological regress.

Technical efficiency change and technological change can be expressed also in percentage, where the positive value means progress, while the negative value means regress.

Whenever the $M_0>1$ it signalizes the enhanced productivity.

Results and discussion

After the database have been obtained, the data were cleaned by the DMUs not appearing in whole period and by DMUs with negative output values as one of the constraint of conventional At the end of the process, the clean database contained 58,929 observations. Table 1 describes the descriptive statistics of the individual farms. The vast variation of variables between the countries was found. As you can see, the highest average and median values of the variables can be observed in case of Czech Republic and Slovakia as a consequence of the highest values of farm size according to Total UAA in ha and to Economic size in ESU. On the other hand, the lowest average and median values of the variables can be observed in case of Poland and Slovenia, where the agricultural sector is dominated by small family farms. The most data points can be observed for Poland while the least for Lithuania.

Technical efficiency

Output-oriented DEA models answer the question by how much can be output quantities proportionally expanded without altering the input quantities (e. g. the output efficiency is 1.30 compared to the best performer DMU, then the outputs should be proportionally expanded by 0.30 (or 30%) to become efficient). The output TE scores for the period under consideration (2004-2012, in case of Bulgaria and Romania (2007-2012)) are presented in Table 2. The average farm´s output TE suggests that CEEc should augment the outputs in average by more than 52 % (1.5267) without changing the input quantities to become efficient. The efficiency scores were ranging from 1.09 in case of Lithuanian farms to 2.28 in Polish farms. The most efficient country was Lithuania in 2005, while the least efficient country was Romania in 2007. The CEE region as a whole performed the best in 2006, where the output TE score was 1.40.

As we mentioned above, Lithuania attained efficiency in terms of farm outputs in 2005 and was close to efficiency frontier over the whole observed period. These results support the findings of Bojnec et al. (2012), who studied TE in new member states of EU over the time period 2001-2006 and concluded that there are opportunities for better use of agricultural resources, since all countries achieved input TE scores lower than 1. Lithuania was valued first in terms gross value added agricultural performance also according to authors Csaki and Jambor (2015), who ranked agricultural performance of newly entered member states of EU. On the other hand, the same authors ranked Poland as the first regarding the benefits of accession to EU, but our results suggest that Poland exhibit the worst farm performance. The reason is that there are many small, non-commercial family farms in Poland.

Over the observed period 2007-2012, the average TE score for Bulgaria was 1.93 and 1.85 for Romania. Both countries have the highest share of agriculture on GDP compared to the rest of CEEc; Bulgaria 5.36% and Romania 7.10% (Csaki and Jambor, 2013). Thus, high TE scores are the result of inefficiency in inputs use. Bulgaria and Romania have more labor units employed on farms compared to other CEEc, signalizing the lower level of economic development and farm fragmentation as a result of land reform (Bojnec et al., 2012).

Total factor productivity index and its components in CEEc

The components of Malmquist index; TECH and TCH are presented in Table 3 and 4, while the TFP change from one year to another is presented in Table 5.

The TFP over the period 2004-2012 increased in all CEEc, except Bulgaria and Romania, thus the components of TFP contributed to TFP

Country	Obs.	Stat. var.	Crop output [EUR]	Animal output [EUR]	Total labour input [AWU]	Total UAA [ha]	Buildings [EUR]	Machinery [EUR]	Consumption of materials [EUR]	Livestock unit [LU]	Total subsidies (excl. on investment) [EUR]	Economic size [EUR]
		Average	128417.27	109491.18	14.14	337.95	56399.28	99967.26	173568.13	140.03	48022.43	269.48
		Median	16142.30	0.00	4.62	35.95	5456.93	9682.87	27791.31	0.00	7562.12	63.25
BGR	**3426**	St. dev.	255040.39	605805.91	33.82	604.06	213655.44	241508.02	502600.82	681.45	86744.07	707.75
		Skewness	3.32	9.83	12.40	2.46	8.21	5.22	8.46	9.02	2.86	8.73
		Kurtosis	13.70	114.61	253.69	6.47	82.10	38.57	95.93	101.91	10.72	104.83
		Average	359111.55	393753.48	24.26	756.87	821594.46	575877.66	702388.06	370.72	194347.21	770.81
		Median	158742.06	96425.73	9.02	463.48	212497.92	251814.52	323301.76	111.76	109360.03	357.63
CZE	**2718**	St. dev.	447046.19	534281.02	28.39	797.53	1243979.25	742182.95	835875.70	474.98	207257.64	884.75
		Skewness	1.71	1.58	1.31	1.09	2.75	2.32	1.49	1.62	1.15	1.30
		Kurtosis	3.30	2.06	1.14	0.44	12.60	8.27	2.29	2.72	0.65	1.25
		Average	61560.27	80951.61	4.36	251.56	108516.83	103976.28	117782.75	82.70	33693.82	143.98
		Median	24468.08	12038.70	2.00	137.00	25585.87	49482.21	50113.85	20.37	17980.70	65.54
EST	**2457**	St. dev.	104151.38	234466.42	8.56	325.53	314495.92	153500.67	228532.26	233.33	46796.20	264.71
		Skewness	3.55	5.40	5.96	2.82	6.11	2.88	4.65	6.11	3.36	4.54
		Kurtosis	15.09	35.14	46.04	8.81	44.99	10.06	26.44	48.42	14.19	24.98
		Average	120744.83	49410.01	6.77	323.63	94733.05	85532.67	149694.41	53.70	63831.75	194.80
		Median	33335.73	0.00	1.68	122.01	10566.64	15742.14	40442.49	0.00	20838.66	58.25
HUN	**855**	St. dev.	229684.25	263475.80	16.57	597.70	214352.20	187337.02	367237.27	221.32	149065.05	428.63
		Skewness	3.28	8.15	4.57	3.26	3.72	3.83	5.48	5.47	5.19	4.36
		Kurtosis	12.67	71.64	22.76	11.31	16.34	17.40	36.82	30.13	32.58	20.59
		Average	184194.45	37362.00	5.76	334.85	56459.07	213061.53	137608.13	41.02	37910.14	182.61
		Median	96697.88	0.00	3.39	233.07	12422.60	112396.46	95926.69	0.00	27736.50	135.92
LTU	**432**	St. dev.	222137.49	89950.56	8.85	311.83	124548.34	248945.38	138180.34	96.18	33933.02	167.69
		Skewness	1.82	3.24	4.55	1.13	3.70	1.87	1.54	3.25	1.16	1.36
		Kurtosis	3.11	11.00	23.73	0.39	14.38	4.06	2.20	11.27	0.90	1.65
		Average	80894.08	79859.31	8.06	291.17	60496.69	100356.37	139910.01	98.06	45958.27	141.75
		Median	18327.21	11179.18	2.44	118.40	4842.80	28743.14	45978.74	19.59	18278.68	52.90
LVA	**3123**	St. dev.	193696.05	216933.59	16.11	476.03	268624.82	199609.01	264882.87	259.83	83173.36	262.41
		Skewness	7.14	6.92	4.00	4.20	10.21	4.71	4.03	8.42	6.68	5.02
		Kurtosis	74.96	77.09	18.25	27.57	131.33	30.56	20.75	116.56	102.15	40.27
		Average	18601.09	24111.68	2.09	33.28	43837.61	33615.63	29142.60	30.96	7130.02	45.10
		Median	8854.34	11378.88	1.88	21.67	29189.98	18741.63	16725.06	17.83	4457.87	29.15
POL	**42291**	St. dev.	38776.42	53222.08	1.63	48.99	57951.65	48048.56	49379.28	61.40	10666.97	67.30
		Skewness	13.68	10.58	13.73	12.16	7.73	5.89	9.76	15.33	11.12	12.79
		Kurtosis	366.66	186.80	317.87	266.38	114.96	80.26	161.74	463.14	249.98	327.53
		Average	208000.97	108591.68	13.87	607.39	79154.02	190239.12	241767.59	197.80	108068.63	407.04
		Median	27278.43	0.00	5.40	39.00	7322.85	18114.55	40395.02	0.00	10459.19	83.57
ROU	**1248**	St. dev.	441896.23	500787.24	24.46	1193.16	239837.64	391293.64	558597.31	872.67	214325.70	903.37
		Skewness	6.06	7.96	5.90	4.50	5.82	3.92	6.31	6.10	4.95	5.64
		Kurtosis	55.29	83.75	58.61	30.42	44.73	20.84	54.59	42.50	39.88	41.59
		Average	330040.03	346304.73	32.23	1026.67	1025651.89	220923.89	690387.81	379.97	236664.22	618.37
		Median	149519.32	87771.07	20.21	711.57	156159.72	110149.94	402571.40	209.65	140022.69	345.98
SVK	**1224**	St. dev.	422703.97	536479.02	36.92	1044.92	2029346.12	294048.28	844139.14	534.13	275801.07	749.05
		Skewness	2.38	2.39	1.49	1.50	3.13	2.65	1.91	2.56	2.00	2.06
		Kurtosis	7.40	7.15	1.97	2.45	12.20	9.76	3.77	9.30	6.14	5.01
		Average	17744.25	31682.04	2.49	23.50	95279.74	48975.39	37012.19	33.54	12952.80	54.99
		Median	9287.91	19663.71	2.16	18.40	63207.36	34697.22	26290.80	23.79	8897.13	39.34
SVN	**1161**	St. dev.	31467.48	42536.56	2.95	18.68	106350.82	62387.45	36900.63	40.28	13907.58	54.53
		Skewness	5.11	4.32	11.31	3.27	2.43	7.93	2.87	4.81	3.91	3.05
		Kurtosis	35.48	32.09	149.44	15.41	7.95	129.28	11.74	35.48	20.53	14.89

Source: own processing based on FADN data

Table 1: Descriptive statistics of the data in CEEc.

Index	out_DEA (CRS)									
Year/Country	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**geomean**
Bulgaria	:	:	:	1.8919	2.0475	2.3330	2.0694	1.7028	1.6161	*1.9287*
Czech Republic	1.3648	1.3905	1.2594	1.3333	1.3323	1.4605	1.4033	1.3103	1.3269	*1.3524*
Estonia	1.2990	1.3253	1.2547	1.2242	1.3467	1.4739	1.3649	1.3635	1.4171	*1.3391*
Hungary	1.3393	1.6709	1.4099	1.6084	2.0803	1.4968	1.6442	1.3848	1.4741	*1.5546*
Lithuania	1.0720	1.0000	1.1307	1.1208	1.1454	1.0584	1.0703	1.1146	1.0765	*1.0868*
Latvia	1.4283	1.3618	1.3307	1.2924	1.3999	1.3177	1.3037	1.3068	1.3097	*1.3383*
Poland	2.1165	2.2807	2.0833	2.3922	2.0817	2.2976	2.3518	2.3172	2.6558	*2.2800*
Romania	:	:	:	2.4663	1.9677	1.7047	1.9715	1.5677	1.5829	*1.8529*
Slovakia	1.3908	1.4188	1.3713	1.3671	1.3324	1.6041	1.3964	1.4323	1.2886	*1.3978*
Slovenia	1.4719	1.4324	1.3882	1.6196	1.2785	1.4379	1.4210	1.2772	1.3205	*1.4017*
Avg. CEE	*1.4353*	*1.4850*	*1.4035*	*1.6316*	*1.6012*	*1.6185*	*1.5996*	*1.4777*	*1.5068*	*1.5267*

Note: : - not available, median values
Source: own processing based on FADN data

Table 2: Technical efficiency scores for CEEc over 2004-2012.

Index	Efficiency change									
Year/Country	**2004-2005**	**2005-2006**	**2006-2007**	**2007-2008**	**2008-2009**	**2009-2010**	**2010-2011**	**2011-2012**	**Avg.**	**Total**
Bulgaria	:	:	:	1.30	12.41	-6.03	-14.50	-3.71	*-2.11*	*-10.53*
Czech Republic	0.00	6.32	-3.35	0.00	-6.68	1.33	3.08	-1.03	*-0.04*	*-0.32*
Estonia	0.00	0.00	0.00	-3.17	-0.57	1.67	0.00	0.00	*-0.26*	*-2.08*
Hungary	-11.92	14.85	-9.12	-5.94	36.41	0.00	12.76	-1.49	*4.44*	*35.55*
Lithuania	0.00	0.00	0.00	0.00	6.73	0.00	0.00	0.00	*0.84*	*6.73*
Latvia	0.78	0.00	1.80	-3.55	0.57	0.00	0.00	0.00	*-0.05*	*-0.40*
Poland	-7.45	10.07	-12.73	15.18	-9.26	-3.13	2.45	-11.25	*-2.02*	*-16.13*
Romania	:	:	:	-13.97	-9.21	7.78	-11.16	0.00	*-5.31*	*-26.55*
Slovakia	0.00	2.91	0.00	2.31	-5.59	1.33	0.00	4.64	*0.70*	*5.59*
Slovenia	0.00	0.00	-10.27	20.15	-0.40	0.00	4.45	0.00	*1.74*	*13.94*
Avg. CEE	*-2.32*	*4.27*	*-4.21*	*1.23*	*2.44*	*0.30*	*-0.29*	*-1.28*	*0.02*	*0.13*

Note: : - not available, median values, percentage change
Source: own processing based on FADN data

Table 3: Technical efficiency change for CEEc.

growth. The results shows that TFP growth caused by TECH or process of catching up can be observed in case of Hungary by 4.44%, Lithuania by 0.84%, Slovakia 0.70% and Slovenia by 1.74%. The rest of the countries experienced the deterioration of TECH. Bulgaria reported a decrease in TECH by 2.11%, whereby the TECH increase can be seen between years 2007-2008 and 2008-2009. Romania exhibited the average decrease in TECH by 5.31%, caused by decreased TECH over the observed period, except to the year 2010. It must be noted that there are data gap for Bulgaria and Romania over the period 2004-2006. The total technical efficiency change in CEE region as a whole in period 2004-2012 attained the positive value of 0.13 %, while the best performer country in the process of catching up was Hungary, while, on the other hand, the least performer country in CEE region over the observed period was Romania, where the contribution of technical efficiency change to TFP growth was – 26.55%. These results were supported by the fact that in case of Poland only 1.66% of farm attained output TE score equal to one (the most efficient), while the share of farms which attained the output TE score higher than 2 (the least efficient) was 65.09%. On the other hand, our analysis revealed that in case of Lithuania 41.90% of farm attained output TE score equal to one (the most efficient), while the share of farms which attained the output TE score higher than 2 was only 3.24%.

The average growth in TFP due to the TCH can be observed in all countries except Estonia, Romania and Slovakia (Table 4). The highest average technological progress was in case of Poland, by 5.06%, while, on the other hand, the least performer was considered as Romania (-1.29).

Index					Efficiency change					
Year/Country	**2004-2005**	**2005-2006**	**2006-2007**	**2007-2008**	**2008-2009**	**2009-2010**	**2010-2011**	**2011-2012**	**Avg.**	**Total**
Bulgaria	:	:	:	8.60	24.98	-1.93	-14.41	-7.36	*1.97*	*9.87*
Czech Republic	6.63	-9.26	11.87	-2.85	13.84	0.70	0.44	-0.80	*2.57*	*20.56*
Estonia	-4.82	-6.92	1.57	-2.59	16.15	-12.86	0.66	8.44	*-0.05*	*-0.38*
Hungary	17.22	-21.80	7.82	79.38	-35.75	10.45	3.55	-2.19	*7.33*	*58.66*
Lithuania	0.05	-17.89	27.31	14.77	-23.60	4.44	1.86	14.88	*2.73*	*21.83*
Latvia	1.88	-7.46	-0.40	10.46	-3.71	-1.89	1.25	4.84	*0.62*	*4.97*
Poland	5.60	-9.75	15.04	-10.94	8.00	15.13	-0.12	17.55	*5.06*	*40.50*
Romania	:	:	:	-3.21	-19.51	35.90	-13.75	-5.87	*-1.29*	*-6.44*
Slovakia	-2.12	3.85	10.45	-16.53	8.41	-2.28	1.28	-10.43	*-0.92*	*-7.38*
Slovenia	3.27	-5.64	21.66	-15.97	9.50	-4.34	0.56	-2.42	*0.83*	*6.63*
Avg. CEE	*3.47*	*-9.36*	*11.91*	*6.11*	*-0.17*	*4.33*	*-1.87*	*1.66*	*2.01*	*16.09*

Note: : - not available, median values, percentage change
Source: own processing based on FADN data

Table 4: Technological change for CEEc.

Index					Efficiency change					
Year/Country	**2004-2005**	**2005-2006**	**2006-2007**	**2007-2008**	**2008-2009**	**2009-2010**	**2010-2011**	**2011-2012**	**Avg.**	**Total**
Bulgaria	:	:	:	12.27	37.79	-12.20	-29.21	-11.97	*-0.66*	*-3.32*
Czech Republic	6.06	-0.36	7.28	-0.61	4.27	4.23	5.37	-3.58	*2.83*	*22.66*
Estonia	-0.02	-5.49	5.78	-7.80	13.00	-9.18	2.56	5.21	*0.51*	*4.06*
Hungary	-0.36	-7.01	-4.31	45.48	-9.90	-1.19	26.26	-10.98	*4.75*	*38.00*
Lithuania	0.37	-16.79	29.36	9.20	-11.57	0.05	10.34	17.41	*4.80*	*38.39*
Latvia	6.22	-6.58	3.42	1.71	1.91	0.64	7.58	6.51	*2.68*	*21.42*
Poland	-1.03	-0.45	-0.48	3.53	-3.49	9.53	3.20	4.16	*1.87*	*14.96*
Romania	:	:	:	-25.62	-23.53	52.36	-28.68	-10.44	*-7.18*	*-35.91*
Slovakia	-3.56	12.41	9.36	-11.03	-4.34	10.44	5.53	-4.43	*1.80*	*14.38*
Slovenia	8.56	-0.75	9.56	2.78	2.81	0.30	13.16	-5.02	*3.92*	*31.39*
Avg. CEE	*2.03*	*-3.13*	*7.50*	*2.99*	*0.70*	*5.50*	*1.61*	*-1.31*	*1.99*	*15.88*

Note: : - not available, median values, percentage change
Source: own processing based on FADN data

Table 5: TFP change for CEEc.

The highest technological change in CEE region was observed between years 2006 and 2007, where the technological progress changed by 11.91%. Based on Table 3 and 4, we can conclude that the TFP growth was mainly driven by TCH in CEEc, because of the fact that contribution of TECH to TFP was in average 0.02% (0.13% in total), while the contribution of TCH to TFP was in average 2.01% (16.09% in total). Our results are supported by the findings of the authors mentioned in the literature review (Serrão, 2003; Akande, 2012; Fogarasi, 2006; Coelli et al., 2006; Domanska et al., 2014).

The average decrease of TFP over the period 2007-2012 can be observed in case of Bulgaria (by 0.66%) and Romania (by 7.18%) (Table 5). The CEE region as a whole performed the best between years 2006 and 2007, where the increase in TFP was 7.50% in average. The best performer country was Lithuania, where the average growth of TFP attains 4.80% (38.39% in total during the 9 years period). The average TFP growth for CEEc over the period 2004-2012 was 1.99 % mainly due to the TCH. Domanska et al. (2014) studied the TFP of agricultural sector in EU states over the period of 2007-2011, finding the increase by 2.4%. Our results suggest that in CEEc which joined the EU after 2004, the TFP growth was caused by TCH, because of the changes of the structure in the agriculture after the accession. The results can be used for the comparison of the trend in individual economies. The analysis was provided individually for each country, so the data from different countries have not been considered as they have they own different and specific frontier.

Based on other authors' findings, we can explain the differences between efficiency and technology in CEEc by natural agricultural factor endowments, average farm size, farm specialization, institutional developments (Bojnec, et al., 2010), imperfections on the credit and land markets (Latruffe, et al., 2008) severe lack of financing in the agricultural sector (Swinnen and Gow, 1999). Further studies are required to tackle the issue, how to explain the differences in the gap between the countries and how to ensure the sustainable growth of efficiency in the CEEc.

Conclusion

We investigated the farms output Technical Efficiency in ten Central and Eastern European countries, as well as the Total Factor Productivity development over the period 2004-2012 (2007-2012 in case of Bulgaria and Romania).

We found, that none of the countries were efficient in terms of farm performance over the observed period, although Lithuania was close to score 1 throughout the studied years. The least efficient country over the observed period was Poland.

The results showed that Total Factor Productivity growth caused by process of catching up can be observed in case of Hungary by 4.4%, Lithuania by 0.8%, Slovakia 0.7% and Slovenia by 1.7%. The rest of the countries experienced the deterioration of Technical Efficiency. On the other hand the average growth in Total Factor Productivity due to the Technical Change was observed in all countries except to Estonia, Romania and Slovakia. The highest Technical Change was observed in case of Poland, by 5.1%. Based on the results, we can conclude that the TFP growth was mainly driven by TCH in CEEc, because of the fact that contribution of TECH to TFP was in average 0.02% (0.13% in total), while the contribution of TCH to TFP was in average 2.01% (16.09% in total). The average Total Factor Productivity growth in Central and Eastern European countries over the period 2004-2012 was 1.99%.

Even though the policy regimes have changed and shifted toward market economy, it seems the sector of agriculture in Central and Eastern European countries cannot break the issue of inefficient input use. This can be partly attributed to the remainings of former regimes, but also to failure in adapting the efficient policy and support systems in agriculture. Thus, it would be beneficial for Central and Eastern European countries to model the proper supporting scheme considering the full impact on agricultural performance of individual farms.

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