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ECONOMIC EFFICIENCY OF CENTRAL AND EAST EUROPEAN FARMS BASED ON DEA - COST APPROACH

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Abstract

The paper addressed an approach on the economic efficiency of farms among ten Central and East European Countries by means of the technical and allocative efficiency, through the DEA-COST method. For the analyze we used two years from the FADN dataset (2013 and 2016): inputs - labor (AWU), land (UAA) and average capital; outputs - total output and farm net income; input prices - rent, wages and depreciation. The main results of our research showed that the average technical efficiencies for the farms sample over the analyzed period are relatively high (around or more than 0.90) and allocative and economic efficiencies are moderate (0.60-0.70) stressing that the farms have similar management practices and technologies but they are not fully cost efficient. In 2016, only farms from Romania and Latvia are completely efficient with respect to all three analyzed efficiency measures, while the most inefficient are the farms from Slovenia. Also, we observed that in the CEE analyzed countries the main cause for cost inefficiency is allocative (inefficient mix of inputs relatively to optimal level).

Key words**:** *data envelopment analysis, allocative efficiency, economic efficiency, farms*

INTRODUCTION

The development of farm economic efficiency (technical and allocative) and its connection with size and specialization in CEE countries was investigated in the last decade to assess the performance of agricultural sector. In 2004, Gorton and Davidova [2] made an empirical study on six CEE countries regarding farm productivity and efficiency by a DEA approach and concluded that corporate farms are "inherently less efficient for all farming activities than family farms" and that "in countries in transition where small family farms are well established and managed continuously by the present farm household, they appear to be less inefficient compared to larger cohorts as against countries where small family farms are a relatively new phenomenon". In addition, in 2007, Bojnec and Latruffe [1] showed that "farms producing a large output are highly efficient regarding their decision of input quantities used (technical and scale efficiencies), while farms using a large labor force are highly efficient also regarding the input quantities, but particularly regarding their choice of input mix in terms of their respective prices (allocative and cost efficiencies)". In 2016, Stetco [3] pointed out for 2007-2013 period a growth in economic efficiency of farms (case of Romania), but also denoted "the allocative inefficiency (inefficient mix of inputs) as major cause for not acquiring optimum levels in 2013 despite the improvement in technical efficiency (an increase in farm volume activities)".

MATERIALS AND METHODS

Although the overall situation of agriculture in CEE countries is similar (land defragmentation, low efficiency, etc.), there are some disparities in their process of transformation which affect the production structure. According to Záhorský and Pokrivčák (2017) [5] "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". By applying DEA approach, the results obtained

by different studies revealed that "the most efficient countries were Hungary, Romania and Slovenia and the least efficient countries were Latvia and Slovakia" (Záhorský and Pokrivčák, 2016) [4]. Our paper aims to complete these studies by assessing the technical, allocative and economic efficiency of 10 CEE countries (Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovenia). We selected these countries base on available FADN data for years 2013 and 2016.

At the CEE farm level, we noticed an average agricultural output of around 70 thou euro, with a small increase in the analyzed period and a clear inequality among the countries (from a minimum of almost 11 thou euro in Romania to a maximum of around 300 thou euro in Czech Republic) (Table 1). The gaps are due to the difference in physical dimension which oscillated between around 9 ha in Romania and over 200 ha in Czech Republic. Thus, for selected counties, the average physical dimension was around 60 ha per farm. The average farm capital varied between a minimum of 29 thou euro and over 500 thou euro in the mentioned countries. The differences are major including the input prices, the lowest prices being observed in Slovenia and Romania.

If we look closely to the data we observe also that Estonia and Czech Republic present the biggest UAA per farm, Croatia, Poland and Slovenia have farms between 10 and 20 ha and Romania and Slovenia farms under 10 ha. However, after Czech Republic, which has an AWU per farm over 5, we observe that Bulgaria, Estonia and Latvia have a moderate level of AWU per farm (over 2). Also, we observe a high level of the average farm capital in Hungary, Latvia and Slovenia.

In these conditions, due to all these differences, becomes very important to test the efficiency at farm level base on the report between input and outputs by data envelopment approach.

Table 1. Data at farm level, on selected CEE countries, 2013 and 2016

Year	Country	Inputs			Outputs		Input prices		
		Total labor (AWU)	Total UAA (hectare)	Average farm capital (euro)	Total output (euro)	Farm net income (euro)	Wages paid	Rent paid	Depreciation
2013	(BGR) Bulgaria	2.41	37.86	62,952	39,178	8,101	4,650	5,894	4,878
	(CZE) Czech Republic	5.79	201.99	715,048	293,428	47,882	57,043	12,399	33,941
	(EST) Estonia	2.05	136.95	224,668	117,833	17,086	16,228	2,499	17,201
	(HRV) Croatia	1.84	15.71	89,157	23,045	5,363	1,633	529	4,173
	(HUN) Hungary	1.58	48.72	135,220	68,104	18,293	8,545	3,609	6,315
	(LTU) Lithuania	1.75	48.55	88,751	38,925	12,903	2,049	1,105	7,336
	(LVA) Latvia	2.09	69.09	111,660	58,424	9,650	5,449	858	9,034
	(POL) Poland	1.70	18.81	85,337	30,203	9,867	1,403	355	4,781
	(ROU) Romania	1.19	9.27	28,556	11,795	5,525	554	458	1,223
	(SVN) Slovenia	1.38	10.56	101,921	22,839	4,950	543	355	7,481
	Minimum	1.19	9.27	28,556	11,795	4,950	543	355	1,223
	Maximum	5.79	201.99	715,048	293,428	47,882	57,043	12,399	33,941
	Average	2.18	59.75	164,327	70,377.4	13,962	9,809.7	2,806.1	9,636.30
	Std.	1.25	59.66	189,937.50	79,787.50	12,150.15	16,397.30	3,629.07	9,033.94
2016	(BGR) Bulgaria	2.24	38.97	69,254	37,146	6,215	4,716	6,842	5,509
	(CZE) Czech Republic	5.60	204.63	565,649	307,424	37,162	61,533	16,121	39,450
	(EST) Estonia	1.87	127.32	222,467	103,022	-1,889	16,922	3,744	16,679
	(HRV) Croatia	1.72	18.33	104,756	31,393	11,072	3,164	708	5,159
	(HUN) Hungary	1.57	47.93	148,132	76,341	20,878	8,838	3,822	6,607
	(LTU) Lithuania	1.66	47.94	90,715	33,822	10,553	2,430	1,514	8,729
	(LVA) Latvia	1.96	63.43	97,981	53,899	13,761	6,430	1,087	9,394
	(POL) Poland	1.63	18.78	83,815	26,246	7,723	1,406	421	4,849
	(ROU) Romania	1.06	9.36	29,023	11,896	5,166	470	545	1,459
	(SVN) Slovenia	1.22	9.78	109,143	23,917	4,881	415	285	7,508
	Minimum	1.06	9.36	29,023	11,896	-1,889	415	285	1,459
	Maximum	5.60	204.63	565,649	307,424	37,162	61,533	16,121	39,450
	Average	2.05	58.65	152,093.50	70,510.60	11,552.20	10,632.40	3,508.90	10,534.30
	Std.	1.23	58.91	146,098.61	83,096.52	10,286.12	17,612.97	4,655.44	10,353.01

Source: Own calculation.

DEA-COST models generated by Win4DEAP were used with an input-orientation, two outputs and three inputs. We generated the technical efficiencies (TE) and the allocative efficiencies (AE). AE shows the "ability of a DMU to utilize inputs in optimal proportion at a certain level of prices" or "the level of inputs at which a firm obtains the

minimization of production costs" [3]. By multiplying those two types of efficiencies we can measure the economic (cost) efficiencies (EE).

RESULTS AND DISCUSSIONS

Technical efficiency score (under CRS assumption) in 2013 was 97.5% and ranged from 84.8% to 100.0%. From the sample, 7 countries achieved full technical efficiency, 2 countries (Latvia and Lithuania) were technical efficient (over 90%) and Croatia presented a moderate score of 84.8% (Table 2).

At CEE farm level, the allocative efficiency was 77.9% (with a minimum of 36.7% in Slovenia and a maximum of 100% in Romania and Bulgaria). Thus, a CEE farm can obtain a saving in costs of 22.1% if it has an optimum level of allocative efficiency. The most inefficient country, Slovenia, the minimum costs were exceeded with 63.3%.

By multiplying TE and AE we obtain a medium level of economic efficiency of 76.3%, with a minimum of 36.7% in Slovenia and a maximum of 100% in Bulgaria and Romania. At CEE level we obtained 23.7% cost savings, but in Slovenia (the most economic inefficient region) the economic efficiency would have increased with 63.3% if the farms would have been operated at optimum level.

In all considered countries the inefficiency related to the costs is due in particular to an inefficient mix of inputs (low allocative efficiency). The most inefficient countries are Slovenia, Croatia and Czech Republic (they overcome the minimum costs with 63.3%, 56.4% and 34.1%). In Croatia, Lithuania and Latvia the inefficiency is due also to technical inefficiency but in lower proportion.

In 2016, technical efficiency score (under CRS assumption) was a little lower of 95.8% and ranged from 76.7% to 100.0%.

From the sample, 8 countries achieved full technical efficiency, 1 country (Bulgaria) was technical efficient (over 90%) and Lithuania and Poland presented moderates scores (76.7% and 82.9%) (Table 3).

Table 2. The technical, allocative and economic efficiency DEA-Cost Scores of CEE countries in 2013

	TE	AE	EE
Bulgaria	1.000	1.000	1.000
Czech Republic	1.000	0.659	0.659
Estonia	1.000	0.843	0.843
Croatia	0.848	0.514	0.436
Hungary	1.000	0.906	0.906
Lithuania	0.964	0.908	0.875
Latvia	0.940	0.894	0.841
Poland	1.000	0.701	0.701
Romania	1.000	1.000	1.000
Slovenia	1.000	0.367	0.367
Average	0.975	0.779	0.763
Minimum	0.848	0.367	0.367
Maximum	1.000	1.000	1.000
Cost savings			
Bulgaria	0	0	0
Czech Republic	0	34.1	34.1
Estonia	0	15.7	15.7
Croatia	15.2	48.6	56.4
Hungary	0	9.4	9.4
Lithuania	3.6	9.2	12.5
Latvia	6	10.6	15.9
Poland	0	29.9	29.9
Romania	0	0	0
Slovenia	0	63.3	63.3
Cost savings average	2.5	22.1	23.7
Cost savings for the most technically inefficient country	15.2	63.3	63.3

Source: Own calculation with Win4Deap 2

The allocative efficiency increased to 85.6%, with a minimum of 39.8% in Slovenia and a maximum of 100% in Romania and Latvia.

At an optimum level of allocative efficiency, a CEE farm can have a cost saving of 14.4% and in Slovenia (the most inefficient country) the cost saving would've been of 60.2% if the Slovenian farms would have reached the production frontier.

The situation reveals a slightly improvement in allocative efficiency which reflect in a higher level of economic efficiency (81.8%). However, we observed a minimum of 39.8% in Slovenia and a maximum of 100% in Romania and Latvia.

In these conditions, at CEE level, we obtained 18.2% cost savings, but in Slovenia (the most economic inefficient region) the economic efficiency remained over 60%.

Excepting Bulgaria and Lithuania, in all other countries the allocative inefficiency is predominant. The most inefficient countries were Slovenia, Poland and Croatia (they overcome the minimum costs with 60.2%, 38.8% and 35.4%) and the most efficient are the farms from Romania and Latvia.

Table 3. The technical, allocative and economic efficiency DEA-Cost Scores of CEE countries in 2016

	TE	AE	EE
Bulgaria	0.979	0.997	0.975
Czech Republic	1.000	0.988	0.988
Estonia	1.000	0.842	0.842
Croatia	1.000	0.646	0.646
Hungary	1.000	0.970	0.970
Lithuania	0.767	0.979	0.751
Latvia	1.000	1.000	1.000
Poland	0.829	0.737	0.612
Romania	1.000	1.000	1.000
Slovenia	1.000	0.398	0.398
Average	0.958	0.856	0.818
Minimum	0.767	0.398	0.398
Maximum	1.000	1.000	1.000
Cost savings			
Bulgaria	2.1	0.3	2.5
Czech Republic	0	1.2	1.2
Estonia	0	15.8	15.8
Croatia	0	35.4	35.4
Hungary	0	3	3
Lithuania	23.3	2.1	24.9
Latvia	0	0	0
Poland	17.1	26.3	38.8
Romania	0	0	0
Slovenia	0	60.2	60.2
Cost savings average	4.2	14.4	18.2
Cost savings for the most technically inefficient country	23.3	60.2	60.2

Source: Own calculation with Win4Deap 2

If we compare the situation on SO classes (economic dimension) we observe that the farms with higher dimensions overcame minimum cost with only around 23-26%. They are close of optimum that the others farms. Also, we observe the following results:

-Romania is the most efficient in almost all farms;
-Latvia reach full efficiency only in farms with 8,000-25,000 SO and Bulgaria only in farms with 100,000-500,000 SO;
-in Bulgaria, almost all farms are technical efficient which means that they are producing the maximum output with a minimum quantity of inputs; we encounter this situation only in Czech Republic in farms with 100,000-500,000 SO and in Latvia in farms with 25,000-50,000 SO (in 2016).

Also, analyzing the results we may conclude that we have a moderate efficiency (an overcame of minimum cost under 30%) in:
-8,000-25,000 SO – Bulgaria and Hungary (in 2013); Bulgaria, Estonia and Romania (in 2016);
-25,000-50,000 SO – Bulgaria (in 2013); Latvia (in 2016);
-100,000-500,000 SO – Estonia, Hungary, Lithuania, Latvia and Poland (in 2013); Czech Republic, Croatia, Hungary, Latvia and Poland (in 2016).

Romania is the only country full efficient (technical and allocative) in the both years, which means that almost all farms between 8,000 and 500,000 SO obtain an output adapted to their capacity and have an optimum mix of inputs.
If we compare the results by specialization categories we observe that milk farms are the most efficient in both years.

Table 4. The cost savings of CEE countries in 2013 and 2016 on SO classes

	2013								2016							
	8,000-25,000 SO		25,000-50,000 SO		50,000-100,000 SO		100,000-500,000 SO		8,000-25,000 SO		25,000-50,000 SO		50,000-100,000 SO		100,000-500,000 SO	
	EE	% of AE	EE	% of AE	EE	% of AE	EE	% of AE	EE	% of AE	EE	% of AE	EE	% of AE	EE	% of AE
Bulgaria	6.1	0.0	20	23.0	31.1	36.7	0	0.0	22.8	36.0	47.1	42.5	50.3	56.1	0	0.0
Czech Republic	39.5	66.1	52	72.1	46.6	82.8	37.3	39.9	41.5	92.0	54.2	60.3	50.2	69.9	26	47.3
Estonia	31.1	69.1	31.1	100.0	48.9	100.0	29.9	100.0	29.4	91.5	49.1	72.7	53.7	100.0	34.4	100.0
Croatia	57.9	88.8	48.1	100.0	58	90.7	53.3	64.5	61.6	85.2	47.6	96.8	41.8	100.0	29.9	63.5
Hungary	23.9	100.0	31.6	100.0	39.8	100.0	29	83.4	30.4	100.0	35.5	100.0	32.7	100.0	18.7	100.0
Lithuania	31.2	43.6	35.3	72.5	45.2	93.4	24.6	100.0	44.3	60.7	51.2	59.6	45.7	78.8	30.2	83.1
Latvia	0	0.0	30.3	67.0	35.9	78.3	15.4	100.0	0	0.0	28.4	39.4	36.3	58.1	11.2	83.0
Poland	51.2	71.7	49.5	100.0	53.4	100.0	17	100.0	56.7	56.3	59.3	84.1	56.9	99.3	26.1	100.0
Romania	0	0.0	0	0.0	0	0.0	0	0.0	9.7	100.0	0	0.0	0	0.0	0	0.0
Slovenia	61.7	100.0	62.7	100.0	66.2	100.0	52.1	100.0	61	100.0	65.6	100.0	68.5	100.0	52.7	100.0
Average	30.3	77.6	36.1	86.1	42.5	89.6	25.8	82.2	35.8	79.9	43.8	74.7	43.6	85.8	22.9	86.0

Source: Own calculation with Win4Deap 2

They are close of optimum that the others farms and overcame the minimum cost with around 17-18%. The most inefficient are the farms from COP sector specialized in field crops.
Also, we may observe that:

-Romania and Bulgaria were the most efficient in 2013, but in 2016 only the milk farms from Romania are reaching full efficiency;
-in 2013 Estonia reach full efficiency in milk and mixed farms and, in 2016, the optimum is reached by field crops farms from Croatia, milk farm from

Latvia, Hungary and Romania and mixed farms from Czech Republic and Latvia;
-in 2016, the field crops farms from Lithuania, Latvia, Poland and Romania were moderate technical efficient (they produced the maximum output with a minimum quantity of inputs); we encountered this situation only in the milk farms from Latvia (2013) and from Czech Republic (in 2016).
Also, analyzing the results we may conclude that we have a moderate efficiency (an overcame of minimum cost under 30%) in:
-Field crops farms - Hungary and Latvia (in 2013); Bulgaria, Czech Republic and Latvia (in 2016);
-Milk farms - Hungary, Lithuania and Latvia (in 2013); Bulgaria, Czech Republic, Estonia, Croatia and Lithuania (in 2016);
-Mixed farms – Czech Republic, Hungary, Lithuania and Latvia (in 2013); Bulgaria, Estonia, Hungary and Lithuania (in 2016).
We may conclude that the milk farms are more efficient (technical and allocative) in the both years (the output is adapted to the capacity and inputs have an optimum or close to optimum allocation). The most inefficient are the farms from field crops sector.

Table 5. The cost savings of CEE countries in 2013 and 2016 on Specialization categories

	2013						2016					
	Field crops		Milk		Mixed		Field crops		Milk		Mixed	
	EE	% of AE	EE	% of AE	EE	% of AE	EE	% of AE	EE	% of AE	EE	% of AE
Bulgaria	0	0.0	0	0.0	0	0.0	17.9	11.7	13.2	60.6	6.8	100.0
Czech Republic	32.5	100.0	43.2	78.9	26.6	100.0	11.9	100.0	6.5	4.6	0	0.0
Estonia	39.2	100.0	0	0.0	0	0.0	41.8	99.3	7.7	100.0	1.8	0.0
Croatia	43.2	83.6	33.9	93.2	47.2	59.7	0	0.0	23.9	90.0	43.2	62.0
Hungary	19.4	100.0	11.2	100.0	3.4	100.0	30	100.0	0	0.0	3.5	100.0
Lithuania	31.8	50.3	6.3	100.0	8.3	100.0	44.7	21.5	28.5	71.9	25	46.0
Latvia	24.7	83.0	7.5	24.0	3.9	59.0	25.1	34.3	0	0.0	0	0.0
Poland	41.4	100.0	37.7	100.0	34	67.4	58.4	41.4	42.9	100.0	47.2	42.6
Romania	0	0.0	0	0.0	0	0.0	35.5	0.6	0	0.0	40	100.0
Slovenia	64.8	100.0	47.9	100.0	65.9	100.0	71.2	100.0	50.3	100.0	62.1	100.0
Average	29.7	90.9	18.8	90.4	18.9	83.6	33.6	59.2	17.3	87.3	23.0	74.3

Source: Own calculation with Win4Deap 2

CONCLUSIONS

Based on 2013 data, we concluded that the allocative inefficiency was comprised between 63.3% and 0% with an average of 22.1% and the technical inefficiency was comprised between 15.2% and 0% with an average of 2.5%. In this way, we conclude that the major source of economic inefficiency was the allocative one (wrong mix of inputs). However, the economic efficiency over 70% suggests that farms from CEE countries were productive at a cost close to minimum. The farms from Romania and Bulgaria reached full technical and allocative efficiency. Also, the most efficient farms were the ones with higher economic dimension (over 100,000 SO) and the ones from milk sector.
In 2016, we obtained an allocative efficiency comprised between 60,2% and 0% (with an average of 14.4%) and a technical inefficiency was comprised between 23.3% and 0% (with an average of 4.2%). As we can observe, except Bulgaria and Lithuania, in all countries the main source of economic inefficiency was allocative. The full efficiency was reached only by Romania. The most efficient farms remained the ones with big economic dimensions and the ones from milk sector.
Our paper build on DEA-COST allowed us to compare farms from different CEE countries based on FADN data from 2013 and 2016 in connection to the structural changes. Although if we couldn't compare directly these two years, we may observe that the differences between countries are lower in terms of efficiency. Thus, it exists an obvious tendency to minimize the costs and to increase the efficiency, but there are still problems in technological capacities (the adaptation of inputs to the level of output) and especially difficulties in the allocation of inputs (an inefficient mix of inputs). The most efficient countries in 2016 were Romania and Latvia (followed closely by Czech Republic, Bulgaria and Hungary) and the most

inefficient country was Slovenia (followed by Poland and Croatia).

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