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DATA ENVELOPMENT ANALYSIS APPROACH ON THE EFFICIENT USE OF RURAL HUMAN RESOURCES IN AGRICULTURE, INDUSTRY AND CONSTRUCTIONS DURING 2006-2013

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Abstract

The paper studied the rural human resources efficiency at regional level by using the DEA nonparametric method (Data Envelopment Analysis). The application of this cutting edge method enables the calculation of efficiency scores based on a series of inputs (occupied population in agriculture, industry and construction) and outputs (gross value added in agriculture, industry and construction). The data regarding the rural human resources are retrieved from the Amigo data base, the regional GVA from Tempo online data base and the analysis is performed by MAXDATA 6.3 Beta program. The results revealed that the majority of the regions reach performance with the current input structure, with the exception of the North-East and North-West regions which need to reduce the number of workers in agriculture and increase the GVA from industry and constructions to support real economic growth.

Key words**:** *data envelopment analysis, effective use, human resources, rural areas*

INTRODUCTION

Evaluation of human resource efficiency in rural areas is a significant issue in the development and promotion of social and economic policies aimed at their efficient management and development. Decreasing employment, decreasing numbers of youth entering the labor market or increasing inactive population, the lack of jobs and low skills are just some of the problems facing human resources pools in rural areas. This phenomenon, if not managed effectively, creates long-term negative effects on rural development and reduced performance of local economies.

Assessment of human resources in rural Romania involves two approaches: using indicators collected in the rural areas according to the Romanian legislation (National Institute of Statistics) and indicators collected by the European Union classification of rural areas (Eurostat). Romanian rural areas, regardless of classification, face significant discrepancies compared to the national average and to the urban areas, in terms of both educational and professional training of the population, and in terms of the labor market function, as in most rural areas there is little diversification of economic activities, and the population is mainly employed in agriculture or in agriculture related activities. In the context of the previously mentioned issues facing the human resources, the research we performed in this paper is intended to highlight the efficient use of human resources in rural areas over the period 2006-2013.

MATERIALS AND METHODS

In time, the complexity of the concept of human resources has lead to a real necessity of measuring the labor factor productivity at national or regional level. Over time, in addition to analytical methods and econometric models, nonparametric models have also been developed, in which the Data Envelopment Analysis (DEA) has been widely used for assessing labor efficiency [3].

DEA is a non-parametric research technique, a mathematical optimization method, based on a simple linear sequence of programs used to evaluate the technical efficiency of the

"decision making units" (The Decision Making Units, DMU, are characterized by the transfer of a set of inputs into outputs through a uniform production function [4]).

DEA models can be input oriented (objective: to minimize inputs while maintaining the same level of outputs) and output oriented (objective: increasing outputs with the same level of inputs) [1]. As our goal is to measure human resource efficiency, we used an input orientation approach, with the assumption that a DMU (region) can produce the same level of output by using fewer inputs. Since each region uses various amounts of inputs to produce different levels of output, the method compares each region (DMU) with the most effective region (DMU). DEA will actually measure inefficiency and its determinants by evaluating the changes in technical and relative efficiency.

DEA uses the following notation: "n" – the number of DMUs (regions) to be assessed; each DMU has 'm' inputs and produces 's' outputs; in year 'j' a DMU_j consumes 'x_{ij}' from input 'i' and produces 'y_{rj}' of output 'r'; λ_j are the weights assigned by the linear program, 'Ɵ' is the calculated efficiency; 's_i' and 's_r' are errors in input and output; "ε" is defined as an element smaller than any positive real number [2], [5].

CRS - input oriented programming:

$$Min\ \theta + \varepsilon \left[\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+\right]$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + S_i^- = \theta x_{i0}, i = 1, 2 \dots, m$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - S_r^+ = y_{r0}, r = 1, 2 \dots, s$$

$$\lambda_j, S_i^-, S_r^+ \geq 0, \quad j = 1,2, \dots, n$$

VRS – input oriented programming:

$$Min\ \theta + \varepsilon \left[\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+\right]$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + S_i^- = \theta x_{i0}, i = 1, 2 \dots, m$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - S_r^+ = y_{r0}, r = 1, 2 \dots, s$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

1.

$$\lambda_j, S_i^-, S_r^+ \geq 0, \quad j = 1,2, \dots, n$$

For the analysis of efficiency scores we used MAXDATA 6.3 Beta program, which allows generation of CRS (technical efficiency), VRS (pure technical efficiency) and scale efficiency scores (VRS/VRS) under input oriented assumptions. This program allowed us to rank regions according to their efficiency scores, due to the fact that the DEA scores are identical within the DMU (in our case regions) as they operate at optimal scale between them, showing the best combination of inputs for a given level of output. Our approach aims to measure labor efficiency and the efficiency of employment in agriculture, industry and construction in rural areas, respectively, for a given level of gross value added of the three sectors at regional level.

RESULTS AND DISCUSSIONS

Under the CRS assumption, in 2006 and 2013, the Central, South-East, South-West and West regions had an optimal structure reaching performance of agriculture, industry and construction human resources (inputs) in relation to the gross added from these sectors (outputs). The North East and the North-West had high efficiency while South-Muntenia showed average efficiency (50-70%). Under these circumstances, the average technical efficiency of regions was 0.8672, lower than 2006 by approx. 6.0%, the largest decrease occurring in the Northeast region. Under the VRS assumption, the average efficiency score in 2013 was 0.9121 (compared to 2006 when all regions were considered efficient), which means that regions should reduce inputs by almost 8.8 % in order to achieve optimum production frontier (Table 1).

In the South-Muntenia region, which experienced decreasing returns to scale, inefficiency is due to a higher dimension of GVA (AGR, IND, CONS) as compared to the

human resources structure, which places it at approx. 30% against the efficiency frontier.

Table 1. The DEA Model (inputs- population from AGR, IND, CONS; outputs- gross value added from AGR, IND, CONS)

DMU	Input - Population (n°)			Output- Gross added value (thou RON)		
	AGR	IND	CONS	AGR	IND	CONS
2006						
Central	263050	119344	103506	3955.2	10731.9	2743
North-East	132277	119437	95625	3571.7	12180.7	2718.1
North-West	623292	115146	123868	4868.9	7402.9	2818.4
South-Muntenia	298275	78836	92749	3885.7	9428	3608
South-East	397169	205415	172677	4347.1	14138	2875.2
South- -West Oltenia	361071	64700	72485	2852.3	8037.2	2406.1
West	121583	86190	65095	2883	8855.2	2516.5
2013						
Central	276598	138989	107561	3717.6	16813.3	4322.9
North-East	101180	106755	106403	3647.2	22703.3	4471
North-West	705935	144934	138015	5109.2	14662.6	4551.8
South-Muntenia	253488	101445	97396	5874.2	16574.6	5209.2
South-East	318062	201073	201972	6143.4	26350.6	4852.3
South- -West Oltenia	353818	58620	59072	3622	17433.5	3826.5
West	137452	90037	67564	3380.5	20174.8	3191

	CRS	VRS	CRS/VRS	RTS
2006				
Central	1.0000	1.0000	1.0000	CRS
North-East	0.9293	1.0000	0.9293	DRS
North-West	0.8800	1.0000	0.8800	DRS
South- Muntenia	0.6475	1.0000	0.6475	DRS
South- East	1.0000	1.0000	1.0000	CRS
South- -West Oltenia	1.0000	1.0000	1.0000	CRS
West	1.0000	1.0000	1.0000	CRS
Average	0.9224	1.0000	0.9224	-
2013				
Central	1.0000	1.0000	1.0000	CRS
North-East	0.6063	0.6114	0.9917	DRS
North-West	0.7674	0.7732	0.9925	IRS
South- Muntenia	0.6965	1.0000	0.6965	DRS
South- East	1.0000	1.0000	1.0000	CRS
South- -West Oltenia	1.0000	1.0000	1.0000	CRS
West	1.0000	1.0000	1.0000	CRS
Average	0.8672	0.9121	0.9544	
2013/2006 (%)				
Central	100.0	100.0	100.0	
North-East	65.2	61.1	106.7	
North-West	87.2	77.3	112.8	
South- Muntenia	107.6	100.0	107.6	
South- East	100.0	100.0	100.0	
South- -West Oltenia	100.0	100.0	100.0	
West	100.0	100.0	100.0	
Average	94.0	91.2	103.5	

Note: IRS- increasing return to scale; DRS- decreasing return to scale; CRS- constant return to scale;
Source: National Institute of Statistics; MAXDATA 6.3 Beta

The North-East region, also with decreasing return to scale, should significantly reduce human resources in agriculture and increase the value added by industry and constructions.
On the other hand, in order to achieve optimal parameters, the North West region should reduce inputs (mainly in agriculture, followed by industry) and increase the gross value added in agriculture and industry (to increase productivity).
If we apply the DEA approach to each sector, we will see that the Central region presents optimal efficiency in the branch of agriculture, followed by the West region with a level of inefficiency of only 26.4%.
South-Muntenia and the South-East present efficiency under the VRS assumption due to the high level of GVA in agriculture, but they are at a level of approx. 40-50% from the efficiency frontier.
The North-East, North-West and South-West regions, where most of the population work in agriculture, registered a very low level of technical efficiency (20-30%), but, due to a quite low GVA compared to other regions, they obtained a high scale efficiency level (Table 2).

Table 2. DEA Model (input- population from AGR; output - gross value added from AGR)

DMU	CRS	VRS	CRS/VRS	RTS
Central	**1.0000**	**1.0000**	1.0000	CRS
North-East	0.2008	0.2850	0.7046	DRS
North-West	0.3729	0.3832	0.9730	DRS
South-Muntenia	0.5358	**1.0000**	0.5358	DRS
South-East	0.6429	**1.0000**	0.6429	DRS
South- -West Oltenia	0.2840	0.2860	0.9931	IRS
West	0.6823	0.7361	0.9269	Increasing

Note: IRS- increasing return to scale; DRS- decreasing return to scale; CRS- constant return to scale;
Source: National Institute of Statistics; MAXDATA 6.3 Beta

In the branch of industry, the South-West region is the most efficient, followed by the Western region with a level of inefficiency of 27.1%.
The Central and South-Muntenia regions present efficiency under the VRS assumption due to the high level of GVA, but they are under the optimum efficiency scale.
The North-East, North-West and South-East regions recorded a low level of technical

efficiency (below 50%), but, due to a quite low level GVA, they obtained a high scale efficiency level.

Table 2. The DEA Model (input- population from IND; output - gross value added from IND)

DMU	CRS	VRS	CRS/VRS	RTS
Central	0.7151	**1.0000**	0.7151	DRS
North-East	0.3402	0.4045	0.8411	IRS
North-West	0.4068	0.4218	0.9644	IRS
South-Muntenia	0.4407	**1.0000**	0.4407	DRS
South-East	0.5494	0.5779	0.9507	IRS
South - West Oltenia	**1.0000**	**1.0000**	1.0000	CRS
West	0.7534	0.9292	0.8109	DRS

Note: IRS- increasing return to scale; DRS- decreasing return to scale; CRS- constant return to scale;
Source: National Institute of Statistics; MAXDATA 6.3 Beta

In the branch of constructions, the South-West region remains the most performant, followed by the South-East region with a level of inefficiency of only 17.6% and efficiency under the assumption of VRS. Other regions have an average technical efficiency (between 50-40%) and high scale efficiencies. The South-Muntenia region holds the last position with inefficiency over 60%.

Table 3. The DEA Model (input- population from CONS; output - gross value added from CONS)

DMU	CRS	VRS	CRS/VRS	RTS
Central	0.6487	0.7231	0.8971	DRS
North-East	0.5091	0.5737	0.8875	DRS
North-West	0.6204	0.6771	0.9163	DRS
South-Muntenia	0.3709	0.4332	0.8561	DRS
South-East	0.8257	**1.0000**	0.8257	DRS
South - West Oltenia	**1.0000**	**1.0000**	1.0000	CRS
West	0.7291	0.8743	0.8339	IRS

Note: IRS- increasing return to scale; DRS- decreasing return to scale; CRS- constant return to scale;
Source: National Institute of Statistics; MAXDATA 6.3 Beta

CONCLUSIONS

In conclusion, the analysis of people employed in agriculture, industry and constructions and the gross value added in these sectors shows that, at the current level of outputs, the most efficient are the Central, South-East, South-West and West regions, while the North East region, in order to achieve an optimum size, should reduce human resources especially in agriculture and increase the gross value added in industry and constructions. Also, the North-West region needs to reduce human resources in agriculture and industry and increase the gross value added in these industries.

The DEA linear programming scores allow us to conclude that, to be effective, at the current level of GVA, there is a clear need to:

-reduce the human resources in agriculture in the North-East, North-West, South-West and West regions; increase GVA in agriculture in the West region;

-reduce the human resources in industry in the West region; reduce the human resources and increase the GVA in the North-East, North-West and South-East regions;

-reduce human resources in constructions in the Central, North-East, North-West, South-East, West and South-Muntenia; the West region also has to increase GVA in the constructions sector.

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