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THE EFFICIENCY FORECAST OF RURAL HUMAN RESOURCES USE BY THE DATA ENVELOPMENT ANALYSIS APPROACH

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Abstract

The structure of rural human resources (from agriculture, industry, constructions) represents the most important production factor in order to achieve economic growth (high GDP). In terms of efficiency, it is more important to assess the way in which the combination of human resources between these three branches contributes to GDP formation. To do this assessment for the period 2013-20120, we applied the nonparametric method of DEA (Data Envelopment Analysis). This method enables ranking regions based on a series of inputs (rural population occupied in agriculture, industry and constructions) and outputs (rural gross domestic product). The data regarding the rural human resources are retrieved from the Amigo data base, the rural GDP Eurostat and the analysis was performed by MAXDATA 6.3 Beta program. The results revealed that, by 2020, if maintaining the 2006-2013 trends, the average technical efficiency will decrease by 5.4%, only the Central and the South-West regions will be performing well and the North-East and North-West regions will become more inefficient. Our results reveal that, in the majority of regions, there is a clear need to reduce the population from agriculture, to increase the population from industry and constructions, and to increase de productivity, to ensure real economic growth.

Key words**:** *efficiency, forecast, rural human resources*

INTRODUCTION

Over the last decades the disparities between urban and rural areas have been deepened, most countries facing real problems in providing human resources capable of meeting regional economic and social needs, especially in the context of macroeconomic structural instability, income inequality, unemployment, etc. With the economic crisis of recent years, many countries have reduced social spending measures, especially in health and education, which will have a negative impact on long-term human resources development.

These problems become even more important when viewed in the context of expected changes in the coming decades, such as the changes in the demographic structure, the deepening inequalities, the rising costs of health services, the negative effects of climate phenomena, the globalization of economic effects, the migration on the labor market, etc. Rural areas in particular present other important issues, such as limited access to education and health, lack of productive employment, gender discrimination, lack of access to modern technologies, labor migration, lower labor productivity etc.

All these problems require the development of effective measures for ensuring human resources efficiency, the stability of the labor market and economic growth, both nationally and regionally. Understanding how the inputs structure can compete to ensure technical and scale efficiency in relation to outputs is an important element in identifying the sources of regional inefficiency and in identifying viable solutions for increasing the efficiency of human resources in rural areas.

MATERIALS AND METHODS

The Data Envelopment Analysis was developed starting from Farrell studies [3] in 1957. In 1958, Charnes, Cooper şi Rhodes [2] created the CCR model utilized to compute the constant return to scale (CRS) and in 1984, Banker, Charnes şi Cooper [1] modified

the DEA methodology for the cases when we do not operate with optimum parameters.

The DEA is a non-parametric, mathematical optimisation mehod, used to calculate technical, purely technical and scale efficiencies for Decision Making Units (DMUs). The DEA method has two approaches: input oriented (indentify the inputs quantities which can be reduced without modifying the outputs) and output oriented (identify the measure in which the outputs can be increased without modifying the utilized inputs). The model, for an input oriented approach, has the folowing formulae:

- Constant return to scale:

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

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

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

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

- Variable return to scale:

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

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

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

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

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

Where: ‘n’ - the number of DMUs (regions); 'm' – inputs; 's' outputs; year 'j'; a DMU_j consumes 'x_{ij}' from input 'i' and produces ‘y_{rj}’ of output ‘r'; λ_j - the weights, 'Θ' - calculated efficiency; 's_i' and 's_r' are errors in input and output; "ε" - an element smaller than any positive real number [2], [5].

We generated the CRS (technical efficiency), VRS (pure technical efficiency) and scale efficiency scores (VRS/VRS) under input oriented assumption by MAXDATA 6.3 Beta program. Based on these scores, we ranked the regions, starting from efficiency scores which show the best combination of inputs for a given level of output.

By using this method our aim was to measure rural labor efficiency. Inside the DEA model, we used the rural population from agriculture, industry and constructions as inputs, and the rural gross domestic product as output. The forecast of these variables for year 2020 was made starting from the 2006-2013 data, based on a three year moving average trend. The research had the following steps:

- compute the three year moving average for variables and the centered moving average;
- apply the linear trend equation by a regression function:

$Y_i = a + b\,t$, where:

’Y’ - the projected value of Y for a selected value of t
‘i’ - the region
’a’ - the free element
’b’ – correlation coefficient, respectivelly the mean change in Y from a one unit change of t
‘t’ – time

The 2013-2020 variables dynamics and the ranking of regions based on projected technical efficiency were compared with the DEA parameters for 2013. In this way we identified the solutions to reach performance and efficiency in labor use.

RESULTS AND DISCUSSIONS

According to the DEA analysis, in 2013, the most efficient regions were the Central and the South-West. Also, we identified a region with high efficiency, over 70% (the West region), two regions with average efficiency, between 50-70% (the North-West and the South-East regions) and two regions with low efficiency, under 50% (the North-East and South-Muntenia) (Table 1).

The North-East region is ranked as the last

with inefficiency of almost 70% proving a sub-optimal dimension of human resources compared to the obtained DGP. The medium technical efficiency under the CRS assumption was 0.6889 and under the VRS assumption was 0.8495, which means that the regions should reduce the inputs by almost 15% in order to reach the production frontier.

Table 1. The DEA model (inputs – population from agriculture, industry and constructions; output – gross domestic product)

	CRS 2013	VRS 2013	RTS	Efficiency
Central	1.0000	1.0000	CRS	Max.
North-East	0.3321	0.4445	IRS	Low
North -West	0.6628	0.7064	IRS	Average
South - Muntenia	0.4916	1.0000	DRS	Max. VRS
South - East	0.5210	0.7956	IRS	Average
South -West	1.0000	1.0000	CRS	Max.
West	0.8149	1.0000	IRS	Max VRS
Average	0.6889	0.8495		

Source: MAXDATA 6.3 Beta

In South-Muntenia region, which experienced decreasing returns to scale (economies of scale), inefficiency is mainly due to the high dimension of the output faced with the capacity of existing human resources (inputs should be increased, especially in agriculture and industry) (under the region VRS assumption it is more performant). In the West region, which experienced increasing returns to scale, the inefficiency under CRS and the efficiency under VRS demonstrate that this region must decrease human resources in all three branches. In the South-East, North-West and North-East regions, inefficiency is due to the low level of GDP relative to inputs (increasing returns to scale, economies of scale) which means that they must reduce inputs, especially in agriculture, and increase GDP.

The DEA recommendations for optimization, under the VRS assumption were to decrease human resources and to increase GDP for the North-East, the North-West and the South-East, the other regions being at optimum efficiency under the VRS assumption. Our forecast, based on the evolution of variables in the intervals 2006-2013, shows a variation of inputs variables between regions (Table 2).

Based on 2006-2013 trends, in the Central Region we may observe a marked decrease in population in agriculture, a slight decrease of population in industry and a rise of population in constructions. If this tendencies are maintained, this region can keep an optimal structure compared to the other regions (Table 3).

Table 2. The evolution of variables compared with the recommendation from the DEA performed for 2013

		AGR	IND	CONS	PIB
Central	DEA - 2013	-	-	-	-
	2013-2020 (%)	38.9	63.1	115.9	116.1
North-East	DEA - 2013	↓	↓	↓	↑
	2013-2020 (%)	118.5	95.9	95.0	115.1
North -West	DEA - 2013	↓	↓	↓	↑
	2013-2020 (%)	114.0	131.4	111.3	113.2
South - Muntenia	DEA - 2013	-	-	-	-
	2013-2020 (%)	59.6	57.2	96.7	136.4
South - East	DEA - 2013	↓	↓	↓	↑
	2013-2020 (%)	104.9	68.2	81.0	127.4
South -West	DEA - 2013	-	-	-	-
	2013-2020 (%)	117.2	41.7	34.2	126.7
West	DEA - 2013	-	-	-	-
	2013-2020 (%)	92.2	102.1	110.7	123.9

Source: MAXDATA 6.3 Beta

Table 3. DEA - 2020

		CRS 2020	2013-2020 (%)	VRS 2020	2013 - 2020 (%)
Central	DEA - 2013	1.0000	100.0	1.0000	100.0
	2013-2020 (%)				
North-East	DEA - 2013	0.2447	73.7	0.3511	79.0
	2013-2020 (%)				
North - West	DEA - 2013	0.5138	77.5	0.5827	82.5
	2013-2020 (%)				
South - Muntenia	DEA - 2013	0.6394	130.1	1.0000	100.0
	2013-2020 (%)				
South - East	DEA - 2013	0.5596	107.4	0.8314	104.5
	2013-2020 (%)				
South - West	DEA - 2013	1.0000	100.0	1.0000	100.0
	2013-2020 (%)				
West	DEA - 2013	0.7705	94.6	1.0000	100.0
	2013-2020 (%)				
		0.6754	98.0	0.8236	96.9

Source: MAXDATA 6.3 Beta

On the other hand, in the South-West and South-East regions, the optimal structure is reached based on the rise of population from agriculture and a high decrease of population from industry and constructions. This is not a viable solution to reach performance. The regions need to raise the GDP and to sustain the sectors with a real impact on economic growth.

By 2020, South-Muntenia region will remain performant under the VRS assumption and will show an increase of technical efficiency by 30.1%. We recommend, however, the

growth of population from industry and the growth of GDP and labor productivity in this branch.

If the current trends are kept, the North-East, North-West and West regions may show an increase in inefficiency and a raising gap faced with the optimal structures of the other regions over the next few years. This requires reducing the population in agriculture and promoting employment in industry and constructions to support the economic growth.

CONCLUSIONS

In conclusion, the comparative analysis of people occupied in agriculture, industry and constructions versus the GDP reveals that, at the current level of output, the most efficient regions are the Central and South-West ones, while, in order to achieve an optimum size, other regions (excepting the South and West) should decrease inputs (especially agricultural workers) and increase GDP. By 2020, the Central region maintains optimal structure due to the decrease of employment in agriculture and industry and population growth in constructions; the South-West and South-East regions remain effective due to population growth in agriculture and declining employment in industry and constructions (non-optimal economic situation); by 2020, South-Muntenia region will remain effective under the VRS assumption and will register an increase of technical efficiency by 30.1%; the North-East, North-West and West regions present a growing inefficiency and a gap against the optimal structures of other regions.

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