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THE EFFICIENCY OF INVESTMENT AT REGIONAL LEVEL IN ROMANIA: AN APPROACH WITH DATA ENVELOPMENT ANALYSIS

Abstract: *In contemporary economic and social context, a key factor of countries sustainable and balanced development is their investment policy. In order to highlight Romania's regional efficiency, our paper applies a three input – one output data envelopment analysis (DEA) model on the 42's counties panel data from 2005 to 2010. We used an output oriented BCC model. The results suggest that there are significant differences between the efficiency of Bucharest-Ilfov region and the one of the other regions, and a direct relation, a positive influence of the investment input on the efficiency score.*
Key words: *Data Envelopment Analysis (DEA), investments, regional development.*

JEL Classification: C02, O47, R11

1. INTRODUCTION

Investments are recognized as one of the determinants of economic growth in any country in the world. As member of the EU, Romania has access to cohesion and structural funds which represent an important source of investment financing.

In Romania, although the investments have increased in recent years, significant disparities exist between regions in terms of their effectiveness and contribution to economic growth.

The regional European Union (EU) policy is an investment policy that intends to support the economical competition and growth. The regional policy concentrates its funds in areas and sectors in which the results might be significant, thus being the expression of the EU solidarity with less developed regions. The regional policy's objective is to reduce the major economical, social and territorial disparities between Europe's regions.

On the 6 October 2011, the European Commission developed a series of legislative proposals regarding the cohesion policy for the period 2014-2020. These ones will be analyzed by the EU Council and by the European Parliament in the period 2012-2013. The new regulations are expected to enter into force in 2014.

The main purpose of the new policy aims aspects regarding investments in the economical growth and the employment (European Commission, 2011). The budget of the cohesion policy post-2013 is of 336 Milliard EUR, and will be divided depending on the regions' development level.

Taking into account the framing necessity within the European policy's specific, at the level of regions in Romania, there must be realized a detailed evaluation of the efficiency and of the development level in order to frame them in the mentioned categories, to benefit of funding and to develop a balanced and sustainable investment policy.

The purpose of this article is to highlight the regional efficiency and to quantify the influence of the investments on the development level, using the DEA methodology.

2. LITERATURE REVIEW

The degree of development and specialization of the regions of a country is studied by many papers around the world (Andrei, Iacob and Vlad, 2007).

For Romania are of interest the applications of econometric models for studying the link between foreign direct investment and economic growth, by application of different cointegration techniques (Ruxanda, Stoian, 2008).

However, the studies regarding the efficiency of investment in Romania are few and are not made by regions or counties.

The idea of efficiency measurement relies on system theory, which sees an organization as a system where inputs are the resources that are utilized for obtaining desirable outputs (Daft, 2010). The traditional model of efficiency determines a ratio of the output that was obtained from the process and the input used by the process (Pasupathy, 2002). But this equation takes into account only one input and one output.

Considering this limitation of the efficiency score, Farrell (1957) introduced a new measure of efficiency to take into account all inputs and outputs. This measure was defined in such a way so as to overcome the limit of traditional model, and to know how far "a given industry can be expected to increase its output by simply increasing its efficiency, without absorbing further resources". This new measure of efficiency is known as technical efficiency and analyzes an organization within a group of comparable organizations and it is evaluated by comparing it with some ideally performing firm.

Farrell (1957) addressed to the measurement of relative efficiency in the presence of multiple inputs and outputs by assigning weights to the variables so that the overall relative efficiency score is actually a ratio of the weighted sum of the outputs to the weighted sum of the inputs.

In multiple inputs and outputs efficiency measurement is common to apply the same set of weights to the inputs or outputs of all units. In this way, equal importance is given to a particular input or output for all analyzed organizations.

Further, the analyzed organizations manage their process differently hence value their inputs and outputs differently. This gives rise to differing weights. To overcome these drawbacks, Charnes, Cooper and Rhodes (1978) arrived at a mathematical programming approach that determines the weights and computes the efficiency score.
This model, known as the CCR model, was developed to measure the relative efficiency of a group of homogenous firms or decision making units (DMUs).
A DMU can be defined as an entity responsible for converting input(s) into output(s) and whose performances are to be evaluated (Kuah & Wong, 2011). This model determines the best set of weights for each DMU.
The most basic DEA model considers that there are *n* DMUs. Each DMU*j* (*j* = 1, 2, …, *n*) uses *m* inputs *xij* (*i* = 1, …, *m*) and generates *s* outputs *yrj* (*r* = 1, …, *s*). The input weights is *vi* (*i* = 1, …, *m*) and the output weights is *ur* (*r* = 1, …, *s*). The DMU*j* that will be evaluated on the trial to be designated as DMU*0* (*0* = 1, 2, …, *n*). The efficiency of each DMU*0*, *e0*, is thus found by solving the linear programming below:

$$\max e_o = \sum_{r=1}^{s} u_r y_{rj0}$$

subject to $\sum_{i=1}^{m} v_i x_{ij0} = 1$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0$$

$$u_r, v_i \geq 0$$

where:
η - efficiency of unit j
u_r – weight on output r
v_i – weight on input r
y_{rj} – quantity of output r for unit j
x_{ij} – quantity of input i for unit j

The model is run *n* times in identifying the relative efficiency scores of all the DMUs. Each DMU selects a set of input weights *vi* and output weights *ur* that maximize its efficiency score. The efficiency scores would fall in between 0 and 1. Generally, a DMU is efficient if it obtains the maximum score of 1; else, it is inefficient (Kuah &Wong, 2011).
The CCR model assumes constant returns to scale while determining the efficiency of the DMUs. Banker, Charnes and Cooper (1984) modified the CCR model by

adding a constraint to account for the variable returns to scale. The difference between the two models is the additional constraint $e\lambda = \sum_{j=1}^{n} \lambda_j = 1$

Data envelopment analysis (DEA), as a very useful management and decision tool, has found surprising development in theory and methodology and extensive applications in the range of the whole world science. It can be used to study the efficiency of a country's regions. Some DEA regional efficiency studies can be noticed in Table 1.

Table 1. DEA regional studies

Year	Authors	Analyzed country	DMUs	Inputs	Outputs	DEA model
2012	Zhang H. et al.	China	30 provinces	Fixed-asset investment; Net fixed asset of industry; Number of employee of industry	Gross Domestic Product (GDP); and the Value-added of industry	CCR efficiency Cross-efficiency
2011	Bruni M. E., Guerriero, F. & Patitucci V.	Italy	20 regions	energy consumption	GDP, CO2 emissions, poverty rate	4 models
2006	Coli M., Nissi E. & Rapposelli A.	Italy	103 provinces	number of employees	GDP, NO_2 concentration, PM10 concentration	CCR model

3. RESEARCH METHODOLOGY

One of the main objectives of European Economic and Social Cohesion Policy is Convergence. It refers to the reduction of development disparities between regions. In Romania the National Sustainable Development Strategy and the Regional Operational Program reveals the disparities between regions and support their mitigation (NSDS, 2008).

On the other hand, public authorities are interested in knowing the efficiency gaps between regions in order to promote policies to attract investment and to boost their efficiency.

For a sustainable and balanced development of the 8 national regions is necessary to evaluate and quantify the gaps between them.

This paper highlights the investment efficiency of each region towards the most developed region, using DEA methodology. Specific elements of the model are presented in Table 2.

The data set contains three inputs and one desirable output for 42 Decision-Making Units (DMUs) grouped into 8 regions and 4 macro regions. Values of period 2005-2010 are used in analysis.
The values for each considered variable were taken from the Romanian National Institute of Statistics databases (NIS, 2013).

Table 2 . DEA variables

Variable	Type of variable	Unit	DMUs	Period
Net Investments	Input	millions euro	42 Romanian Counties	2005-2010
Active Enterprises	Input	number of enterprises		
Employees	Input	thousands		
GDP/capita	Output	euro/inhabitant		

Specialized sources express the efficiency (Vasilescu, 2009) through two relationships: $e = \frac{E_{max}}{\varepsilon}$ or $e = \frac{E}{\varepsilon_{min}}$. In this work we consider suitable to use the approach on maximizing the impact in terms of a given effort. The considered inputs do not have to be minimized; these need to be managed efficiently, in order to obtain a higher level of development (GDP/capita).
Based on Banker, Charnes and Cooper (1984) model presented by Indira Gandhi Institute of Development Research (IGIDR, 2005) the output-oriented measure of the efficiency is obtained from the solution of the following program:

$$\max \phi$$

$$\text{s.t.} \sum_{j=1}^{N} \lambda_j x^j \leq x^t;$$

$$\sum_{j=1}^{N} \lambda_j y^j \geq \phi y^t;$$

$$\sum_{j=1}^{N} \lambda_j = 1;$$

$$\lambda_j \geq 0 \,(j = 1, 2, ..., N).$$

where $\sum_{j=1}^{N} \lambda_j^* y^j = \phi^* y^t = y_*^t$ and (x^t, y_*^t) is the efficient output-oriented projection of (x^t, y^t).

Because an increase in inputs does not yield the same increase in output, we use the variable returns to scale model (Hussain & Jones, 2010).

$\sum_{j=1}^{N} \lambda_j = 1$ is the constraint of convexity (BCC model) (Pasupathy, 2002).

4. RESULTS AND DISCUSSIONS

The efficiency scores of considered DMUs have been determined via Frontier Analyst (Banxia Software, 2010), a data envelopment analysis specialized software. The relative efficiency of Romanian counties is shown in table 3.

Table 3 . Efficiency scores of Romanian counties

Regions		County	2005	2006	2007	2008	2009	2010
Macro region 1	North West	Bihor	72.28	66.24	75.02	74.13	72.01	74.72
		Bistrita-Năsăud	87.64	93.44	88.04	83.86	87.72	90.03
		Cluj	71.77	70.15	82.35	76.33	70.87	92.61
		Maramures	68.22	71.16	63.01	60.96	65.82	63.22
		Satu-Mare	84.82	80.21	74.88	77.14	76.01	78.01
		Sălaj	100.00	100.00	100.00	100.00	100.00	100.00
		Average efficiency NorthWest	80.79	80.20	80.55	78.74	78.74	83.10
	Centre	Alba	80.42	95.54	98.47	94.76	89.91	100.00
		Brasov	69.58	64.77	83.15	76.35	65.23	94.09
		Covasna	100.00	100.00	100.00	100.00	100.00	100.00
		Harghita	89.68	100.00	85.49	85.04	95.46	96.02
		Mures	77.29	75.67	69.41	63.02	65.24	65.02
		Sibiu	67.21	66.17	76.63	77.46	72.46	83.19
		Average efficiency Centre	80.70	83.69	85.53	82.77	81.38	89.72
	Macroregion 1		80.74	81.95	83.04	80.75	80.06	86.41
Macro region 2	NorthEast	Bacău	72.02	65.39	59.42	57.27	62.18	62.49
		Botosani	62.27	71.80	74.59	70.19	100.00	100.00
		Iasi	60.74	58.52	56.29	62.53	53.12	66.11
		Neamt	64.28	62.58	56.28	59.32	62.84	66.62
		Suceava	63.18	55.38	51.06	44.87	60.75	59.28
		Vaslui	52.52	100.00	53.93	63.78	100.00	100.00
		Average efficiency NorthEast	62.50	68.95	58.59	59.66	73.15	75.75
	SouthEast	Brăila	76.75	73.88	72.60	89.11	91.17	82.95
		Buzău	64.09	68.42	60.97	59.31	55.81	75.09
		Constanta	73.79	66.78	70.18	65.70	64.71	69.85
		Galati	63.60	62.21	60.98	64.97	58.58	64.95
		Tulcea	91.04	98.31	100.00	100.00	100.00	98.56

		Vrancea	70.00	100.00	70.14	74.24	75.86	79.95
		Average efficiency SouthEast	73.21	78.27	72.48	75.56	74.36	78.56
	Macroregion 2		67.86	73.61	65.54	67.61	73.75	77.15
Macro region 3	South	Arges	64.68	60.51	68.98	67.08	70.11	75.10
		Călărasi	66.45	63.56	66.70	83.55	79.03	96.38
		Dâmbovita	76.46	73.96	73.29	65.11	68.36	82.17
		Giurgiu	100.00	100.00	100.00	100.00	100.00	100.00
		Ialomita	100.00	100.00	100.00	100.00	96.33	100.00
		Prahova	58.53	55.36	60.25	55.64	59.00	54.85
		Teleorman	72.36	78.15	69.12	72.54	70.42	63.89
		Average efficiency South	76.93	75.93	76.91	77.70	77.61	81.77
	Bucharest-Ilfov	Bucharest	100.00	100.00	100.00	100.00	100.00	100.00
		Ilfov	100.00	100.00	100.00	100.00	100.00	100.00
		Average efficiency Bucharest-Ilfov	100.00	100.00	100.00	100.00	100.00	100.00
	Macroregion 3		88.46	87.97	88.45	88.85	88.80	90.89
Macroregion 4	SouthWest	Dolj	65.23	65.37	65.56	69.11	54.99	62.36
		Gorj	99.00	100.00	100.00	100.00	99.63	100.00
		Mehedinti	85.67	90.60	100.00	100.00	100.00	100.00
		Olt	54.58	49.49	59.75	60.02	56.93	68.44
		Vâlcea	88.87	86.36	79.46	78.45	79.26	78.20
		Average efficiency SouthWest	78.67	78.37	80.95	81.52	78.16	81.80
	West	Arad	96.09	99.93	100.00	93.88	93.31	96.24
		Caras-Severin	91.69	88.84	90.59	88.36	100.00	100.00
		Hunedoara	80.32	86.99	85.05	89.14	85.17	95.90
		Timis	80.86	80.31	82.92	75.84	80.04	92.96
		Average efficiency West	87.24	89.02	89.64	86.81	89.63	96.27
	Macroregion 4		82.95	83.69	85.30	84.16	83.90	89.04

We can observe in table that there are 6 efficient counties in 2005 (Sălaj, Covasna, Giurgiu, Ialomita, Bucharest, Ilfov), 10 in 2006 (Sălaj, Covasna, Harghita, Vaslui, Vrancea, Giurgiu, Ialomita, Bucharest, Ilfov,Gorj), 10 in 2007 (Sălaj, Covasna, Tulcea, Giurgiu, Ialomita, Bucharest, Ilfov, Gorj, Mehedinti, Arad), 9 in 2008 (Sălaj, Covasna, Tulcea, Giurgiu, Ialomita, Bucharest, Ilfov, Gorj, Mehedinti), 10 in 2009 (Sălaj, Covasna, Botosani, Vaslui, Tulcea, Giurgiu, Bucharest, Ilfov, Mehedinti, Caras-Severin) and 12 (Sălaj, Alba, Covasna, Botosani, Vaslui, Giurgiu, Ialomita, Bucharest, Ilfov, Gorj, Mehedinti, Caras-Severin) in 2010. Five counties (Sălaj, Covasna, Giurgiu, Bucharest , Ilfov) are on the efficiency frontier for the entire time period 2005-2010.

To analyze the relative efficiency of the 8 Romanian development regions, we present in table 4 the average efficiency of each region.

Table 4. Efficiency scores of Romanian development regions

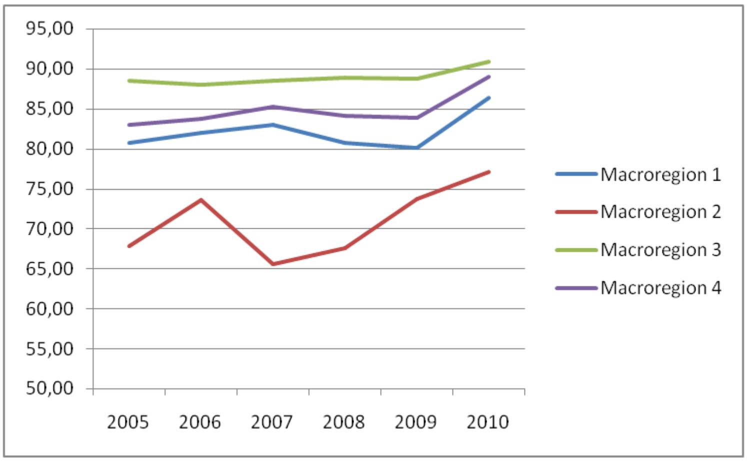
Development region	2005	2006	2007	2008	2009	2010	Regional average efficiency 2005-2010
Average efficiency **NorthWest**	80.79	80.20	80.55	78.74	78.74	83.10	**80.35**
Average efficiency **Centre**	80.70	83.69	85.53	82.77	81.38	89.72	**83.97**
Macroregion 1	80.74	81.95	83.04	80.75	80.06	86.41	82.16
Average efficiency **NorthEast**	62.50	68.95	58.59	59.66	73.15	75.75	**66.43**
Average efficiency **SouthEast**	73.21	78.27	72.48	75.56	74.36	78.56	**75.40**
Macroregion 2	67.86	73.61	65.54	67.61	73.75	77.15	70.92
Average efficiency **South**	76.93	75.93	76.91	77.70	77.61	81.77	**77.81**
Average efficiency **Bucharest-Ilfov**	100.00	100.00	100.00	100.00	100.00	100.00	**100.00**
Macroregion 3	88.46	87.97	88.45	88.85	88.80	90.89	88.90
Average efficiency **SouthWest**	78.67	78.37	80.95	81.52	78.16	81.80	**79.91**
Average efficiency **West**	87.24	89.02	89.64	86.81	89.63	96.27	**89.77**
Macroregion 4	82.95	83.69	85.30	84.16	83.90	89.04	84.84

We have one efficient region Bucharest-Ilfov, followed with a difference of 10.23 units by the West Region (Arad, Caras-Severin, Hunedoara , Timis). The Centre region (Alba, Brasov, Covasna, Harghita, Mures, Sibiu) is placed at 16.03 points from the efficient region, NorthWest (Bacău, Botosani, Iasi, Neamt, Suceava, Vaslui) at 19.65, SouthWest (Dolj, Gorj, Mehedinti, Olt, Vâlcea) at 20.09, South (Arges, Călărasi, Dâmbovita Giurgiu, Ialomita, Prahova, Teleorman) at 22.19 and SouthEast (Brăila, Buzău, Constanta, Galati, Tulcea, Vrancea) at 24.60 efficiency units. The lowest score 66.43 is registered for NorthEast region (Bacău, Botosani, Iasi, Neamt, Suceava, Vaslui).

At the regions level, the analysis of the obtained values highlights some disparities between the 8 regions, and significant gaps between each region and the efficiency frontier on which is placed only the Bucharest-Ilfov region.

At the macroregions level (Figure 1), the highest average efficiency corresponds to Macroregion 3 (South and Bucharest-Ilfov regions). Follows the Macroregion 4 (SouthWest and West), Macroregion 1 (NorthWest and Centre) and with the lowest score the Macroregion 2 (NorthEast and SouthEast).

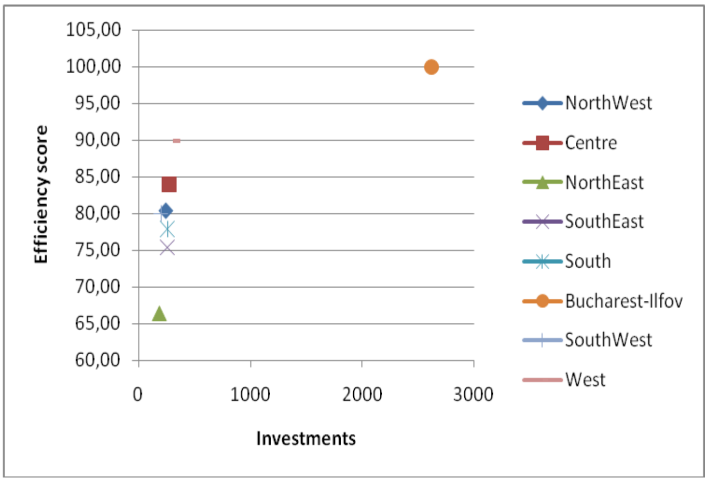
Figure 1. Macroregional efficiency trend



It can be noticed that the macroregional efficincy follows the general trend of the economic and social conditions of the analyzed period. The causes are of complex and uncertain nature. Only the Macroregion 2 has a different evolution because as the weakest developed region, during the economic mondial crisis period, has received particular founds to decrease its development disparities.
The figure realized based on the efficiency scores emphasizes the fact that Romania was in a momentary unfavorable situation. Yet there still exist premises of a not very spectacular growth, but which might confer credibility and performance at the level of the economic and social system. The maintenance and confirmation, especially of a growth trend, considered to be sustainable at the efficiency level is a major provocation, conjugated at the public local and central authorities' level.
One of the main factors that can support this sustainable and balanced development is the regional investment policy. In our further considerations we present the intensity of the corelation between the efficiency and the value of the investments of each reagion.

Therefore, the most significant considered input, with a great influence on the level of efficiency is the value of Investments (Figure 2a).

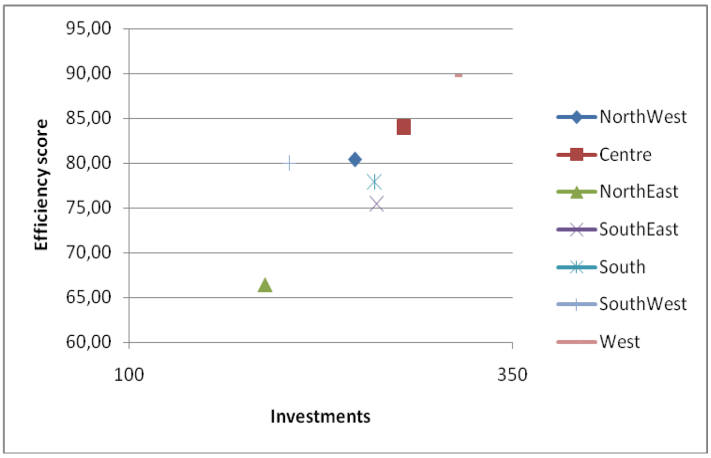
Figure 2a. Efficiency-Investments scatter (average 2005-2010)



It can be seen a direct, positive relation between the two indicators. Higher investments in a region increase its efficiency.

In the figure 2.a. it can be observed very well the relation because of the scale used and of the consideration of Bucharest-Ilfov outlier region whose investment far exceed the series average. Therefore, in order to determine the intensity of the correlation between the investments value and the regional efficiency score the series outlier is removed. The simple scatter of the correlation is presented in figure 2b.

Figure 2b. Efficiency-Investments scatter (average 2005-2010) no outlier



The simple regression model that highlights the relation between the average efficiency score and the average investments of the analyzed regions is presented below:

Efficiency Score = a*Investment + u

where: Efficiency Score - dependent variable;
Investment – explanatory variable;
a- coefficient of explanatory variable; shows the influence of Investments changes on Efficiency Score;
u- constant term.

In highlighting the existing influence, we estimated the model's parameters (Table 5).

Table 5. The results of the regression analysis

Variable	Coefficient	Std. Error	t-Statistic	Prob.
I	0.137318	0.045256	3.034273	0.0289
C	44.71372	11.46911	3.898621	0.0114
R-squared	0.648056	Mean dependent var		79.09195
Adjusted R-squared	0.577667	S.D. dependent var		7.251042
S.E. of regression	4.712244	Akaike info criterion		6.173162
Sum squared resid	111.0262	Schwarz criterion		6.157707
Log likelihood	-19.60607	F-statistic		9.206812
Durbin-Watson stat	1.402260	Prob(F-statistic)		0.028940

The method used for estimating the parameters is Least squares (results obtained by using an econometric analysis informatics program), method chosen due to the model's validity (Fisher test - Prob(F) value smaller than 0.05) and for meeting the assumptions for error autocorrelation (Durbin-Watson statistics), and normal distribution of the residue (Jarque-Bera test) and homoscedasticity (White test - probability greater than 0.05) (Stock & Watson, 2003).
To test the null hypothesis that the residuals from our ordinary least-squares regression are not auto-correlated we have compared the Durbin-Watson statistic d=1.4 with the tabulated (Gujarati, 2004) lower (d_L=0,7) and upper (d_U=1.3) critical values at significance α=0.05, for k=1 explanatory variable and n=7 considered regions. Therefore, the relation $d_U=1.3 < d=1.4 < 4-d_L=3.3$ indicates to accept the null hypothesis of no autocorrelation.
To test the significance of the slope we applied t-Student test (statistical test applied in order to establish the meaning of the parameters for a regression model). The hypotheses of the test are: H0: a=0 (the slope of the regression line doesn't differ significantly from zero, which is equivalent to saying that, the regression model is not significant) and H1: $a\neq0$ (the slope of regression line differs significantly from 0). Prob.= 0.028<0.05, therefore we reject the null hypothesis

and we do not accept that the regression model is significant from a statistical point of view.

The equation model resulted:

Efficiency Score = 0.14* Investment + 44.7

Thus, the increase by 1 million of investments in the region, increases the average efficiency score by 0.14.

We can draw out from the analysis of the results issues that refers to the intensity of the correlation between the 2 variables. Since the regression model has a constant term, and the value for determining R^2 is 0.648, we can say that, 64.8% from the dispersion of the Efficiency Score variable can be explained through the Investment variable. This value reflects a correlation between the two variables, and also the hypothesis that indicate the use of three inputs for the calculation of the efficiency, the investments being only one of them.

5. CONCLUSIONS

Since 1998 there are in Romania eight development regions: NorthWest, Centre, NorthEast, SouthEast, South, Bucharest-Ilfov, SouthWest, West. These are grouped in 4 macroregions: Macroregion 1 (NorthWest and Centre), Macroregion 2 (NorthEast and SouthEast), Macroregion 3 (South and Bucharest-Ilfov), Macroregion 4 (SouthWest and West).

In order to support the balanced development of regional and local strategies and sustain economic and social development of Romania according to the objective convergence of the European Union Cohesion Policy, our research highlights the efficiency of each Romanian macroregion, region and county.

Thus, the average efficiency related to the period 2005-2010 is 88.90 for Macroregion 3, 84.84 for Macroregion 4, 82.16 for Macroregion 1 and 70.92 for Macroregion 2.

Whether the macroregional differences are not substantial, at the regional level the results obtained by evaluating the efficiency with DEA methodology shows that there are significant differences between the efficiency of Bucharest-Ilfov region and of the other regions. In comparison with the region situated on the efficiency frontier Bucharest-Ilfov 100%, rates of the other regions are in descending order: West 89.77, Centre 83.97, NorthWest 80.35, SouthWest 79.91, South 77.81, SouthEast 75.40, NorthEast 66.43.

The validity of this conclusion is supported by other studies, based on other methodologies. Surd, Kassai and Giurgiu (2011) have observed the hypertrophy overheads Bucharest-Ilfov, deviating significantly from the other seven regions, both by population, the high degree of absorption or resources development.

The main recommendation for supporting throughout the country a balanced development aims issues related to the investment policy. The context of globalization and increasingly rapid evolution of society highlights the need to recognize the importance of the interdependencies between economic development and investment policy.

The analyzed regression model highlights a direct relation, a positive influence of the Investment input on the efficiency score of Romanian regions. Therefore, the investment policy is extremely important in the sustainable and balanced development of regions.

The limits of the research refer to: first, more inputs and outputs could be used to describe the regional efficiency (eg. undesirable outputs). Second, in real world the assumption may not always be true because of uncertainty. DEA faces the situation of imprecise data, especially when a set of decision-making unit (DMUs) contains missing data, judgment data, forecasting data or ordinal preference information. Uncertain information or imprecise data can be expressed in interval or fuzzy numbers (Wang, Greatbanks & Yang, 2005), by using a fuzzy DEA approach.

In conclusion, our research results can be the basis of future studies on the regional allocation of investment funds. This may be the way to reduce the development differences and to progress on the convergence of the eight regions, and support our country convergence with the European Union developed ones.

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