Non-parametric methods applied in the efficiency analysis of European structural funding in Romania

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Abstract

One of the most widely used methods in assessing the efficiency of public policies and programs for a set of units is Data Envelopment Analysis (DEA). DEA is a non-parametric method which identifies an efficiency frontier on which only the efficient Decision Making Units (DMUs) are placed, by using linear programming techniques. By applying non-parametric techniques of frontier estimation, the efficiency of a DMU can be measured by comparing it with an identified efficiency frontier. In this paper we have used DEA for evaluating the efficiency of the European structural funds allocated to finance the educational infrastructure through the Regional Operational Program 2007-2013, implemented in Romania. The output variables measure the educational performance as well as the school drop-out rate, while the focal input variable is the value of European funds. Romanian counties are considered to be the decision making units (DMUs). Our results confirm the deep disparities existing between Romanian counties concerning the efficient use of European structural funds.

Keywords: European structural funds, efficiency, Data envelopment analysis, infrastructure, regions

JEL classification: H83, R58, C61

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1 Introduction

After becoming a Member State of the European Union, starting with the programming period of 2007-2013, Romania benefited from structural and investment funds[2], designed to help it cope with the economic challenges and disparities, as well as to take advantage of the opportunities available in the country. For Romania, the European Union funds represent financial instruments set up to assist in reducing the regional disparities and fostering growth through investments in domains such as employment, social inclusion, rural and urban development or research and innovation. During the programming period 2007-2013, Romania benefited from a budget of 27.5 billion euros, out of which 19.2 billion euros were for the structural and cohesion funds and 8.3 billion for the Common Agricultural Policy.

The aim of the paper is to analyse the regional disparities existing between Romanian counties regarding the efficiency of the European structural funds[3] (hereafter SF) allotted for financing the educational infrastructure. One of the most relevant needs for Romania's social development is improving the quality of educational infrastructures and reducing the regional disparities existing between Romanian regions in this case. The Regional Operational Programme through the Key Area of Intervention 3.4 „Rehabilitation, modernisation, development and equipping of pre–university, university education and continuous vocational training infrastructure" was the programme that addressed the needs for the educational infrastructure development.

[2] Since 2007, the EU Cohesion policy has revolved around three objectives: Convergence (81.7% of the total Cohesion Policy payments), Competitiveness and employment (15.8%) and Territorial cooperation.

[3] In this paper we use the term "European Structural Funds" to refer to the financial tool set up to implement the regional policy of the European Union. Alongside with the Cohesion funds, they aim to reduce regional disparities in income, wealth and opportunities. In Romania, like in other European countries, the European Structural Funds are made up of the European Regional Development Fund and the European Social Fund and are implemented through Operational programmes.

In this research we have used a non-parametric method widely utilised for evaluating the efficiency of regional units, namely Data Envelopment Analysis (DEA). The efficiency was computed in various models, both output and input oriented, using STATA 20.

The contribution of the paper is twofold: the paper approaches the efficiency of using structural funds in the first Programming period in Romania, being one of the first attempts to apply DEA methodology in this respect; at the same time, the study is focused on the counties, at NUTS3 level, and ways to improve regional policies implementation in Romania, in the second programming period, 2014-2020. The study fills a gap in the literature related to public programming and planning, provides valuable information for decision makers and also opens room for further research on this challenging topic.

This paper is structured as follows: The second section presents the Romanian context related to the existing needs in education, while Section 3 briefly reviews the literature on the impact of structural funds on economic growth and the economic convergence process, respectively. Sections 4 and 5 discuss the method applied and subsequently the variables and model specifications, followed by the presentation of the results in Section 6. Finally, section 7 concludes.

2 The Romanian context: needs in the educational system and policy responses

A basic structure of education levels in Romania includes: kindergarten, primary school, middle school, high school and higher education and education in Romania is compulsory for 11 years (from the preparatory school year to the tenth grade). With the exception of kindergarten and higher education, the private sector has a very low presence in the Romanian education system. Therefore, the education system is mainly financed from the state budget; the general government expenditure on education as a share of GDP fell from 3.0% in 2012 to 2.8% in 2013, which indicates an obvious under financing of the educational sector. This is reflected in low wages, but also in the poor state of the educational equipment, learning spaces, as well as in the related facilities.

The situation is even more difficult for the schools in disadvantaged communities. In a report published in 2014, Fartuşnic et al. found that the core financial source of these schools is state funding and their entire annual budget covers only administrative costs and teachers' salaries. It seems obvious that such institutions have insufficient resources for infrastructural development.

The access to schooling of children from disadvantaged areas, especially from rural areas, but also of those from vulnerable social environments is difficult in Romania. In some cases, school capacity is deficient; there are large distances to the closest school and inadequate transportation facilities. A large number of education units need rehabilitation works and equipping with didactic equipment, IT and specific documentation materials. Fartuşnic (2014) noticed that according to the data on early school leaving provided by the Romanian National Institute for Statistics, the share of early school leavers in rural areas is three times higher than in urban areas and there are also important differences between Romanian regions: the highest rates were recorded in the North-East, South-East and South Muntenia regions, while the lowest were in the Bucharest Ilfov and Western regions.

Under such circumstances, the national strategy in the field made it a priority to set up and develop the education infrastructure, to increase education accessibility and quality. The Regional Operational Programme 2007 – 2013 through the Key Area of Intervention 3.4. "Rehabilitation, modernisation, and development and equipping of pre-university, university education and continuous vocational training infrastructure" (hereafter KAI 3.4) has the purpose to address the existing needs. In terms of the activity proposals, the activities that required special attention referred to "the construction, consolidation, rehabilitation, modernisation, extension of buildings located on the technical and vocational campuses; the equipment with teaching materials, professional training materials, IT equipment and specific equipment for residential spaces; the rehabilitation, consolidation, modernisation of buildings and fields on university campuses; the rehabilitation and/or consolidation of buildings located within the continuous professional formation institutions; and the modernisation of utilities, including the demand for special facilities for people with disabilities, for all types of infrastructure"[4]

In the context of a chronic lack of financial resources invested in education in the past 25 years, the successful implementation of the projects financed through European SF at national level becomes a top priority. The efficiency of using SF is crucial, since the specific needs are usually in high numbers and of significant relevance and the final goal is increasing the quality and performance of the education system in Romania. It is important to mention that this paper does not provide an impact analysis of SF, but an evaluation of the efficiency of using SF in achieving the specific objectives.

3 Literature review

Given the relevance and the high interest in the EU Cohesion Policy, the evaluation of the performances of various financing programs has become a high priority and it involved a large spectrum of both quantitative and qualitative methods. In their paper (2010) Mohl and Hagen prove that the econometric evaluation of EU Cohesion Policy is hampered by several econometric issues, such as reverse causality, measurement error, omitted variables, strict functional form assumptions and the potential inclusion of inappropriate control variables. Starting with this finding, we attempted to apply non-parametric methods for evaluating the performance in using structural funding at regional level in Romania. The existing results on

[4] http://www.inforegio.ro/ro/

the efficiency of using structural funds for the regional development are relying mainly on parametric approaches and econometric modelling. The advantages of non-parametric approaches are less exploited and this paper aims at testing the performance of such techniques in this field.

DEA approach involves the application of the linear programming technique to trace the efficiency frontier. It was originally developed to measure the performance of various non-profit organizations, such as educational and medical institutions, which were highly resistant to traditional performance measurement techniques due to the complex and often unknown relations of multiple inputs and outputs and non-comparable factors that had to be taken into account. In recent years it has been successfully applied in measuring the efficiency of both for-profit and non-profit organizations, such as the effectiveness of regional development policies in Northern Greece by Karkazis and Thanassoulis (1998). Coelli, Rao and Battese (1998) introduce the reader to this literature and describe several applications. DEA was launched by Charnes et al. (1978) under the assumption that production exhibited constant returns to scale. Banker et al. extended it to the case where there are variable returns to scale.

Governmental efficiency in general and public policies efficiency became research subjects of an increasing number of papers. Zhu (2002) provides a series of Data Envelopment Analysis (DEA) models for efficiency assessment and for decision making purposes. Rhodes and Southwick (1986) use DEA to analyze and compare private and public universities in the USA. More recently, Singh (2016) uses DEA for ranking the Indian states in their efficiency of applying a large welfare scheme for poverty alleviation. Using a sample of 31, an input and output oriented DEA model was applied, with constant and variable return to scale proving that 11 units were technically efficient.

There are several applications of the DEA method for Romania; Roman and Suciu (2012) provide an efficiency analysis of research activities using input oriented DEA models and

Nitoi (2008) assesses the efficiency of the Romanian banking system using an input oriented with variable returns to scale DEA model. DEA has also been used to assess different aspects of the medical field like hospital efficiency (Nedelea et al., 2010; Mecineanu et al., 2012) or health systems efficiency (Asandului, Roman, Fatulescu, 2014).

USING a panel of NUTS3 regions, Becker et all (2010) find positive growth effects of Objective 1 funds, but no employment effects. Puigcerver-Peñalver (2007) finds that structural funds have positively influenced the growth process at regional level although their impact has been much stronger during the first Programming period than during the second one. Rodriguez-Pose and Fratesi (2004) distinguish between various structural funds expenditure and conclude that only structural fund expenditures for education and investment have a positive effect in the medium run, whereas expenditures for agriculture do not.

Mohl and Hagen (2010) evaluate the growth effects of European structural funds payments at regional level. Using a new panel dataset of 124 NUTS regions for the time period 1995-2005, they found empirical evidence that the effectiveness of structural funds in promoting growth is strongly dependent on which financing objective is analysed. The payments of Objective 2 and 3 have a negative effect on GDP.

4 Method and models specifications

First presented in 1978 and based on the paper of Farrell, the first DEA model is known in the literature as the CCR model, after its authors, Charnes, Cooper and Rhodes. It is a non-parametric method which identifies an efficiency frontier on which only the efficient Decision Making Units (DMUs) are placed, by using linear programming techniques. The method depends on a number of output and input variables that are employed for computing the efficiency score for each DMU.

Since it is of high importance which are the variables selected in the model and how many these are, a strong experience in the field of application of the method is needed. At the same time, the number of DMU could also be a challenge for applying the method in public policy evaluation: for the purpose of the paper, we follow the suggestion of Mohl and Hagen (2010) who recommend to use regional data that would allow for a more accurate analysis of the funding's efficiency and also for maximizing the discrimination existing between various DMU.

In general there is a trade-off between the number of variables included in the models and the number of DMU and this issue was studied by various researchers. For instance, Dyson et al. (1991) recommend a total of two times the product of the number of inputs and outputs variables. Golany and Roll (1989) recommended that the number of DMU should be at least twice the number of inputs and outputs considered. On the other hand, Charnes and Cooper (1991) have suggested that there should be three times as many DMUs as the number of inputs plus outputs.

Following the rule of thumb suggested by Cooper et al (2007) we estimate that the minimum number of DMUs required is achieved:

$n \geq max\{m * s, 3(m + s)\}$,

where n is the number of DMUs, m is the number of inputs and s is the number of outputs.

For a model relying on three inputs and three outputs, as in the present research, it would be recommended that at least 18 DMUs should be included in the estimation of the efficiency frontier. This condition is satisfied, since there are 31 DMUs involved in the analyzed models.

4.1 Model for an output-oriented specification

The DEA models could be input or output oriented: an input-orientated model looks at the amount by which inputs can be proportionally reduced, with fixed outputs, while an output-oriented DEA model looks at maximizing the outputs obtained by the DMUs while keeping the inputs constant.

In the particular case of our research, the linear programming problem to be solved, in the output oriented and variable-returns to scale hypothesis, is sketched below (Charnes, Cooper and Rhodes, 1978).

Suppose there are k inputs and m outputs for n DMUs. For the i-th DMU, yi is the column vector of the inputs and xi is the column vector of the outputs. We can also define X as the (k×n) input matrix and Y as the (m×n) output matrix. The DEA model is then specified with the following mathematical programming problem, for a given i-th DMU:

$$\begin{cases} \max\limits_{\phi,\lambda} \phi \\ -\phi y_i + Y\lambda \geq 0 \\ x_i - X\lambda \geq 0 \\ N_1\lambda \leq 1 \\ \lambda \geq 0 \end{cases} \qquad (1)$$

In problem (1), ϕ is a scalar and $1 \leq \phi \leq \infty$.

ϕ-*1* is the proportional increase in outputs that could be achieved by the i-th DMU with the input quantities held constant.

The measure $1/\phi$ is the technical efficiency score and varies between 0 and 1. If it is less than *1*, the public intervention is inside the frontier (i.e. it is inefficient), while if it is equal to 1 it implies that the intervention is on the frontier (i.e. it is efficient).

The λ vector is a (*n*×*1*) vector of constants that measures the weights used to compute the location of an inefficient DMU if it were to become efficient. The inefficient DMU would be projected on the production frontier as a linear combination of those weights, related to the peers of the inefficient DMU. The peers are other DMUs that are more efficient and therefore are used as references for the inefficient DMU. N_1 is a n-dimensional vector of ones.

Adding the restriction

$N_1 \lambda <= 1$ in DEA model

the convexity of the frontier is imposed, accounting for variable returns to scale. Dropping this restriction would amount to admit that returns to scale were constant. The linear programming problem (1) is solved for each of the *n* DMUs resulting in *n* efficiency scores.

The scale efficiency could also be computed for the DMUs in the sample. This is the ratio between the efficiency scores in the CRS and VRS hypotheses and accounts for the increase, decrease or constant return to scale.

4.2 Model for an input-oriented specification

The specifications of the mathematical programming problem, for a given i-th DMU are described below, and one problem for each DMU has to be solved:

$$\begin{cases} \min_{\theta,\lambda} \theta \\ -y_i + Y\lambda \geq 0 \\ \theta x_i - X\lambda \geq 0 \\ N_1\lambda \leq 1 \\ \lambda \geq 0 \end{cases} \qquad (2)$$

In the problem above, the inverse of scalar θ ranges between 0 and 1 and is the technical efficiency score. Like in the previous case, if it is equal to 1, it implies that the DMU is efficient, while if it is less than 1, the DMU is inefficient. The model specification under the hypothesis of variable return to scale implies the condition of convexity of the frontier.

In the present research we have applied the DEA input and output oriented models considering both the constant and variable return to scale and the scale efficiency was also computed.

5 Model specifications and data

The variable of interest in our models is the total value of the projects financing the educational infrastructure through KAI 4.3 at county level. Out of the total number of projects contracted, we have selected the projects which had been finalized by April 2014, resulting 131 projects with a total value of 723 million lei. The projects devoted to financing higher education and research infrastructure were in a small number and therefore were excluded from the analysis. The data is provided by the Ministry of Regional Development and Public Administration and it covers the projects financed between 2007 and 2014. Other two inputs also considered in the efficiency evaluation are: the teacher/student ratio that counts for the human resources and the number of classrooms/student ratio that counts for fixed capital. The data provided by the National Institute for Statistics refers to 2014.

The output variables were selected in line with one of the objectives of the KAI 3.4, that were to increase the educational performance and accessibility. Therefore, the average pass rates at the National Evaluation and the National Baccalaureate exam were included in the set of output variables, as proxy for educational performance. These indicators are reported by the Ministry of National Education at various regional levels, counties included. The variation of dropout rate was included as the third output, as a measure of the education accessibility. The variable is reported at county level by National Institute of Statistics. The output variables refer to 2014 (dropout rate) and 2015 (graduation rates), knowing that it takes a period of time for a programme to produce effects. As in other studies (Roman and Suciu, 2012), it is common to have a time gap between input and output variables in DEA models.

6 Results and discussions

6.1 Data and variables

Table 1 summarizes the descriptive statistics for the set of input and output variables. The two indicators accounting for the performance of the undegraduate education system, namely the graduation rate at the Baccalaureate exam and the graduation rate at the National Evaluation, provide a moderate homogeneity. The first one has the minimum value recorded in Ilfov (29,26%), that is an outlier of the series, while the maximum graduation rate was registered in Cluj (71,74%). The mean of the sample is 58,64%, in line with the national average of 59,25%. The graduation rate for the National Evaluation ranges from a minimum score of 61,04% in Olt to 88% in Cluj, with an average of 75%.

Table 1. Descriptive statistics of the selected variables

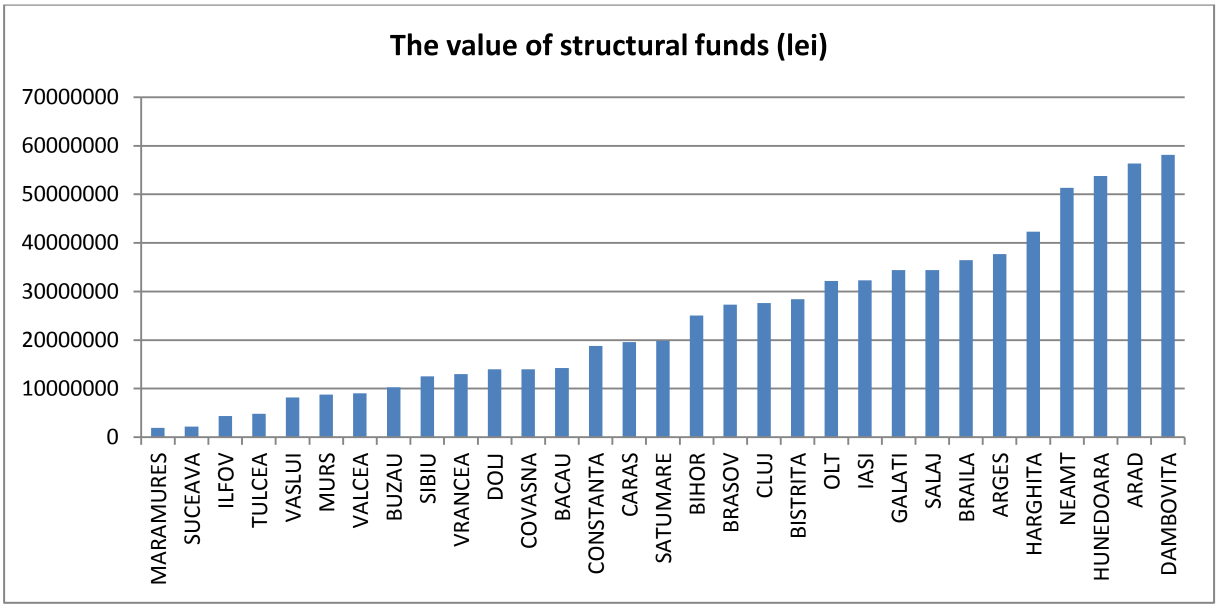
	Graduation rate at Baccalaureate (%)	*Graduation rate at the National Evaluation (%)*	*Index of Dropout rate*	*Classrooms/ 100 pupils*	*Teachers/ 100 pupils*	*European SF (lei)*
Mean	58.64	75.03	0.9786	3.5462	5.6814	24299352
Median	60.23	75.1	0.9524	3.5309	5.6376	19844435
Standard Deviation	8.27	6.05	0.2415	0.5256	0.4460	16467902
Sample Variance	0.68	0.37	0.0583	0.2762	0.1989	2.71E+14
Range	42.38	27.82	1.1545	2.1937	2.2620	56218240
Minimum	29.26	61.04	0.3000	2.3332	4.2560	1907876
Maximum	71.64	88.86	1.4545	4.5269	6.5180	58126116
Coeff. of variation	14%	8%	25%	15%	8%	68%
Count	31	31	31	31	31	31

The modest performance of the undegraduate education system generated vivid debates in the Romanian media and also among education decision makers and researchers that tried to identify the possible causes for the situation, spreading from the poor education conditions in some schools, the lack of interest of teachers who are underpaid, the lack of parental involvement, to the shifts in youth behavior and lack of student interest in learning and preparing for a career.

The variation of the dropout rate has a moderate homogeneity described by a coefficient of variation of 25% and the mean and median are very close to each other, pointing out the symmetry of the series. On average, the counties in the sample faced a slow decrease in the dropout rate, but, at the same time, there are regional differences. The highest decrease in the dropout rate (by 70%) appears in Hunedoara, while the highest increase (of 38%) is registered in Ilfov. Variables accounting for human and fixed capital are homogenous and Ilfov is again in the most disadvantageous situation with the minimum values of 2.3 classrooms per 100 pupils and 4.2 teachers per 100 students. The best ranked are Sălaj and Vâlcea. The values of ESF are by far the most heterogeneous, having a coefficient of variation of 68%. Maramureş attracted the lowest amount, while Dâmboviţa attracted the highest amount. The distribution of the European funds across Romanian counties, also presented in Figure 1, confirms the important differences in attracting European funds for the educational infrastructure. Although all of the Romanian counties seem to have similar problems related to the lack of finance for education, many of these were not successful in applying for or implementing projects for tackling this issue.

The correlation matrix was computed as a decision instrument in selecting the input and output variables. If there are strong correlations between these variables, the number of variables could be reduced by eliminating some of the variables correlated. The values of the correlation coefficients reported below show that all the variables considered for the analysis could be included in the DEA models, since the correlation existing between them is modest. It should be noted that the statistical significance of the Pearson's correlation coefficients reported in Table 2 is not of interest for this research, as the statistical inference is not followed.

Figure 1.



Source: authors' computations, based on data from Ministry for Regional Development and Public Administration, www.inforegio.ro

In order to reduce the heterogeneity in the dataset, the log transformation was applied on the data. The newly created variable has a coefficient of variation of 5%.

Table 2. Correlation matrix for the input and output variables

	Graduation rate at Baccalaureate (%)	Graduation rate at the National Evaluation (%)	Index of Dropout rate	Classrooms/ 100 pupils	Teachers/ 100 pupils	European SF (lei)
Graduation rate at Baccalaureate (%)	1					
Graduation rate at the National Evaluation (%)	0.4700	1				
Index of Dropout rate	-0.1997	0.3515	1			
Classrooms/ 100 pupils	0.2379	-0.1542	-0.2111	1		
Teachers/ 100 pupils	0.1228	-0.3157	-0.2207	0.6693	1	
ESF (lei)	0.0864	-0.1183	-0.2139	0.1933	0.1683	1

6.2 Results of the DEA analysis

Several DEA models, both input and output oriented were applied for better evaluating the efficiency of European SF invested in education in Romania.

In the first DEA input oriented Model 1.1, we consider the European SF as input variable and the three output variables. There are eight counties on the efficiency frontier, namely: Brăila, Cluj, Harghita, Ilfov, Maramureş, Suceava, Vaslui and Vrancea (see Table A1 in the Appendix). These counties were less successful in attracting SF, and yet they manage to generate good education performance. This implies that SF only are not a sufficient condition for achieving educational performance, and they need to be supported with other resources. Model 1.2 described below includes all the input and output variables for generating TE scores, computed in the CRS and VRS versions of DEA.

The average efficiency score under the assumption of constant return to scale is 0.887, while in the case of variable return to scale the average efficiency is slightly higher, 0.919. In both cases, the scores distributions are homogeneous. In practice, it is less likely to have constant return to scale, and therefore in the following table the results from Model 1.2, input oriented with VRS, are detailed.

Table 3. Results from the Model 1.2, input oriented with VRS: counties distributed according to efficiency scores.

	Inefficient counties			**Efficient counties**
	TE < Q1	**Q1<TE<Q2**	**Q2<TE<Q3**	**TE=1**
1.	Arges	Arad	Brasov	Braila
2.	Caras	Bihor	Bacau	Buzau
3.	Covasna	Bistrita	Sibiu	Cluj
4.	Dambovita	Dolj		Constanta
5.	Mures	Hunedoara		Galati
6.	Olt	Neamt		Harghita
7.	Salaj	Satu Mare		Iasi
8.	Valcea	Tulcea		Ilfov
9.				Maramures

10.				Suceava
11.				Vaslui
12.				Vrancea

The median score is 0.932, slightly higher compared to the average, implying a dominance of high values which is also reflected by the share of counties situated on the efficiency frontier.

We consider that the most appropriate model for the current research is the output oriented one, which assumes maximizing the outputs with the same level of inputs. Keeping in mind that the expected impact of investing SF in educational infrastructure is improving the educational performance of students, by increasing the quality of the educational facilities, the focus of the output oriented model is on the output indicators: the model assumes the maximization of output variables, achieved with given inputs. Therefore, the most relevant models seem to be the DEA output oriented models, described in the following part of the paper. The efficiency scores for the applied DEA models are reported in Appendix.

The first output oriented DEA model considers the SF as input variable and the three output variables. On the efficiency frontier we find almost the same counties as in the input oriented specification model: Brăila, Cluj, Hunedoara, Iasi, Maramures, Suceava, Tulcea and Vâlcea (see Table A2 in Appendix). With the exception of Hunedoara County, all the other counties have registered low levels of SF invested in educational infrastructure, implying that high levels in the output variables were achieved with fixed, yet low levels SF.

Under these circumstances it is interesting to analyze the counties' performance when the set on input variables is increased with human resources and fixed capital. The average efficiency scores are 0.885 in the CRS version and 0.928 under the VRS assumption. The extended results after applying the DEA model in the complete model specification, considering three inputs and three outputs, are presented in Table A2. Although efficiency scores were computed in both the CRS and VRS versions of DEA, in the following table we report the synthesis of the results of the VRS model.

Table 4. Results of Model 2.2, output oriented with VRS: counties distributed according to efficiency scores.

	Inefficient counties			**Effcient counties**
	TE < Q1	**Q1<TE<Q2**	**Q2<TE<Q3**	**TE=1**
1.	Arad	Arges	Braşov	Brăila
2.	Caraş	Bacau	Buzau	Cluj
3.	Damboviţa	Bistrita	Bihor	Constanta
4.	Dolj	Covasna	Sibiu	Galaţi
5.	Harghita	Satu Mare	Vrâncea	Hunedoara
6.	Mureş	Vaslui		Iaşi
7.	Neamţ	Sălaj		Ilfov
8.	Olt			Maramureş
9.				Suceava
10.				Tulcea
11.				Vâlcea

The results in Table 4 deserve further discussion. The distribution of the counties seems to be more balanced compared to Model 1.2 and the median score is 0.924, almost identical with the mean value. In the first quartile there are eight counties that are the least efficient. These counties have modest education performance, but manage to attract high amounts of funding for improving their educational infrastructure. Counties such as Arad, Dâmboviţa or Harghita are among the top recipients of such financial resources, but the efficiency of using them is relatively low. In the second group, with efficiency scores ranging between the first and second quartile, there are seven counties, while five counties have efficiency scores between the second and third quartile. Among these are counties such as Braşov, Vrâncea, Sibiu, Bihor or Buzau. About one third of the counties in our sample are efficient: Brăila, Cluj, Constanţa, Galaţi, Hunedoara, Iaşi, Ilfov, Maramureş and Suceava. Not surprisingly, on the efficiency frontier we find almost the same set of counties like in the previous models. Among these we found counties that have attracted financial resources above the average and managed to report good educational performance. These counties are Brăila, Galaţi, Hunedoara and Iaşi. On the efficiency frontier there are also counties with the lowest values of attracted funds and with low levels of output indicators, such as Maramureş, Vâlcea, Tulcea, Ilfov. These results confirm that when combined with human resources and fixed capital, the SF invested through KAI 4.3 in Romania has led to higher values of output indicators.

The scale efficiency was also considered in the analysis, and scale was computed as the ratio between efficiency scores produced in the CRS and VRS models. Not surprisingly, the findings from both CRS and VRS models reflect a decreasing return to scale for the great majority of the DMUs, with a coefficient of returns to scale lower than 1. This implies that an increase in inputs will generate a smaller increase in outputs. Finally, five counties that were efficient in both models presented are also scale efficient: Brăila, Constanţa, Galaţi, Ilfov, Maramureş, and Suceava.

7 Conclusions

In this research, the efficiency in using European structural funds for improving the educational infrastructure was computed in several DEA models, both output and input oriented. More than that, in the developed models both CRS and VRS was employed, the focus being on output oriented model with VRS. The results confirm that there are disparities among Romanian counties: the counties with a low accession rate to structural funds are the ones with the lowest efficiency scores: Caraş, Vălcea, Mureş, Dâmboviţa, Sălaj, Olt. On the other hand, on the efficiency frontier we have found counties with high SF values: Brăila, Hunedoara, Constanţa, Galaţi, Ilfov, Maramureş, Suceava and Vrancea.

The conclusions confirm the efficiency in using European structural funds in a number of counties that have attracted important amounts of money, but at the same time there are counties which are far from the efficiency frontier.

It is important to mention that our purpose in not to assess the impacts of the KAI 3.4 and the current research does not have the ambition of providing an impact evaluation, but to assess the efficiency of using European SF, at county and regional level and to provide a ranking of Romanian counties. This can be a strong starting point in validating the future impact evaluations of the programme and also in understanding the regional disparities in accessing SF for education. The projects implemented in counties with modest technical efficiency scores could be closer monitored and better supported in achieving their results. In such cases, the county administration needs to support various projects for generating a synergetic effect that could contribute to decreasing the regional disparities existing in the Romanian education system.

Appendix: Efficiency scores from DEA models
Table A1

	Input oriented models					
	Model 1.1: Input: European Structural Funds Outputs: Graduation rate at Baccalaureate, Graduation rate at the National Evaluation, Index of Dropout rate			Model 1.2: Inputs: Classrooms/ 100 pupils, Teachers/ 100 pupils, European Structural Funds Outputs: Graduation rate at Baccalaureate,Graduation rate at the National Evaluation, Index of Dropout rate		
	CRS	VRS	S	CRS	VRS	S
ARAD	0.034	0.036	0.948	0.832	0.908	0.916
ARGES	0.053	0.053	0.995	0.796	0.848	0.939
BACAU	0.136	0.136	0.998	0.869	0.938	0.926
BIHOR	0.085	0.086	0.988	0.858	0.869	0.987
BISTRITA	0.068	0.069	0.990	0.809	0.875	0.925
BRAILA	0.062	1.000	0.062	1.000	1.000	1.000
BRASOV	0.085	0.147	0.576	0.955	0.956	1.000
BUZAU	0.224	0.752	0.298	1.000	1.000	1.000
CARAS	0.093	0.103	0.906	0.620	0.733	0.845
CLUJ	0.084	1.000	0.084	0.932	1.000	0.932
CONSTANTA	0.106	0.111	0.951	1.000	1.000	1.000
COVASNA	0.147	0.152	0.967	0.713	0.762	0.936
DAMBOVITA	0.031	0.033	0.934	0.768	0.842	0.912
DOLJ	0.167	0.197	0.844	0.857	0.858	0.999
GALATI	0.057	0.059	0.979	1.000	1.000	1.000
HARGHITA	0.068	1.000	0.068	0.867	1.000	0.867
HUNEDOARA	0.033	0.035	0.933	0.788	0.907	0.869
IASI	0.067	0.068	0.986	0.991	1.000	0.991
ILFOV	0.622	1.000	0.622	1.000	1.000	1.000
MARAMURES	1.000	1.000	1.000	1.000	1.000	1.000
MURES	0.226	0.238	0.947	0.750	0.814	0.922
NEAMT	0.038	0.038	0.998	0.859	0.930	0.924
OLT	0.066	0.067	0.982	0.780	0.831	0.939
SALAJ	0.058	0.059	0.985	0.770	0.823	0.935
SATUMARE	0.095	0.098	0.972	0.809	0.894	0.905
SIBIU	0.185	0.397	0.467	0.952	0.953	0.999
SUCEAVA	1.000	1.000	1.000	1.000	1.000	1.000
TULCEA	0.408	0.409	0.996	0.898	0.932	0.963
VALCEA	0.196	0.210	0.933	0.749	0.808	0.926
VASLUI	0.297	1.000	0.297	0.974	1.000	0.974
VRANCEA	0.207	1.000	0.207	1.000	1.000	1.000
Averge	0.193	0.373	0.771	0.877	0.919	0.953

Table A2

	Output oriented models					
	Model 2.1: Input: European Structural Funds Outputs: Graduation rate at Baccalaureate, Graduation rate at the National Evaluation, Index of Dropout rate			Model 2.2: Inputs: Classrooms/ 100 pupils, Teachers/ 100 pupils, European Structural Funds Outputs: Graduation rate at Baccalaureate, Graduation rate at the National Evaluation, Index of Dropout rate		
	CRS	VRS	S	CRS	VRS	S
ARAD	0,034	0,859	0,040	0,834	0,862	0,968
ARGES	0,052	0,901	0,058	0,824	0,901	0,915
BACAU	0,136	0,918	0,148	0,898	0,918	0,978
BIHOR	0,085	0,959	0,089	0,861	0,959	0,898
BISTRITA	0,068	0,891	0,076	0,829	0,891	0,930
BRAILA	0,061	1	0,061	1,000	1,000	1,000
BRASOV	0,075	0,923	0,081	0,909	0,924	0,984
BUZAU	0,204	0,954	0,214	0,973	0,982	0,991
CARAS	0,087	0,77	0,113	0,626	0,770	0,813
CLUJ	0,083	1	0,083	0,931	1,000	0,931
CONSTANTA	0,102	0,899	0,113	1,000	1,000	1,000
COVASNA	0,136	0,902	0,151	0,728	0,902	0,807
DAMBOVITA	0,036	0,849	0,042	0,826	0,879	0,940
DOLJ	0,129	0,848	0,152	0,801	0,860	0,931
GALATI	0,056	0,893	0,063	1,000	1,000	1,000
HARGHITA	0,043	0,838	0,051	0,727	0,838	0,868
HUNEDOARA	0,098	1	0,098	1,000	1,000	1,000
IASI	0,076	1	0,076	1,000	1,000	1,000
ILFOV	0,452	0,937	0,482	1,000	1,000	1,000
MARAMURES	1,000	1,000	1,000	1,000	1,000	1,000
MURES	0,214	0,882	0,243	0,757	0,882	0,858
NEAMT	0,038	0,886	0,043	0,875	0,891	0,982
OLT	0,048	0,719	0,067	0,706	0,735	0,961
SALAJ	0,057	0,895	0,064	0,783	0,895	0,875
SATUMARE	0,095	0,894	0,106	0,845	0,894	0,945
SIBIU	0,162	0,935	0,173	0,901	0,935	0,964
SUCEAVA	0,986	1	0,986	1,000	1,000	1,000
TULCEA	0,45	1	0,450	1,000	1,000	1,000
VALCEA	0,278	1	0,278	0,987	1,000	0,987
VASLUI	0,245	0,914	0,268	0,911	0,923	0,987
VRANCEA	0,151	0,91	0,166	0,918	0,928	0,989
Averge	0,185065	0,915355	0,194682	0,885484	0,928032	0,951632

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