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Data Envelopment Analysis for the efficiency of Academic Departments

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Abstract: *Efficiency in the higher education system has become important as regards the sizing and shaping of the inputs according the the outputs to be achieved. At institutional level, the university is interested mostly in the efficiency of its organizational structures: faculties and the academic departments. This study is using Data Envelopment Analysis (DEA) – a management tool, to identify the relative technical efficiency of academic departments at Transilvania University during the academic year 2014-2015. Two types of software offer the same results, yet differently presented. The ranking of the most efficient departments allow identification of the well organized departments and faculties of the University. New input and new output variables are used to evaluate technical efficiency of academic departments face to the already used variables in all the previous published studies. The input and output variables were selected in order to characterize the two directions: academic and scientific research. The results of DEA model offer useful basis, for university leading staff, in the action of improving the efficiency of academic management.*

Key-words: *efficiency, academic departments, Data Envelopment Analysis*

1. Introduction

The financing policies of the Romanian higher education system impose for Higher Education Institutions (HEIs) to apply quality and performance management within their own structures. The strategic management in HEIs must be based on the efficiency analyses of the academic departments, as main units of teaching and research. The purpose of this study is to evaluate the technical efficiency of the departments of Transilvania University of Braşov, during the academic year 2014-2015.

The main tool - Data Envelopment Analysis (DEA) - was applied for each academic year in order to offer images of relative efficiency of departments at Transilvania University level. The obtained results offer rankings of departments related to their efficiency and allow some conclusions about the dynamics of performance management of University leading staff.

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DEA analyses were performed using two types of software: OSDEA – a free *Open Source Data Envelopment Analysis* solver (http://gplv3.fsf.org/), developed by Juergen Ebert and Mark James, and EMS – *Efficiency Measurement System*, product of Holger Scheel (2000) and Csaba Meszaros [7].

2. DEA Methodology

Data Envelopment Analysis (DEA) is a method used for measuring the relative efficiency of a certain number of *producers* called *decision making units*, DMUs, being a set of comparable units.

Each *producer (DMU)* has inputs (X) and outputs (Y). Seeing a DMU as a cybernetic system, its feed-back represents the management process and the efficiency of this process is a function depending on inputs and outputs.

The collected data are the inputs and the outputs for all producers, as presented in Figure 1.

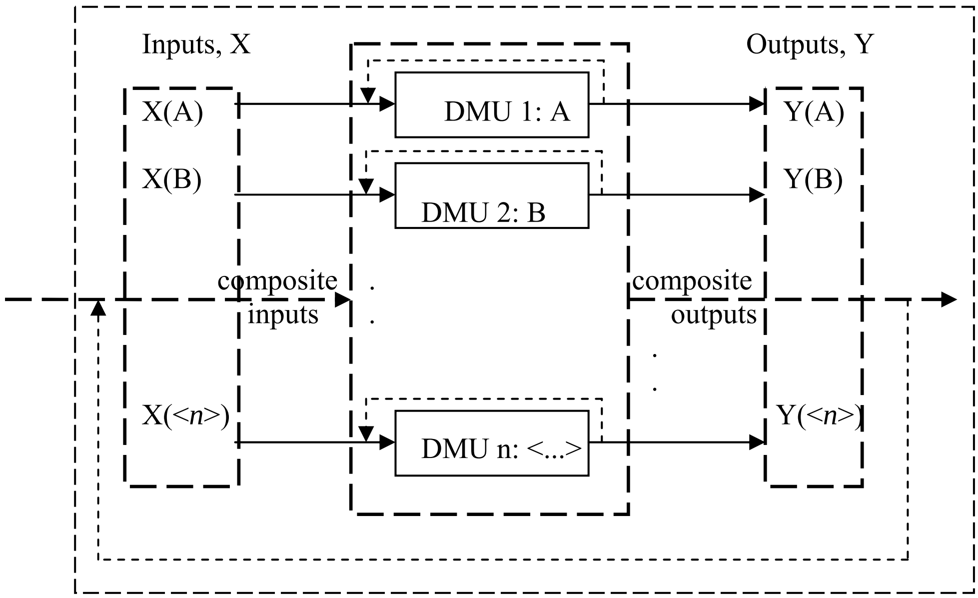

Fig. 1. *Organizational structures at institutional level*

Instead of evaluating DMUs' efficiencies relative to their average level, in a traditional approach, DEA is a non-parametric technique which considers the position of each DMU compared with that of a given producer, in this case, an extreme point, which is the "best" DMU.

The essence of the problem is based on the assumption that, if a the producer A obtains Y(A) units of output using X(A) units of input then, the others should be able to act in the same manner if they are efficiently operating as A has done. The producers can be combined in a virtual composite producer with composite inputs and composite outputs. Comparing a DMU to a virtual producer which may obtain more outputs with the same inputs or same outputs with less inputs - concludes that the original producer can be considered *inefficient*.

Finding the best producer for a DMU is solved by one linear programming problem, whereas if considering all producers, there will be solved *n* linear programming problems.

Efficiency can be considered as a ratio of outputs and inputs, more exactly as the ratio between the weighted sum of outputs and weighted sum of inputs. The efficiency score of a DMU is a value between 0 and 1; the value 1 indicates a relatively efficient DMU and a value less than 1 shows an inefficient DMU. This efficiency score varies and depends on the input and output variables used as factors.

There are different ways of considering the producers' scaling up or down and their combining ways give different DEA models. The main constraints envisage the virtual DMU to produce at least the same outputs as the analyzed DMU and how much less inputs can be used for this purpose by the virtual DMU. The factor of scaling back the inputs for the same quantity of outputs is a measure of DMU efficiency. The model is called *input-oriented*. The percentages of other producers used for building the virtual producer signify the intensity factors of DMUs, which are compared with the considered DMU, defining the hypothetical DMU.

Another DEA form may envisage the virtual DMU using the same inputs to produce more outputs as the analyzed DMUs and how much more outputs can be achieved by the virtual DMU. This model is called *output-oriented*.

Based on size of inputs and outputs, DEA allows different returns to scale to increasing or decreasing efficiency. A DMU which achieves economies of scale producing more outputs is an example of Increasing Returns to Scale (IRS). If some limits for outputs exist then the problem is of Decreasing Returns to Scale (DRS). A DMU operates at decreasing returns to scale (DRS) if a proportionate increase in all of its inputs conducts to a less than proportionate increase in its outputs. A mixed approach between the two cases needs Variable Returns to Scale (VRS). When DMU linearly scales the inputs and outputs, without increasing or decreasing efficiency, there are Constant Returns to Scale (CRS), meaning that an increase in inputs determines a proportionate increase in the outputs [8].

Graphically, for a reduced number of inputs and output, as one input – two outputs or two inputs - one output, the line which defines maximum combinations of outputs that can be produced for a given set of inputs is called *the efficiency frontier* and all DMUs lie on or below it, signifying measures of their relative efficiency.

DEA has some weaknesses because it does not offer the value of "absolute" efficiency compared to a "theoretical" one. The extreme point technique is not always the right way of presenting the DMUs' positions, but it is appropriate when the researcher is interested in estimating "relative" efficiency of a DMU compared to the peers. The measurement errors can easily affect the results.

The efficiency score of a DMU is a value between 0 and 1; the value 1 indicates a relatively efficient DMU and a value less than 1 shows an inefficient DMU. This efficiency score varies and depends on the input and output variables used as factors.

DEA method became more and more popular as a management tool used for performance evaluation of organizational structures. Some groups of Internet users as Productivity Analysis Research Network make popular DEA, as an important management tool for analyzing the efficiency.

3. DEA for efficiency of Academic Departments

A higher education institution with its academic departments as DMUs in the fields of higher education services and scientific research may be seen as in Figure 1. Since academic departments have their own management leading staff, they can be seen as DMUs.

The *inputs* can be considered as certain variables characterizing the dimension and the quality of organizational academic structures and the efforts of their members to sustain the study programs coordinated by each department.

Outputs may refer to the two directions: scientific research and academic results. For the results of scientific research of departments' members the variables may reflect the importance of published articles, research contractual activities and scientific recognition, both at national and international level. The academic results may be counted by the number of graduates, or number of promotions, number of students, number of PhD students.

The composite inputs, composite outputs and DMUs' management activities are controlled and managed at university level by the top management staff. There can be seen the cybernetic systems of DMUs as components of University, comprising all in a high level cybernetic system, having with its own feed-back of top management process.

The number of academic departments (DMUs), seen as the sample size, must be sufficiently large relative to the number of input and output variables. There are the following rules to be respected [7]:

- a rule of thumb of Banker, Charnes and Cooper (1984) as **Error! Reference source not found.**, where *s* is the number of output variables, *m* the number of input variables, and *n* the number of DMUs,

- the number of **Error! Reference source not found.**.

The DEA model for evaluating the efficiency of university academic departments can use CRS assumption. The inputs are slowly changing from one year to another and the outputs are mostly proportional with the inputs. These conclusions are consequences of the rules within the national education system and also rules at university level which are referring to the academic norm of each didactic position in the functions plans of departments, to the number of students in a group and the number of allowed places for each specialization, according not only with the human resources of learning processes, but also with the physical infrastructure at institutional level.

The assumptions of DEA such as VRS, IRS or DRS are not appropriate to be considered in the context of higher education system.

In *input-oriented DEA model*, the CRS assumption allows DMUs to scale up or down their inputs to achieve some constant value of outputs. An inefficient unit in the input-oriented model becomes efficient by proportionally reduction of its inputs while its outputs proportions are held constant.

In *output-oriented DEA model*, the CRS assumption allows DMUs to scale up or down their outputs using constant values of inputs. An inefficient unit in output-oriented model is made efficient by proportionally increasing of its outputs, while the inputs proportions remain the same.

Both types of models can be properly used in evaluating the efficiency of university academic departments. At institutional level, the university leading staff may chose which DEA model is mostly corresponding with their management strategies. The results of chosen model can be used to better emphasize the most efficient departments and how to act for improving the efficiency of the others in order to efficiently use the inputs to achieve the best results in the academic and scientific research directions. In this way DEA represents a decision making tool for top management.

4. Literature Review

DEA method is widely used in many areas of activity, such as: manufacturing, banking system, education system, health care system, management evaluations, commerce and in other industries and organizations.

The work of Charnes, Cooper, and Rhodes (1978) [3] and then Seiford and Thrall (1990) [1] form the basis of DEA method development.

The first DEA model was built by Chames, Cooper and Rhodes (1978) and its name is CCR. The CCR model is based on the notion of overall efficiency of the unit, defined as a ratio. Even that a lot of DEA models have appeared meantime, the CCR model is the most widely used. The CCR model works with Constant Return to Scale (CRS).

The BCC model was established by Banker, Chames and Cooper (1984) and it measures the technical efficiency as the convexity constraint, for the composite unit which is the virtual DMU, of similar scale size with the analyzed DMUs. Each composite unit is a convex combination of its reference units. The composite unit is a hypothetical efficient unit, built from a DMU's references units corresponding to the proportions given by the dual weights [7].

In the CCR model, the weights are associated with factors: inputs and outputs variables. The dual weights are obtained from the dual CCR model, and they are associated to the DMUs. Each dual weight represents the importance of DMU in the mix of input-output variables of the composite unit (Oral and Yolalan 1990) [9]. The composite unit is a combination of efficient units, enveloping an inefficient unit.

A given DMU is inefficient if the dual model of CCR succeeds in building a hypothetical composite unit which outperforms the analyzed one. The efficiency is at least equal to the one obtained by the CCR model. The DMUs with the lowest inputs and the highest outputs are considered as efficient. The BCC model works with Variable Returns to Scale (VRS). CCR models give the same efficiencies either input or output-oriented, but BCC models calculate different efficiencies.

As established by Agha, Kuhail, Abdelnabi, Salem and Ghanim (2011) [1], all the previous published studies using DEA method in the higher education system can be classified in two groups: studies envisaging the efficiencies of universities and the other treating the efficiencies of academic departments within a certain university. Their article also belongs to the second group and refers to the academic departments of the Islamic University in Gaza. They also made a resume of input and output variables used by the authors: Lopes and Lanzer (2002) [5], Moreno and Tadepalli (2002) [6], Abbott and Doucouliagos (2003) [2], Kao and Hung (2006) [4] in their DEA analysis of departmental activities within a university.

This study belongs to the second group of cases, analyzing the efficiency of academic departments in Transilvania University of Braşov, Romania. This study uses some different variables for inputs and outputs as compared to all the other studies unfolded and published until now. New input and new output variables are used here to evaluate technical efficiency of academic departments face to the already presented variables in the previous studies.

5. Research results and discussions

Transilvania University from Braşov has 18 faculties, which cover engineering sciences, social sciences, letters, music, sport and medicine. Each faculty has at least one department, but there are also faculties with two or three departments. The University has 30 academic departments. In Table 1, there is presented the University structure of faculties and their own academic departments.

All the 30 departments are considered as DMUs of a DEA analysis undertaken for the university year 2014-2015. The input and output variables are the same for all DMUs; they are established and calculated, using the same methods, being comparable data for all departments.

No. fac.	*Faculties*	*No. dept.*	*Dept.*	*Name of departments*
1	Mechanical Engineering	1	ATR	Automotive and Transport Engineering
		2	IMEC	Mechanical Engineering
2	Technological Engineering and Industrial Management	3	IMI	Engineering and Industrial Management
		4	IF	Manufacturing Engineering
3	Materials Science and Engineering	5	IMS	Materials Engineering and Welding
		6	SM	Materials Science
4	Electrical Engineering and Computer Science	7	IEFA	Electrical Engineering and Applied Physics
		8	ATI	Automatics and Information Technology
		9	EC	Electronics and Computers
5	Silviculture and Forestry Engineering	10	SIL	Forest Sciences
		11	EFAP	Forest Management and Engineering
6	Wood Engineering	12	PLD	Wood Engineering
7	Civil Engineering	13	IC	Civil Engineering
		14	ICT	Installations for Civil Engineering
8	Food and Tourism	15	IMAT	Food and Tourism
9	Product Design and Environment	16	DMM	Product Design and Environment
10	Mathematics and Computer Science	17	MIN	Mathematics and Computer Science
11	Economic Sciences and Business Administration	18	MTSA	Marketing, Tourism and International Relations
		19	MIE	Management and Economic Informatics
		20	FCTE	Finance, Accounting and Economic Theory
12	Psychology and Education Sciences	21	PFE	Psychology and Teaching Staff Training
13	Physical Education and Mountain Sports	22	PM	Motrical Performance
		23	EFMS	Physical Education and Special Motricity
14	Music	24	IPM	Interpretation and Music Pedagogy
15	Medicine	25	DFPC	Fundamental Disciplines and Clinical Prevention
		26	SPC	Medical and Surgical Specialties
16	Letters	27	LSC	Literature and Cultural Studies
		28	LTA	Theoretical and Applied Linguistics
17	Law	29	DR	Law
18	Sociology and Communication	30	SSC	Social Sciences and Communication

Table 1. *Organizational structures at Transilvania University in 2014-2015*

The input and output variables were selected in order to characterize the two directions: academic and scientific research – appropriate for Transilvania University, ranked at national level as HEI for education and research. For each DMU the variables considered as inputs are:

- the number of conventional hours paid for all the members of the department, reflecting the aspect of education and

- the number of doctoral programs coordinators in their field of recognition at national and at university level, reflecting the aspect of research.

For each DMU the variables considered as outputs are:

- the percentage of achieving the planned number of evaluation points of yearly scientific research activities. The evaluation research activity at university level internally established a certain level of points for each professional position and scientific title of departments' members. The sum of the evaluation points accomplished by all the members of a department is compared with the planned value and the University yearly ranks the departments in decreasing order of the percentage of achieving the research plan, emphasizing their scientific research performance.

- the number of doctoral students being enrolled in PhD programs;

- the number of license programs coordinated by each department;

- the number of master program coordinated by each department.

The output variables reflect also the two aspects: the educational one and the scientific research.

The number of study programs substitutes the output of graduates' number used by some of the above mentioned studies. We consider that more information about efficiency is given by the number of study programs, because the number of students allowed for each coordinated specialization represents the decision of each department depending on their professional structure of members.

5.1. Efficiency of academic departments at Transilvania University, in university year 2014-2015

Applying input-oriented CCR model on the data collected for the 30 academic departments of Transilvania University in university year 2014-2015, there can be seen the efficient departments in Table 2, using two software: OSDEA and EMS.

Both OSDEA and EMS software show 12 departments being efficient. The efficiency calculated scores are the same: OSDEA automatically considers 100% for all the departments being efficient and EMS let the values over 100%, as they are calculated. For this reason the average score is different for OSDEA score face to that obtained with EMS. The EMS score represents the super-efficiency of each department. The efficiency score is the ratio between the sum of weights multiplied by corresponding outputs and the weighted sum of inputs. Here in Table 2 we expressed them in percentages to better see the relative efficiency of departments.

Peer Group of OSDEA shows for each department whose best practices to be considered for improving its efficiency. EMS in addition shows the number of each DMU which is benchmark and its influence proportion. The *lambdas* of OSDEA appear in EMS, at *benchmarks*, the importance factors are shown in brackets, following the number of each significant DMU and signifying its importance for the considered DMU.

The Peer Groups indicated by OSDEA are recognized by EMS at Benchmarks and presented in Table 2. In the column of Benchmarks there are some numbers right justified, which signify the number of appearances of the considered department as benchmarks for the others.

No	DMU Name	OSDEA			EMS	
		Objective Value	Effi-cient	Peer Group	Score	Benchmarks
1	ATI	76.8%		IMS, ICT, MTSA, SM.	76.8%	11 (0.04) 17 (0.07) 22 (0.73) 29 (0.18)
2	ATR	88.6%		FCTE, IMI, MTSA.	88.6%	9 (0.15) 16 (1.15) 22 (0.08)
3	DMM	72.0%		IMS, ICT, SM.	72.0%	11 (0.48) 17 (2.34) 29 (0.96)
4	DFPC	77.4%		FCTE, LSC, MTSA.	77.4%	9 (0.56) 20 (0.62) 22 (0.16)
5	DR	96.8%		FCTE.	96.8%	1
6	EFMS	100%	Yes	EFMS.	117.2%	3
7	EC	62.9%		IMS, ICT, MTSA, SM.	62.9%	11 (0.28) 17 (0.38) 22 (0.46) 29 (0.01)
8	EFAP	100%	Yes	EFAP.	107.1%	1
9	FCTE	100%	Yes	FCTE.	120.4%	13
10	IF	83.2%		FCTE, IMI, SM.	83.2%	9 (0.40) 16 (0.82) 29 (0.15)
11	IMS	100%	Yes	IMS.	110.2%	4
12	IMAT	93.0%		EFMS, IMS, ICT.	93.0%	6 (0.51) 11 (0.52) 17 (1.71)
13	IC	39.4%		FCTE, IMI, MIE, MTSA, SM.	39.4%	9 (0.03) 16 (0.02) 21 (0.16) 22 (0.13) 29 (0.01)
14	IEFA	100%	Yes	IEFA.	101.3%	0
15	IMEC	70.5%		EFMS, EFAP, MTSA, SIL.	70.5%	6 (0.02) 8 (0.26) 22 (0.12) 27 (0.32)
16	IMI	100%	Yes	IMI.	109.3%	4
17	ICT	100%	Yes	ICT.	153.6%	7
18	IPM	78.3%		FCTE.	78.3%	1
19	LTA	74.2%		EFMS, FCTE, MTSA.	74.2%	6 (0.15) 9 (0.56) 22 (0.34)
20	LSC	100%	Yes	LSC.	114.3%	2
21	MIE	100%	Yes	MIE.	103.7%	1
22	MTSA	100%	Yes	MTSA.	112.8%	7
23	MIN	78.4%		FCTE, IMI, SM.	78.4%	9 (1.40) 16 (0.26) 29 (0.26)
24	PM	98.4%		FCTE.	98.4%	1
25	PLD	96.1%		FCTE, SM.	96.1%	9 (0.39) 29 (0.82)
26	PFE	87.9%		FCTE, ICT.	87.9%	1
27	SIL	100%	Yes	SIL.	125.3%	1
28	SPC	66.7%		LSC.	66.7%	5 (0.02) 9 (0.02) 17 (0.05) 18 (0.02) 20 (0.67) 24 (0.05) 26 (0.02) 30 (0.02) (DR, FCTE, ICT, IPM, LSC, PM, PFE, SSC)
29	SM	100%	Yes	SM.	170.3%	7
30	SSC	85.3%		FCTE, ICT.	85.3%	9 (0.50) 17 (1.50)
	average	***87.5%***		***average***	***95.7%***	

Table 2. *Results of OSDEA and EMS, using input-oriented CCR DEA models*

Concerning this aspect there are some small differences between the results offered by the presented software. For example, at department 28 SPC, OSDEA offers at Peer Group only the department LSC, but EMS offers eight departments through which LSC can be identified by its number and its influence factor 20 (0.67).

In this way the best practices of department FCTE appears 13 times, instead of 12 times, as OSDEA established, without considering its own appearance. Table 3 presents the 12 efficient academic departments of Transilvania University, for which OSDEA gives the value 1 at score efficiency or 100%, and also the conclusion "Yes", in Table 2. The EMS gives the same scores of efficiency for all departments like OSDEA, in Table 2, excepting the efficient ones, for which the scores are called super-efficiencies.

The order of the departments which offer the best practices for the others are presented in Table 3, in descending order of their benchmarks appearances, excepting themselves.

Nr.	*Abreviations*	*Name of efficient departments*	*Peer Groups of OSDEA*	*EMS*	
				Super-efficiency	*Benchmarks*
1	FCTE	Finance, Accounting and Economic Theory	12	120.36%	13
2	SM	Materials Science	7	170.34%	7
3	MTSA	Marketing, Tourism and International Relations	7	112.81%	7
4	ICT	Installations for Civil Engineering	6	153.64%	7
5	IMS	Materials Engineering and Welding	4	110.24%	4
6	IMI	Engineering and Industrial Management	4	109.25%	4
7	EFMS	Physical Education and Special Motricity	3	117.18%	3
8	LSC	Literature and Cultural Studies	2	114.29%	2
9	SIL	Forest Sciences	1	125.29%	1
10	EFAP	Forest Management and Engineering	1	107.11%	1
11	MIE	Management and Economic Informatics	1	103.70%	1
12	IEFA	Electrical Engineering and Applied Phisics	0	101.33%	0

Table 3. *Efficient departments after CCR input-oriented models*

The most efficient department is FCTE, which is considered 13 times by EMS, respectively 12 times by OSDEA. It can be said that 13 departments could find the best practices of FCTE department; 7 departments could learn from the departments: SM, MTSA and ICT, and so on. The ranking of the departments after their super-efficiency is presented in Table 4.

After using DEA input-oriented and output-oriented models with two different software: OSDEA and EMS, we found the same results: 12 departments are efficient and 18 departments are not quite efficient. The efficiency scores vary from 39.4% to 100%. From those 18 departments which are not relatively efficient, 12 departments have their efficiency scores under the departmental average score at university level: 87.5%. The university average is quite a high value, but only 6 departments from the inefficient 18 departments are paced over the average university level of efficiency.

Nr.	*Dept.*	*Name of department*	*EMS: Super-efficiency*
1	SM	Materials Science	170.34%
2	ICT	Installations for Civil Engineering	153.64%
3	SIL	Forest Sciences	125.29%
4	FCTE	Finance, Accounting and Economic Theory	120.36%
5	EFMS	Physical Education and Special Motricity	117.18%
6	LSC	Literature and Cultural Studies	114.29%
7	MTSA	Marketing, Tourism and International Relations	112.81%
8	IMS	Materials Engineering and Welding	110.24%
9	IMI	Engineering and Industrial Management	109.25%
10	EFAP	Forest Management and Engineering	107.11%
11	MIE	Management and Economic Informatics	103.70%
12	IEFA	Electrical Engineering and Applied Physics	101.33%

Table 4. *Ranking of the most efficient departments with input-oriented DEA (EMS)*

As a consequence, some faculties will be efficient, but not the others.

The conclusion is that only 3 of the 18 faculties of Transilvania University can be considered as efficient, in the following order:
- Materials Science and Engineering with the departments: SM and IMS;
- Economic Sciences and Business Administration, with all the three departments found in the list of the efficient departments: FCTE, MTSA and MIE;
- Silviculture and Forest Engineering with the departments: SIL and EFAP.

These faculties have good structures and their departments are well-sized for the number of coordinated study programs, the number of students, and also referring to the research activity.

Transilvania University has 15 inefficient faculties. Table 5 presents the faculties with the scores of their own departments and the average score of each faculty.

Nr. fac	*Faculties*	*Nr. dept*	*Dept.*	*Efficiency scores 2014-2015*
1	Mechanical Engineering	1	ATR	88.6%
		2	IMEC	70.5%
		average		**79.5%**
2	Technological Engineering and Industrial Management	3	IMI	100%
		4	IF	83.2%
		average		**91.6%**
3	Materials Science and Engineering	5	IMS	100%
		6	SM	100%
		average		**100%**
4	Electrical Engineering and Computer Science	7	IEFA	100%
		8	ATI	76.8%
		9	EC	62.9%
		average		**79.9%**
5	Silviculture and Forest Engineering	10	SIL	100%
		11	EFAP	100%
		average		**100%**
6	Wood Engineering	12	PLD	**96.1%**
7	Civil Engineering	13	IC	39.4%
		14	ICT	100%
		average		**69.7%**
8	Food and Tourism	15	IMAT	**93.0%**
9	Product Design and Environment	16	DMM	**72.0%**
10	Mathematics and Computer Science	17	MIN	**78.4%**
11	Economic Sciences and Business Administration	18	MTSA	100%
		19	MIE	100%
		20	FCTE	100%
		average		**100%**
12	Psychology and Education Sciences	21	PFE	**87.9%**
13	Physical Education and Mountain Sports	22	PM	98.4%
		23	EFMS	100%
		average		**99.2%**
14	Music	24	IPM	**78.3%**
15	Medicine	25	DFPC	77.4%
		26	SPC	66.7%
		average		**72.0%**
16	Letters	27	LSC	100%
		28	LTA	74.2%
		average		**87.1%**
17	Law	29	DR	**96.8%**
18	Sociology and Communication	30	SSC	**85.3%**
	University Level	**average**		**87.5%**

Table 5. *Efficiency scores of faculties, in 2014-2015*

At university level, 9 faculties from 18, have their average scores under the university average score of 87.5%. These faculties are presented in Table 6.

Faculties with scores < university average	**Score**
Letters	87.1%
Sociology and Communication	85.3%
Electrical Engineering and Computer Science	79.9%
Mechanical Engineering	79.5%
Mathematics and Computer Science	78.4%
Music	78.3%
Medicine	72.0%
Product Design and Environment	72.0%
Civil Engineering	69.7%

Table 6. *Ranking of faculties placed under the average, at university level*

From the 15 inefficient faculties, there are 6 faculties placed over the university efficiency score, meaning that the university management could emphasize on management strategies for the 9 faculties from Table 6.

Using the CCR output oriented DEA model with CRS, the results are the same as those presented in Table 2 and Table 3.

Analyzing the correlation coefficients between the efficiency scores of DEA model and the input and output variables to see if there exists any size effect over the efficiency, we can admit that there does not act this effect. In Table 7 there are presented the correlation coefficients between the efficiency scores and the mentioned variables.

(Efficiency score)	Input variables		Output variables			
	nr_hours	nr_dr_coord	nr_lic	nr_master	proc_research	nr_drd
r score, var.	-0.436	-0.008	-0.010	0.075	0.171	0.118

Table 7. *Correlation coefficients of CCR results*

The number of conventional hours which clearly is related to the size of department is weakly correlated with the efficiency, but the correlation is inverse, meaning that when increasing the number of hours, the efficiency decreases. With all the other variables there is no correlation, meaning that the DEA model can be used and considered for the chosen variables (Avkiran, 2002), Agha, Kuhail, Abdelnabi, Salem and Ghanim (2011) [1].

5.2. Reconsidering the efficiency of academic departments at Transilvania University

The EMS results after reanalyzing the efficiency of academic departments, for the university year 2014-2015, are presented in Table 8.

2014–2015	DMU	Scores for input oriented DEA		
		2 inputs & 2 outputs	2 inputs & 4 outputs	4 inputs & 2 outputs
1	ATI	72.6%	76.8%	86.3%
2	ATR	76.1%	88.6%	79.0%
3	DFPC	77.4%	77.4%	119.6%
4	DMM	49.9%	72.0%	55.3%
5	DR	78.5%	96.8%	199.4%
6	EC	57.0%	62.9%	75.1%
7	EFAP	107.1%	107.1%	134.6%
8	EFMS	112.0%	117.2%	119.1%
9	FCTE	101.6%	120.4%	101.6%
10	IC	34.5%	39.4%	44.6%
11	ICT	73.0%	153.6%	73.7%
12	IEFA	100.9%	101.3%	106.4%
13	IF	60.4%	83.2%	62.1%
14	IMAT	59.0%	93.0%	69.2%
15	IMEC	70.3%	70.5%	132.4%
16	IMI	94.1%	109.3%	94.1%
17	IMS	90.2%	110.2%	90.4%
18	IPM	78.3%	78.3%	94.6%
19	**LSC**	**114.3%**	**114.3%**	119.2%
20	LTA	56.0%	74.2%	63.2%
21	MIE	79.7%	103.7%	79.7%
22	MIN	45.2%	78.4%	47.8%
23	MTSA	107.0%	112.8%	107.0%
24	PFE	82.9%	87.9%	83.8%
25	PLD	71.7%	96.1%	71.7%
26	**PM**	**98.4%**	**98.4%**	119.2%
27	**SIL**	**125.3%**	**125.3%**	177.9%
28	SM	121.0%	170.3%	121.0%
29	**SPC**	**66.7%**	**66.7%**	136.4%
30	SSC	69.3%	85.3%	70.0%
	average	*81.0%*	*95.7%*	*97.8%*

Table 8. *Analyzing different variables of inputs and outputs for DEA models*

The three last columns of Table 8 contain the scores of efficiency using as it follows: the already described variables for inputs and for outputs “2 inputs & 2 outputs”, the 2 mentioned inputs, but 4 variables for outputs, including the number of license programs and number of master programs obtaining “2 inputs & 4 outputs” and the third column where the two previous variables considered as outputs were considered as inputs “4 inputs & 2 outputs”.

The analysis for the university year 2014-2015 can consider as inputs: the number of conventional hours of the department and the number of doctoral coordinators, but also the number of license programs and master programs can be considered as input variables. Output variables are: the percentage of achieving the evaluation points of scientific research activities and the number of doctoral students in PhD programs. This is the case of last column in Table 8, described as “4 inputs & 2 outputs”. The way of considering “4 inputs & 2 outputs” is more adequate as “2 inputs & 4 outputs”, because the number of license programs and number of master programs are decisions of academic departments depending on the human resources and the scholar infrastructure they dispose of.

The conclusion is that considering the number of license programs and master programs as output variables, the case “2 inputs & 4 outputs”, presented in second column of scores in Table 8, four departments: ICT, IMI, IMS and MIE - become efficient; they were inefficient in first stage of analysis.

When considering the number of license programs and master programs as input variables, the case “4 inputs & 2 outputs”, the four departments automatically receive back the same scores as in first analyzed case “2 inputs & 2 outputs”. But other five departments, which initially were not efficient, they become efficient: DFPC, DR, IMEC, PM, SPC. There are nine departments whose efficiency is related, to a high extent, to the number of undergraduate programs and master programs coordinated by the respective departments. The results being sensitively affected by the status of these variables, the first case “2 inputs & 2 outputs” seems to be the best to be considered.

6. Conclusions

For inputs we considered the number of conventional hours sized for the staff department to ensure the academic education for the number of students sized in groups and specializations and also the number of doctoral coordinators in each department. As output variables we considered: the number of undergraduate programs, the number of master programs, the percentage of achieving the research norm for each department, depending on the number and function of each individual and the number of doctoral students.

After using DEA input-oriented and output-oriented models with OSDEA and EMS, we found the same results: 12 departments are efficient and 18 are not efficient. The efficiency score varies from 39.4% to 100%. From the 18 departments which are not relatively efficient, 12 departments have their efficiency score under the average score of a department: 87.5%. Only 6 departments out of 18 are placed over the average university level of efficiency.

Analyzing the correlation coefficients between the efficiency scores of DEA model and the input and output variables to see any size effect over efficiency, we admitted that this effect does not act. There is no correlation of CCR results with the variables, meaning that DEA model can be considered for the chosen variables.

The input and output variables were selected in order to characterize the two directions: academic and scientific research. Transilvania University was ranked at national level for education and research.

The university leading staff may use the results of DEA model for the development of managerial strategies. The results can be used to better emphasize the most efficient departments and how to act in order to improve the efficiency, in order to efficiently use the inputs to achieve the best results in the academic and scientific research directions. In this way DEA represents a decision making tool for our University top management.

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