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Use of Data Envelopment Analysis to Measure the Performance Efficiency of Academic Departments

Adrian SÎRBU[a]*, Dragoş CIMPOIEŞ[a], Anatol RACUL[a]

[a]The State Agrarian University of Moldova, 44 Mircesti str, 2049, Chisinau, Republic of Moldova

Abstract

In this study, Data Envelopment Analysis is used to measure relative efficiency of academic departments of the Faculty of Economics. Input and output criteria are determined and measured utilizing the academic staff performance measurement scheme of the departments of the State Agrarian University of Moldova. Twelve inputs and two outputs which strongly influence the efficiency of the academic departments were selected. The second objective is to rank the academic departments according to their performance efficiency.

1. Introduction

Higher education contributes significantly to the development and economic growth of a country by training and providing a required quantity of qualified specialists in various fields of the national economy.

Consequently, it is necessary to thoroughly evaluate the academic performance of higher education institutions in order to find out if all the expenses are charged for research, teaching and learning, and innovation activities. Also, it is necessary to identify optimal performance standards by means of which higher education institutions would be able to harness more effectively the relationship between the totality of existing resources in any form whatsoever for inputs and outputs. (Toma, 2014)

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* Corresponding author. Tel.: +373-79167664, +373-22-432395, Fax: +373-22-312276.
E-mail address: a.sirbu@uasm.md

The need to evaluate the performance of the teaching staff at agricultural institutions of higher education and research creates preconditions necessary to comply with the demands of the occupied position and professional skills and abilities of the evaluated persons. It is also needed to ensure a motivation system, as efficient as possible to improve the level of individual performance. Based on these periodic assessments of professional performance we should identify certain common components in order to determine the salaries and/or bonuses depending on the individual performance of the teaching staff within a certain period.

Individual performance reflects both quantitative and qualitative results obtained by the lecturer, based on the completion and execution of the tasks in the individual plan. The university teaching staff of a university in the Republic of Moldova is divided into five teaching degrees: university assistant, university lecturer, senior lecturer, associate professor and full professor. The evaluation of the individual performance is the process of measuring and assessing the performance level reached by the lecturer in accordance with obligations stated in the individual plan and common evaluation criteria.

The evaluation of the teaching staff is based on the following fields of activity: teaching; scientific research and the lecturers's impact on the development of the higher education institution where he or she works.

The Faculty of Economics of the State Agrarian University of Moldova (SAUM) is the only economic faculty in Moldova that trains specialists in agricultural economics and food production.

In 2015 the educational process at the Faculty of Economics of SAUM is ensured by seven departments, five of which are specialized departments: "Foreign Languages", "Social Sciences", "Management", "Marketing and Procurement", "Economy and International Economic Relations", "Finance and Banking", "Tourism" (Tomiţa, 2015., Toma, 2015).

In recent years some studies were conducted to determine academic performance and efficiency of higher education institutions using the DEA (Data Envelopment Analysis) method. In order to highlight the importance of the DEA method implementation we should state that our research is mostly done in two directions: at the level of academic teaching staff performance (ATS) and at the level of departments or faculties within this institution were the first, who used the DEA method in their research, based on the data regarding the academic performance of universities in Australia (Abbott, 2003). In 2013 Indian researchers, Tyagi et al, conducted a study to determine the performance and its change in dynamics of ATSs in India (Tyagi, 2013).

2. Materials and Methods

The basic aim of this research is to identify and evaluate the level of academic performance of the teaching staff at agricultural HEIs. Our research included 71 lecturers of the Faculty of Economics of the State Agrarian University of Moldova. The period of analysis is 2009 - 2014. Data were collected, based on the Reports on the Scientific and Innovative Activity of the State Agrarian University of Moldova in the period mentioned above. The mathematical processing of the primary data was performed by means of the application software (DEAP Version 2.1), developed by T. Coelli (Coelli, 1997). There are two types of linear programming used to evaluate the performance of decisional units. The first method is BCC, which explicitly states what resources should be used to get the priority in the competition and the second linear programming method is CCR, which defines the relationship between performance and variables INPUT - OUTPUT. Taking into consideration that the primary data used in the assessment are categorical (obtained according to the Likert scale) our study is focused on the BCC method intended to evaluate the academic performance of the teaching staff (Cooper, 2001).

Efficiency of the decision making units (DMU) can be defined as a weighted sum of outputs over the weighted sum of inputs as shown in the equation:

$$\theta_0\,(u,v) = \textstyle\sum_r u_r\, y_{r0}\, /\, \sum_r v_i\, x_{i0} \qquad\qquad (1)$$

where:

θ_0: the staff's relative efficiency

u_r: weight given to the output, r = 1…3

v_i: weight given to the input, i = 1…12

$$\min \varepsilon \, \theta - \varepsilon \left(\sum_{i=1}^{12} s_i^- + \sum_{r=1}^{3} s_r^+ \right) \tag{2}$$

Subject to:

$$\sum_{j=1}^{12} x_{ij} \, \lambda_j + s_i^- = \theta \, x_{i0} \tag{3}$$

$$\sum_{j=1}^{12} y_{rj} \, \lambda_j - s_r^+ = y_{r0} \tag{4}$$

$$\lambda_j \geq 0, \; j = 1 \dots 12$$

For the BCC model:

the constraint $\sum_{i=1}^{12} \lambda_i = 1$ is added $\tag{5}$

where:

s_i^- and s_r^+: are slack variables used to convert the inequalities to equivalent equations and $\varepsilon > 0$ is an Archimedean element defined to be smaller than any positive real number;

: is the vector of intensity factors that defines the hypothetical DMU to which DMU_{j0} is compared;

θ: is the radial (input reducing) measure of technical efficiency (Kao, 2008).

The efficiency of a decisional unit is measured as compared to all other DMUs under the restriction that all DMUs lie on or below the efficient frontier, that is the measures of relative efficiency.

3. Results and Discussions

The statistical data that have been selected and systematized include academic results achieved by 71 lecturers of the Faculty of Economics of the State Agrarian University of Moldova during 2009-2014. The content of this research was systematized using two basic components grouped both vertically and horizontally. The corresponding systematization has been developed while processing the primary data (Koksal, 2006., Moreno, 2002).

The model used to evaluate the academic performance involves the following endogenous variables as resultative factors:

Y_1 – the lecturer's scientific degree or its absence when he/she was assessed (no scientific degree - 1, PhD - 2 and Doctor Habilitatus - 3);

Y_2 – the lecturer's academic degree, when he/she was assessed (university assistant – 1, university lecturer – 2, senior lecturer – 3, associate professor - 4 and full professor - 5).

The following items were used as causative factors (input variables):

X_1 – the number of participations with theses, presentations at both national and international scientific conferences (symposiums);

X_2 – the number of international publications (other articles);

X_3 – the number of national publications

(articles in journals of A, B and C category and other journals and collections);

X_4 – the number of both national and international publications (monographs, textbooks);

X_5 – the number of national and international publications (academic works, chapters (collections, lecture notes) in monographs and collections);

X_6 – the number of participations at national and international projects as a coordinator;

X_7 – the number of participations at national and international projects as a member;

X_8 – the period of PhD studies;

X_9 – the age, at which a PhD degree is obtained;

X_{10} – promotion of scientific achievements in mass media and educational articles in newspapers, magazines, etc.;

X_{11} – participation at scientific conferences, exhibitions, workshops, fairs and round tables;

X_{12} – the data concerning SAUM researchers' missions and trainings.

Having evaluated the lecturers' academic performance in accordance with the primary data which include two output variables (Y_1 and Y_2) and twelve input variables (X_1 ... X_{12}) by means of VRS (variable returns to scale model) and DEA (multi-stage), we have received the lecturers' efficiency score. Table 1 includes results for each lecturer with the score from zero to one. Maximum value 1 means that the competitor is placed first and his/her score is compared with a lower performance (Salah, 2011).

Table 1. Evaluation results of the lecturers according to the DEAP software.

The teacher's order number	Academic performance
1	0.857
2	1.000
3	0.857
4	0.857
5	0.714
6	0.667
7	0.917
8	1.000
9	0.833
10	1.000
11	1.000
12	0.897
13	0.800
14	0.724
15	0.800
16	0.857
17	0.714
18	0.714
19	0.714
20	0.667
…	…
mean	0,818

If we analyze teachers staff of the faculty by sex, we obtained the following result: male 24 lecturers are 33.80% of the total and female - 47 persons, representing 66.20% of the total staff.

According to Figure 1, in the teaching staff of the faculty of economics by scientific degree is distributed as follows: there are 36 lecturers without any scientific degree, 29 lecturers are PhD degree holders and 6 lecturers hold the highest scientific degree of Doctor Habilitatus. Analyzing the academic performance of the teaching staff, it can be outlined that the highest level of academic performance is associated with the holders of the Doctor Habilitatus degree (their rating is 0.919).
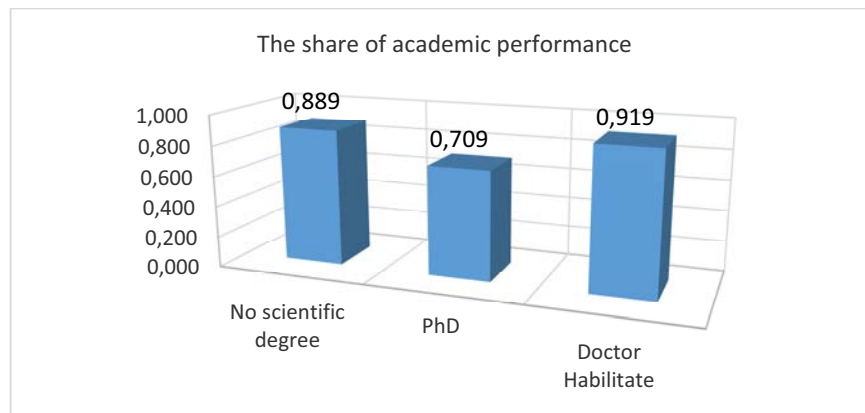

Fig. 1. The share of academic performance of the teaching staff of the Faculty of Economics according to the distribution of scientific degrees.

The next place belongs to the lecturers who have no scientific degree (their rating is 0.889). PhDs are on the last place with the rating of 0.709. The leading share of Doctors Habilitatus is explained by their vast experience accumulated during the years of research and teaching practice. Those who do not have any scientific degree are unexpectedly on the second place. The only explanation to that phenomenon is that this category of the teaching staff works over their PhD dissertations. Therefore, they are highly motivated to write many scientific articles, monographs, notes, students' guides, etc., and to finally obtain a scientific degree. Instead, those who have already obtained a PhD degree, are in the period of stagnation from the scientific point of view, as most of them do not intend to move higher on scientific job ladder by obtaining the degree of doctor habilitatus.

In order to diminish the negative impact of the most important segment of the teaching staff, PhDs should be involved in as many research projects, extra-curricular activities, etc. as possible. Also, a reserve fund for motivating financially those with high academic performance is welcome. Analyzing the academic performance of the teaching staff by academic degrees, the following results are revealed (Figure 2).
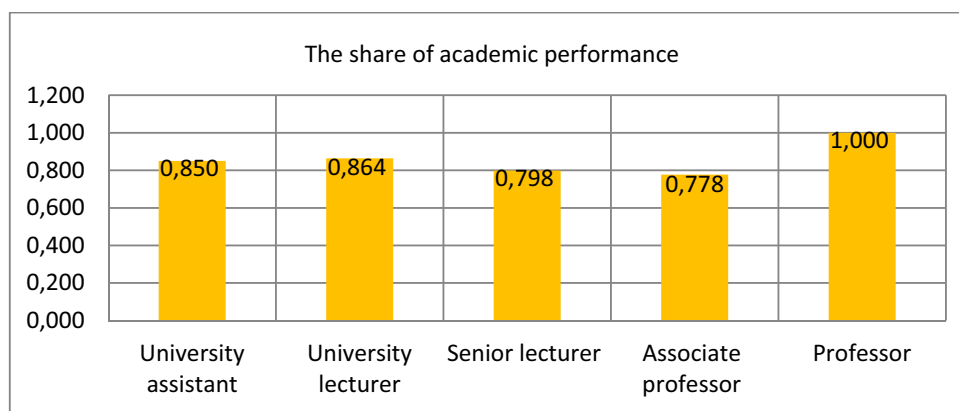

Fig. 2. The academic performance of the teaching staff of the Faculty of Economics by teaching degrees.

The highest performance is registered at full professors. They are followed by university lecturers with a rating of 0.864, the fact that proves the idea that the academic performance of the lecturers, who work on their PhD theses, is quite high. As they are forced and/or motivated to a certain extent by requirements, specified by the National Council for Accreditation and Attestation on the obtaining a PhD degree (the development of at least five scientific works (including two articles in the ISI journals, national and international they also are required to take part in at least one scientific national and international scientific conference. The low performance of associate professors is directly related to the idea that all of them are PhD holders and only few of them are motivated to go further on scientific career ladder (see Figure 1).

Performance evaluation of the teaching staff of the Faculty of Economics is presented as the weighted average of the lectures' academic performance in the corresponding departments (Figure 3).

The highest level of academic performance is achieved by the department of "Foreign Languages" it is determined by the fact that the lecturers of this department, being fluent in many foreign languages have a large academic activity by collaborating (translate scientific articles, textbooks, monographs, etc.) with many researchers from different areas of science (horticulture, veterinary medicine, agronomy, etc.), as compared to lecturers of specialized departments. It is followed by performance by the teaching staff of the Department of "Management" (0.86). Such positive result is explained by the fact that two thirds of the highest scientific degree holders of the Faculty are members of that department. Their high personal contributions have a significant positive impact on the overall performance of the department. The third place by academic performance belongs to the Department of "Marketing and Procurement" (0.84): 57.14% of the total number of the members of this department are associate professors and holds a PhD degree at the same time. These lecturers' average age is 44.75 years old, being at a high level of professional experience and a corresponding academic performance. The score of the Department of "Tourism" is 0.04 points less and equals 0.80. The academic performance of this department is based on the fact that

only one lecturer holds the academic title of associate professor and only 50% of the lecturers have a PhD degree. However, most of them are involved in numerous extracurricular activities, contributing significantly to a high performance of that department.
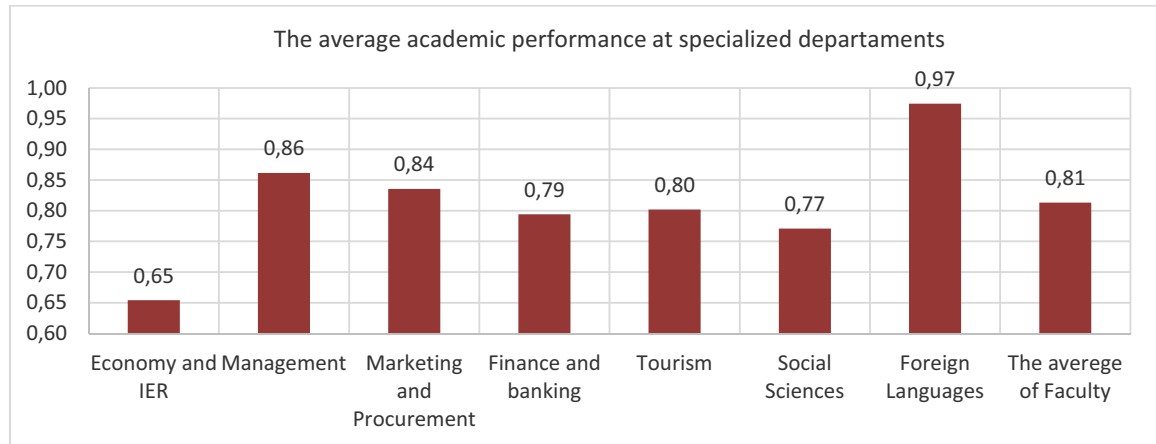

Fig. 3. The average academic performance of the teachers of the Faculty
of Economics according to the distribution of specialized departments.

The lowest score of academic performance of the Faculty of Economics of SAUM is gained by the members of the Department of "Economy and International Economic Relations". Such results are determined by the age of the teaching staff: most of the lecturers are among the youngest specialists of the faculty, with an average age of 34.7. On the contrary, the number of lecturers older than 40 (as a rule, they are the most experienced specialists) is insignificant. Moreover, only 5 lecturers of this department (35.7%) do not have a PhD degree.

The technical efficiency score is determined by the method of functions "distance from the border". In Table 2 the techniques used to evaluate individual performance of the lecturer under the code 1810003 used the correlation between initial and final value, as well as the displacement factor. Local leaders of the lecturer are also presented and their share in performance.

In 2009-2014 the analyzed academic performance equaled to 0.857 points due to vertical and horizontal variables in the table mentioned above. Vertical indicators that show the content of academic activities, obtained by lecturer 1810003, particularly provide the information on academic inputs and outputs. Horizontal factor 2 is the initial value that influenced directly this score of 0.857 of the above mentioned lecturer. Factor 3 is dedicated to the data that reflect the radial dynamics of academic results; if the data have results with a negative factor or ≥ 0, this index has some reserves as compared to the minimum needed to achieve academic performance; lecturer 1810003 has some reserves for all the outputs (from 1 to 12).If we analyze the importance of the data related to Factor 4, which is important when we take into account the minimum academic reserve, we should state that outputs 5, 8 and 9 have the greatest reserves as to the improvement of the academic performance.

Having analyzed the data on Factor 5, we can directly compare the academic performance results of lecturer 1810003 during the mentioned period. For example, let us take the data obtained in output 9: the result obtained equals 6.000 - the minimum necessary result is 3,429. Therefore, the analyzed lecturer has a reserve of academic performance (2.571 points). Moreover, he has a reserve regarding the tendency of development and obtaining academic performance as compared to lecturer 1810011 respectively by (0,286) and as compared to lecturer 1810002 respectively by (0.571). This academic reserve is entirely explained by the fact that the analyzed lecturer has a scientific degree of Doctor Habilitatus and an academic title of associate professor. However, lecturers 181002 and 1810011 are university professors, and respectively the analyzed lecturer tends to or should receive the academic degree of full professor. (Bălan, 2015)

Table 2. A model to determine the academic performance of a lecturer of the Faculty of Economics (Code number 1810003).

Results for a lecturer: **1810003**					
Technical efficiency = **0.857**					
PROJECTION SUMMARY:					
1		2	3	4	5
Variable		Original value	Radial movement	Slack movement	Projected value
Scientific degree	1	2,000	0,000	0,000	2,000
Academic degree	2	4,000	0,000	0,000	4,000
The number of participations with theses, presentations at scientific national and international conferences (symposium)	1	2,000	-0,286	-0,857	0,857
The number of international publications (other articles)	2	2,000	-0,286	-0,857	0,857
The number of national publications (articles in journals of, category A, B, and C, and other journals and collections)	3	1,000	-0,143	0,000	0,857
The number of national and international publications (monographs, textbooks)	4	1,000	-0,143	0,000	0,857
The number of national and international publications ((academic works chapters (collections, lecture notes) in monographs and collections))	5	5,000	-0,714	-3,429	0,857
The number of participations in national and international projects as coordinator	6	2,000	-0,286	-0,857	0,857
The number of participations in national and international projects as a member	7	1,000	-0,143	0,000	0,857
The period of PhD studies	8	6,000	-0,857	-1,143	4,000
The age, at which a PhD degree is obtained	9	6,000	-0,857	-1,143	3,429
Promotion of scientific achievements in mass media and education articles in newspapers, magazines, etc	10	1,000	-0,143	0,000	0,857
Participation at scientific conferences, exhibitions, workshops, fairs and round table	11	1,000	-0,143	0,000	0,857
The data concerning SAUM researches`s missions and trainings	12	1,000	-0,143	0,000	0,857
LISTING OF PEERS:					
Peer Lambda weight					
11 0,286					
2 0,571					

The score of both academic and scientific activities is the outcome of our research, as we evaluated the academic performance of the teaching staff of the Faculty of Economics. The model used is the weighted average score of 0.818 and it distributes lecturers and faculty departments depending on this average. One can also analyze every lecturer individually (for example, Table 1 shows such a comparison). High accuracy is an advantage of this technique used to evaluate the academic performance and it does not depend on the measuring unit.

4. Conclusions

This research is based on the use and analysis of statistical data of the teaching staff at the Faculty of Economics of SAUM by means of the DEA programme. We have determined the level and score of academic performance at the level of individual lecturers and departments of structure faculty above mentioned. The evaluation period was starting 2009 until 2014 inclusive. Two main research inputs data were selected on the basis of holding title scientific degree and teaching activity of lecturers analyzed. As outputs, twelve variables that directly expresses the academic achievement of each lecturer individually were selected. in the highest academic performance within the

Faculty of Economics is registered at the Department "Foreign Languages" while the lowest score is obtained by the department "Economy and International Economic Relations". Therefore, the last department must intensify research and teaching activities.

The differences among the scores registered by individual lecturers and departments could determine the top management of the State Agrarian University of Moldova to introduce a contingency payment scheme in order to stimulate the teaching staff to achieve a higher academic performance.

Acknowledgements

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