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Performance Assessment of Education Institutions through Interval DEA

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Abstract: In this study, the Data Envelopment Analysis (DEA) non-parametrical method was used to assess a set of twenty- one education departments of the Islamic Azad University- Zahedan branch in Iran in 2008-2009 academic years, the results showed eight departments with perfect performance. In DEA models, the efficiency each Decision Making Unit (DMU) is evaluated in best conditions. So such evaluation can be interpreted as optimistic. In this study, in addition to calculation of efficiency through usual method, the efficiency of each educational department is estimated from the pessimistic point of view and with the interval efficiency determination of each educational department, the ranking of units will be dealt with. We also use optimism coefficient as a new method in ranking. One of the most significant advantages of this method is the compatibility and stability of which in ranking, also efficient departments is generally reduced and regarding the optimism coefficient, the manager's opinion to measure efficiency has been considered as well.

Key words: Data envelopment analysis, performance assessment, interval efficiency, cross efficiency

INTRODUCTION

Data envelopment analysis (DEA) was introduced by Charnes *et al.* (1978). One of the scores of DEA method is lack of necessity of definition of relationship depends between inputs and outputs. It was originally intended for use as a performance measurement tool for organization that lacked a profit motivation. However since its introduction, it has been developed and expanded for a variety of uses in for-profit as well as not-for-profit situation. Measuring performance can be simultaneously done on the basis of quantitative and qualitative concept of system.

The history of DEA application in educational assessment: In recent years, numerous studies were carried out for universities performance assessment using DEA method. Universities are institutes with many inputs and outputs. At least two different outputs of education and research are products of each university. A number of most important studies done in this field are as follow:

Rodhes and Southwick (1986); carried out an analysis on the efficiency of private universities in comparison to state universities in USA through the DEA model which all the country's universities were viewed as DMU. Tomkins and Green (1988) used DEA for 20 accountancy departments test in UK. DMUs were universities accountancy departments in this case which studies from two grounds of education and research were. Harris (1990), carried out a study in relation to research performance in Australian Economics University. DMUs were the Australian Economics departments which were analyzed from the research programme perspective.

The economic efficiency of university department also studied (Hashimoto and Cohn, 1997). Melville and Debasish (1998) published the result of using Data Envelopment Analysis (DEA) to assess the relative efficiency of 45 Canadian universities. These results were obtained from nine different specifications of inputs and outputs. Sarrico and Dyson (2000) explored the contribution of DEA methodology to inform management. They described Warwick University's performance. The Australia universities technical and scale efficiency was also carried out by Abbott and Doucouliagos (2003). Martine (2003) also used this method to investigate Zaragoza University's teaching departments' performance assessment. Chapple *et al.* (2005) extended evidence on the relative performance of U.K. university Technology Transfer Offices (TTOs) using Data Envelopment Analysis (DEA) and Stochastic Frontier Estimation (SFE).

DEA MODELS

Data envelopment Analysis model is a non-parametrical model which it is usable for different systems performance assessment. One of the most important scores of DEA is its usability for systems having multi-inputs and multi-outputs. If the number of

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inputs and outputs are more than one, sum inputs and outputs multiplications are used:

- Virtual output = $u_1y_{10}+u_2y_{20}+...+u_sy_{s0}$
- Virtual input = $v_1x_{10}+vx_{20}+...+v_sx_{s0}$.

To compare homogenous systems with identical inputs and outputs, we need a mathematical model. This model was propounded as the CCR model by Charnes *et al.* (1978). The optimum coefficients for each of the DMUs are separately calculated so that the most efficiency for the viewed DMU is obtained. In this model, the maximum amount in relation to virtual output to virtual input is assessed for each DMU, so that the efficiency of none of DMUs should not be more than a (100% efficiency) while all the variables multipliers should be positive. This model is formulated as follow:

Max:

$$\theta_o = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}}$$

Subject to:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1 \quad j=1, 2, ..., n$$

$$u_r \ge \varepsilon, \quad v_i \ge \varepsilon \qquad r = 1, \ldots, s, \qquad i = 1, \ldots, m \qquad (1)$$

The $\epsilon \ge 0$ is a non-Archimedean constant. In the light of the above model, the efficiency score of each DMU is bigger than zero and smaller or equals one. A DMU is a perfect efficient, if and only if the improvement possibility of none of inputs and outputs exist without worsening other inputs and outputs (Pareto-Koopmans Efficiency). The optimal values v_i^* and u_r^* may be interpreted as weights (v_i and u_r are the variables of the above models). These values are determined through solution of the model. θ_o^* is highest rating that allow for a DMU.

It also should be noted that DEA assesses relative efficiency, i.e., estimation the influence of DMUs that have complete efficiency.

The model (1) is changed to a linear planning through changing a variable as follow:

Maximize:

$$\sum_{r=1}^{s} u_r y_{ro}$$

Subject to:

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 1 \quad j=1, 2, ..., n$$

$$u_r \ge \varepsilon, \; v_i \ge \varepsilon \; r = 1, \ldots, s, \; i = 1, \ldots, m \qquad (2)$$

As it is stated by Charnes *et al.* (1978), this implies that the conditions for Pareto-Koopman optimality, because increase in this maximum value is obtained only when some values input (x_{ij}) is increased or if some of the values output (y_{rj}) are reduced (Cooper *et al.*, 2007).

EDUCATIONAL EVALUATION THROUGH DEA METHOD

To evaluate educational system cannot be used of market evaluation mechanisms such as benefit assessment to determine DMU performance or inputs and outputs economic value, because inputs and outputs generally stand in the education, research and service departments which the measurement or presentation of an assessment unit is very difficult. DEA method also emphasizes university targets for inputs and outputs choice and makes possible the choice of qualities input and output indicators to the system. There is also the permission for the choice of several inputs and outputs.

Indicators (variables): The choice of indicators or in other words, effective factors on efficiency assessment in a university has great importance, because to succeed in performance assessment, precise choice and suitable one in selecting important factors and comparable in units under consideration should be carried out.

In this study, the application of DEA method in educational assessment, Islamic Azad University, Zahedan unit's educational departments in 2008-2009 academic years is studied. The definition of indicators which show produced output in one educational unit or inputs to be viewed are not simple due to numerous effective factors. The Islamic Azad University, Zahedan unit's educational departments are viewed as DMUs. The effective indicators on educational department's efficiency can be the number of teaching staff (including: professors, assistant professor, lectures and educational experts, who are full-time and half-time), the performed research work by the teaching staff of each educational departments (including: books compilation and translation, published articles or presented in authentic conferences and reports and research projects) the number of registered students, the number of graduates, the number of passed students to higher levels (such as a two-years course to BA, BA to MA and to PHD), educational possibilities etc.

Table 1: The gathered information to assess educational departments of Islamic Azad University, Zahedan Unit, Academic year 2008-2009

Education department	No. of registered students in academic year 2008-2009	Scientific board's concession	Guest lecturers number of units	Number of graduates	Number of students passing to higher level	Research work (project, article, books)
Nursing	433	5	88	56	1	45
Midwifery	242	1	55	35	2	10
Laboratory sciences	233	2	38	46	6	40
Veterinary	406	1	65	51	6	0
Management	989	10	140	75	2	60
Judicial law	1276	9	145	148	2	60
Accountancy	2190	6	165	189	2	20
Geography	634	6	82	68	4	40
Physical education	757	4	78	103	2	10
Mathematics	650	12	64	25	2	130
Geology	525	6	90	43	8	120
Computer	1020	2	100	116	1	0
Civil	1718	11	140	111	4	50
Industrial	1025	6	120	80	3	90
Agriculture	655	11	88	30	10	50
Electronics	924	5	92	39	1	20
Persian literature	360	6	72	31	1	20
Islamic knowledge	779	8	102	146	1	10
Elementary education	589	5	92	115	1	0
Empirical science	441	4	80	35	1	20
Arabic literature	258	5	50	11	1	20

Table 2: Efficiency of DMUs in CCR model

No.	Education department	Efficiency	No.	Education department	Efficiency
1	Laboratory science	1	12	Industrial	0.75
2	Veterinary	1	13	Agriculture	0.7197
3	Computer	1	14	Geography	0.6648
4	Elementary education	1	15	Nursing	0.6550
5	Geology	1	16	Civil	0.6021
6	Islamic knowledge	1	17	Management	0.4366
7	Physical education	1	18	Persian literature	0.4362
8	Applied Mathematics	1	19	Empirical sciences	0.4020
9	Midwifery	0.996	20	Electronics	0.3664
10	Accountancy	0.9268	21	Arabic literature	0.366
11	Law	0.7776			

In the light of the above-mentioned, the gathered information are written in the Table 1.

By using the above table's information in the DEA linear programming models (CCR model) the following results are obtained (Table 2).

The above table yields that eight DMUs are efficient but their rank is undefined in comparative together, also two DMUs have average ratings greater than 0.90. The Arabic literature department has minimum efficiency equal 0.366.

THE EFFICIENCY ASSESSMENT IN PESSIMISTIC VIEWPOINT

In most DEA models, weights for each DMU are so calculated that the most efficiency for that DMU is obtained, whilst weights are calculated separately for each DMU. So this kind of assessment can be called optimistic assessment (Liang *et al*., 2008). In this section, we deal with pessimistic viewpoint of efficiency and through using this method, interval efficiency each DMU is calculated.

We, in this article, use the multiplication efficiency method to calculated pessimistic efficiency. In this method, DEA model is solved for each DMU to get the optimistic efficiency. Now, if the value of obtained variables for other DMUs to be viewed in dependent objective of fractional DMU with the selection of least pessimistic efficiency in identical conditions for all DMUs is calculated, i.e., θ_{kj} scores which are the jth DMU efficiency scores are determined against kth DMU weights:

$$\theta_{kj} = \frac{\sum_{r=1}^{s} u_{rk} y_{rj}}{\sum_{i=1}^{m} v_{ik} y_{ij}} \quad k = 1, ..., n, \; j = 1, ..., n \tag{3}$$

All matrix components multiplication efficiency is between zero and one, $0 | \theta_{kj} \leq 1$ and diagonal multiplication efficiency matrix (θ_{kk}), is the DEA efficiency score usual for (optimistic efficiency). If DMU_k is efficiency $\theta_{kk} = 1$ and otherwise inefficiency, the least existing value in this matrix can show the worst conditions for the efficiency of each DMU (θ_0^{1*}). In this method the pessimistic efficiency is smaller than optimistic efficiency and because efficiency of each DMU

even in the worst conditions will not be zero, so none of the DMUs have interval efficiency [0, 1].

This method (Cross-efficiency evaluation) not only provides a ranking among the DMUs but also eliminates unrealistic DEA weighting schemes without requiring a priori information on weight restrictions.

INTERVAL RANKING

When the efficiency of each DMU is merely calculated optimistically, the efficiency score of each DMU is the DMUs rank which is of course methods such as Andersen-Petersen's method should be used to rank efficient units. Now, that we have obtained the efficiency of each DMU in the form of interval, it is obvious that ranking on the basis of optimistic efficiency causes the loss of a lot of information.

Definition:

- DMU_o is a strong efficient whenever $\theta_o^{l*} = \theta_o^{u*} = 1$
- DMU_o is efficient whenever $\theta_o^{l*} < 1$, $\theta_o^{u*} = 1$
- DMU_o is inefficient whenever $\theta_o^{u*} < 1$

For interval efficiency ranking many methods can be used: First DMUs are ranking on the basis the upper limit and if DMUs have identical upper limit, ranking is carried out with comparison to low ranking. If $[\theta_o^{l*}, \theta_k^{u*}] \leq [\theta_t^{l*}, \theta_t^{u*}]$, DMU_t is rated as more efficient than DMU_k.

Optimistic coefficient method, in this method to assess the efficiency of each DMU, a set of multiplications from the upper limit and the lower limit are used. The coefficients are determined in the light of decision maker and the existing conditions. Meanwhile the collection of two coefficients (the upper limit coefficient and the upper limit coefficient) should become one.

INTERVAL EFFICIENCY IN PERFORMANCE ASSESSMENT OF EDUCATION

By using the above method, the section 3 data, interval efficiency of educational departments is as Table 3.

If ranking is first carried out on the basis of the upper limit and about departments having identical the upper limit, the ranking will be like the above table.

If optimism coefficient is used for ranking, the upper limit and the lower limit interval efficiency, each should be multiplied by an appropriate number explaining the decision maker's optimism, so that the collection of two chosen numbers become one as coefficient.

By using the questionnaires and assessing the views of authorities and the students, optimism coefficient for each department is determined and then the average of these coefficients were chosen as optimism coefficient, the resulting value 0.64 is for optimism and 0.36 for pessimism.

CONCLUSION

Universities are in the present arena, one of the major sponsors of education and provision of efficient manpower needed for the country. So, assessment of their performances and determination of their weak and strong points can continuously be effective in reaching to their aims. Researchers in their studies concerning the performance of the set of training organizations which train society's manpower are looking after indicators which can compare them on the basis of these indicators. These indicators can be quantitative or qualitative. The indicators should be chosen so that they reflected the institution's performances. Generally speaking, the trained force in the institution and also the rate of learning concepts and the application of science by graduates and individuals' thought results in the form of articles, books and other tools, reflects graduates' knowledge, awareness and the various sciences that they can be suitable indicators for further assessment of an educational institution. Therefore, performance assessment indicators: number of service receiving students in an academic year, number of graduates, number of passing students, scientific board's concession, guest lecturers, the concession of chosen research work were selected. The unit under investigation was all Islamic Azad University, Zahedan unit's all educational departments in all levels of two year post university course, B.A and M.A. to carry out a more accurate assessment and also efficiency was

Table 3: Interval efficiency of DMUs and Ranking of DMUs with using optimistic coefficient

Education department	Interval efficiency	Efficiency	Education department	Interval efficiency	Efficiency
Laboratory science	[1,1]	1	Industrial	[0.5324,0.75]	0.6717
Geology	[0.5644,1]	0.8432	Geography	[0.5543,0.6648]	0.6250
Mathematics	[0.4288,1]	0.7944	Nursing	[0.5147,0.6550]	0.6045
Islamic knowledge	[0.7924,1]	0.9253	Agriculture	[0.2926,0.7197]	0.5659
Physical education	[0.7561,1]	0.9122	Civil	[0.4551,0.6021]	0.5492
Elementary education	[0.7513,1]	0.9105	Management	[0.3810,0.4366]	0.4166
Veterinary	[0.5781,1]	0.8481	Persian literature	[0.3125,0.4362]	0.3917
Computer	[0.6969,1]	0.8909	Empirical sciences	[0.3322,0.4020]	0.3769
Midwifery	[0.5516,0.996]	0.8360	Electronics	[0.2730,0.3664]	0.3328
Accountancy	[0.6445,0.9268]	0.8252	Arabic literature	[0.2011,0.366]	0.3066
Law	[0.6343,0.7776]	0.7260			

determined with two optimistically and pessimistically viewpoints. Then interval efficiency is calculated to determine optimistic efficiency from CCR model and pessimistic efficiency through cross-efficiency. This method is better in relation to methods used so far to determine the pessimistic efficiency, because despite the IDEA model, a DMU which stands both the border of efficiency and inefficiency does not occur, while in other model DMU is resulted with interval efficiency which shows the best efficiency in optimism case that is opposes the efficiency CCR's model concepts. Finally, we have dealt with using interval ranking concepts to educational departments ranking.

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