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Evolution of Azad Universities Efficiency Using Data Envelopment Analysis Route

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Abstract—*Data envelopment analysis (DEA) and fuzzy methods have been used for evaluating the efficiency of decision making units (DMU) that falls into two categories of efficient and deficient units. Decision making units could be schools, banks, hospitals, etc. In this research paper, affecting indexes on the efficiency of Azad Universities are introduced which some have Fuzzy parameters. The relative efficiency of these parameters were evaluated using DEA and through collecting data from high schools. Alternatively, the inefficiency sources are determined for the deficient units and some strategies are suggested to achieve efficiency boundaries and performance improvement.*

1. INTRODUCTION

The efficiency of any organization is important and an effective technique is required for the assessment of its performance. Data envelopment analysis (DEA) is a non-parametric method for estimating the efficiency of decision making units with multiple inputs and outputs [1-3]. It can be used to measure the efficiency of a single-input single-output ratio to a multiple-input multiple-output ratio by using a ratio of the weighted sum of outputs to the weighted sum of inputs [2, 4].

The measurement of efficiency is of great importance due to its significance economic consequences [5, 6]. The accuracy in the measurement of inputs and outputs was required in traditional DEA methods such as CCR and BCC [2, 4]. Although, various techniques are applied to compare the fuzzy numbers, DEA has several advantages such as functional relationship between production inputs and outputs [7]. Moreover, it is a suitable route for the assessment of multiple inputs and outputs efficiencies [6, 8]. Fuzzy approach is a suitable technique when we face inherent imprecision or vagueness [9]. Efficiency is a concept of enhancement which is considered to improve the level of well-being. It is defined as the ratio of output to input in economics and its value is always smaller than 1 [5].

Several factors have positive effects on the enhancement of efficiency of universities such as teacher quality (both qualifications and experience), the size of universities, and number of students in a school, management [8] and reallocation of existing expenditures [6] in right ways, place [3] where schools are built.

In this study, we propose an interactive evaluation process for the measurement of the relative efficiencies of a set of DMUs in fuzzy DEA with consideration of the DMs' preferences. We have constructed a linear programming (LP) model with fuzzy parameters and calculate the fuzzy efficiency of the DMUs for different inputs [7, 10-13]. We then evaluated the performance of Azad Universities during the academic year 2010-2013. Our sample consists of 75 Azad Universities. We consider that the variables with missing values are of fuzzy nature. The main aim in university assessment is to evaluate the fact that how much the provided resources or inputs to the universities have been efficiently used and had impact on universities efficiency or performance.

2. REVIEW OF LITERATURE

Previous studies on the performance and efficiency of educational centers using non-parametric fuzzy DEA methods include notably fuzzy set algebra developed by Lotfi Zadeh (1965), fuzzy mathematical programming approach by Sengupta (1992), and a mathematical programming approach using transforming fuzziness by Triantis and Girod (1998). Guo and Tanaka (2001), León et al. (2003) and Lert-worasirikul et al. (2003) proposed three similar fuzzy DEA models [4]. For the first time, Charnes, Cooper, and Rhodes (1978) [6], introduced a DEA method for determining the efficiency of decision making units. In 1993, Anderson and Peterson [2] proposed the super-efficiency method for ranking efficient DMUs [1, 14].

3. THEORY OF DATA ENVELOPMENT ANALYSIS

There are different factors which are affecting on the efficiency of universities such as the administrator of universities, efforts of the authorities and the director general, in line with supply and resource allocation, and their

geography location. Data development analysis is an important route to assess the efficiency of decision making units. DMU's usually use a set of input parameters and convert them into a set of output parameters. DEA successfully divides DMUs into two efficient and deficient decision-making units. This study evaluates the relative efficiency of high schools using input parameters such as; 1) Administrative staff, administrative office, experience, edge, degree, experts. 2) Educational space and Facilities high schools such as laboratories, workshops, site audiovisual, 3) Teaching staff such as research performance (number of papers, writing books, translating books, conferences, studies, workshops made up), and 4) Quality of education and output indicator includes; I) Graduates percent passing II) The number of students passing. Moreover, the outcome of each session such as homework, midterm exams and participate in class and answer questions during teaching is evaluated. All these factors contribute to the final grade teacher for assessing student abilities. A performance result comparing inputs and outputs is a single decision maker. The efficiency related to a single input and output is defined as follows:

$$\text{Efficiency} = (\text{output} / \text{input}) \quad (1)$$

In the case of one input and one output, the single decision maker j-th (j = 1, ..., n) by taking $X_j$to produce output Y_j, the efficiency (performance) of k_{th} the E_k have to be shown by the following fraction is calculated:

$$E_k = \frac{y_k}{x_k} \quad (2)$$

In case of multi-input and multi-output, if the price (weight) to specify all possible outcomes and the cost (weight) of all inputs is known, the efficiency (performance) is calculated from the following equation:

$$E_j = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \quad (3)$$

Where u_r price (weighted) outputs have r (r = 1, ... , s) and $v_i$is the cost of (weight) of input i, (i = 1, ..., m). This functionality is known as economic efficiency, relative performance of each unit by dividing the unit's performance to the greatest efficiency is achieved. Thus, the relative efficiency of units is always less than or equal to one [6, 7, 10]. For example, the relative performance of the k_{th} is displayed by RE_k as follows:

$$RE_k = \frac{E_k}{max\{E_j : j = 1,\ldots,n\}} \quad (4)$$

Production function shows the maximum amount of output that can be achieved from different combinations of inputs.

3.1. Fuzzy BCC Model

Nature of BCC model in input, output, and dual P^{th}decision unit for evaluating the input and output of fuzzy numbers, triangular and trapezoidal fuzzy numbers are obtained similar to that one of these models in the following cones [15];

Min θ_p

$$\text{s.t} \sum_{j=1}^{n} \lambda_j x_{ij}^m \le \theta_p x_{ip}^m \text{ , i= 1,…,m}$$

$$\sum_{j=1}^{n} \lambda_j x_{ij}^p \le \theta_p x_{ip}^p \text{ , i= 1,…,m}$$

$$\sum_{j=1}^{n} \lambda_j x_{ij}^o \le \theta_p x_{ip}^o \text{ , i= 1,…,m}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj}^m \ge y_{rp}^m \text{ , r = 1,…,s}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj}^p \ge y_{rp}^p \text{ , r= 1,…,s}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj}^o \ge y_{rp}^o \text{ , r= 1,…,s}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \ge 0,$$

$$j=1,\ldots,n \quad (5)$$

Azad universities often have efficiency with variable scales. This means increasing the ratio of inputs to a constant does not necessarily increase the outputs by same proportion. For example, if educational facilities, number of staff and so on increase twofold proportionally, outputs such as the number of students and academic quality do not necessarily increase twofold. Output may increase less than 2, equal to 2 or greater than 2. Thus, a range is used with variable scale. This means that the BCC model should be used to calculate the relative performance of high schools. A linear programming problem must necessarily be solved for each high school. This computer program is written using GAMS software which results are discussed below. The modified model from the Azad universities evaluation, with 4 inputs and 2 outputs, can be written as follows:

$$\text{Min p} = q - \frac{1}{4}\sum_{i=1}^{4} \frac{s_i^-}{x_{ip}}$$

$$s.t. \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = q x_{ip} \text{ , I = 1,…, 4}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = q y_{rp} \text{ , r = 1, 2}$$

$$q + \frac{1}{2}\sum_{r=1}^{2} \frac{s_r^+}{y_{rp}} = 1$$

$$\lambda_j \ge 0 \qquad , s^- \ge 0 \ , s^+ \ge 0 \ , q \ge 0$$

$$\sum_{j=1}^{6} \lambda_j y_{2j} \ge 2$$

$$\sum_{j=1}^{6} \lambda_j y_{2j} \le \sum_{j=1}^{6} \lambda_j y_{1j}$$

$$q y_1 + s^+ = t_1$$

$$t_{1 \in z}$$

$$q y_{2p} + s_2^+ = t_2$$

$t_{2\epsilon z}$

$\lambda_j \geq 0$ (6)

Model must be solved 6 times per training group. After solving the model L (optimal value of the objective function), the vector of this group is obtained, followed by a suitable model for inefficient groups to achieve the level efficiency [15].

4. METHODOLOGY

Certain parameters are used in order to assess the efficiency of Azad Universities. The number of these parameters was over 70 which are merged due to the similarity between some of them. Parameters are classified into two categories; inputs and inputs.

4.1. Inputs parameters

4.1.1. Educational space

This parameter indicates the use of educational facilities at each university which composed of variety of factors including total area, the entire infrastructure, the number of classes, sports facilities, libratory, library and so on in which all the above factors are merged together with the help of some weights in order to quantify the overall educational space of each university as an index. Educational space scoring parameter can be obtained for each school by a linear combination of features including multi's Azad university ($\alpha_{1)}$, the number of non-class room (α_2), the number of classes (α_3), total area (α_4), and useful area (α_5) using the following formula:

$$\mathbf{I_{1=}}\ 2N(\alpha_1) + 3N(\alpha_2) + 5N(\alpha_3) + 2N(\alpha_4) + 3N(\alpha_5) \quad (7)$$

For example the calculation for high school no. $S_{37}$is as: *25(9) +2(5176) +7(1792) =23121*

In the above equation N () function is the normal mechanism. Educational environment is a parameter in the interval [79.12 and 55.40].

4.1.2. Administrative Staff's Score

A parameter that each university has been obtained by a linear combination of the following factors was considered for administrative staff of each university according to the experience, work duration and academic qualification. Administrative staff's scoring can be stated as:

I_2 =2(Diploma number)+3(A.A.number) +5(B.A.number) +7(M.A.number) +3(Registrar number) +1(servitornumber) +2(0-5 work experience) +3(work experience 5-10)+4(10-15 years of service) +5(15-20 work experience) +7(20-25 work experience) +9(25-30 work experience), or it can be rewritten as:

I_2= $2N(b_1)+3N(b_2)+5N(b_3)+7N(b_4)+3N(b_5)+1N(b_6)+2N(b_7)+3N(b_8)+ 4N(b_9)+ 5N(b_{10})+7N(b_{11})+9N\ (b_{12})$ (8)

N(.) is the normal mechanism function, and b is a parameter of each above factor's.

4.1.3. Academic Staff's Score

Some advantages should be considered for all academic staff in a high school. A parameter for each university has been obtained by a linear combination of factors include teachers and trainers based on years of teaching experience, educational qualifications etc. The academic staff's score can be calculated as follows:

I_3 = **[**Average work experience for teachers) + (number of expert/Total) + (number of Diploma) + 2 (number

of Associate degree) + 4 (number of bachelors) + 5 (number of masters)]/ number of classes.

It can be written as follow:

$\mathbf{I_3}$=N $[Nx_1+N(x_2/x_3) +Nx_4+2Nx_5+4Nx_6+5Nx_7]/Nx_8$ (9)

4.1.4. Academic Quality of 1st Semester

This parameter indicates the quality of the students at the beginning of the course. We want to know how good a student has started the course and finally, how this quality will be changed. Therefore, it is composed of the percentage of students' passing in various subjects.

4.2. Outputs parameters

4.2.1. Number of Students

This parameter is composed of the number of students indifferent years that is the sum total of universities students at different levels.

4.2.2. Passing percentage (Students Academic Performance)

One of the most important criteria in evaluating the relative performance of each university is student's educational quality. This performance is the result of students passing scores in various subjects. Since the passing percentage of each subject may differ from one to another, hence, special coefficients were calculated with some weights in this study. With the help of these weights, the total weighted percent of total passing in various subjects have been calculated. The obtained passing percentage which is a qualitative option was

converted to a fuzzy option and then to specified numbers using related fuzzy theories. Finally, the weighted average of these coefficients is considered as the final weight.

5. RESULTS AND DISCUSSION

In the DEA approach, we have chosen an input orientation and assessed its corresponding efficiency. Optimal decision has to be made efficiently and optimal utilization practices to assess which is the maximum expected result that is achieved by schools directors. Obviously, in order to use the resources properly, decreasing the cost of inputs and increasing the outputs are essential. In other words, by reducing the number of input, output can be increased in order to be more effective, and both have been done to evaluate the effectiveness of universities. Therefore the above indicators from qualify to fuzzy and from fuzzy to quantity have been studied using data envelopment analysis BCC model by applying GAMS software, and then efficient DMUs and inefficient DMUs are compared with each other's [15]. Using BCC model, the significance coefficients of each subject can be obtained. The parameters which have been studied are listed intable1.

The efficiency of university is calculated using DEA models. Then, the rate and extent of weakness of each deficient university is determined for each input and output parameters. Each Azad university makes use of **four inputs** (Educational space, Administrative staff, Academic Staff, and Academic Quality of 1st semester) to produce **two outputs** (Academic Quality of 2nd Semester and Number of Students). The method of data collection and concluding parameters are described as follow:

5.1. Inputs

The input data of the Azad Universities are summarized in the table 2. The related parameters for inputs include:

5.1.1. Educational space

The parameter indicates the rate of using educational facilities available at each university. This range is (61220 – 2250) with the average of 14950.07across all high schools.

5.1.2. Administrative staff

It simply refers to a parameter that reflects the quality and quantity of administrative staff at a university including director, deputy, registrar and servitors. The index range is (10-182) with an average of69.48.

5.1.3. Academic staff

It is a parameter that reflects the quality and quantity of universities lecturers. The range of variation is (66.27-.91) for this index which shows a very large extent and reflects differences in the teachers quality of training at two universities. The average is 17.94 for this parameter which shows the low status of the teaching staff in the majority of Azad universities in terms of quality and quantity.

5.1.4. Academic Quality of 1st Semester

This parameter shows the quality of the students in the first semester. Since the evaluation of the university in second semester is aimed, so we wanted to know that students had what qualities at the beginning of the second semester and by what means they achieve the quality at the end of the second semester. The index changes in (100- 37.07) range with the mean value of 74.75 [15].

5. 2. Outputs

5.2.1. Academic Quality of the 2nd Semester

It is a parameter that reflects the quality of Azad university in the second semester and composes of the percentage of students passing various subjects. It varies from100 to32.86and has the average of 78.18.

5.2.2. Number of Students

It is composes of the total number of students from different levels and varies at (855-15) distance with the 273.16 average.

The output data of the Azad Universities are summarized in the tables 3 and 4. The data is analyzed by modeling as like the following graph. It is defined from left side as: ineffective, less effective, middling, high, very much [15].

6. CONCLUSIONS

The In summary, the data envelopment analysis model has been successfully applied with fuzzy parameters to calculate the relative efficiency of Azad Universities. In order to ameliorate the efficiency of Azad Universities, the acceptance of student at university should be according to the educational facilities, academic environment, etc. Moreover, the extra classes could be run for some difficult subjects such as Mathematics, Physics, Chemistry, and Electronics. Additionally, school managers should provide enough and advanced facilities for laboratories so that students can perform the experiments which are related to the theoretical parts of their studies. Furthermore, they should employ the well educated and experienced teachers and making the academic environment friendly, fair, and conducive for students. Last but not least, they can provide academic camps for students to improve their mental conditions and gain more satisfaction.

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