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Statistical analysis of the foundation universities in Turkey

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Abstract

The aim of this study is to determine the efficiencies of the foundation universities by using data envelopment analysis (DEA) which is a performance measurement method for increasing the efficiency of educational institutions. The foundation universities are also ranked with the super-efficiency analysis. The number of academic personals, the number of undergraduate students and the number of scientific projects are used as input variables while using the number of undergraduate students, the number of graduate students as output variables for 45 foundation universities in Turkey for the academic year 2015-2016. The results show that Sabanci University is the super-efficient. On the other hand, Ozyegin University is the most inefficient foundation university in Turkey; whereas, Halic University, Ihsan Doğramaci University, Istanbul Arel University, Koc University, Sabanci University and TOBB Economy and Technology University are found to be efficient. In conclusion, the overall average efficiency of the foundation universities is low which means that the universities are technically inefficient. This can be interpreted as the higher education sector performing equally not well for the academic year 2015-2016.

Keywords: Foundation university, efficiency, performance, data envelopment analysis.

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1. Introduction

There are many different methods to rank efficient universities over their inefficient counterparts. Evaluating the efficiency of universities is significant for effective allocation and the usage of educational resources. Some characteristics of universities cause difficulty in measuring their efficiency, such as universities are non-profit making organizations; therefore, it is not possible to assign monetary values to the inputs and outputs and universities produce multiple outputs (e.g. graduates and publications) using multiple inputs (e.g. lecturers and facilities) etc. From the last quarter of the twentieth century, a global economic structure has been formed by the process of transition to information society and knowledge economy. In this new structure, individuals' economic power, knowledge and education levels, the competitiveness of countries' capital have begun to be measured. This process increased expectations from universities which are primarily responsible of knowledge generation and sharing. In addition to these expectations, high percentage of young population in developing countries and naturally because of this, the increase in demand for higher education, force universities to use their resources effectively.

A variety of methods have been used to evaluate the performance of universities, while the most common methods are stochastic frontier analysis (SFA) and data envelopment analysis (DEA). SFA is good in handling data with certain level of uncertainty; however it is not easy to be applied in a multiple inputs and outputs situation. On the other hand, DEA has become a popular performance measurement tool for non-profit institutions like schools, hospitals, and universities due to its capability of handling multiple inputs and outputs without a priori assumptions on the monetary values of the inputs and outputs.

DEA measures the relative efficiencies of organizations with multiple inputs and multiple outputs. The organizations are called the decision-making units (DMUs). It assigns weights to the inputs and outputs of a DMU. It thus arrives at a weighting of the relative importance of the input and output variables that reflects the emphasis that appears to have been placed on them for that particular DMU. At the same time, though, DEA then gives all the other DMUs the same weights and compares the resulting efficiencies with that for the DMU of focus.

The fundamentals of DEA methodology and a review of DEA applications in universities will be presented in Section 2. The mathematical model for this study is discussed in Section 3. A hypothetical example is used to illustrate the application and implication of the model in Section 4. Lastly, Section 5 concludes the paper with some future works.

2. Literature Review

2.1. Application of DEA in universities

DEA was first introduced by Charnes, Cooper and Rhodes (1978). It is a powerful method used to measure the relative efficiency of a group of homogenous firms or DMUs. A DMU can be defined as a transform of input(s) into output(s) and whose performances are evaluated. The main advantage of DEA is to measure relative efficiencies of multiple-input and multiple-output DMUs without prior weights on the inputs and outputs. This paper is not intended to consider of the main topics of DEA. Readers, who are interested in various topics of DEA, are advised to refer to the literature reviews done by Cook and Seiford (2009).

DEA has been applied to evaluate the relative efficiencies among universities and relative efficiencies among university departments or courses. There have been many studies on DEA applications in the context of university departments. Johnes (1993) applied DEA for efficiency of Department of Economics In UK. Then, Johnes and Johnes (1995) investigated performances of UK universities. Kao and Hung (2006) used data envelopment analysis to assess the relative efficiency of the academic departments at National Cheng Kung University in Taiwan. The relative effectiveness of state and foundation universities was determined with DEA by Ahn and Seiford (1993). The relative effectiveness of 38 state universities in Australia was determined by Abbott and Doucouliagos (2003) and the efficiency of the 15 state universities in Germany was determined by Fandel (2007) by the help of DEA. In addition, DEA was used to analyze the effectiveness of American universities by Dundar and Darrell (1995) and the Canadian state universities by McMillan and Debhasish (1997). Similarly, DEA was used for the universities in England by Athanassopoulos and Shale (1997)). Avkiran (2001) used DEA to examine the relative efficiency of Australian universities. Abramo et al. (2008) presented a methodology of measuring the technical efficiency of research activities. Wolszczak-Derlacz and Parteka (2011) examined efficiency and its determinants in a set of universities from several European countries. Recently, Barra and Zotti (2016) applied DEA to assess technical efficiency in a big public university.

There is no exact standard to guide the inputs/outputs selection in university efficiency assessment. For examples, Ahn and Seiford (1993) selected faculty salaries, state research funds, administrative overheads, and total investment in physical plants as inputs and number of undergraduate enrolments, number of graduate enrolments, total semester credit hours, and federal and private research funds as outputs; while Johnes and Johnes (1993) chose the quantity and quality of undergraduates, number of postgraduates, number of teaching and research staffs, administration expenditures, library and computer facility expenditures, and value of interest payments and depreciations as inputs and quantity and quality of first degree graduates, number of higher degree graduates, and research grants as outputs. Generally, the agreed inputs for universities can be classified as human and physical capital, and the outputs should arise from teaching and research activities. The inputs and outputs as well as the DEA model used in this study are presented in the next section.

2.2. Mathematical model

In the DEA, a change in the input variable is concerned about the direction of the change in output or fixed return. The model under constant returns to scale CCR is defined by Charnes, Cooper and Rhodes (1978) and the model under variable returns to scale BCC is defined by Banker and Cooper (1992). DEA models, based on the distance from the boundary of the efficient production in effective units, can be grouped as input and output oriented models. In the input-oriented model, the required input combinations are determined producing most effective output combinations. In output-oriented model, it is decided as a maximum output by a particular combination of inputs.

Suppose that the producer uses the input vector $x \in R_{+}^{m}$ to produce the output vector $y \in R_{+}^{s}$; i.e., all data are assumed to be nonnegative, but at least one component of every input and output vector is positive. A pair of such semi-positive input x and output y, are called the decision making units. The Production Possibility Set (PPS) is represented as $T = \{(x, y) \in R_{+}^{m+s} \mid \text{input } x \text{ can produce output } y\}$. The production possibility set T is generally close and convex. Additional properties of set T are given as follows:

1. The observed DMU belongs to T; ($(x_j, y_j) \in T, \quad j = 1, \ldots, n$).
2. If $(x, y) \in T$, then $(tx, ty) \in T, \quad t > 0$.
3. For any $(x, y) \in T$, any semi-positive $(\bar{x}, \bar{y})$ with $\bar{x} \geq x$ and $\bar{y} \leq y$ is included in T.

Arranging the data set in matrices $X = (x_j)$, and $Y = (y_j)$, $j = 1, \ldots n$, the PPS T can be defined by

$$T_c = \{(x, y) \mid \lambda^T X \leq x, \ \lambda^T Y \geq y, \ \lambda \geq 0\}.$$

where $\lambda \in R_+^n$ is a semi-positive vector. Adding the constraint $\lambda^T e = 1$, with $e = (1,1,\ldots,1)^T$, to T_c is equivalent to omitting the postulate 2, then T_v is defined as follows:

$$T_v = \{(x, y) \mid \lambda^T X \le x,\ \lambda^T Y \ge y,\ e^T \lambda = 1,\ \lambda \ge 0\}$$

T_c and T_v are called the production possibility sets of CCR model and BCC model in DEA to gather with constant return to scale and variable return to scale, respectively. To evaluate the efficiency of $DMU_o\ (o \in \{1,\ldots,n\})$, the input-oriented model (1) and the output-oriented model (2) are applied.

$$\begin{aligned} \text{Min} \quad & \theta \\ \text{s.t.} \quad & \lambda^T X \le \theta \mathrm{x_o}, \\ & \lambda^T Y \ge y_o, \\ & \lambda \in \Lambda. \end{aligned} \qquad (1)$$

and

$$\begin{aligned} \text{Max} \quad & \varphi \\ \text{s.t.} \quad & \lambda^T X \le \mathrm{x_o}, \\ & \lambda^T Y \ge \varphi y_o, \\ & \lambda \in \Lambda. \end{aligned} \qquad (2)$$

The models (1) and (2) are called envelopment form CCR model if $\Lambda = \{\lambda \mid \lambda \ge 0\}$ and envelopment form BCC model if $\Lambda = \{\lambda \mid \lambda \ge 0,\ e^T \lambda = 1\}$.

3. Results

Higher Education Council of Turkey has the responsibility of the university education in Turkey. In this study, input and output data set of 45 foundation universities are used to determine relative efficiency levels in producing research and educational outputs. The most important assumption of DEA is to produce the same kind of output of DMUs with similar strategic objectives by using the same kind of input (Golany and Yu, 1997). Data for four input variables and three output variables are obtained from the web pages of National Scientific and Technological Research Council (www.tubitak.gov.tr), The Council of Higher Education (www.yok.gov.tr) and Student Selection and Placement Center (www.osym.gov.tr) for the academic year 2015-2016. Input and output variables are presented in Table 1.

Table 1. Input and output variables of the DEA model for foundation universities

Inputs	Outputs
Number of Academic Personals	Number of publications
Number of Undergraduate Students	Number of undergraduates
Number of Projects	Number of graduates
Total Budget	

In this study, output-oriented and variable return to scale BCC model is applied to 46 DMUs using input and output variables in Table 1. The super-efficiency model is also used to determine efficiencies of foundation universities. Then, the relative efficiencies of universities are summarized in Table 2.

Table 2. Efficiency scores of Turkish foundation universities for the academic year 2015-2016

No	University	Efficiency Score (%)	Reference Set	Super Efficiency Score (%)	Super Efficiency Rank
1	Acibadem University	271.40	38 (0.69)	271.40	35
2	Atilim University	164.91	16 (0.15) 38 (1.17)	164.91	19
3	Avrasya University	181.34	14 (0.03) 29 (1.91)	181.34	23
4	Bahçeşehir University	155.45	16 (0.64) 38 (1.37)	155.45	17
5	Başkent University	130.70	19 (3.01) 37 (0.02)	130.70	11
6	Çag University	145.23	16 (0.62) 38 (1.11)	145.23	16
7	Cankaya University	237.28	16 (0.31) 38 (0.59)	237.28	32
8	Doğuş University	110.17	14 (0.19) 11 (0.59)	110.17	7
9	Fatih Sultan Mehmet University	196.63	373 (2.41)	196.63	27
10	Gedik University	130.75	16 (0.17) 37 (0.29) 38 (0.08)	130.75	12
11	**Haliç University**	**100.00**	**10**	**79.92**	**4**
12	Hasan Kalyoncu University	463.41	11 (0.50)	463.41	42
13	Işik University	248.74	11 (0.14) 16 (0.19) 37 (0.20) 38 (0.42)	248.74	34
14	**Ihsan Doğramaci University**	**100.00**	**4**	**44.69**	**2**
15	Istanbul 29 Mayis University	229.51	19 (0.07) 37 (0.42)	229.51	31
16	**Istanbul Arel University**	**100.00**	**22**	**82.15**	**5**
17	Istanbul Aydin University	194.61	38 (1.50)	194.61	26
18	Istanbul Bilgi University	218.47	16 (0.84) 38 (1.11)	218.47	29
19	Istanbul Bilim University	239.39	16 (0.18) 29 (0.33) 38 (0.68)	239.39	33
20	Istanbul Gelişim University	128.37	14 (1.05) 11 (0.82)	128.37	10
21	Istanbul Kemerburgaz University	184.73	16 (0.07) 38 (0.83)	184.73	24
22	Istanbul Kültür University	136.10	16 (0.66) 38 (0.57)	136.10	14
23	Istanbul Medipol University	347.51	38 (1.44)	347.51	38
24	Ist. Sabahattin Zaim University	190.97	38 (0.61)	190.97	25
25	Istanbul Sehir University	130.22	37 (1.94)	303.22	45
26	Istanbul Ticaret University	125.78	16 (0.24) 38 (0.79)	125.78	9
27	Izmir University of	164.52	16 (0.35) 29 (0.80)	164.52	18

	Economy				
28	Kadir Has University	141.64	16 (0.31) 38 (0.43)	141.64	15
29	**Koç University**	**100.00**	**1**	**97.27**	**6**
30	Kto Karatay University	352.15	16 (0.03) 37 (0.50) 38 (0.53)	352.15	39
31	Maltepe University	131.37	11 (1.16)	131.37	13
32	Nişantaşi University	219.72	16 (0.68) 38 (0.15)	219.72	30
33	Nuh Naci Yazgan University	198.56	16 (0.11) 29 (0.79)	198.56	28
34	Okan University	114.56	11 (1.68)	114.56	8
35	Özyeğin University	710.12	11 (0.17) 16 (0.16) 38 (0.51)	710.12	45
36	Piri Reis University	372.01	14 (0.04) 17 (0.02) 37 (0.73)	372.01	4
37	**Sabanci University**	**100.00**	**15**	**43.30**	**1**
38	**Tobb Economy and Tech. University**	**100.00**	**29**	**79.79**	**3**
39	Toros University	353.23	11 (0.29)	353.23	40
40	University of Turkish Aeronautical Association	344.79	16 (0.05) 37 (0.10) 38 (0.75)	344.79	37
41	Ufuk University	177.44	11 (0.41)	177.44	21
42	Antalya International University	301.32	37 (0.01) 38 (0.48)	301.32	36
43	Uskudar University	564.84	16 (0.20) 29 (0.25) 38 (0.89)	564.84	44
44	Yaşar University	174.41	16 (0.14) 37 (0.13) 38 (1.47)	174.41	20
45	Yeditepe University	180.79	11 (1.02) 16 (0.46) 38 (1.62)	180.79	22

It was determined that 100 percent efficiency in DEA results which were efficient or productive university. Based on Table 2, 6 of the 45 foundation universities can be said to be effective in 2015-2016. Therefore, approximately 13% of foundation universities in Turkey proved to be effective. In addition, the efficiency values of the Ozyegin University was found to be the lowest. A reference set of this university had Halic University (Rank: 4), Istanbul Arel University (Rank: 5) and TOBB Economy and Technology University (Rank: 3). According to the super-efficiency values in 2015-2016, Sabanci University was found to be the most efficient university. This result is similar to the world university rankings. According to the results of the QC and THE institutions, Sabancı University was among the world's top 500 universities in 2015.

4. Conclusion

The aim of university is to educate individuals with the necessary information used in the business life. However, the number of personnel and financial resources are not unlimited in universities. Therefore, the university is required to use the most effective limited resources. In this study, the efficiencies of the foundation universities in Turkey were determined using DEA for the 2015-2016 academic year. As a result, it was determined that 6 of the 45 foundation universities were efficient in 2015-2016. Foundation universities, in general, was determined to be ineffective.

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