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Evaluation of Technical Efficiency in the Education Departments of the Oil Ministry Subsidiaries Using Data Envelopment Analysis (DEA)

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ABSTRACT: The main purpose of this study is Evaluation of technical efficiency in the education departments of oil Ministry subsidiaries, using data envelopment analysis. In this study, the performance of education departments in the 12 oil Ministry subsidiaries, has been studied during 2011-2012. The results show that the managerial courses that held in this period, with assumption of constant and variable return to scales, the average technical efficiency of education departments are 0.89 and 0.96. That assuming constant return to scale, DMU1, DMU2, DMU5, DMU8 and assuming variable return to scale DMU1, DMU2, DMU3, DMU5, DMU7, DMU8, DMU9 are efficient units. With the assumption of constant and variable return to scale, the average technical efficiency of education departments in held public courses are 0.90 and 0.95.The assuming constant return to scale, DMU2 , DMU3 , DMU12 and assuming variable feedbacks to scale, DMU1, DMU2, DMU3, DMU5, DMU7, DMU8, DMU9, DMU12 are efficient units. The average technical efficiency in held specialized courses, assuming constant and variable return to scale are 0.89 and 0.95. The assuming constant return to scale, DMU1, DMU2, DMU5 and assuming variable return to scale, DMU1, DMU2, DMU3, DMU5, DMU6, DMU8 are efficient units.

Keywords: Technical Efficiency, Economic Efficiency, Allocation Efficiency, Data Envelopment Analysis, Education Departments.

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INTRODUCTION

Today's world is the world of changing. Rarely is going a day without an innovation in the world of economy, a change in production or in the services status. In such circumstances, more organizations are looking for a solution to keep up with these conditions. The solution offered by most experts is training and development of human resources. Increasing domination of man over nature and knowledge and awareness of the unknown and research for finding new techniques and tools to resolve issues and problems in the society, especially in the developing countries, has given more importance and effectiveness to the concept of manpower training.

Education has always been intended as a trustable means for improving the performance qualities and to solve the organization problems, and shortcoming in it is one of the key and critical issues to any organization. Therefore education is alike the heart that with its every beat gives blood to all aspects and organs of the organization. And it's full of new information and new findings and technical innovations. Every moment that it stops causes collapse of organization and the whole system destruction.

The education can provide these goals that's accompanied with proper courses, and correct planning, generated from the organization's goals. And be obtained from the analysis and study of organization's different parts and expert's opinion, managers and direct supervisors. All programs and job training activities should systematically have been evaluated and to be used of evaluation sources for information and completion of programs and job training activities. Employee training is very important at the oil ministry and establishing job training institutions in this ministry is an evidence is for this claim. With regard to these cases, the objectives of this research, in addition to study technical and scale efficiency of educational institutions under the assumption of constant and variable returns to scale, can mention to trends of change check in the sample of offices efficiency over time, determine department's additional inputs, etc. This study answers the fundamental questions which are, as follows:

How much is the efficiency of education departments in the state of constant and variable return to scale?

Has the technical efficiency of education departments increased over time?

This paper is organized in four sections. The first section checks the theoretical and empirical background. The second part is devoted to the research methodology. In third section, the results of the study are assessed. The final section is devoted to conclusions and suggestions.

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Theoretical Principle and Literature Review

Efficiency in three domains of engineering, management and economics is discussable. This term was first introduced in the domains of physics and thermodynamics, and later entered in other domains. Efficiency in the domain of physics(in mechanical and closed systems) divided by actual production(real) potential output(nominal), and the value obtained is always smaller than one unit. In addition to inputs and physical capital in domain of management science, inputs and human capital are also considered. Therefore, the value considered for the ability of people is not confined to the borders since the efficiency of individuals with regard to the encouragement and punishment, may be more or less than it can be. Finally, in the domain of economics science, as well as the ratio of output to input efficiency is defined and its value is always smaller than one. In this case, the efficient firm is considered to have fewer inputs to produce their products (Abtahi and Kazemi, 1996). Following the excellence and Evolution of human knowledge in economics, scholars and experts were offered another definition for efficiency so that is agreed with existing realities. Accordingly, they defined efficiency in the general case, as the ratio weighted average of outputs to the weighted average inputs used in the production the desired unit (Imami Meibodi, 2005).

Types of efficiency in Farrell's perspective include: technical efficiency, allocative efficiency, structural efficiency, and economic efficiency. Technical efficiency reflects the ability of a firm to maximize output given resources and factors of production. In another words, the ability to convert inputs such as labor and machinery into output, compare with the best performance will be measured by technical efficiency (Pierce, 1997).

Allocative efficiency implies to produce the best combination of products by using the least costly combination of inputs. Thus, allocative efficiency requires the selection of a set of production factors that produce a certain level of product with minimal cost. Structural efficiency of an industry can be achieved of weighted average efficiency firms in that industry. We can compare the efficiency of different industries with different products by using structural efficiency criteria. Economic efficiency is a combination of technical and allocative efficiency, because it indicates the degree of success of operation is to minimize the cost of producing a certain amount of product (Imami Meibodi, 2005). A theoretical framework for measuring efficiency was described by Farrell in 1957. But the applied possibility of its measurement by the efforts of economists and specialists in operation research was provided through Econometrics method stochastic frontier Analysis (SFA) in 1977 and the Data Envelopment Analysis linear programming (DEA) in 1978. First study was done in method of stochastic frontier analysis by Aigner and Cho. Those are separated both methods statistical deterministic parametric and statistical parameter. Data envelopment analysis method based on a series of optimization is through using linear programming, which are also said to be nonparametric method. In this method, the characterization type of the production function is not required (Cobb - Douglas, Trans logs, etc.) and the efficient frontier curve is created a series of spots that is determined by linear programming; Linear programming method determines after a series of the optimization whether the desired decisions unit is on the efficiency line or out of it. Hereby, efficient and inefficient units are separated from each other, the efficiency obtained is relative and not absolute (Imami Meibodi, 2005).

MATERIAL AND METHODS

Firms' performance evaluation in data envelopment analysis under accomplished two assumption constant and variable return to scale with two different approaches, input-oriented and output-oriented. Given the above assumption, evaluation of firm performance is done through two models, CCR and BCC. Technical efficiency of decision making units i^{th} according to CCR model. And an input orientation is calculated as follows:

$$TE_{\circ}^{CRS} = \min_{\lambda,\theta} \theta_i$$

$$\begin{aligned} St: \quad & -y_i + Y\lambda \geq \circ \\ & \theta_i X_i - X\lambda \geq \circ \\ & NI' \lambda \geq \circ \\ & \lambda_j \geq \circ \end{aligned}$$

In the above model, TE represents the technical efficiency and θ is a scalar integer expressing technical efficiency under the assumption of constant feedbacks to scale θ value located between zero and one. And whatever is closer to one indicates a higher efficiency level. λ is a 1 × N vector of Fixed numbers that indicates the weight of the reference sets for inefficient units. λ's amount is unknown, and optimal quantities are obtained by solving model. Y is a matrix N × M of output and X is a matrix N × K of the inputs. N, K and M are in turn number of firms, number of inputs and number of output. y_j and x_j are the vectors (1 × M And 1 × K) of inputs and outputs of j firm. Since all the units do not operate at optimal scale, assuming constant return to scale cannot always be appropriate. Hence, we can convert the model CCR to model BCC, include variable return to scale assumption by adding the convexity constraint NIλ´=1 in the above model.

In measuring the efficiency of input-oriented approach, with no change in output produced, the probability of proportional reduction of inputs is measured. Since the variable return to scale model only indicates that firms do not operate in the range of constant return to scale, to determine the type (increasing or decreasing) return to scale we introduced the third constrain to descending return to scale**,** i.e. NIλ´≤1. The DEA approach, the efficiency of each of the surveyed firms, determined in contrast with the performance of other firms. On the basis, this method offers the amount required reducing in each of the inputs (either radial motion or the motion on the efficiency boundary) and/or an appropriate increase in output with the respect to the performance of the firm reference in direction improve the performance of inefficient firms as well as calculating units efficiency. How to determine reference units for inefficient units will be described in the next section.

Reference Set

If producers in an industry be capable of producing maximum output by using certain amount of input, or with minimum inputs have produced a certain amount of output, other producers in this industry will be efficient only if they have the same production as the desired firms. In the method of data envelopment analysis, there are techniques to determine how many firms there are reference to inefficient units, and dominance method is one of them. There is one objection in the nonparametric method or DEA structure that this method compares inefficient firms with efficient firms by convex combination, not existing firms. Herein, Talkns presented dominance method in 1993. In the case of multi-input and multi-output dominance method structure can be expressed by using an input orientation or output. For example, firm k has been dominate of input on firm k´ if and only if:

$$y_{km} \geq y_{k'm} \qquad m = 1, 2, \ldots, M$$
$$X_{kn} \leq X_{k'n} \qquad n = 1, 2, \ldots, N$$

Or in other words, firm kth has been dominate of input on firm k´ if the unit kth unit produces more or equal product to unit k´ and at least uses one of its inputs less or equal to unit k´. Another type of dominance cases, is the strict dominance that dominate of inputs and outputs are considered Simultaneously, Firm k strongly dominant firm k, if and only if:

$$y_{km} > y_{k'm} \qquad m = 1, 2, \ldots, M$$
$$X_{kn} < X_{k'n} \qquad n = 1, 2, \ldots, N$$

Means that, if the firm k produces more output, by using less inputs, it's strictly dominant on k´ unit (Khataee and Yousefi Haji Abad, 2006).

Efficiency evaluation of education departments of organizations does not have much experience in Iran and the world. However, the efficiency evaluation of education units, education groups and schools separately conducted research in some of these studies are stated here.

Outside the Iran, Badri and El mourad (2012), Efficiency evaluation of 22 public schools in Abu Dhabi. Agha et al. (2011), Efficiency evaluation 30 education groups of Gaza Islamic University. Angulo Meza et al. (2011), Efficiency evaluation 13 local center of distance learning in the state of Rio de Janeiro, Brazil, Corazon Gwendolyn and Cabanda (2009), Efficiency evaluation 16 colleges and universities of Metro Manila in the Philippines, have been investigated by using DEA mathematical models. In Iran, the alem Tabriz et al. (2011), Efficiency evaluation 11 Faculty of Shahid Beheshti University, Taghizadeh and Fattahi sarand (2008), the Efficiency evaluation 28 academic unit of Islamic Azad University of East Azerbaijan province, Zorriye Habib and Maghboli (2011), Efficiency evaluation 5 education groups of Islamic Azad University, Hashemi et al. (2009), performance 11 education groups of engineering faculty, Islamic Azad University, Saveh, have been evaluated by using DEA models.

MATERIAL AND METHODS

Statistical Society of research includes the education departments of the Oil Ministry subsidiaries period of time is, the years 2011-2012. Inputs in this research include: the cost of specialized training courses, managerial, public, teachers assessment points in, specialized, managerial, public; training courses and outcomes, including total points score evaluated the specialized, managerial, public training courses. In this research, data analysis takes place using BCC model with input-oriented approach. To perform these analyses, the statistical software DEAP2 is used.

RESULTS

After collecting the required data via DEAP2, by a multi-stage method during 2011-2012, take action to calculate the technical efficiency of subsidiary education departments of Oil Ministry. Due to the confidentiality of the collected data, the sample companies in this study are named DMU1 to DMU12. It is noteworthy that unit 8 is not held the managerial courses in 2011.Units 4 and 11 also did not hold public courses. Because the assessments made in the above courses, these units are not considered. The results are presented in the following tables. Overall, the results of technical efficiency evaluation using BCC model with input-oriented approach, show, the

average technical efficiency education departments in managerial courses held in the years studied, in CRS mode 89% in VRS mode 96%. This means that these departments on average should, save 4% of their inputs to achieve input Technical efficiency, and save nearly 11% in their inputs to achieve input technical efficiency and the optimal scale. Average technical efficiency education departments in held specialized courses, are CRS mode 89% and VRS mode 95%. This means that these departments on average should save 5% of their inputs to achieve input Technical efficiency, and save nearly 11% in their inputs to achieve input technical efficiency and the optimal scale. Average technical efficiency education departments in held public courses, are CRS mode 89% and VRS mode 95%. This means that these departments on average should save 5% of their inputs to achieve input technical efficiency, and save nearly 10% in their inputs to achieve input technical efficiency and the optimal scale.

Table1. Efficiency rate of education departments in managerial courses in 2011

Company's Name	Efficiency rate			Returns to scale
	CRS	VRS	SC	
DMU_1	1	1	1	-
DMU_2	0.982	0.995	0.987	irs
DMU_3	0.907	1	0.907	irs
DMU_4	0.764	0.883	0.865	irs
DMU_5	1	1	1	-
DMU_6	0.853	0.933	0.914	irs
DMU_7	0.907	1	0.907	irs
DMU_9	0.887	0.986	0.900	irs
DMU_{10}	0.817	0.920	0.889	irs
DMU_{11}	0.849	0.920	0.924	irs
DMU_{12}	0.615	0.975	0.631	irs
Average	0.871	0.965	0.902	irs

Table2. Efficiency rate of education departments in managerial courses in 2012

Company's Name	Efficiency rate			Returns to scale
	CRS	VRS	SC	
DMU_1	0.967	0.984	0.982	irs
DMU_2	1	1	1	-
DMU_3	0.962	0.966	0.996	irs
DMU_4	0.821	0.892	0.921	irs
DMU_5	1	1	1	-
DMU_6	0.919	0.975	0.942	irs
DMU_7	0.923	1	0.923	irs
DMU_8	1	1	1	-
DMU_9	0.903	1	0.903	irs
DMU_{10}	0.849	0.905	0.938	irs
DMU_{11}	0.850	0.910	0.934	irs
DMU_{12}	0.934	0.987	0.946	irs
Average	0.927	0.968	0.957	

Table3. Efficiency rate of education departments in specializd courses in 2011

Company's Name	Efficiency rate			Returns to scale
	CRS	VRS	SC	
DMU_1	1	1	1	-
DMU_2	1	1	1	-
DMU_3	0.910	1	0.910	irs
DMU_4	0.745	0.886	0.841	irs
DMU_5	1	1	1	-
DMU_6	0.832	0.929	0.896	irs
DMU_7	0.793	0.842	0.941	irs
DMU_8	0.909	1	0.909	drs
DMU_9	0.878	0.964	0.910	irs
DMU_{10}	0.857	0.906	0.949	irs
DMU_{11}	0.889	0.977	0.910	irs
DMU_{12}	0.923	0.996	0.926	irs
Average	0.895	0.958	0.933	

Table 4. Efficiency rate of education departments in specializd courses in 2012

Company's Name	Efficiency rate			returns to scale
	CRS	VRS	SC	
DMU_1	1	1	1	-
DMU_2	0.964	0.992	0.972	drs
DMU_3	0.950	0.976	0.973	irs
DMU_4	0.789	0.891	0.885	irs
DMU_5	1	1	1	-
DMU_6	0.889	1	0.889	irs
DMU_7	0.858	0.883	0.971	irs
DMU_8	0.926	0.926	1	-
DMU_9	0.869	0.971	0.895	irs
DMU_{10}	0.829	0.880	0.941	irs
DMU_{11}	0.872	0.993	0.879	irs
DMU_{12}	0.924	0.996	0.928	irs
Average	0.906	0.959	0.944	

Table5. Efficiency rate of education departments in publice courses in 2011

Company's Name	Efficiency rate			returns to scale
	CRS	VRS	SC	
DMU_1	0.976	0.993	0.983	irs
DMU_2	1	1	1	-
DMU_3	0.974	0.981	0.993	irs
DMU_5	0.971	1	0.971	drs
DMU_6	0.793	0.810	0.979	irs
DMU_7	0.765	1	0.765	irs
DMU_8	0.928	1	0.928	drs
DMU_9	0.959	1	0.959	irs
DMU_{10}	0.870	0.870	0.999	irs
DMU_{12}	1	1	1	-
Average	0.924	0.965	0.958	

Table6. Efficiency rate of education departments in publice courses in 2012

Company's Name	Efficiency rate			returns to scale
	CRS	VRS	SC	
DMU_1	0.974	1	0.974	drs
DMU_2	1	1	1	-
DMU_3	1	1	1	-
DMU_5	0.928	0.941	0.986	drs
DMU_6	0.812	0.839	0.968	irs
DMU_7	0.705	1	0.706	irs
DMU_8	0.892	0.896	0.996	irs
DMU_9	0.786	0.956	0.822	irs
DMU_{10}	0.769	0.828	0.929	irs
DMU_{12}	1	1	1	-
Average	0.887	0.946	0.938	

In the DEA method, for each inefficient firms, are introduced a firm or a combination of two or more efficient firms as reference. For example, in Table 7, for Unit2, reference Unit1, Unit7 and Unit3 are specified. On the basis dominance method, Unit1 is strictly dominant on Unit2. This means that unit1, has produced more output by using fewer inputs. In other words, Unit1 has the input and output dominating on the unit2.The necessary amount of savings in each of the inputs is shown in table 8 for being efficient of inefficient units in held managerial courses in 2011. With the optimal amounts of inputs and outputs in each of the education departments, the following formula is obtained: For example, in Table 8, unit 4, to achieve the efficiency boundary, should reduce the amount of 261,139.073 billion Rials of training costs and in order on to adapt on its image on the efficiency boundary should save 969,700,927 million Rials. In held managerial courses in 2011, the maximum amount of savings in the first input, it must be done in unit 10.

Table7. Determine the refrence units for inefficient units in managerial courses in 2011

inefficient education departments	The reference education departments	weight of reference education departments
DMU_2	DMU_3 , DMU_7 , DMU_1	0.858 , 0.034 , 0.108
DMU_4	DMU_7	1
DMU_6	DMU_3 , DMU_7 , DMU_1	0.065 , 0.895 , 0.040
DMU_9	DMU_1 , DMU_3	0.615 , 0.385
DMU_{10}	DMU_7 , DMU_5	0.200 , 0.800
DMU_{11}	DMU_7 , DMU_5	0.200 , 0.800
DMU_{12}	DMU_3 , DMU_7	0.705 , 0.295

Table8. Rate of necessary decline in inputs of managerial courses of inefficient education departments in 2011

Inefficient education Departments	The savings amount in inputs		The amount of necessary increase in outputs
	Cost of courses		The total score of evaluation
	Motion to achieve efficient boundary	Motion On efficiency boundary	
DMU_2	1029.639	-	-
DMU_4	261139.073	969700.927	1
DMU_6	65395.965	-	-
DMU_9	3094.314	-	3.854
DMU_{10}	765735.632	7455336.368	-
DMU_{11}	121494.253	92577.747	-
DMU_{12}	19603.389	-	23.827

DISCUSSION

In this study, data envelopment analysis is used to evaluate the technical efficiency of education departments Oil Ministry subsidiaries, during 2011-2012. The results of the study, diagnose causes of being inefficient and how to achieve optimum level of efficiency. According to the results obtained in 2011 and 2012 respectively 18 and 25 percent of education departments, in managerial courses, are efficient in both CRS and VRS modes. In other words, just the same education departments in the managerial courses, could achieve both technical and scale efficiency. Assuming variable return to scale, units 1, 3, 5, 7 in 2011 and Unit 2, 5, 7, 8, 9 in 2012, assuming constant return to scale, in 2011, Units 1 and 5 and in 2012, Units 2, 5 and 8 in management courses, are efficient during the years 2011 and 2012, respectively 16 and 25 percent of education departments, are efficient in both CRS and VRS modes in specialized courses. In other words, just the same education departments, could achieve both technical and scale efficiency in the managerial courses.

Assuming a variable return to scale, units 1, 2, 3, 5 and 8 in 2011 and units 1, 5, 6 in 2012, assuming a constant return to scale, units 2, 5, 8, are effective. During the years 2011 and 2012 respectively 20 and 30 percent of education departments are efficient in both CRS and VRS modes in public courses. In other words, just the same education departments, could achieve both technical and scale efficiency in the managerial courses. Assuming variable return to scale, units 2, 5, 7, 8, 9, 12 in 2011 and units 1, 2, 3, 7, 12 in 2012, assuming a constant return to scale, in 2011, units 2 and 12, and in 2012, 2, 3 and 12, are effective. Generally, the units that their teachers had higher academic level, did not necessarily achieve higher efficiency levels.

By using the findings of this research, the following recommendations can be used to improve the efficiency of the education departments.

1. DEA method is optimized Objective function with respect to either assuming constant return to scale (CRS) or variable return to scale (VRS). According to material provided, we know that, CRS assuming long-term goals and VRS assumption pursues short-term goals, therefor long-term and short-term goals can be assigned for the education departments, which hopefully increase departments' technical efficiency with applying these goals.

2. Although the efficiency results of education departments in VRS modes shows a high average, but it should be reminded that this function only reflects the short-term efficiency, and efficiency rate in the short term (a pure technical efficiency), and it cannot be a suitable criterion for setting up programs to improve efficiency and productivity. After all education departments should have also benefited of scale efficiency in long-term in addition to pure technical efficiency. This shows a wide range of more suitable planning to take the inefficient units and make them efficient. In this case, if all the inefficient education

departments, have the ability to decrease the Suggested Amounts that is determined based on their homogeneity education departments performance, they can significantly prevent the waste of resources in the country.

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