International Research Journal of Applied and Basic Sciences
© 2013 Available online at www.irjabs.com
ISSN 2251-838X / Vol, 5 (1): 53-59
Science Explorer Publications

IRJABS

Evaluating schools' performance using Data Envelop Analysis (DEA) (Case study: Schools in Western Mazandaran)

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ABSTRACT: The most important goal of the present paper is to evaluate performance of schools in western Meandering using DEA technique. This is an applied research the population of which is composed of 43 high schools in the mentioned region in the year 2012 and all these schools were selected as the statistical sample. The paper investigates all available evidence on organizational performance evaluation to collect required data, study the current status of schools and answer questions proposed in this field. Finally, Dea Solver Software was used to analyze collected data. Findings showed that among 43 considered high schools 16 (Somayyeh, Soudeh, Shahed, Shahid Dastgheib, Pasdar Hekmat, Shohadaye Hoveyzeh, Forough Danesh, Taghva, Sadra, Azadegan, Kimia, 17 Shahrivar, Shahid Helli, Khatam-ol-Anbia, Pasdar Hekmat and Tohid) were selected as efficient schools compared to others and the remaining 27 schools are less efficient. Besides, inefficiency and weaknesses of these schools were determined using reference units.
Keywords: Data Envelopment Analysis (DEA), input, output, efficiency

INTRODUCTION

Historically, human being has faced limitations and scarcity and these remain permanent in the future. Limitations are sensible concerning capital, human labor, energy, etc. Hence, individuals try to use available resources and equipments in the best way and employ their talents and abilities to attract and equip these resources. In this field, the issue of efficiency measurement is of great importance for many economists. To meet this goal they consider efficiency enhancement in production entities such as capital, labor, etc, and many economic, scientific and technical advances are principally based on this issue. Efficiency improvement is a basic responsibility of managers. Human Resources Management (HRM) involves the knowledge, art and skill to conduct, develop and lead the implementation process of those plans through which required human resources are provided based on organizational goals. On the role of managers in improvement and efficiency believes optimized use of organizational resources is a distinct responsibility of managers from those involved in entrepreneurship and institutional administration.

The Research Theoretical Framework

In a thesis for Master's Degree Hadian (2003) examined efficiency of 10 Iranian banks for a period of two years (1997 – 1999) and found the average of technical, consecratory and economic efficiencies (84.2%, 86.4% and 74.3%, respectively). Farzipour (2005) evaluated the efficiency of research vice-presidencies of Islamic Azad University branches in Tehran and concluded that Karaj and Tehran Markaz (Central Tehran) branches have the most efficient research vice-presidency offices. In a research titled "the use of DEA to evaluate the performance of instructional faculties in Islamic Azad University of Tonekabon" Hatamian et al (2011) indicated that Accounting and Inorganic Chemistry faculties were the most efficient ones. The optimized response of management faculty was also estimated.

$\lambda_2 = 0.6, \lambda_6 = 0.4$

This means that management can be considered as an efficient (but not highly efficient) faculty. If it did use policies of accounting and inorganic chemistry faculties toward the λ then it could be considered as highly efficient.

In a research on measuring the efficiency of Indian banks using DEA, Mainland (2002) showed that state banks in India are less efficient than private and foreigner ones.

In 2003, Martin examined performances of the 52 departments of Saragossa University using cumulative DEA. Results of this research showed that among all departments 50 ones have a very low level of

performance. Besides, he found that there is no correlation between education and research and an insignificant correlation between research and quality. In 2001, Lopez and Lanzer investigated performances of 58 departments of a Brazilian university. In their research, the university's performance was evaluated from four aspects: educational productivity, research productivity, services and quality. Their results showed that after solving the model, the 8 countries were divided into three groups. Then, England, Netherlands and Australia had a good performance in the three models. France and Germany were in a medium level and Spain, Finland and Italy were ranked in the third group with the weakest performance.

Performance Evaluation

It is a process used to measure, value and judge the performance during a certain period. From an organizational aspect performance evaluation usually equals activity effectiveness. Effectiveness means the extent of achieving goals through tasks and operations efficiency.

Performance evaluation includes measuring the performance through comparing the current status with the desired of ideal status based on predetermined indicators which have certain features (Seyed Javadin, 2005).

From an organizational aspect performance evaluation usually equals activity effectiveness. Effectiveness means the extent of achieving goals through tasks and operations efficiency (Taheri, 2003, p31).

In terms of resource usage performance evaluation is defined in the form of efficiency indicators. If in the simplest definition the ratio of input to output is called efficiency, then the performance evaluation system, in fact, measures the efficiency of managerial decision made on optimized use of resources and equipments (Taheri, 2003).

Performance evaluation the process of comprehensively measuring the performance in the form of terms such as efficiency, effectiveness, significance, empowerment and responsibility based on the framework of certain principles in order to meet organizational, structural and planning goals and long-term development of the organization (Effati Dariyani, 2007).

Performance evaluation is a process of measurement, valuing and judging (Managerial System Modification, 1996).

Efficiency is a concept enhancement of which is considered by most policy-makers and economist to improve the level of well-being, convenience and life expectancy in human life. Efficiency is mostly considered in three fields: engineering, management and economy. The term was first proposed in the field of physics and thermodynamics and then entered other fields and scopes. In 1957, Farel used a certain method to measure efficiency in a manufacturing unit. He applied his own model to estimate the efficiency in agriculture industry of the US. However, he failed to present a method involving multiple inputs and outputs. Finally, efficiency in economics was defined as the ratio of output to input and its value is always smaller than 1. Respecting the expected or standard output the efficiency is calculated using the following equation (Sumant, 1984):

Efficiency = real output + expected output

Absolute efficiency: The y^x output is assumed for an input unit in certain decision-making units (in international standard). Having assumed one input unit, he decision-making unit produces y_0 output. Then, the absolute efficiency equals $\frac{y_0}{y^x}$. For example, a student gain the score 15 from standard of 20, hence, his absoulute efficiency equals $\frac{15}{20}$ (1).

Relative efficiency: Imagine that decision-making units have produces y output units from x input units. The relative efficiency of the unit number k is:

$$REk = \frac{\frac{y_x}{x_x}}{\max\left\{\frac{y_j}{x_j}\middle| j = 1,2,\dots,n\right\}}$$

For instance, if 5 students of a class get scores of 8, 10, 11, 12 and 15 (from the standard of 20), no one has the absolute efficiency (1) but the score 15 is considered as the best score of the class. Here, the relative efficiency is $\frac{8}{15}, \frac{10}{15}, \frac{11}{15}, \frac{12}{15}$ and $\frac{15}{15}$. As can be seen, at least one efficiency value equals 1.

Input and Output

The indicator in which efficiency is increased by increasing and stabilizing other indicators is the output indicator.

The indicator in which efficiency is decreased by increasing and stabilizing other indicators is the input indicator.

Production Possibility Set

This set is shown by T and includes:

T = {($^{x}_{y}$)| input for minimum x can produce up to y output}

Proposed Principles in the T set

A) Inclusion Principle: T set is not null.

B) Possibility Principle: If $\binom{x}{y}$ is a member of T, then for every x$\bar{x}$> we have (x y) € T and if (x y) is a member of T, for every Y<Y we have (x y)€ T.

C) Axiom of Convexity: if (x1 y1) and (x2 y2) belong to the T, then for every λ€[0, 1] we have:

$\binom{x_2}{y_2}\in$ T-λ)1+($\binom{x_1}{Y_1}$λ

D) Return to Constant Scale: If (x1 y1) belong to the T, then for every ∝ > 0 we have

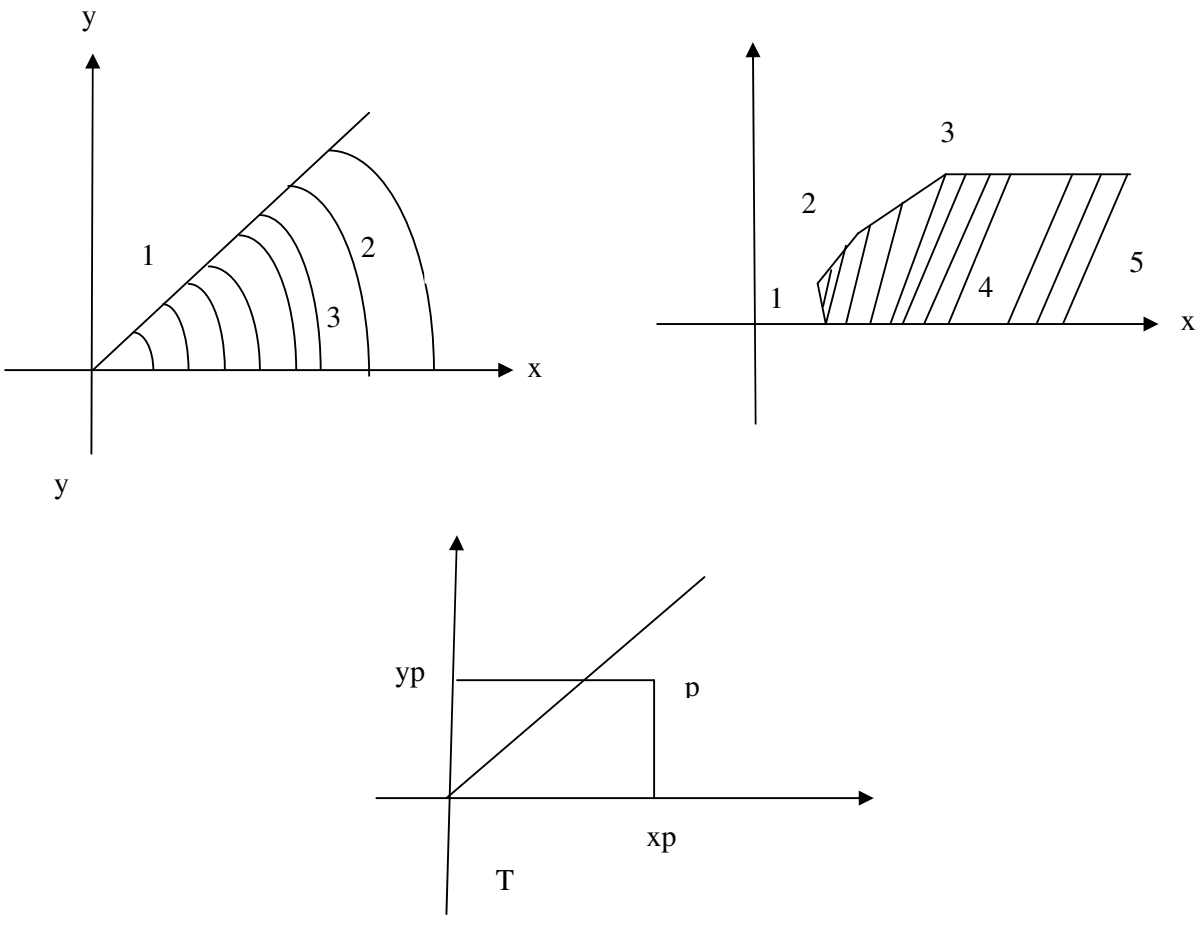
$\binom{\propto x_1}{\propto y_1}$ € T

Definition: The T technology in which all four mentioned principles are true is shown with Tc. In general, it can be written as:

Tc = $\left\{\binom{x}{y}\middle| x \geq \lambda x; \& y \leq \lambda y; \lambda \geq 0\right\}$

If the last principle is omitted from the technology then Tc switches to Ty.

1) Input-based CCR Model



RESEARCH METHOD

Efficiency Measurement Models
Input-based CCR Model

The main goal is to evaluate the organization number P. The first method in Tc is to reduce inputs in order to take an inefficient unit to efficiency threshold. This means that if (xp yp) is not on the threshold we have to do some thing to put (θxp yp) on the threshold. The lowest value of θ is called efficiency. Therefore, the model for calculation of DMU_p efficiency in input nature in Tc is as following:

Min θ
s.t

$$\sum \lambda_j x_j \leq \theta X_p \quad \sum \lambda_j y_j \geq Y_p$$

λ≥0

It is also as follows in Ty:

$$\sum \lambda_j x_j \leq \theta X_p$$

$$\sum \lambda_j y_j \geq Y_p$$

$$\sum \lambda_j = ١$$

λ≥0

This model is called BBC and can be solved by the software DEA SOLVER. The following questions are answered after solving the problem by this software.

1. Specifying efficient and inefficient units and efficiency of DMU_p
2. Identifying weaknesses of inefficient units and the extent of weakness in each indicator.
3. Pattern allocation to improve inefficient units
4. Ranking of decision-maker units
5. Another model is also used to evaluate efficiency based on which:

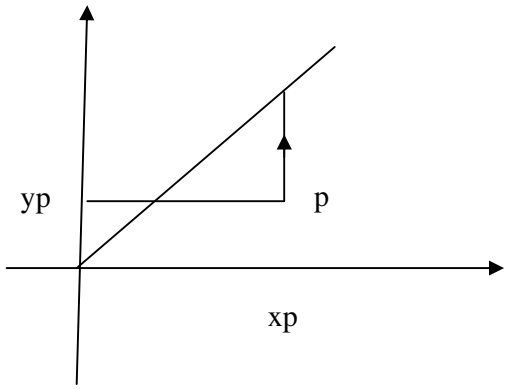
U and V are weights of inputs and outputs of which the software calculates the best weights and the efficiency extent.

Max uy_p

s.t: uy_j-$vx_j \leq 0$ و j=1,…,n

vx_p=1 u,v≥ 0

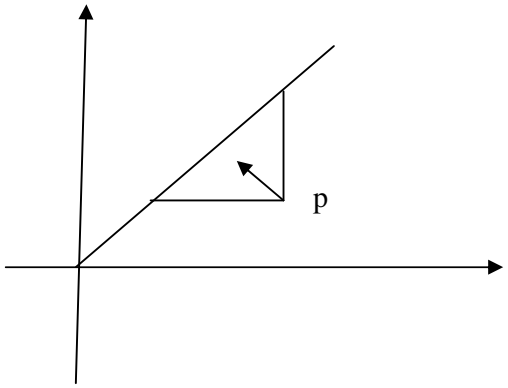
2. Output-based CCR Model



An inefficient unit can be taken to the efficiency threshold by increasing outputs. This means that if (xp yp) is inefficient, φ must be calculated such that (xp φyp) is placed on the threshold.

3. The Compound Model

If a unit is inefficient, it can be taken to the efficiency threshold by simultaneously decreasing the input and increasing the output.



Some Considerations on Mentioned Models

A certain model is selected randomly to be discussed for further analysis of variables.
For example, in the following input-based CCR model
Min θ
s.t

$$(1)\ \sum \lambda_j x_j \le \theta X_p$$

$$(2)\ \sum \lambda_j y_j \ge Y_p$$

λ≥0

The calculated value of θ is exactly the efficiency of unit number P

0 < θ ≤ 1 is always true. If for some organization θ < 1, those are considered as inefficient organizations but if θ = 1 that is called an efficient organization (weakly or strongly efficient). The row (1) in the model is not solely an inequality but it is considered as an inequality relative to number of xp inputs and is called input inequality and row (2) is called output inequality. The term on the left can be equal to (or smaller than) the term on the right in (1). If they are equal, the considered input must not be decreased and if the left one is smaller than the right only the difference between these two must be removed form the input. This amount is called wasted input and is represented with $\overline{S}$. For example, $\overline{S_2}$ = 4 means that 4 units must be decreased form the second input indicator in order to achieve the efficiency threshold. The same is true for terms of row (2). For instance, if the excess (surplus) of rows in (2) is represented by S^+ and we have S_2^+ = 3, this means that 3 units must be added to the second indicator to achieve the efficiency threshold. Regarding these explanations a unit is considered efficient in which θ = 1. But, if $S^+ = \overline{s} = 0$, then the unit is strongly efficient. There is an interesting debate on the variable λ. First, λ exists for every organization being evaluated. λ ≠ 0 in estimated optimized answers (calculated by the software) means that the decision-maker unit has to obey some policies of other units to extent of the figure calculated for λ (weight). These obeyed organizations are those for which the λ was not zero.

For example for a certain organization θ is 0.7 and $\lambda_1 = \lambda_3 = 0$ and $\lambda_2 = 0.2$ and $\lambda_4 = 0.6$. This means that the organization is inefficient but of obeyed policies of organizations 2 and 4 then it could be considered efficient. Interestingly, in evaluation of each unit every corresponding λ of efficiency unit can be other than zero.

Table 1. schools informations

School's name	No. of students	No. of teachers	Area	No. of awards	No. of 1-9 rankings	No. of accepted in Konkoor
Imam Khomeini	322	25	2500	0	0	70
Taleghani	286	23	3500	0	0	52
Khatam-ol-Anbia	32	8	800	0	2	0
Ghorbani	124	18	1500	0	0	35
Isargaran	209	16	700	0	0	0
Shahed	304	24	2800	2	3	45
Dr. Hesabi	180	12	800	2	2	15
Fatemeh Zahra	374	19	1500	0	0	67
Nehzat	329	21	1900	2	2	50
Somayeh	77	12	1700	0	1	57
Soudeh	48	7	800	0	0	9
Meraj	90	10	1400	0	0	0
Shahed	305	21	2000	3	3	60
Sadra	73	7	500	0	0	11
Talashgaran	67	8	700	0	0	15
Shahid Bakhshi	202	13	1800	0	0	40
Shahid Jamali	208	29	700	0	0	14
Shahid Dastgheib	150	26	1200	2	2	71
Pasdar Hekmat	235	34	2105	0	1	91
Velayat Faghih	305	41	1000	0	0	54
Parvin etesami	243	34	1250	1	1	65
Azadegan	216	30	460	0	0	91
Shahid Nattaj	152	26	1200	0	0	0
Shahid Ghazi	190	22	1500	0	0	0

RESULTS

After solving the Enveloped model of BCC, the optimized answer of each unit was estimated as follows:

Table 2. the optimized estimated answer of each unit

DMU	Score	Excess student S-(1)	Excess Teacher S-(2)	Excess Area S-(3)	Shortage Award S+(1)	Shortage 1-9 ranking S+(2)	Shortage Konkoor S+(3)
Imam Khomeini	0.840259	123.6923	0	1370.769	0	0	0
Taleghani	0.64813	94.76923	0	903.0769	0	0	0
Khatam-ol-Anbia	1	0	0	0	0	0	0
Ghorbani	0.511777	0	0	202.9826	0	0.657814	0
Shahed	0.97561	88.55	0	1154	0.875	0	0
Dr. Hesabi	1	0	0	0	0	0	0
Fatemeh Zahra	0.933866	224.7671	0	0	0	0.369737	0
Nehzat	0.798765	46.85372	0	0	0	3.81E-02	0
Sommayeh	1	0	0	0	0	0	0
Soudeh	1	0	0	0	0	0	0
Shahed	1	0	0	0	0	0	0
Sadra	1	0	0	0	0	0	0
Talashgaran	0.899868	0	0	0	0.116968	0.23509	0
Shahid bakhshi	0.668896	106.4	0	0	0	0.8	0
Shahid Jamali	0.157227	0	3.60E-02	168.6331	0	5.76E-02	0
Shahid Dashtgheib	1	0	0	0	0	0	0
Pasdar Hekmat	1	0	0	0	0	0	0
Velayat Faghih	0.593407	89	11	540	0	0	0
Parvin Etesami	0.824176	67.04	6.426667	341.0667	0	0	0
Azadegan	1	0	0	0	0	0	0
Motaghin	0.306253	0	1.07955	0	0.452345	0.755722	0
Heiyat Omanaei	0.468896	0	0	0	0	0	0
17 Shahrivar	1	0	0	0	0	0	0
Ayatollah Khamenei	0.388106	87.84274	47.125	335.6855	0	0	0
Bentolhoda	0.333333	162	48	288	0	0	35
Fazilat	0.333333	90.5618	26.64045	0	0	0	26.10112
Etrat	0.275	4.5	15	0	1.5	1.5	0
Foroogh Danesh	1	0	0	0	0	0	0
Sama	0.165165	0	7.71223	210.9353	0	0.539568	0
Narjes	0.671062	70.7421	42.56096	0	0	0	0
Hoveyzeh	1	121	34	320	0	0	0
Taghva	1	0	0	0	0	0	0
Kimia	1	0	0	0	0	0	0
Shahid helli	1	0	0	0	0	0	0
Sherafati	0.747719	0	0	0	0.352014	0.369249	0
Tohid	1	0	0	0	0	0	0

Evaluation of Schools

Among the 43 high schools investigated in western Mazandaran, three inputs were considered: number of students, teachers and the area of educational space. Outputs included the number of students' ranks in different exams, number of gained awards and number of accepted students in Azad and Satate university entrance exams.

Data is available as the following table.

Among the 43 investigated schools 8 ones have a descending efficiency, 3 schools have constant efficiency and the remaining ones benefit from increasing efficiency.

According to previous studies, the nature of applied model depends on the influence of control a manager has on inputs and outputs. Among standard DEA models the BCC approach (with input-centered nature) was employed to evaluate the efficiency of investment units since experts of capital market believe that management can achieve better results by exert stronger control on inputs than outputs. In this pattern, the total value of the variable W determines the ratio of efficiency to DMU scale. In fact, by selecting this method we were meant to specify efficient units and investigate scale and technical efficiency of DMU.

DISCUSSION AND CONCLUSION

Results show that among the 43 investigated high schools in western Mazandaran 16 schools are more efficient than others and the remaining 27 schools are at a level lower than the efficiency threshold. The extent of inefficiency and weakness of all these schools were also determined according to reference units. Respecting data presented in above tables inefficient schools in current status can be identified easily. The lowest efficiency belongs to Shahid Jamali high school the reason of which (based on above reference units) is characterized by the big number of teachers, area of educational space and the small number of 1-9 rankings. Managers of organizations and administrations need to measure and evaluate performance of their subsets to control their organization and compare different units to be aware of weaknesses and strengths and propose necessary suggestions for more improvement. Data Envelopment Analysis is a method used to compare and evaluate relative efficiency of decision-maker units each of which has various inputs and outputs. Therefore, it is concluded that Khatam-ol-Anbia, Soudeh, Somayyeh, Taghva, Kimia, Shahid Helli, Dr. Hesabi, Hoveyze, Pasdar Hekmat, Shahid Dastegheib high schools are considered as efficient units. In brief, the present paper tried to answer this question: which schools in Mazandaran are efficient and which are inefficient? Considering the wide application of DEA in performance evaluation of many service and industrial units, it was used to answer the research question. After determining measurement scales and valuing them for every certain school, DEA method was applied to compare schools' performances and finally, efficient and inefficient schools were identified.

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