Evaluating the Performance of State University, National Important Institute and Private Deemed Universities in Chennai (India) by using Data Envelopment Analysis

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Abstract— **Education Institution evaluation is one of the most critical activities in teaching and learning process. Selecting the wrong institution could be enough to deteriorate the whole process and operational positions. This paper proposes and demonstrates the application of Data Envelopment Analysis (DEA) in evaluating the performance measures of Indian institute of technology, Chennai and Anna University, Chennai. It was also formulated taking eight Private Deemed universities relative performance efficiency in relation to input and output variable. The result of the paper can be used to identify best educational institute for the purpose of maximizing the contribution to Society.**

Index Terms—**Data Envelopment Analysis (DEA), Decision Making Unit (DMU), SIPOC, DEA Frontier and CRS model.**

I. Introduction

Both Anna University-Chennai and Indian institute of technology-Madras (Chennai) are the leading and top technical institutions in India. The Indian Institute of Technology Madras (IIT Madras) is an autonomous public engineering institution located in Chennai, Tamil Nadu. It is recognized as an Institute of national importance by the government of India founded in 1959 with technical and financial assistance from the government of the former West Germany. Anna University in Chennai was established on 4th September 1978 as a unitary type of University. It provides higher education in Engineering, Technology and allied Sciences relevant to the current and projected between the academic and industrial communities. The university was formed by bringing together and integrated two well known technical institutions in the city of Madras. College of Engineering, Guindy (CEG) (1974), Madras Institute of Technology, Chrompet (MIT) (1949) and three Technological Departments of the University of Madras. Alagappa College of Technology (ACT) (1944), School of Architecture and planning (SAP) (1957). Both institutions are funded, Monitored and controlled by central and state government.

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II. Literature review

Data Envelopment Analysis (DEA) is a non-parametric method in operation research and economics for estimation of production frontiers. It is used to empirically measure productive efficiency of decision making units (DMU). Non-parametric approaches have the benefit of not assuming a particular functional form/shape for the frontier; however they do not provide a general relationship (equation) relating output and input. This paper reports DEA frontier to measure the performance and efficiency of state national important Institute and Private Deemed Universities in Chennai (India).

Yu et al. (2006) measured the relative performance efficiency in peoples' hospital of Perking University, China. Data Envelopment Analysis (DEA is a linear programming based techniques for measuring the relative performance efficiency of organizational units where the presence of multiple inputs and outputs) was used. They found and compared the relative performance efficiency of several departments based departments based on source data from the hospital. From the paper, it is clearly inferred that DEA can be used to aid in resources allocation decision such as beds relocation, staff appointment and medication process improvement.

Lin et al (2003) measured the overall efficiency, technical efficiency and Scale efficiency in Taiwan Power Company services center in China by using DEA. The authors considered number of Staff, General equipment as input parameters and number of Customer, Distribution network transformer capacity as output parameters.

Ahmad Vessal (2007) measured the relative efficiencies of several universities in two different time periods. Using this Technique it is possible to identify which schools are relatively inefficient compared to the composite school. Efficiency ratings change could be attributed to changes in their inputs and outputs.

*M. Abbott, C. Doucouliagos (2003***)** measured the rising of young students who have been participating in higher education. Governments around the world have been faced with increasing pressure on their finances, giving rise to the need to operate universities with a higher degree of efficiency in his paper, non parametric techniques are used to estimate technical and scale efficiency of individual

Australian Universities. Various measures of output and input s are used. His results shows that regardless of the output-input mix, Australian Universities as a whole recorded high levels of efficiency relative to each other.

Gerhard Reichmann (2004) analyzed the technical efficiency of 118 randomly selected university libraries from German-speaking countries (Austria, Germany, Switzerland) and English-speaking countries (USA, Australia and Canada) using DEA. DEA efficiency scores are calculated using library Staff, measured in fulltime equivalents, and book materials held as inputs, and the number of serial subscriptions, Total circulations, regular opening hours per week, and book materials added as outputs. Among the 118 university libraries analyzed 10 are rated fully efficient. However, comparing group specific efficiency scores, there are no significant differences between libraries from English speaking and German speaking countries or between small and large university libraries.

III. PROBLEM DESCRIPTION

A. Problem Background

SIPOC diagram is a tool used by a team to identify all relevant of a process improvement project before work begins. SIPOC (Suppliers, Inputs, Process, Output and Customers) analysis used to understand the key elements of the process and defined the boundary of the process. The following table shows the SIPOC diagram for all Educational institutions.

TABLE I

SIPOC DIAGRAM FOR TEACHING AND LEARNING PROCESS FOR ALL EDUCATIONAL INSTITUTIONS IN CHENNAI

Suppliers	Inputs	Process	Output	Customer
State and central Government fund, Private organization, Project agencies fund, Alumni fund.	Merit and reservation Based students. Infrastructure and faculties	Teaching and learning. Process, research, project consultancy work.	Placements, patents right, society contribution.	Multinational companies and civil service organizations.

B. Problem Definition

Currently institutions all have approximately 5000-7000 Students studying per year so that the institutions evaluation is essential need.

C. Problem Objective

The objective of the paper is to confirm the feasibility and value of using DEA to measure institutions performance measurements.

D. Assumptions

Institution performance measure using DEA depends on the selection of feasible and appropriate key input and output variables which is occasionally limited by data collection problems. Government institutions data have collected from website source and through RIGHT TO INFORMATION ACT (Indian Act 2005) and Private Institutions data have collected from website source and university brochure.

IV. METHODOLOGY SELECTION

In teaching learning process is looking for institution evaluation so that DEA methodology as chosen. DEA methodology for evaluation process is shown in figure 1.

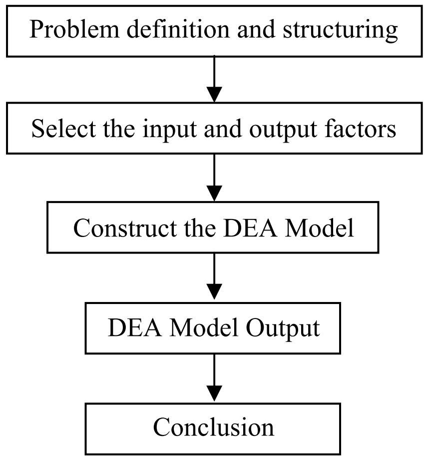

Fig 1: DEA methodology for educational institution evaluation process.

V. MATHEMATICAL ANALYSIS

A. Efficiency Measure

Efficiency for the purpose of DEA is defined as the ratio of weighted output to weighted input. Therefore, if $X_{1j}, X_{2j}, X_{3j} \ldots X_{mi}$ are the m inputs and $Y_{1j}, Y_{2j}, Y_{3j} \ldots Y_{ni}$ are the n inputs of the unit j then its efficiency ɵ, is defined as

$$\theta = \frac{v_1Y_{1j} + v_2Y_{2j} + v_3Y_{3j} + \ldots\ldots\ldots\ldots + VnY_{ni}}{u_1X_{1j} + u_2X_{2j} + u_3X_{3j} + \ldots\ldots + \mathrm{U}_m X_{mi}}$$

Where, $V_1, V_2, V_3 \ldots V_n$ are weights for the outputs and $U_1, U_2, U_3 \ldots U_m$ are weights for the inputs.

B. DEA Model

The model that we have used for the analysis is the constant returns to scale CRS model. The solution of DEA requires that the weights for inputs and outputs of each unit be selected to maximize its efficiency under certain constraints. In other words, we allow each unit to pick most favorable weights for its specific situation. Thus, in mathematical CRS mode1

$$Maximize.\theta = \frac{v_1Y_{10} + v_2Y_{20} + v_3Y_{30} + \ldots\ldots + V_nY_{n0}}{u_1X_{10} + u_2X_{20} + u_3X_{30} + \ldots + \mathrm{U}_m X_{m0}}$$

$$\frac{v_1Y_{1j} + v_2Y_{2j} + v_3Y_{3j} + \ldots\ldots\ldots\ldots + VnY_{ni}}{u_1X_{1j} + u_2X_{2j} + u_3X_{3j} + \ldots\ldots + \mathrm{U}_m X_{mi}} \leq 1$$

j = 1……n

$V_1, V_2, V_3 \ldots V_n \geq 0$

$U_1, U_2, U_3 \ldots U_m \geq 0$

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Where θ is the designated unit for an optimization run and n is the total number of the units in the study. That is, in each optimization run the efficiency of a specific unit is maximized and it is then repeated for all the units.

Instead of solving the problem as stated above an equivalent model is usually solved since it requires lesser computation and easier to implement. The equivalent representation is obtained by first converting the optimization problem into a linear programming (LP) problem and then using the duality principle, which gives the following model:

Minimize θ

Subject to

$$\sum_{j=1}^{n} \lambda_j X_{ij} + S_i^- = \theta X_0$$

i = 1……m; j = 1…….n

$$\sum_{j=1}^{n} \lambda_j Y_{ij} - S_r^+ = Y_0$$

X_{ij} be the amount of input i used by DMU j

Y_{rj} be the amount of output r used by DMU j

S_i^- be non zero input slack

S_r^- be non zero output slack

n be number of DMUs

m be number of inputs

DMU is efficient when the following two conditions are satisfied.

1. $\theta_0 = 1$
2. S_i^- , $S_r^+ = 0$

If suppose one DMU is inefficient, the modification of inputs and outputs can be calculated as follows to change and calculate target efficiency.

$X_{i0}^* = \theta_0 X_{i0} - S_i^-$ i = 1 … m;

$Y_{r0}^* = Y_{i0} + S_r^+$ r = 1 … m

X_{i0}^*, Y_{i0}^* are target inputs and outputs of an inefficient DMU_0.

TABLE II
PROPOSED MODEL FOR ALL EDUCATIONAL INSTITUTIONS PERFORMANCE

Inputs		Outputs
Faculty and Students ratio No. of departments No. of research centre Amount spent per year for infrastructure (fund from state, central Government and Private organization)	Educational Institutions	No. of students placed No. of patents received Top magazine rating (acceptance ratio)

VI. INPUT AND OUTPUT FACTORS

Vessal Ahmad (2007) proposed 9 institution evaluation parameters like acceptance rate, student/faculty ratio, faculty resource rank, financial resources rank, student rank, academic reputation, alumni giving rate, actual graduating rate, average freshman retention rate. C. Doucouliagos and M. Abbott (2003) have analyzed the Australian universities efficiency through DEA with input parameters like acceptance rate, student/faculty ratio, faculty resource rank, financial resource rank. student selectivity rank, and output parameters like academic reputation, alumni giving rate, alumni graduation rate, average freshman retention rate. Based on the above two papers and Indian educational systems which are considered only for measureable input parameters faculty and student ratio, no of departments, o of research centre and amount spent per year for infrastructure. Output proposed in this model includes placements, patents, magazine rating as shown in Table II**:** Presents simplified DEA model with DMU's input and output factors are presented in Table III.

TABLE III
DMU'S INPUT AND OUTPUT FACTORS

DMUs	Faculty and student ratio	No. of departments	No. of research centre	Amount spent per year for infrastructure (Cr)	No. of students placed	No. of patents received	Magazine rating (acceptance ratio)
DMU1	0.0263	16	22	200	1457	78	0.97
DMU2	0.0468	53	46	95	2467	68	0.95
DMU3	0.0327	25	11	25	1725	2	0.16
DMU4	0.0274	51	10	31	3215	4	0.7
DMU5	0.0623	17	3	19	639	2	0.1
DMU6	0.0151	15	6	15	422	1	0.06
DMU7	0.0354	20	5	28	1027	2	0.13
DMU8	0.0226	18	8	20	1956	1	0.09
DMU9	0.0145	10	4	17	725	1	0.03
DMU10	0.0316	24	9	29	1986	3	0.37

VII. RESULTS AND DISCUSSIONS

TABLE IV
CRS EFFICIENCY TABLE

DMU No.	DMU Name	Input-Oriented CRS Efficiency	Sum of Lambdas	RTS
1	DMU1	1.00000	1.000	Constant
2	DMU 2	1.00000	1.000	Constant
3	DMU 3	0.74843	0.812	Increasing
4	DMU 4	1.00000	1.000	Constant
5	DMU 5	0.75461	0.207	Increasing
6	DMU 6	0.34882	0.187	Increasing
7	DMU 7	0.72845	0.375	Increasing
8	DMU 8	1.00000	1.000	Constant
9	DMU 9	0.74268	0.350	Increasing
10	DMU 10	1.00000	1.000	Constant

With the help of Linear Programming software DEA FRONTIER the result of each DMU can be easily calculated. As shown in Table IV, DEA identified DMU1, DMU2, DMU 4, DMU 5, DMU 8, DMU 10 technical and scale efficient and all others are inefficient (Non zero input slack and Non zero output slack are zero). DMU's 3,5,6,7 and 9 $\Sigma\ \lambda_{j/}\ \theta$ = (j = 1 …….n) larger than 1 so the DMUs is scale inefficient.

TABLE V
DMU'S TARGET INPUTS

DMU NO.	DMU Name	Efficiency Input Target Faculty and Students ratio	No. of Departments	No. of Research centers	Amount spent per year for Infrastructure (Cr)
1	DMU1	0.02630	16.00000	22.00000	200.00000
2	DMU2	0.04680	53.00000	46.00000	95.00000
3	DMU3	0.01960	18.71075	7.19600	18.71075
4	DMU4	0.02740	51.00000	10.00000	31.00000
5	DMU5	0.00567	10.02405	2.26383	9.10243
6	DMU6	0.00501	5.23237	1.96701	5.23237
7	DMU7	0.00966	14.56899	3.64225	12.24869
8	DMU8	0.02260	18.00000	8.00000	20.00000
9	DMU9	0.00811	7.42685	2.97074	8.66233
10	DMU10	0.03160	24.00000	9.00000	29.00000

The Table V shows that the DMU3, DMU5, DMU 7 and DMU 9s target inputs are very less compare to current input data it shows the institution will reduce this much of input parameters. For example DMU3s number of department is 18 but target number of department is 25.

TABLE VI
DMU'S TARGET OUTPUTS

DMU NO.	DMU Name	Efficient Output Target number of Students placed	Number of Patents received	Top Magazine rating
1	DMU1	1457.00000	78.00000	0.97000
2	DMU2	2467.00000	68.00000	0.95000
3	DMU3	1725.00000	2.00000	0.16000
4	DMU4	3215.00000	4.00000	0.70000
5	DMU5	639.00000	2.00000	0.14945
6	DMU6	422.00000	1.00000	0.06000
7	DMU7	1027.00000	2.00000	0.18911
8	DMU8	1956.00000	1.00000	0.09000
9	DMU9	725.00000	1.00000	0.05876
10	DMU10	1986.00000	3.00000	0.37000

The Table VI shows that the DMU5, DMU7 and DMU 9s target outputs are less compare to current output data it shows the institution have opportunities to improve the output parameters.. For example DMU7 magazine rating is 0.13 but target magazine rating is 0.18.

VIII. CONCLUSIONS

Achieving high level institution evaluation and performance for teaching and learning process should be one of the top priorities of any institution. This paper presented the methodology of applying data envelopment analysis to compare over all institution performance and demonstrated this application through a case study for society. This DEA application is a systematic analysis to aid decision making for considerations such as availing the maximum number of resources at minimum cost, time and to provide improvement targets such as inventions and consultation services to society.

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