Annals of Pure and Applied Mathematics
Vol. 15, No. 2, 2017, 341-350
ISSN: 2279-087X (P), 2279-0888(online)
Published on 11 December 2017
www.researchmathsci.org
DOI: http://dx.doi.org/10.22457/apam.v15n2a20

Annals of Pure and Applied Mathematics

Benchmarking and Data Envelopment Analysis: An Approach to Rank the Best Performing Engineering Colleges Functioning in Tamil Nadu

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Received 20 November 2017; accepted 10 December 2017

Abstract. The aim of the research work is to investigate and examine performance efficiency of Engineering Institutions functioning in Tamil Nadu individually and to identify the best performing Engineering Institutions.

For this study, researchers collected data on the Engineering Institutions for the financial years 2013-2016 from the official websites of individual Institution, then considering two input and four output variables. The Data Envelopment Analysis technique (CRS & VRS) and Benchmarking Analysis have been employed.
Our Study reveals that as per the analysis of
CRS: IIT Madras, NIT Trichy, PSG, Sri Siva Subramaniya and Thanthai Periyar
VRS:IIT Madras, NIT Trichy, SRM, PSG, R.M.K, Sri Siva Subramaniya and Thanthai Periyar
Thanthai Periyar
Altogether Thanthai Periyar functioning effectively and efficiently and the remaining Engineering Institutions are not functioning up to that expected level.

Keywords: Data envelopment analysis, decision making units, performance, efficiency, benchmarking analysis.

AMS Mathematics Subject Classification (2010): 90B05

1.Introduction

It is one of the main activities of any firm to monitor its efficiency. In the current scenario, there are a number of methods based either on the traditional approach to evaluate the efficiency of a system. Efficiency measurement methods can be divided into three main categories: Ratio Indicators, Parametric and Non-Parametric methods. In selecting indicators to measure efficiency one can focus primarily on a firm's inputs and outputs.

In general, the term productive unit refers to a unit producing certain outputs by using certain inputs. The evaluation of efficiency in production units and determining the sources of their inefficiency is a precondition to effectively improve the performance of any such unit in a competitive environment.

Educational Institutions can be considered as production units too. In general, they are homogeneous units performing similar activities. All inputs and outputs have an impact on the efficient operation of such units, even though some are relatively considered to be more important or less important to each other. Based on the economical term, efficiency refers to the ratio of outputs to inputs. Input refers to the scarce resource and output in terms of goods and services offered to the consumers.

The large number of EngineeringInstitutionsis located in Tamilnadu, the quick Technological Change and the increased competition has added more pressure to improve performance. Instead of studying partial services of Educational Institutions, with the available Financial Management Tool like Ratio Analysis. In this context, the author has introduced the concept of the DEA model in this research paper. This system has the benefit of developing a data-driven technological frontier that necessitates no specification of any scrupulous functional shape or error structure. This study fills the gap in the literature by leaving from the traditional method of evaluating the efficiency of the Educational Institutions.

DEA was first introduced by Charnes et al., (1978) as a Mathematical Programming Model with the help of the theoretical framework given by Farrell, (1957), for computing the relative efficiencies of multiple Decision Making Units (DMUs), and it falls under the special category of Fractional Programming. DEA is a special technique which offers a comparative ratio for each unit in terms of output and input. The ratio is stated as efficiency scores for each unit. The measure of performance lies in the range 0 to 1. If the performance measure is 1 then the organization is considered to be highly efficient and if the measure is tending towards 0, the efficiency is otherwise. One of the significant roles of DEA is that the efficiency scores indicate the gap for potential improvements and developments for inefficient DMUs.

In the Educational Institutions, the DEA model is preferable to an econometric approach of efficiency measurement because it has a number of advantages. There are:

- ✓ It can simultaneously analyze several inputs and outputs, which is an alternative characteristic, because production in the Educational Institutions often involves multiple inputs and outputs.
- ✓ It does not require any assumptions about the functional form of technology, and
- ✓ It calculates a maximal performance measure for each production unit relative to all other production units in the observed population with the sole condition that each production unit lies on or below the external.

2. Review of literature

All the relevant review of literature collected by the researcher based on the proposed title is listed below year wise.

(Ahmad Vessal, 2007) has studied the performance of Universities in California. In order to make a decision, They considered five input measures the namely Acceptance rate of students in university, Student/Faculty ratio, Faculty resources rank, Financial resources rank and Students selectivity rank and four output measures namely Academic reputation, Alumni giving rate, Actual graduating rate and average freshman retention rate.

(Chuen Tse Kuah, Kuan Yew Wong, 2011) has discussed the Efficiency assessment of universities.The researcher analyzed DEA model for jointly evaluating the relative teaching and research efficiencies of universities. The model was tested using a hypothetical example and implications in university performance measurement were described.

(Wei-Hsin Kong and Tsu-Tan Fu,2011)evaluated the performance of business colleges in Taiwan using data envelopment analysis.The researcher constructed a student-based performance evaluation model for business schools in Taiwan.The research study brings that the assurance region data envelopment analysis is better than DEA in measuring the performance of the business colleges in Taiwan.

(Pranesh R.V and John Rajan A. 2013) evaluated 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.

(Samar Al-Bagoury, 2013) has adopted the two stage efficiency analysis and used it to compare the efficiency of African higher education systems in fifteen countries using DEA. And then researcher used the tobit regression to determine the most environmental factors that affecting the efficiency of this institute.

(Michał Pietrzak, Piotr Pietrzak and Joanna Baran, 2016) has studied the Efficiency assessment of public higher education using DEA. Also defines benchmarks for inefficient Higher education institutions and quantify the gaps to be fulfilled by them in order to become efficient.

This paper differs entirely from all other previous works by investigating and examining the current performance of the Engineering Institutions of Tamil Nadu individually, in terms of their efficiency for the period [2013 – 2016] using the Data Envelopment Analysis and especially Benchmarking analysis is used to identify the best Benchmarking College to make the inefficient college into an efficient college. Based on the study, it also classifies the Engineering Institutions into two categories as efficient and inefficient. The remedial measures are discussed in order to improve the efficiency of the Educational Institutions.

3. Research methodology

3.1. Data collection

For this study, the required data of selected Thirty Engineering Institutions based on the availability of reputed data have been taken from the Official Website for the years 2013–2016.

3.2. Selection of input and output variables

Reviewing the literature on the application of DEA, different studies have used different combination of inputs and outputs. For the current study, the researcher considered two input variables and four outputs variables in order to have an elaborate study. The variables under the study are listed below:

Sl. No.	Input Variables	Output Variables
1	Total no. of students	Number of students graduating
2	Total no. of faculties	No. of Students Placed
3		No. of students selected for Higher studies
4		Financial Resource

3.3. Problem definition

3.3.1. Fractional DEA program

Let there be N DMUs whose efficiencies have to be compared. Let us take one of the DMUs. Say the m^{th} DMU. And maximize its efficiency, according to the formula given above. Here the m^{th} DMU is the reference DMU.

The mathematical problem is,

$$Max\ E_m = \frac{\sum_{j=1}^{J} v_{jm} y_{jm}}{\sum_{i=1}^{I} u_{im} x_{im}}$$

Subject to the Constraints

$$0 \leq \frac{\sum_{j=1}^{J} v_{jm} y_{jn}}{\sum_{i=1}^{I} u_{im} x_{in}} \leq 1;\ n = 1,2,K,J$$

$$v_{jm}, u_{im} \geq 0;\ \ i = 1,2,K,I;\ \ j = 1,2,K$$

where,

E_m is the efficiency of the m^{th}DMU,

Y_{ij} is the j^{th} output of the m^{th} DMU,

V_{jm} is the weight of that output,

X_{im} is i^{th} the input of the m^{th} DMU,

U_{jm} is the weight of that input, and

Y_{jn} and X_{in} are output j^{th} and i^{th} input, respectively, of the n^{th} DMU, n = 1,2,…,N.

Note that here n includes m.

3.3.2. Constant returns to scale model

Unit works under constant returns to scale provided an increase in inputs results in a proportionate growth in the output levels. If the input values for a unit are all doubled, then the unit must make twice as much output. In a single input and output case, the efficiency frontier reduces to a straight line.

General form of CCR model:

The general form Output Maximization DEA [CCR] model can be exemplified in the form of Fractional Programming Model as follows:

Here the general model is constructed to maximize the efficiency of the q^{th} output variable:

$$Max\ \ E_q = \frac{\sum_{j=1}^{m} v_{jq} y_{jq}}{\sum_{i=1}^{s} u_{iq} x_{iq}}$$

Subject to the constraints

$$\frac{\sum_{j=1}^{m} v_{jq} y_{jq}}{\sum_{i=1}^{s} u_{iq} x_{iq}} \leq 1; q = 1,2, \dots, n$$

$$v_{jq}, y_{jq}, u_{iq}, x_{iq} \geq 0\ for\ all\ i = 1,2,..s; j = 1,2,..m, q = 1,2, \dots n$$

Solving this Fractional Programming Problem directly is so tedious; so the Fractional Programming model is changed into regular Linear Programming model as described below:

$$Max\ \ E_q = \sum_{j=1}^{m} v_{jq} y_{jq}$$

Subject to the constraints

$$\sum_{i=1}^{s} u_{iq} x_{iq} = 1$$

$$\sum_{j=1}^{m} v_{jq} y_{jq} - \sum_{i=1}^{s} u_{iq} x_{iq} \leq 0\,; \quad q = 1,2, \dots n$$

$$v_{jq}, y_{jq}, u_{iq}, x_{iq} \geq 0\ for\ all\ i = 1,2,..s; j = 1,2,..m, q = 1,2, \dots n$$

The general form of Input Minimization DEA [CCR] Linear Programming model can be represented as follows:

$$Min\ E_q = \sum_{i=1}^{s} u_{iq} x_{iq}$$

Subject to the constraints

$$\sum_{j=1}^{m} v_{jq} y_{jq} = 1; \quad \sum_{j=1}^{m} v_{jq} y_{jq} \ - \sum_{i=1}^{s} u_{iq} x_{iq} \leq 0; \qquad q = 1,2, \dots, n$$

$$v_{jq}, y_{jq}, u_{iq}, x_{iq} \geq 0\ for\ all\ i = 1,2,..s; j = 1,2,..m, q = 1,2, \dots n$$

3.3.3. Variable returns to scale model

If it is suspected that an increase in inputs does not result in a proportional change in the outputs, a model which allows Variable Returns to Scale (VRS) such as the BCC model should be viewed.

General form of BCC model:

The DEA envelopment program for considering variables return to scale is as follows:

$Min\ \theta_m$

Subject to the Constraints

$Y\lambda \ \geq \ Y_m; \quad X\lambda \ \leq \ \theta X_m$

$$\sum_{n=1}^{N} \lambda_n = \ 1;$$

$\lambda \geq \ 0; \quad \theta_m\ free\ variable$

4. Empirical results

4.1. Constant return to scale [CCR model]

Table 4.1 indicates that as per the CCR Model among the 30 Engineering institutions taken for the study five Engineering institutions attained the maximum efficiency score as 1.

Table 4.1: Constant return to scale–efficiency table

Name of the College	2013-14	2014-15	2015-16	Mean
IIT MADRAS	1	1	1	**1**
NIT Trichy	1	1	1	**1**
SRM	0.765	1	1	**0.921667**
PSG	1	1	1	**1**
COIMBATORE INSTITUTE	0.819	0.949	0.941	**0.903**
ALAGAPPA CHETTIAR	0.867	0.879	0.81	**0.852**
MEPCO SCHIENK	0.88	0.874	1	**0.918**
SONA	1	0.865	1	**0.955**
SRI KRISHNA	0.514	0.737	1	**0.750333**
KONGU	0.803	0.882	0.898	**0.861**
KUMARAGURU	0.81	0.91	0.987	**0.902333**
K.S.RANGASAMY	0.905	0.843	0.886	**0.878**
SRI RAMAKRISHNA	0.705	0.742	0.924	**0.790333**
VALLIAMMAL	0.501	0.67	0.73	**0.633667**
KONGUNADU	0.498	0.611	0.795	**0.634667**
R.M.K	0.953	1	1	**0.984333**
KAMARAJ	0.732	0.766	0.91	**0.802667**
VELALAR	0.67	0.697	0.835	**0.734**
KARPAGAM	1	0.963	1	**0.987667**
KCG	0.568	0.625	0.814	**0.669**
ST.PETERS	0.556	1	1	**0.852**
NATIONAL	0.911	0.999	0.917	**0.942333**
SRI SAI RAM	0.634	0.752	0.972	**0.786**
KNOWLEDGE INSTITUTE	0.593	0.64	0.835	**0.689333**
C.ABDUL HAKKEM	0.687	0.836	0.76	**0.761**
SRI SIVA SUBRAMANIYA	1	1	1	**1**
K S R	0.81	0.84	0.911	**0.853667**
PSNA	0.606	0.68	0.809	**0.698333**
ST.XAVIER'S CATHOLIC	1	0.998	0.953	**0.983667**
THANTHAI PERIYAR	1	1	1	**1**
Mean	**0.7929**	**0.8586**	**0.9229**	

4.2. Variable return to scale [BCC model]

Table 4.2 indicates that as per the BCC Model among the 30 Engineering institutions taken for the study seven Engineering institutions attained the maximum efficiency score as 1.

Table 4.2. Variable return to scale–efficiency table

Name of the College	2013-14	2014-15	2015-16	Mean
IIT MADRAS	1	1	1	**1**
NIT Trichy	1	1	1	**1**
SRM	1	1	1	**1**
PSG	1	1	1	**1**
COIMBATORE INSTITUTE	0.877	1	0.971	**0.949333**
ALAGAPPA CHETTIAR	0.87	0.884	0.817	**0.857**
MEPCO SCHIENK	0.881	0.94	1	**0.940333**
SONA	1	0.874	1	**0.958**
SRI KRISHNA	0.575	0.75	1	**0.775**
KONGU	0.805	1	1	**0.935**
KUMARAGURU	0.81	0.911	0.989	**0.903333**
K.S.RANGASAMY	0.946	0.846	0.887	**0.893**
SRI RAMAKRISHNA	0.714	0.745	0.932	**0.797**
VALLIAMMAL	0.536	0.671	0.737	**0.648**
KONGUNADU	0.786	0.841	0.935	**0.854**
R.M.K	1	1	1	**1**
KAMARAJ	0.927	0.941	0.947	**0.938333**
VELALAR	0.712	0.758	0.845	**0.771667**
KARPAGAM	1	0.974	1	**0.991333**
KCG	0.577	0.684	0.817	**0.692667**
ST.PETERS	0.775	1	1	**0.925**
NATIONAL	0.917	1	0.923	**0.946667**
SRI SAI RAM	0.881	0.931	1	**0.937333**
KNOWLEDGE INSTITUTE	0.833	0.834	0.963	**0.876667**
C.ABDUL HAKKEM	0.873	0.842	0.792	**0.835667**
SRI SIVA SUBRAMANIYA	1	1	1	**1**
K S R	0.848	0.86	0.912	**0.873333**
PSNA	0.617	0.694	0.827	**0.712667**
ST.XAVIER'S CATHOLIC	1	1	0.993	**0.997667**
THANTHAI PERIYAR	1	1	1	**1**
Mean	**0.858667**	**0.899333**	**0.9429**	

4.3. Overall mean efficiency

Among all the thirty Engineering Institutions considered for this study, there are only five Engineering Institutions namely, IIT MADRAS, NIT Trichy, PSG, Sri Siva Subramaniya and Thanthai Periyar are highly consistent with the efficiency score of 1 and stands first as shown in the Table 4.3.

Table 4.3. Overall mean efficiency

Name of the College	Mean - CRS	Mean-VRS	Mean
IIT MADRAS	1	1	1
NIT Trichy	1	1	1
SRM	0.922	1	0.961
PSG	1	1	1
COIMBATORE INSTITUTE	0.903	0.949	0.926
ALAGAPPA CHETTIAR	0.852	0.857	0.855
MEPCO SCHIENK	0.918	0.940	0.929
SONA	0.955	0.958	0.957
SRI KRISHNA	0.750	0.775	0.763
KONGU	0.861	0.935	0.898
KUMARAGURU	0.902	0.903	0.903
K.S.RANGASAMY	0.878	0.893	0.886
SRI RAMAKRISHNA	0.790	0.797	0.794
VALLIAMMAL	0.634	0.648	0.641
KONGUNADU	0.635	0.854	0.744
R.M.K	0.984	1.000	0.992
KAMARAJ	0.803	0.938	0.871
VELALAR	0.734	0.772	0.753
KARPAGAM	0.988	0.991	0.990
KCG	0.669	0.693	0.681
ST.PETERS	0.852	0.925	0.889
NATIONAL	0.942	0.947	0.945
SRI SAI RAM	0.786	0.937	0.862
KNOWLEDGE INSTITUTE	0.689	0.877	0.783
C.ABDUL HAKKEM	0.761	0.836	0.798
SRI SIVA SUBRAMANIYA	1	1	1
K S R	0.854	0.873	0.864
PSNA	0.698	0.713	0.706
ST.XAVIER'S CATHOLIC	0.984	0.998	0.991
THANTHAI PERIYAR	1	1	1

4.4. Benchmarking analysis

This analysis is used to identify the Best Benchmarking Engineering Institutions among all the efficient Engineering Institutions. This helps to select the best among the best. According to this report Thanthai Periyar College being the best.

Table 4.4. Bench marking values

Name of the College	2013-14	2014-15	2015-16	Mean
IIT MADRAS	4	1	1	2.00
NIT Trichy	12	13	3	9.33
SRM	0	0	0	0.00
PSG	2	2	5	3.00
COIMBATORE INSTITUTE	0	4	0	1.33

ALAGAPPA CHETTIAR	0	0	0	0.00
MEPCO SCHIENK	0	0	1	0.33
SONA	8	0	8	5.33
SRI KRISHNA	0	0	1	0.33
KONGU	0	0	0	0.00
KUMARAGURU	0	0	0	0.00
K.S.RANGASAMY	0	0	0	0.00
SRI RAMAKRISHNA	0	0	0	0.00
VALLIAMMAL	0	0	0	0.00
KONGUNADU	0	0	0	0.00
R.M.K	1	9	3	4.33
KAMARAJ	0	0	0	0.00
VELALAR	0	0	0	0.00
KARPAGAM	10	0	8	6.00
KCG	0	0	0	0.00
ST.PETERS	0	0	1	0.33
NATIONAL	0	4	0	1.33
SRI SAI RAM	0	0	4	1.33
KNOWLEDGE INSTITUTE	0	0	0	0.00
C.ABDUL HAKKEM	0	0	0	0.00
SRI SIVA SUBRAMANIYA	3	10	8	7.00
K S R	0	0	0	0.00
PSNA	0	0	0	0.00
ST.XAVIER'S CATHOLIC	8	1	0	3.00
THANTHAI PERIYAR	**18**	**17**	**14**	**16.33**

5. Conclusion

The Efficiency Analysis based on Constant Returns to Scale reveals that five Engineering Institutions (IIT MADRAS, NIT Trichy, PSG, SRI SIVA SUBRAMANIYA, and THANTHAI PERIYAR) stand first and the analysis based on Variable Return to Scale Communicates that seven Engineering Institutions (IIT MADRAS, NIT Trichy, SRM, PSG, R.M.K, SRI SIVA SUBRAMANIYA and THANTHAI PERIYAR) takes the first place. Comparing both the analysis one can conclude that IIT MADRAS, NIT Trichy, PSG, SRI SIVA SUBRAMANIYA &THANTHAI PERIYAR is doing exceedingly well.

Among the five top performing Institutions, Thanthai Periyar is the best one according to bench mark analysis. The other remaining 25 Institutions should identify their weaker areas and should try to improve their performance in near future.

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