An Application of Data Envelopment Analysis for Measuring the Efficiency of Minority Institutions

Dr.R.P.Sreedevi

Abstract—This paper describes the technical efficiency and efficiency differences among 19 Minority Technical institutions under JNTUH of Andhra Pradesh in India by a linear programe based technique, Data Envelopment analysis. In this context, it is absolutely essential to assess the quality education offered by the technical institutions with specific reference to the reliability of how and when the learning takes place. Technical Education System (TES) is a growing field that is bringing a paradigm shift in new future directives. To strengthen TES there is a need to effectively assess various institutes. The identification of strongest and weakest functions is important quality education and hence to achieve high standards. DEA efficiency evaluation method identifies the functions that improve the quality of education and bring improvements in the system. The function is identification is based on knowledge based evaluation and it provides valuable inputs for further DEA exercise. In this application the final decision is based on the evaluation of a number of alternatives in terms of various outputs and inputs. The suggested approach can assist decision makers in selecting proper institutes to further strengthen the TES is an efficient and effective manner

Index Terms— CCR Model, DMUS, DEA,Technical Education, Literature, Ranks, Relative Efficiency, Technical Efficiency, Peer count

1 INTRODUCTION

Education System plays a pivotal role for socio-economic development in any country since it deals with knowledge development and dissemination, technology transfer, education and collaborative works with industries. The demand and opportunities in education has resulted in an overwhelming increase in number of educational technical institutes especially in the developing countries like India. The technical institutes in India are currently facing a stiff competition because of opening of the off-shore campus of foreign universities. Highly competitive environment makes quality as a key variable for attracting primary customers (students).

The concept of quality while applied to education sector is not well defined. Definitions of quality in education follow the general definitions of quality. The term has been defined in many ways like "excellence in education", "value addition in education", "fitness of educational outcome and experience for use", "defect avoidance in the education process", and "meeting or exceeding customer's expectations of education". Variations in conceptualizations of quality as well as performance in education pose extreme difficulty while formulating a single and comprehensive quality definition. Moreover, educational services are supposed to be intangible, heterogeneous, and In separable from the administrator's point of view whereas it is variable and perishable for the customers' viewpoint. Further, in this highly competitive environment, students have become more discriminating in their selection and more demanding in regard to choosing appropriate colleges and universities that suits their expectations as well as perceptions. It is also important for the institutions to understand what the incoming students expect from the institution of their choice. Because, if student's perceptions meet the extent of expectation while studying in an institute; according to students viewpoint the institute would be highly appreciated and that message would be conveyed to the junior batch of students community. Therefore, the issue of survival of the institute and the retention of the students has become an area of critical concern for most colleges and universities. Therefore, the administrators of the educational institutions should focus more on improvement of overall quality of education through continuous improvement programmes Usually, technical institutions exhibit highly process oriented and a multi- stakeholder situation leading to a difficulty in aggregating the functional variables (inputs and outputs) for the evaluation of education quality. Therefore, it is desirable to use a tool that is capable of relating customers' perception (input) to the desired performance (output) of the education system so that strategic decision-making can be made easier. It is one such technique that aggregates the input and output components in order to obtain an overall performance measure through comparison of a group of decision units. It evaluates performance of Decision-Making Units (DMUs) by finding out the relative efficiency of the units under consideration. The DMUs can be business units (points of sales, bank branches, dealers, franchisees, etc.), government agencies, police departments, hospitals, educational institutions and even human beings on assessment of athletic, sales and student performance, etc. The major advantages of DEA may be listed as:

- it can handle multiple input and multiple output models
- it does not require the functional relationship between inputs and outputs
- it identifies the possible peers as the role models (benchmarks)
- it determines the possible sources of inefficiency
- it is independent of units of measurement of various parameters.

In this study, an attempt has been made to assess the efficiency of the Minority institutions using various quality dimensions of education through application of DEA. This study seeks to measure the relative efficiency of 19 educational institutions under JNTUH in Andhra Pradesh, India.

2 LITERATURE REVIEW

Identification of inputs and outputs in a service sector is really a challenging task as they are not well defined. In this context, Mahapatra and Khan (2007) have suggested a methodology to find out the factors responsible for quality improvement in education sector via neural network approach [12]. Elangovan et al. (2007) have used an Executive Support System (ESS) approach for improving the quality and productivity in maintenance engineering model [8]. However, DEA approach enables the management to frame right kind of policy for improvement of quality through identification of inefficiencies in certain dimensions in an organisation, both in manufacturing and service industries (Anatiliy, 2007; Parkan, 2006). Pacheco and Fernandes (2003) analysed efficiency of 35 Brazilian domestic airports using DEA and suggested the best quality implementation strategy [2]. Lin et al. (2005) determined the efficiency for a shipping industry using financial indicators through DEA so that Quality Improvement Programme (QIP) can be implemented[10]. Recent studies reveal that DEA has been successfully applied to education sector but each study differs in its scope, meaning and definition. [1] In one such study, the policy for Italian universities has been derived based on computation of Technical Efficiency (TE) using DEA with various input and output specifications (Agasisti and Bianco, 2006). A comparative study on efficiency of private universities and public universities in the USA using DEA has been carried out by Rhodes and Southwick (1986) considering each individual university as a DMU[18]. Tomkins and Green (1988) have used DEA to test the performance of individual departments of a university considering both teaching and research activities and compared the results with the ranking obtained by means of elemental analysis of staff/student ratio[19]. McMullen (1997) applied DEA in order to assess the relative desirability of Association to Advance Collegiate Schools of Business (AACSB) accredited MBA programmes [12]. McMillan and Datta (1998) used DEA to assess the relative efficiency of 45 Canadian universities and found that a subset of universities comprising of three categories such as comprehensive with medical school, comprehensive without medical school and primarily undergraduate universities are regularly found to be efficient. In an attempt to compare the performance of selected schools in the Netherlands, Ramanathan (2001) studied the effect of several non- discretionary input variables which are not under direct control of management on efficiency scores[15]. Calhoun (2003) employed DEA to compare relative efficiencies of private and public Institutions of Higher Learning (IHL) using a sample of 1323 four-year old institutions and introduced a new way for clustering institutions based on revenue management. Data envelopment analysis (DEA), occasionally called frontier analysis, was first put forward by Charnes, Cooper and Rhodes in 1978[5]. It is a performance measurement technique which, can be used for evaluating the relative efficiency of decision-making units (DMU's) in organizations. Examples of such units to which DEA has been applied are: banks, police stations, hospitals, tax offices, prisons, defense bases (army, navy, air force), schools and university departments. One advantage of DEA is that it can be applied to non-profit making organizations. Since the technique was first proposed much theoretical and empirical work has been done. Many studies have been published dealing with applying DEA in real-world situations. Obviously there are many more unpublished studies, e.g. done internally by companies or by external consultants.

3 DATA ENVELOPMENT ANALYSIS

Data Envelopment Analysis is a relatively new "data oriented" approach for evaluating the performance of a set of peer entities called Decision Making Units (DMUS) which convert multiple inputs into multiple outputs. The definition of a DMU is generic and flexible. Recent years have seen a great variety of application of DEA for use in evaluation the performances of many different kinds of entities engaged in many different activities in many different contexts in many different countries. These DEA applications have used DMUS of various forms to evaluate the performance of entities, such as hospitals, US Air force wings, Universities, Cities and Courts, business firms, and others, including the performance of countries, regions etc. Because it requires very few assumptions, DEA has also opened up possibilities for use in cases which have been resistant to other approaches because of the complex (often un known) nature of the relations between the multiple inputs and multiple outputs involved in DMUS.

As pointed out in Cooper, Seiford and Tone (2000), DEA has also been used to supply new insights into activities (and entities) that have previously been evaluated by other methods. DEA studies of the efficiency of different legal organization forms such as "stock" vs "mutual" insurance companies have shown that previous studies have fallen short in their attempt to evaluate the potentials of these different forms of organizations. Similarly a use of DEA has suggested reconsideration of previous studies of the efficiency with which pre and post merger activities have been conducted in banks that were studied by DEA.

Since DEA in its present form was first introduced in 1978, researchers in a number of fields have quickly recognized that it is an excellent and easily used methodology for modeling operational process for performance evaluation. This has been accomplished by other developments. For instance, ZHU (2002) provides performance evaluation and benchmarking. DEA'S empirical orientation and the absence of a need for the numerous a prior assumption.

In their originating study, Charnes Cooper and Rhodes (1978) described DEA as a mathematical programming model applied to observational data provides a new way of obtaining empirical estimates of relations. Such as the production functions and / or efficient production possibility surfaces – that are corner stones of modern economics.

For instance, consider what one wants to mean by "efficiency" or more generally, what one wants to mean by saying that one DMU is more efficient than another DMU. This is accomplished in a straight forward manner by DEA without requiring explicitly formulated assumption and variation with various types of models such as linear and non- linear regression models.

Relative efficiency in DEA accords with the following definitions, which has the advantage of avoiding the need for assigning a prior measures of relative importance to any output .

Definition1.1 (Efficiency- extended Pareto-Koopmans definition):

Efficiency is attained by any DMU iff none of its inputs or outputs can be improved without worsening some of its other inputs or outputs.

In most management are social science applications the theoretically possible levels of efficiency will not be known. The preceding definition is therefore replaced by emphasizing its uses with only the information that is empirically available as in the following definition.

Definition 1.2(relative efficiency):

A DMU is to be rated as fully (100%) efficient on the basis of available evidence iff the performance of other DMUS does not show that some of its inputs or outputs can be improved without worsening some of its other inputs or outputs.

4 CCR Model

Charnes, Cooper and Rhodes introduced a measure of efficiency for each DMU that is obtained as a maximum of a ratio of weighted outputs to weighted inputs. The weights for the ratio are determined by the restriction that the similar ratios for every DMU have to be less than or equal to unity, thus reducing thus reducing multiple inputs and outputs to a single "virtual" input and "virtual" output without requiring pre assigned weights. The efficiency measure is then a function of the weights of the "virtual" input-output combination. Formally the efficiency measure for DMU_0 can be calculated by solving the following mathematical programming problem:

$$Max\ \ h_o(u,v) = \frac{\sum_r U_r Y_{ro}}{\sum_i V_i X_{io}} \qquad \text{Subjected to}$$

$$\frac{\sum_r U_r Y_{rj}}{\sum_i V_i X_{ij}} \le 1 \qquad r = 1,2,.....s;\ j = 1,2,.....n;\ i = 1,2,.....m$$

$$U_r, V_i \ge 0 \quad \text{for all } i \text{ \& } r$$

$$Max\ \ h_o(u,v) = \frac{\sum_r U_r Y_{ro}}{\sum_i V_i X_{io}}$$

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Where x_{ij} = the observed amount of input of the i_{th} type of the j_{th} DMU ($x_{ij} > 0$, i= 1,2,…..m, j= 1,2,…..n) and y_{rj} = the observed amount of output of the r_{th} type for the j_{th} DMU ($y_{rj} > 0$, r = 1,2,….s, j = 1,2,…..n).

The variables u_r and v_i are the weights to be determined by the above programming problem. However, this problem has an infinite number of solutions since if (u*,v*) is optimal then ($\alpha u^*, \alpha v^*$), one can select a representative solution(u,v) for which to obtain a linear programming problem that is equivalent to the linear fractional programming problem.

$$Max\ \ h_o(u,v) = \frac{\sum_r U_r Y_{ro}}{\sum_i V_i X_{io}}$$

5 Emperical investigation

The paper initially illustrates DEA by taking a sample of 19 Minority Technical Institutions under JNTUH in Andhra Pradesh, India using a graphical (pictorial) approach to DEA. This is very useful when attempting to explain DEA to those in the management area. There is a mathematical approach to DEA that can be adopted which is illustrated using Linear Programming technique. Our analysis uses 2 output measures, namely pass percentage of students and students placed and 3 input measures namely, intake of students, faculty and infrastructure in the various Technical Institutions. To compare these institutions and measure their performance a commonly used method is CCR model which takes output measure and divides it by the corresponding input measure. In this case, we analyze the effectiveness of colleges by taking inputs and converting them (with varying degrees of efficiency) into outputs. Out of 19 Minority Institutions only three has been emerged as efficient and the remaining institutions experienced input losses due to over all technical efficiency. The relative efficiency can be further analyzed to improve the performance.

The Technical Efficiency variation for the 16 Minority institutions has the following bounds.

$$0.716 \le \lambda\ (\text{CRTS}) \le 0.948$$

The Technical Efficiency variation for Efficient Institutions is 1.000.

For DMU2 the technical efficiency is **0.770 ≈ 0.8.** According to the "returns to scale constant " its current outputs with only 80% of inputs is produced, it means 20% of inputs are freely disposed or cost lessly disposed.

For DMU 11, the technical efficiency is 0.948 ≈ 0.9. As per "returns to scale constant" it is experienced that 10% of input losses are due to over all technical efficiency. In other words this DMU could have combined 90 percent of its current inputs to produce the current outputs, has been over all technical efficient.

Ranks will be allotted based on peer count. The Efficient DMUs will be awarded ranks based on their peer count. The Efficient DMU with highest peer count will be awarded first, the next highest will be second as it follows.

Table: Technical Efficiency Score & Ranks of DMUS

DMUS	Technical Efficiency	Ranks
1	1.000	1.5
2	0.770	
3	0.716	
4	1.000	
5	0.814	
6	0.810	
7	0.806	
8	0.877	
9	0.816	
10	0.871	
11	0.948	
12	0.872	
13	0.865	
14	0.907	
15	0.938	
16	1.000	1.5
17	0.822	
18	0.831	
19	0.846	

6 conclusions

Education is the basic human requirement and one should take effort to choose the best educational institute. Selection of academic institute depends upon several attributes related to infrastructure, faculty strength, student quality, administration, research and developmental activities, training and placement and many others. However, relative priority of these factors may vary depending on variation of individual view points. This paper set out as a contribution to current educational systems for assessing the effectiveness of educational institutions. A sample of 19 minority institutionsunder JNTUH in Andhra Pradesh, India were analyzed for effectiveness using Data Envelopment Analysis(DEA). The efficient frontier were identified and the relative efficiency of the colleges were established using graphical analysis initially and then the case was formulated as an Linear Programming Problem which was solved using Solver. As this research is confined only to two inputs measure and three output measures, it cannot be generalized unless it is extended to more inputs and output measures. This study provides scope for further research using multiple input and output measures to assess the effectiveness of educational institutions in the service sector and other industrial sectors.

7 References

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