Cost Efficiency of Public Hospitals – A Case Study on District Hospitals in Andhra Pradesh

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ABSTRACT
This paper aims to study the cost efficiency of public hospitals in the State of Andhra Pradesh (before bifurcation). For this purpose 12 district hospitals were selected from different regions of Andhra Pradesh state and their common Decision Making Units (DMUs) identified. The Data Envelopment Analysis (DEA) econometric tool has been used to measure the efficiency and the best performing hospitals have been ranked. The data was collected from Andhra Pradesh Vaidya Vidhana Parishad (APVVP) for five years. The analysis is done by classifying the data into Input, Output and Explanatory variables. The results show that few hospitals are ranked high due to consistent performance and other hospitals who scored less are low performing hospitals during the period of study.

I INTRODUCTION

The present study deals with the comparative study of the cost efficiency of select public hospitals in pre-bifurcation period of Andhra Pradesh. It is often argued that health care institutions are not expected to be efficient, as they do not adhere to neo-classical firm optimization behavior (Rowna, 2000). There has been rapid increase in the application of different methods to measure hospital efficiency; the most commonly devised method for the purpose is Data Envelopment Analysis method.

Data Envelopment Analysis (DEA) is an increasingly popular decision making tool based on linear programming technique for measuring relative efficiencies of a set of comparable entities. It has been extensively applied in performance evaluation and benchmarking of schools, banks, hospitals, manufacturing concerns etc. DEA was introduced by Charnes, Cooper, Rhodes (1978) to assess the relative efficiencies of the organizational units with multiple inputs to produce multiple outputs.

II OBJECTIVES OF THE STUDY

The objectives of the study are:

(a) To make a comparative study of the cost efficiency of select public hospitals in Andhra Pradesh.
(b) To Rank the public hospitals based on their efficiency.
(c) To measure the magnitude of gap between the low performing hospitals from High performing hospitals.

III LITERATURE REVIEW

Carnes, Cooper and Rhodes (1978) introduced the Non –Parametric method of measuring and comparing efficiency that can be used in service sector having multiple Decision Making Units (DMUs) with different units of measurement. The scale of operations is not the aspect of comparison but all the institutions or organization must have the common DMUs existing in the same basic environment. Robert W. Rutledge, Sharon Parsons and Richard Knaebel (1995) emphasized on the DEA methodology and its ability to determine the relative efficiency of each of the latest available data for a mid-sized non- profit hospital in the south east united states .DEA was able to simultaneously consider multiple inputs and outputs with which it classified months as efficient or inefficient. Bill Binglong Wang, Yaser A Ozcan and Thomas T.H.Wan(1999) identified 6010 hospitals for analysis from the American Hospital Association's Annual Surveys for 1989 and 1993 and applied data envelopment analysis (DEA), to study hospital efficiency in the United States. Results suggest that large hospital generally demonstrated higher inefficiency. The major inefficiencies exist in the availability of hospital services, the number of operating beds, the utilization of hospital staffing and operating expenses.

Rowena Jacobs (2000) examined hospital Efficiency using data envelopment analysis and stochastic frontier analysis at UK department of health and compared the efficiency rankings from the cost indices with those obtained using DEA and SCF and paper concluded that each method has particular strengths and weaknesses and potentially measure different aspects of efficiency. Ramesh Bhat, Bharat BhushanVerma and Elan Reuben (2001) focused on analyzing the hospital efficiency of district level government hospitals and grant in aid hospitals in Gujarat

using Data Envelopment Analysis. Duncan Mortimer and Stuart Peacock (2002) compared the policy value of DEA and SFA based measure against more commonly used indicators of hospital performance. The methodology they used is the comparative analysis of DEA and SFA in estimating the relative efficiency if hospitals in Victoria. Possible sources of measured inefficiency were investigated via Battese and Coelli(1995) effects model in the case of SFA based efficiency scores and via second-stage regressions in the case of DEA based efficiency measures. The content and consistency of DEA and SFA based targets and measures are then compared against simple cost/output ratios. Antonio Afonso and Sonia Fernandes(2005) have contributed to DEA efficiency scores and Malmquist indexes for a panel data set comprising 68 Portuguese public hospitals belonging to the National Health System (NHS) in the period 2000-2005, when several units started being run in an entrepreneurial framework. William W.Cooper, Lawrence M. Seiford and Joe Zhu (2007) have provided an introduction to DEA and some of its uses. Milan M. Marti, Marina S. Novakovi and AlenkaBaggia (2008) presented ample possibilities for using the DEA for the evaluation of the performance of bank branches, schools, university departments, farming estates, hospitals and social institutions, military services, entire economic systems (regions) and other things. DEA is a methodology of several different interactive approaches and models used for the assessment of the relative efficiency of DMU and for the assessment of the efficiency.

IV METHODOLOGY

(a) Model Used - Data Envelopment Analysis (DEA) Model

Data Envelopment Analysis (DEA) is a multi-factor productivity analysis model for measuring the relative efficiencies of a homogenous set of Decision Making Units (DMUs). The efficiency score in the presence of multiple input and output factors is defined as:

$$\text{Efficiency} = \frac{\text{Weighted sum of Outputs}}{\text{Weighted sum of Inputs}}$$

$$\text{Maximize} = \frac{\sum_{r-1}^{s} \text{Ur Yrj}}{\sum_{i-1}^{m} \text{Vi Xij}}$$

Subject to: $\sum_{r-1}^{s} \text{Ur Yrj} \div \sum_{i-1}^{m} \text{Vi Xij} \leq 1$; j = 1,…, n

Ur, Vi ≥ 0; r=1,..,s, i=1, …, m

Yrj= amount of output r from hospital j
Xij= amount of inputi to hospital j
Ur = weight given to output r
Vi= weight given to inputi
n = number of hospitals
s = number of outputs
m = number of inputs
Maximize = an LPP concept to Maximize efficiency for utilizing the inputs for the better outputs level

In DEA the efficiency of an organization (district hospitals in this case) is measured relative to a group's observed best practice. This implies that the benchmark against which to compare the efficiency of a particular district hospital is determined by the group of district hospitals in the study and not a value fixed by hospitals outside of the group.
The basic DEA model helps to find answers to questions such as:

(i) Which district hospitals (or hospital departments) are the most efficient?
(ii) If all district hospitals are to perform according to best practice (i.e. the efficient peer hospitals), by how much could inputs/resources be reduced to produce the current output levels; or alternatively, by how much could outputs be increased with the current input levels?
(iii) How much resources can be potentially saved if all district hospitals are operating at an optimal scale?
(iv) Which of the efficient district hospitals can serve as role models for the inefficient ones (so that their method of doing business may be emulated)?

DEA easily accommodates multiple inputs and outputs without the requirement for a common denominator of measurement. This makes it particularly suitable for analyzing the efficiency of hospitals as they use multiple inputs to produce many outputs. Furthermore, it provides specific input and output targets that would make an inefficient hospital relatively efficient. It also identifies efficient peers for those hospitals that are not efficient. This helps the inefficient hospitals to emulate the functional organization of their peers so as to improve their efficiency.

However, like many other empirical methods, DEA has its limitations. First, it produces results that are sensitive to measurement error. For example, if one hospital's inputs are understated or its outputs overstated, it can become an outlier and significantly reduce the efficiency of other hospitals.

Second, DEA measures efficiency relative to the best practice within hospitals in the particular sample. Therefore, it is not possible to compare how district hospitals in Andhra Pradesh fare relative to their counterparts in India with respect to technical efficiency.

(b) Allocative Efficiency

The Allocative efficiency shows whether, for any level of production, inputs are used in the proportion which minimizes the cost of production, given input prices. It determines that level of activities which takes the minimum cost of production or operations for the best output levels. It concentrates more in minimizing the costs of inputs.

(c) Technical Efficiency

The technical efficiency concentrates on conversion of physical inputs, such as labor services and raw materials or semi-finished goods, into *outputs*. Technical efficiency is determined by the difference between the observed ratio of combined quantities of an entity's output to input and the ratio achieved by *best practice*. It can be expressed as the potential to increase quantities of outputs from given quantities of inputs, or the potential to reduce the quantities of inputs used in producing given quantities of outputs. Technical efficiency is affected by the size of operations (*scale efficiency*) and by managerial practices (*non-scale technical efficiency*). It is defined independent of prices and costs.

(d) Scale Efficiency

The scale efficiency determines the extent to which an organization can take advantage of returns to scale by altering its size towards optimal scale (which is defined as the region in which there are constant *returns to scale* in the relationship between outputs and inputs).

(e) Non-scale technical efficiency

The non-scale technical efficiency determines the proportion of *technical efficiency* which cannot be attributed to divergences from optimal scale (*scale efficiency*); sometimes known as managerial efficiency or pure technical efficiency.

(f) Productivity

Measure of the physical output produced from the use of a given quantity of inputs. This may include all inputs and all outputs (*total factor productivity*) or a subset of inputs and outputs (*partial productivity*). Productivity varies as a result of differences in *production technology*, differences in the *technical efficiency* of the organization, and the *external operating environment* in which production occurs.

(g) Returns to scale

The returns to scale show the relationship between the outputs and inputs. Returns can be constant, increasing or decreasing depending on whether output increases in proportion to, more than or less than inputs, respectively. In the case of multiple inputs and outputs, this means how outputs change when there is an equi-proportionate change in all inputs

V DATA COLLECTION & ANALYSIS

(a) Data Collection

Data was collected using a questionnaire that included information on inputs, outputs. The secondary data have been collected directly from the APVVP, Andhra Pradesh VaidyaVidhanaParishad located at Kothi, Hyderabad, India. The data includes selected hospitals of both Telangana& Andhra Pradesh States. Personal interviews were conducted, the response from the finance officer, ETC officers and others was remarkable depending on which the variables were decided. The period of study covered 5 years which includes the financial years from 2005-06 to 2009-10.

(b) Input-Output Data Analysis and methods

(i) Sampling

The study focuses on approximately 50% population of 23 district hospitals in Andhra Pradesh (N = 12) before bifurcation into two separate States, Telangana State and Andhra Pradesh State on 2nd. June 2014. These hospitals are distributed over the 3 regions of the state of Andhra Pradesh namely Andhra (5), Telangana (5) and Rayalseema (2).

(ii) Selection of inputs and outputs

Table 1
Variables and their Description

Variable	Type	Code	Description	Units
Input	Capital	Bed	Number of Beds	Numbers
Input	Operating	Drug	Expenditure on Drugs	Expenses
Input	Operating	Diet	Expenditure on Diet	Expenses
Input	Capital	L&Eq	Expenditure on Lab and equipment maintenance	Expenses
Input	Operating	DT	Expenditure on Domestic travels	Expenses
Input	Capital	BMW	Expenditure on Biomedical wastes	Expenses
Input	Operating	WEOOE	Water Electricity and other office expenses	Expenses
Input	Staff	CAS	Civil Assistant Surgeon	Numbers
Input	Staff	NPS	Nursing and Paramedical Staff	Numbers
Output		IP	In patients	Numbers
Output		OP	Out patients Cases	Numbers
Output		MJS	Major Surgeries Cases	Numbers
Output		TUB	Tubectomy Cases	Numbers
Output		DLV	Deliveries Cases	Numbers
Output		USG	Ultra Sonography	Numbers
Output		X-Ray	X-Ray Cases	Numbers
Output		ECG	ECG Casess	Numbers
Output		LAB	Laboratory Cases	Numbers
Explanatory		PHC	Preventive Health Care	Index (0-1)
Explanatory		MCH	Maternal and child health care	Index (0-1)
Explanatory		CDS	Communicable disease services	Index (0-1)
Explanatory		NCD	Non-communicable disease services	Index (0-1)
Explanatory		CMS	Curative Medical Services	Index (0-1)

(iii) Input Variables

The input variables are broadly classified into capital expenses, labour and Operating expenses. The degree of disaggregation within these categories depended on the homogeneity of an input category, the quality of data within which to measure this input. Nine variables were defined to measure input variable, common to all hospitals. The level of aggregation or disaggregation of each head (staff, capital or operating) depended on the information available. For example the input variable of staff could consist of total staff strength of a particular hospital. The input variable of total staff strength, under the head of staff input was disaggregated as per information available into number of doctors, nurses, paramedical staff, administrative staff and others.

The essential physical infrastructure like OPD, consultation room, ward etc. is measured by creating an index to assess the presence and the absence of the absence of the standard items of infrastructure. The information is collected by administering the questionnaire, consultation with the technical personnel and pilot study. Though it is compulsory to build up the hospitals with the required infrastructure, it was found in few instances that the equipments are not maintained properly depriving the services to the patients.

Three measures of the capital inputs were available; a measure based on the number of beds per hospital, expenditure on Lab and Equipment and the expenditure Bio medical waste, to measure the capital investment. Beds are often used to proxy for capital stock in hospital studies usually because a reliable measure if the value of assets is not available. Operating expenses includes the expenses on drugs, diet and water, electricity and other office expenses. The selected operating expenses were found in the budget on regular basis, where as other items which are released based on the special requirements and that are not regularly released in the budget are ignore for the purpose of reducing data redundancy.

Staff inputs were measured by total time devoted for attending parties and the total manpower employed for attending the patients.

(iv) Output variable

Hospitals provide six major services: outpatient services, in-patient services, major and minor surgeries, deliveries, tubectomy and Laboratory services. Given this homogeneity in types of services provided, the number of cases treated/handled under each category was chosen as a representative measure of these output variables.

Improved health status is the ultimate output of hospitals or the health system at large. However, due to difficulties in accurately measuring improvements in health status, hospital output is measured by an array of intermediate health services that supposedly improve health status.

Although there is a general consensus that the ultimate measure of output should be an improvement in the quantity and quality of life, practical difficulties limit the use of the outcomes approach. Health is multi-dimensional and affected significantly by a host of other socio-economic factors. Consequently, output is measured as an array of intermediate outputs (health services) that supposedly improve health status.

(v) Explanatory Variables

The explanatory variables consist of qualitative variables, Preventive Health care is measures by devising an index for preventive health care services provided by the hospitals by equally weighing the presence and absence of the various standard services provided by the hospitals. It was hypothesized that this would help explaining variance of the number of cases treated. For this purpose an index was devised and the value of this index of services ranges between 0 and 1. Similarly indices are derived for the Maternal and child Health care services and curative medical services. These indices, when regressed against the data for OPD cases and Inpatient cases, help explain the variance and correlation if any between these services and the OPD and inpatient activities.

Assuming that a particular hospital participate in a national communicable and /or non-communicable disease programme if there is a need felt in the region in which the hospital is located.
In the present study an index is devised to measure in binary terms, 0 for the non-availability and 1 for the availability of the explanatory variables.

Buttler(1995) classifies hospital output into four broad categories: inpatient treatment, outpatient treatment, teaching and research. Measuring hospital output by such variables as inpatient days or outpatient visits does not capture the case-mix and the quality of service rendered. Even though the use of Diagnosis-related groups may handle the problem of hospital case-mix; the absence of data makes its use limited in most developing countries.

Table 2
Index for availability of Explanatory Variables

DCHS	PHC	MCH	CDS	NCD	CMS
Mahaboobnagar	1	1	1	1	0
Sangareddy	1	1	0	1	1
Nizamabad	1	0	1	1	1
Karimnagar	1	1	1	0	1
Nalgonda	1	0	1	1	1
Vizianagarm	1	0	1	1	1
Rajahmundry	1	1	1	0	1
Eluru	1	1	1	1	0
Machilipatnam	1	0	1	1	1
Nellore	1	1	0	1	1
Chittor	1	1	1	0	1
Nandyala	1	1	1	1	0

(vi) Data Analysis

The technical efficiency scores are computed using data envelopment analysis program, version 2.1 (XLDEA 2.1) one of the leading and trusted DEA software. Hospital utilization ratios are also computed using Microsoft Excel.

Output-oriented model was used in this study, as the decision to use or not to use the district hospital services is at the discretion of the consumer/client/patient. It is an exogenous factor that hospital managers may not have total control of. But the performance speaks itself.

A DEA Model was run after feeding the input and output variables into the Program. Twelve District hospitals were selected and fed into the model for analysis of technical and allocative efficiency. The DEA Program used for analysis based on the work of Ramesh Bhat and Bharat BhushanVarma (2001). There are two programs available in the computer program. The first involved the constant returns to scale (CRS) and the second one involves the Variable returns to scale (VRS) model. As the selected hospitals are catering to a similar kind of population and operate at the same level, only CRS model is applied. The size of the hospital is not considered as the sample is taken for district hospitals alone. In some studies small, medium and large size hospitals are taken to calculate the efficiency in DEA. But the major limitations of those studies include the failure to consider the size of the organization as part of the variables. In the present study this limitation is overcome by choosing only single range of hospitals that have around 200-350 Bed strength. All the twelve hospitals are operating at the district level; therefore the selected hospitals are single range and single type of hospitals.

VI RESULTS

Data was compiled in the required variables for only 12 hospitals. The findings indicate a minor variation in the size of the district hospitals as indicated by the authorized number of beds. Summary statistics of the key variables is given in Table below in the form of the DEA Efficiency Scores. The efficiency scores are obtained by calculating the selected inputs and outputs of the sample size and comparing them on yearly basis. The table below is the result obtained by using XLDEA2.1

Table 1
Five Yearly DEA Efficiency scores of hospitals for the period of 2006-2010

Hospital Name	2006-07	2007-08	2008-09	2009-10
Mahboobnagar	1.0000	1.0000	1.0000	1.0000
Sangareddy	1.0000	1.0000	1.0000	0.9713
Nizamabad	1.0000	1.0000	0.9638	0.9611
Karimnagar	0.6855	0.7073	0.7105	0.7923
Nalgonda	0.8326	0.9854	1.0000	1.0000
Vizianagaram	1.0000	1.0000	1.0000	1.0000
Rajamundry	0.9687	0.5328	0.6743	0.7207
Eluru	0.9219	0.9271	1.0000	1.0000
Machilipatnam	1.0000	1.0000	1.0000	0.9020
Nellore	0.6365	0.7431	0.7885	0.8033
Chittor	1.0000	1.0000	1.0000	1.0000
Nandyala	1.0000	1.0000	1.0000	1.0000

The Efficiency scores are determined by the ratio of the sum of weighted outputs to the sum of corresponding weighted inputs(Mika Linna 2010).The Efficiency score values ranging from < 0 to 1> which shows the comparative efficiencies of all the hospitals. It follows the theory of constant returns to scale; where in the change in the proportionate inputs do not show an abrupt variation on the outputs or performance.

As depicted by the above table, the value <1.0000> shows those hospitals that are performing efficiently wherein the increase in the input combination will show proportionately positive results as they are efficiently utilizing their available resources. These are the hospitals which are scoring well in their performance, as well as the cost control methods are properly organized and well managed. The measurement of cost efficiency is relatively straightforward using non parametric method (Ray and kim, 1995)

The Efficiency score of 0.80 for District hospitals indicated that on an average the hospitals could increase the output using the same level of resources or reduce the input usage or input cost by 20 percent to deliver the same amount of health care. Only 58 percent of selected district hospitals are able to efficiently use their resources. An interesting observation evident from the table is that the efficiency score for the given hospitals does not follow the exact pattern of increase or decrease of the efficiency.

The technical efficiency scores indicate which of the hospitals are on the efficient frontier and following the best practices are scoring one, and which are less efficient relative to hospitals on the frontier holding the score less than one. The higher the score, the higher the potential increase in output, while maintaining inputs relative to best practice. The various statistics for the input and output variable for the PHC is given in the table above.

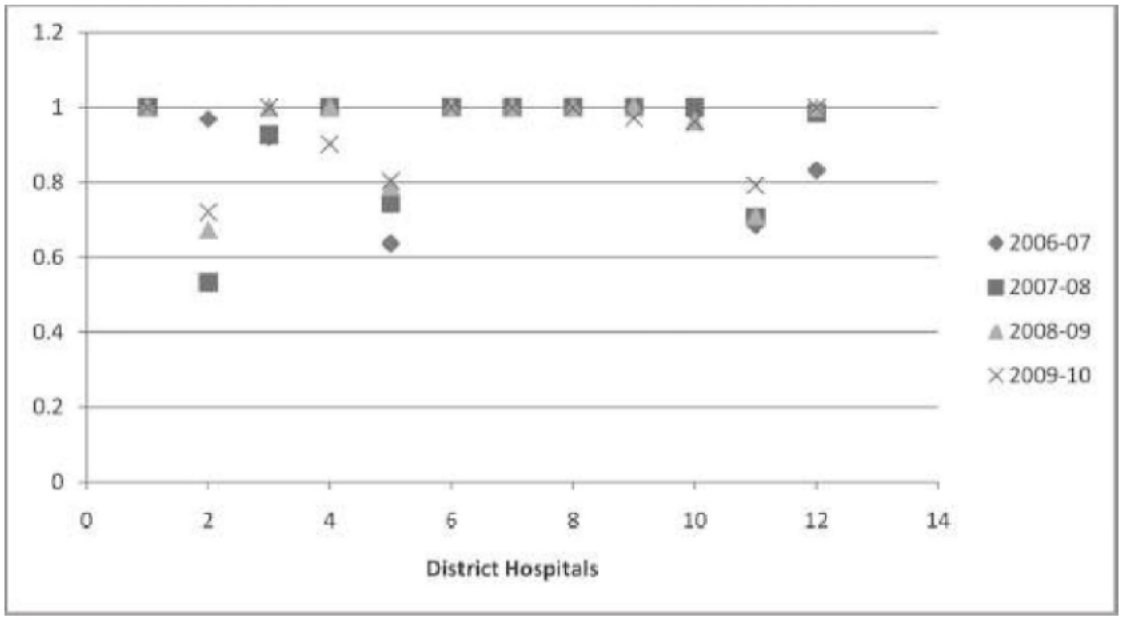

Fig. 1 Technical Efficiency of District Hospitals in Telangana & Andhra Pradesh

Technical efficiency scores only refer to relative performance within the sample. Hospitals given an efficiency score of one are efficient relative to all other hospitals in the sample, but may not be an efficient by some absolute of world standard necessarily. The plot for the individual technical efficiency scores has been plotted in above figure. The labels of the hospitals have been taken as the sequence given in the efficiency scores table. Fifty percent of the hospitals were operating in the efficient frontier throughout the period of the study. 33 percent of the hospitals are able to improve relative technical efficiency throughout the period of study, but they are still required to either reduce their inputs while maintaining the same number of completed treatments if they operate at what appears to be best practice. Else they can increase their outputs to attain the 100 percent technical efficiency by means of optimum utilization of the resources.

Three of the hospitals were found to be reducing their efficiency level that may be due to comparatively lesser population catered to by these hospitals. It may be observed that hospitals in remote areas are less dense or less urbanized areas would be relatively serving lesser population and therefore would be relatively less efficient.

VII CONCLUSION

The review of literature enumerates the suitability of Data Envelopment Analysis for the measurement of cost efficiency of hospitals. The sample hospitals cover the major regions of the Andhra Pradesh State in its pre-bifurcation period. The efficiency score helps ranking of the hospitals on the basis of efficiency of hospitals, the hospitals having the score of 1.000 are consistently performing well with the given inputs by the government and hospitals below the efficiency score show the magnitude of gap to cover for performing well.

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