

HOSPITAL EFFICIENCY AND DATA ENVELOPMENT ANALYSIS

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Abstract

Efficiency which could be related to the performance of the processes is one of the main concerns of the organizations. It is therefore important to measure and perform continuous improvement in the efficiency of the processes. This is also valid for the health services as in all others. In a time for rising demands for healthcare, focus on efficient operations in health care is becoming more imperative. The policy maker's notion of efficiency can be thought of as the extent to which objectives are achieved in relation to the resources consumed. In literature, there have been several modelling and assessment approaches developed for this purpose. This research paper reviews different approaches for hospital efficiency analysis. Main focus of the review is given to data envelopment analysis which is one of the very popular assessment tools for decision making systems.

Keywords: Efficiency Measurement, Data Envelopment Analysis, Health Services.

Introduction

In today's dynamic and rapidly changing socio-economic conditions, all institutions have to search and find ways for continuous improvement. As a service business, healthcare institutions have followed the similar goals with other organizations for achieving performance improvements. In recent years, efficiency has been one of the most important issues for hospitals which used limited resources for maximum value. Efficiency measurement represents a first step towards the evaluation of a coordinated healthcare

system, and constitutes one of the basic means of audit for the rational distribution of human and economic resources (O' Neill, L et al, 2008). Over the past two decades, efficiency measurement has been one of the most intensely explored areas of health services research (Ruggiero, J, 2007). The World Health Report 2000 called attention to the importance of efficiency in all functions of a health system and in ultimately achieving the goals of health improvement, responsiveness and fairness in financing. Efficiency has been the subject of research in a wide range of production activities. It is expressed as a percentage which can be calculated as the ratio total output to total input under specified conditions. Efficiency analysis has always been linked to the relative difficulty encountered in assessing the performance of decision-making units (DMUs) to find its weakness so that subsequent improvements can be made (N. Kontodimopoulos, and D. Niakas, 2005). Measurement of efficiency is especially relevant in settings constrained by scarce resources and given the recent economic downturn and escalating healthcare costs it allows a system to produce more and better at zero cost.

The Concept of Hospital Efficiency

In the Farrell (1957) framework, a hospital is judged to be technically efficient if it is operating on the best practice production frontier in its hospital industry. In the original Farrell framework, the entire observations on given sample is assumed to have access to same technology. Magnussen (1996) stated that measuring technical efficiency allows us to compare hospitals in terms of their real use of inputs and outputs rather than costs or profits. A hospital is said to be technically efficient if an increase in an output requires a decrease in at least one other output, or an increase in at least one input. Alternatively, a reduction in any input must require an increase in at least one other input or a decrease in at least one output. On the other hand allocative efficiency occurs when inputs or outputs are put to their best possible uses in the economy so that no further gains in output or welfare are possible.

To measure hospital's efficiency, the hospital's output(s) must be identified. There are many potential measurements for a hospital's outputs such as number of cases treated, number of procedures performed, and number of patient days, bed turnover, and bed occupancy, among others. The output or combination of outputs to use depends on the objectives of the hospital and on the level of measurement activities (e.g. departmental and institutional level).

The Need to Focus on Hospital Efficiency

Problems of hospital efficiency can be considered in the contexts of three broad groups of countries: high and middle income countries; Eastern Europe and the former Soviet Union (FSU); and low income countries. Although they have obvious differences there are also considerable similarities in the problems they face and the solutions to them. The differences reflect not only per capita health expenditure and variations in disease burden but include cultural and historical influences on funding and services delivery. The similarities, and hence the ability to look internationally for solutions to problems, are:

- the continuing imbalance between resources (especially finance) and demand – whatever the per capita spend - fuelled by population size and age, new technology and greater public expectations;
- the need to shift limited resources to more cost effective interventions in the ambulatory care or primary care settings;
- changes in medical technology which mean that patients typically stay a shorter time in hospital, and hence that throughput per bed can increase;
- Above all the realisation that within the hospital sector there are enormous efficiency gains to be made, which would allow considerable increases in both the quality and quantity of service delivery for the same or less expenditure.

Approaches to Study Hospital Efficiency

In recent years efficiency has become one of the most attractive work areas of healthcare management literature. Some authors argue that hospitals are profit organizations while some others do not agree with them (White and Ozcan, 1996). Hospitals, whether are economic organizations or not (Ferrier and Valdmanis, 2004), have limited resources to gain maximum value like all other organizations (Watcharasriroj and Tang, 2004; Harris et al., 2000).

Studies on hospital efficiency mostly focus on the issue of maximum gain with limited resources (Sorkis and Talloru, 2002). One of the frequently raised issues on these studies is the efficient use of resources and controlling the costs. Thus, the interest on hospital efficiency has increased because of the desire to control the increasing costs. Accordingly,

hospital resources and their processes became critical and, as a result, the number of studies has increased in recent years.

Regression analysis, ratio analysis and non-parametric techniques were applied to analyze the hospital efficiency in the previous studies (Ferrier and Valdmanis, 2004). Data Envelopment Analysis (DEA) is one of the most applied techniques for evaluating hospital efficiency (Linna et al., 2006; Bakar et al., 2010). DEA enables the use of multiple inputs and outputs at the same time for hospital efficiency studies.

Review of Hospital Efficiency Studies based on DEA Technique

Charnes, et al. (1985) conducted arguably the first Data Envelopment Analysis in military hospitals. Authors investigated the efficiency of 24 Army military hospitals during criteria that are still relevant for inclusion in their analysis. The authors selected traditional workload criteria for analysis of outputs including personnel trained, relative work product, and clinic visits. These outputs are considered traditional elements of production in healthcare and are relevant for inclusion along with other less traditional factors.

Grosskopf and Valdmanis (1987) examined 22 public hospital and 60 private not-for-profit hospitals in California. They used DEA method and found that the two classes of hospitals to be facing distinct production frontiers with public hospitals being more efficiency overall.

Valdmanis (1990) applied the DEA method to a group of hospitals and found that government-owned hospitals were more efficient. This might be due to the fact that an imperfect adjustment is made for the quality of output and patient day rather than admission are generally used to measure output. The other surprising result is that for profit hospitals tend to be disproportionately represented among highly inefficient hospitals and are inefficient compared to not-for-profit hospitals when output is measure by discharging.

Ozcan and Luke (1993) used the DEA technique to conduct a national study of the efficiency of hospitals in urban markets. Four variables were analyzed in this study: hospital size, membership in multihospital system, ownership and payer mix. Ownership and percent Medicare were consistently related to hospital efficiency. The Medicare percent was related negatively to technical efficiency. Government hospitals were more efficient and for profit hospitals less efficient than other types of hospitals. Other variables like hospitals size, and membership in a multihospital system were related positively to efficiency.

Ozcan and Bannick (1994) used DEA to study trends in Department of Defense hospital efficiency from 1998-1999 using 124 military hospitals and data from the American Hospital Association Annual Survey. In a 1995 study, these authors also compared Department of Defense hospital efficiency with that of Veteran's Administration hospital efficiency (n=284) using 1989 data. These studies were conducted at the strategic level under a different operational paradigm, prior to the large-scale adoption of managed care.

Puig-Junoy (1998) used a cross-sectional DEA to study technical efficiency among ICUs in Spain using a two stage approach. In the first stage environmental factors, over which the ICU has no control, are ignored. In the second stage variation in operating efficiency was captured by a regression model. By focusing on the services provided by ICUs, the model alleviates the problem of measuring heterogeneous outputs, since all ICUs treat patients that are critically ill. Also analysis used patient-level data rather than aggregate data, and incorporates quality measures, such as mortality probability. Despite the emphasis on quality variables, the author acknowledged that the analysis does not attempt to measure whether patient receive an appropriate amount of care; rather it presents mortality probability data showing severity of illness at admission. Also, the outcomes for these patients are determined by survival status at discharge. The measurement of technical inefficiency requires that ICUs minimise inputs given the amount of outputs produced. The author acknowledged that measuring technical efficiency is adequate when comparing the performance of not-for-profit institution, such as those found in the hospital sector.

Coppola (2003) conducted a DEA study of military hospital using 1998-2002 data. In his study he selected the following input variables: costs, number of beds, number of service offered. For output variables, he used surgical visit, ambulatory patient visit, emergency visits, and live birth. This study is focused on workload as the primary measure for efficiency, a point of view not fully congruent with the current operation of military hospitals.

Another study is by Stanford's (2004) examination of the performance by using DEA of 107 Alabama hospitals in the treatment of acute myocardial infarction patients because it too examined clinical efficiency and quality of care. Cross efficiencies were used to improve the efficiency discrimination between hospitals.

Bates (2006) used data envelopment analysis and multiple regression analysis to examine empirically the impact of various market-structure elements on the technical efficiency of the hospital services industry in various metropolitan areas of the United States. Market-structure

elements include the degree of rivalry among hospitals, extent of HMO activity, and health insurer concentration. The DEA results showed the typical hospital services industry experienced 11 percent inefficiency in 1999. Moreover, multiple regression analysis indicated the level of technical efficiency varied directly across metropolitan hospital services industries in response to greater HMO activity and private health insurer concentration in the state. The analysis suggested the degree of rivalry among hospitals had no marginal effect on technical efficiency at the industry level.

In India there is dearth of literature as very few studies are done on efficiency of hospitals using DEA analysis. However, after a thorough review of literature, a few studies that are conducted in India are presented below.

A study was conducted by Razz, Samandri (2001) of privately funded quality healthcare LV Prasad Eye Institute (LVPEI) and Ophthalmologic Institute in Hyderabad, India using DEA framework. The success of LVPEI in terms of efficiency as brought out by DEA can be attributed to close attentions to three areas of health administration – fiscal solvency, programmatic focus and quality management. Detailed financial audits and policy studies are conducted annually to implement standards for cost contentment and maximize the institute's efficiency.

Another successful study was conducted by Bhat, et al, in 2001 using DEA for district hospitals and grant-in –aid hospitals in Gujarat state. The study makes an attempt to provide an overview of the general status of the healthcare services provided by hospitals in the state of Gujarat in terms of their technical and allocative efficiency. One of the two thrusts behind addressing the issue of efficiency was to take stock of the state of healthcare services (in terms of efficiency) provided by grant-in-aid hospitals and district hospitals in Gujarat. The finding of the study suggests that the efficiency variations are significant within district hospitals than within the grant-in-aid institutions. The overall efficiency levels of grant-in-aid institutions are higher than the district level hospitals.

Mathiyazhgan in (2006) highlights the cost efficiency using DEA of public and private hospitals in Karnataka state in India. The analysis infers that (a) hospitals (both public and private together in the analysis) are cost inefficient in the state, which is due to technical and allocative system of resources of the hospitals (b)the private hospitals appear relatively less inefficient than the public hospitals (c) the main determinants of the technical and allocative inefficiencies of the public hospitals are due to inappropriate interventions of inpatient days

care, share of medical personnel, beds capacity, quality indices and choice of the locations while in the case of private hospitals, it relates only to beds capacity and quality indices.

About Data Envelopment Analysis (DEA) Technique

DEA has become a widely used technique for efficiency measurement. It is mainly based on the earlier concept of Frontier Analysis (Farrel, 1957) and it became popular after it was first introduced in the article by Charnes et al. (1978). It assesses the relative efficiency scores of a particular set of Decision-Making-Units (DMU), which produce a variety of outputs by using several inputs. This approach uses a mathematical programming method to create a set of weights for each inputs and out-puts, which considers how efficiency in the DMUs can be improved, and ranks individual DMUs based on efficiency score (Liu et al., 2007; Bakar et al., 2010). DEA computes each hospital's efficiency by maximizing the ratio of the weighted sum of output variables and the weighted sum of input variables (Kumar, 2010). DEA has been used for measuring the efficiency of many other application areas including banks, airlines, universities, etc.

DEA evaluates the relative technical efficiency with linear programming model by using input and output variables from similar and homogeneous decision making units (DMU). DEA has two key advantages for efficiency analysis: (1) it readily analyzes multiple inputs and outputs at the same time therefore, (2) captures more specific production characteristics of each unit (Ferrari, 2006). DEA model calculates an efficiency score for each DMU. Efficiency scores of DMUs which are equal to 1 are called "efficient" and different to 1 are called "inefficient" (Zhu, 2003). DMUs' scores are compared with one another and the set of most effective DMUs is called "efficiency frontier" (Junoy, 2000). Consequently, as Kumar and Gulati (2008) stated, DEA outlines an efficiency frontier over the data points to determine the efficiency of each DMU relative to this frontier. In this benchmark model there are two assumptions: (1) input oriented (while outputs are hold constant and inputs are decreased), (2) output oriented (while inputs are hold constant and outputs are increased), (Harris et al., 2000). Although some authors used output oriented approach to analyze hospital performance with DEA (e.g., Biqrn et al., 2003; Hu and Huang, 2004) the majority of the past studies suggested the in-pup oriented approach for measuring hospital efficiency (e.g., Ferrier and Valdmanis, 2004; Lynch and Ozcan, 1994; O'neill and Dexter, 2004). The

reason is that the selected input variables in most of the studies are more controllable than the outputs.

The first DEA model developed by Charnes et al. (1978), named the CCR model, was based on the assumption of Constant Return to Scale (CRS). Later, Banker et al. (1984) enhanced the CCR model and developed the BCC model using the Variable Return to Scale (VRS), in 1984. Consequently, Nayar and Ozcan (2008) concluded that DEA is constructive technique for healthcare managers to investigate opportunities in accordance to efficiency improvement. Kirigia et al. (2008) state that in the context of hospitals, efficiency means providing maximum services out of obtainable resources or minimizing the use of available resources to produce a given level of services.

Advantages and Disadvantages of DEA

The five key *advantages* of DEA technique for efficiency analysis can be summarized as:

- It readily analyzes multiple inputs-outputs at the same time.
- It captures more specific production characteristics of each unit (Ferrari, et al, 2006).
DEA model calculates an efficiency score for each DMU. Efficiency scores of DMU's which are equal to 1 are called 'efficient' and less than 1 are called inefficient. (Zhu, 2003).
- Decision making units are directly compared against a peer or a combination of peers.
- It is underpinned by economic theory and methods.
- It focuses on relative and not absolute efficiency.

Certain *precautions* while using DEA:

- i) The impact of omitting important variables. Hence, careful specification of the model is a must.
- ii) The impact of outliers that refers to an observation which appears to be inconsistent with the remainder of the set of data (V. Barnett and T. Lewis, 1995). When inputs are understated or outputs are overstated it becomes an outlier which affects efficiency.
- iii) The impact of missing observations. The missing observations or the missing values may adversely affect the result.

All three situations may cause the efficiency scores to be wrongly computed. So the *weaknesses* of DEA can be stated as follows:

- When complex production processes are involved, specifying a model populated with good quality data can be difficult for several reasons. In particular an unmanageable number of variables may be needed to capture the process adequately or the quality of available data may be too poor to provide accurate measurement and produce valid results.
- DEA is a deterministic rather than statistical technique. DEA produces results that are particularly sensitive to measurement error. DEA only measures efficiency relative to best practice within the particular sample. Thus, it is not meaningful to compare the scores between two different studies.
- DEA results are insensitive to statistical noise and the measurement of comparative efficiency rests on the hypothesis that efficient units are genuinely efficient.
- Another weakness is that since DEA is a non-parametric technique, statistical hypothesis testing is difficult to be done.

Conclusion

It is well- known and clear from the above basic understanding that there is a scarcity of resources in the health sector. At the same time, there is a growing need and demand for quality health services for all, particularly in light of growing and aging populations and increasing diversity and complexity of diseases. The pursuit of efficiency and equity in resource allocation and use is accepted as a major goal of health systems among policy makers. Hence, it is necessary to undertake the study of efficiency in the functioning of organizations like hospitals that provide healthcare services to the people.

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