DETERMINANTS OF COST EFFICIENCY OF PUBLIC AND PRIVATE HOSPITALS OF KARNATAKA STATE IN INDIA

MAATHAI K. MATHIYAZHAGAN[1]

Abstract

The main objective of this paper is to analyze the determinants of cost efficiency of public and private hospitals of Karnataka State in India. This is estimated through the parametric (stochastic frontier) and nonparametric (data envelopment) methods by using the Hospitals Facility Survey (2004) in Karnataka. The findings indicate that the choice of methods did not make any significant difference in the results and they are robust. 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; and (c) the main determinants of the technical and allocative inefficiencies of the public hospitals are 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. It emphasizes that hospitals need to maintain the quality of healthcare services under the emerging competitive environment in the State; otherwise, it would be subject to financial vulnerability since private hospitals highly depend on the user fee payment of the patients. Need based financing through "capitation fee" and an effective alternative payment mechanisms such as user fee with a protected social justice criteria for poor in the public hospitals are the worth considering options in the State.

Keywords: Hospital costs efficiency, stochastic frontier, data envelopment

JEL classification: I1, I12, I18

1. Introduction

'Hospital' is an economic institution with a social role in the community. Cost of providing hospital care services is very important under the scarce resources of health sector in developing countries like India. The national average expenditure on hospital and dispensaries of revenue account in India was around 43.99 per cent in 1950-51, which had been reduced to 25.75 per

1 Research Fellow, Institute of South Asian Studies, National University of Singapore, 469A Tower Block, Bukit Timah Road, #07-01, Singapore-259770, Email: isasmkm@nus.edu.sg, maatha@singnet.com.sg

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cent in 1994-95 and 15.76 per cent in 2003-04 respectively.[2] This same trend has been reflected at the State levels with significant variations. The highest proportion had been reported in Tamil Nadu State, which accounted for nearly 65.17 per cent in 1950-51 and had reduced to 43.52 per cent in 1994-95. It is imperative to note that Karnataka State, which is the focus of this paper, reported the second highest proportion spent on hospital and dispensaries. It accounted for nearly 63.04 per cent in 1950-51 and it had been drastically reduced to 22.91 per cent in 1994-95. It may be due to shift in the government policies towards healthcare delivery system in India. A low share of total hospital resources suggests that the government has emphasized on primary healthcare and their concern in reaching the rural population. It confirms from the recent estimation that for almost seven years between 1997-98 and 2003-04, spending on primary healthcare level by the Karnataka State remained fairly stable, which accounted to nearly 55 per cent (Mathiyazhagan, 2004a, 2004b). Though the share of tertiary level healthcare has increased from 27 per cent in 1997-98 to 34 per cent in 2003-04, there was a sharp decline in the share of spending on secondary level healthcare from 23 per cent to 13 per cent in the same period. Although the share of government health resources going to hospitals is a rough indicator of the structure and emphasis within the health sector, there is a need for the analysis whether the share of health sector resources used by the hospitals are economically efficient at State levels in India. The hospital care is valuable but it has been considered to be costly (Mathiyazhagan 2003a; 2003b) and therefore a better understanding of the hospital performance could be useful to improve social welfare in India.

In recent years, there has also been a growing trend towards the private healthcare providers in India (Bhat, 1993; Mathiyazhagan, 2003a). This trend has brought into the forefront investigations of difference in operating performance of costs of different types of hospitals ownership at State levels in India. However, the studies on hospital costs function literature in India are very few irrespective of numerous studies available at the international levels. The exiting studies such as Krishnan et al (2005), Bhat et al (2001), Parikh and Karnad (1999), Sharma (1998) and Goldar and Agarwal (1995) were focused only on estimating unit cost of the different healthcare services of the hospitals. The cost per out-patient visit at primary level was higher than at the secondary level. Further, at the primary and secondary level, non-physician cost was more than the physician cost and for tertiary level, physician cost was much higher than the other costs. These findings were common in all these existing studies, which focused only on the public hospitals. In fact, none of these studies give any account of cost efficiency of hospitals and its determinants in India. Therefore, this paper focuses on cost efficiency of public and private hospitals and its determining factors in Karnataka State, India.

2. Analytical Framework for Hospital Costs Efficiency Function

Hospital cost efficiency function can be estimated by setting parametric and non-parametric models. Most parametric models are similar to the specification of a Stochastic

[2] Compiled and estimated from the combined finance and revenue accounts for the respective years, Reserve Bank of India.

Frontier (SF) cost function by Aigner et al., (1977),[3] while non-parametric models are basically drawn from Data Envelopment Analysis (DEA).[4] These models adopt conceptually similar theoretical approaches and estimate the general cost efficiency and decomposition of cost efficiency into technical and allocative efficiency. However, there are problems in decomposition of cost efficiency by using stochastic frontier models (Atkinson and Cornwell, 1993; Kumbhakar, 1996). In terms of computational procedure, the SF analysis necessitates a large sample size for statistical reasons. In addition, it is generally regarded as a disadvantage that the distribution of the technical inefficiency has to be specified, i.e. half-normal, normal, exponential, log-normal and so on.[5] Therefore, this paper uses the stochastic frontier cost function for estimating overall cost efficiency along with DEA. It is useful to check are there any differences in estimation of the parameters between these two models. If there is any significant difference in the estimated parameters, the robust model is used for the decomposition of the cost efficiency into technical and allocative efficiency of the hospitals.

Cost efficiency of the hospitals was estimated with short-run multi-product cost functions since major capital investments were excluded from the analysis. An appropriate functional form for the analysis was derived after a set of statistical specification tests. It was found that Box-Cox transformed frontier cost function would best describe the costs of public and private hospitals of the sample and its equation as follows:

$$\ln\frac{C_i}{w_i} = \alpha + \sum_{j=1}^{m}\beta_j y_{ij}^{(\lambda)} + \delta \ln w_i + u_i + v_i \qquad \dots (1)$$

Where C is total costs, w and y are input prices and outputs respectively. The Box-Cox transformation is $y^{(\lambda)}=(y^{\lambda}-1)/\lambda$. Using the cost functions, Shephard's (1970) lemma gives the input choices, which are efficient and thus provide the benchmark against actual demands. In order to estimate individual efficiency measures, residual has been decomposed by using the technique suggested by Jondrow et al., (1982). Accordingly, the conditional estimates of u_i, $E[u_i|v_i+u_i]$, were used to find estimates for the individual inefficiency terms.

The DEA models assume the production possibilities set to be convex and to exhibit constant or variable returns to scale. It is not necessary to make assumptions about the parameters and the functional form of the production correspondence. Advantage of DEA is relatively easy to use when the decision making units (DMUs) use multiple outputs. The

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3 The parametric method like SFA is an econometric technique, which uses regression analysis to estimate a conventional cost function that efficiency of a trust is measured using the residuals from the estimated equation. The error term is therefore, divided into a stochastic error term and a systematic inefficiency term. The recent work on cost efficiency of hospitals includes Wagstaff (1989), Zuckerman et al (1994), Wagstaff and Lopez (1996), and Rosko (2001).

4 DEA is a linear programming method, which enables the measurement of efficiency consistent with the theoretically based concept of production efficiency. It examines the relationship between inputs into a production process (resources used in a hospital) and the outputs of that process (for example number of patients treated within each hospital). Some of the works include Burgess and Wilson (1996), Magnussen (1996) Linna (1998), Seiford (1994), and Wagstaff (1989).

5 See more details in A.C. Worthington (2004) Frontier Efficiency Measurement in Healthcare: A review of empirical techniques and selected applications. Medical Care Research and Review, 61(2): pp.1-36.

efficiency scores are determined by the ratio of the sum of weighted outputs to the sum of corresponding weighted inputs. The weights are determined so as to show the DMU at maximum relative efficiency. Cost efficiency can be measured if input prices are available in addition to output and input data. Therefore, the measurement of the cost efficiency by DEA is obtained via a two-stage process: (1) compute the minimum price-adjusted resource usage given technological constraints and (2) compare this minimum to actual observed costs. Let x = (x_i ......x_k) є R_i^k denote a vector of inputs and y = (y_i......y_m) є R_i^m denote a vector of outputs. The cost efficiency model (DEACE1) can be specified as:

$$Min_{p.x} \sum_j w_{j0}.x_j$$

Subject to :

$$\begin{aligned} & p.Y \geq y_0 \\ & p.X \leq x \\ & p_i \geq 0 \\ & \sum_{i=1}^{n} p_i = 1 \end{aligned} \qquad \ldots (2)$$

where Y is an n×m matrix of observed outputs for n hospitals and X is an n×k matrix of inputs for each hospital. P is a vector 1×n vector of intensity variables and w = (w_i......w_k) єR_i^k denotes input prices. The constraints of the model (2) define the input requirement set given by

$$L(y) = \left\{ x : p.Y \geq y_0, p.X \leq x, p_i \geq 0, \sum_{i=1}^{n} p_i = 1 \right\} \qquad \ldots (3)$$

The input requirement set specifies a convex technology with variable returns to scale (VRS), which is imposed by the constraint $\sum_{i=1}^{n} p_i = 1$. Leaving the constraint out of the model, captures the changes in the technology to constant returns to scale (CRS). In this paper, CRS model (DEACE2) was also estimated to control any possible identification problems.

The cost minimizing set of inputs x^* can be used to calculate the cost efficiency (CE) by CE = $w'.x^*/w'.x$, where x are actual, observed inputs used. Another possibility for obtaining cost efficiency estimates is to measure a 'global cost efficiency', where total costs TC=w'.x are used as the input variable. The usual meaning of allocative inefficiency is that the input factor mix is suboptimal with respect to prevailing input prices when different sets of prices are defined exogenously for each decision making unit (DMU). Assuming identical input prices, cost efficiency has been calculated by following linear program (DEA3):

$$Min_{p, \lambda_{CE}} \lambda_{CE}$$

Subject to:

$$p.Y \geq y_0$$
$$p.C \leq \lambda_{CE}.c_0$$
$$p_i \geq 0 \qquad \dots (4)$$
$$\sum_{i=1}^{n} p_i = 1$$

Where c is a scalar representing a cost level or budget level, C is the n×1 matrix of observed costs and λ_{CE} is the weight[6] given to hospitals in forming a convex combination of the output or input vector. In eliminating the summation constraint, changes the model (DEA4) to constant returns to scale (CRS).

The decomposition into allocative and technical components can be estimated by solving the following linear program, which gives the input oriented technical efficiency[7] component (details in Hollingworth *et al* 1999 and Jacobs *et al* 2006):

$$\text{Min}_{p,\lambda}\,\mu$$

Subject to:

$$p.Y \geq y_0$$
$$p.X \leq \mu.x$$
$$p_i \geq 0 \qquad \dots (5)$$
$$\sum_{i=1}^{n} p_i = 1$$

Since the technical inefficiency component is given by solution TE= μ^*, it is simple to calculate the allocative efficiency[8] by AE=CE/TE. The summation constraint on intensity variables p in the equation (5) imposes variable returns to scale (VRS). Eliminating the summation

6 When weighting, this paper have followed the approach used in Sexton, Leiken, Nolan et al (1989); Ozcan, Luke and Haksever (1992) and Ozcan and Luke (1993). It uses the relative costs attached to the DRGs as aggregation weights.

7 The basis of DEA to measure technical efficiency uses Farrell's concept within a single dimension. In the simple case of a single input-output firm and within a single time period, technical efficiency, is defined as TE=y/x. The more output (y) is produced from a given amount of input (s) the greater is TE. However, the inputs and outputs can not be simply summed up. Rather, weights are assigned to each input and output. For a sample of hospitals, a measure of technical efficiency can be calculated for each hospital, defined as the ratio of weighted sum of the outputs relative to a weighted sum of its inputs. The objective of each hospital is to maximize this ratio suhject to its technological constraints. When this maximum is attained, TE = 1 and when not TE < 1. There is a difficulty in solving maximizing input and output ratios. But it can be reformulated into a straightforward linear programming (LP) problem by constraining the numerator or denominator of the efficiency ratio to equal unity. The decomposition of allocative and technical efficiency can be undertaken by regressing efficiency scores against various explanatory variables which are thought to influence performance; where Tobit analysis is the most appropriate technique, with DEA scores being maximum likelihood estimators.

8 This is the reciprocal measure of the distance function by Farrell (1957) and Shepard (1970).

constraint, changes the model to constant returns to scale (CRS). The scale efficiency of cost (SCE) measure has been estimated as the ratio of CRS technical efficiency to VRS technical efficiency (i.e., $SCE = TE_{CRS}/TE_{VRS}$).

The aim of the analysis is not to measure efficiency *per se* but to analyze their determinants. The determinants of various components of cost efficiency scores were estimated by using two methods viz., ordinary least squares regression for parametric efficiency scores and censored Tobit model for DEA scores. The efficiency score was modified to explain the degree of inefficiency by setting $\Phi = (1/\phi) - 1$. In this case, the inefficiency scores are regressed i.e. the negative sign of a coefficient means an association with efficiency, which allows it to be modeled by the following form:

$$\Phi^* = \sum_i \beta_i . x_i + \varepsilon \qquad \dots (6)$$

$$\Phi = 0 \ (\text{if } \Phi^* \leq 0)$$

$$\Phi = \Phi^* \ (\text{if } \Phi^* > 0)$$

where $\varepsilon \sim N(0, \sigma^2)$, and β_i are the parameters for explanatory variables x_i.

3. Variables and Data Source

The total operating costs (TOC) of the hospital has been used as a dependent variable in the model. It is measured as a sum of recurrent cost of hospital in a given year. It includes all production related costs of a hospital. Three variables are used as measure of outputs (y_i) in the analysis. It includes (a) total number of outpatient visits, (b) DRG weighted total inpatient days and (c) weighted sum of quality index of the hospitals. The measurement of the outpatient visits is sum of outpatient visits and emergency visits. In the case of inpatient days care services; it used a DRG patient classification system with weighted average costs incurred by each episode classifications. The weighted average cost was used for the eight main DRGs specialization of the hospitals.

The case mix of the hospitals by the degree of specialization in terms of DRGs has been used as one of the determinants of inefficiency of the hospital costs. It has been measured as number of cases belonging to hospital and DRG category by index method.[9] It is a cost-

[9] DRG-Index for inpatient days $= \sum_j q_{ij} . \ln\left(\frac{q_{ij}}{p_j}\right)$, where DRG-IID is a DRG index for inpatient days, q_{ij} is the proportion of each DRG case to total DRG cases in a hospital, p_j is the proportion of sum of all DRG cases in all hospitals to total cases (i.e. total cases of inpatient and outpatient cases treated in the hospital). The estimated DRG-IID is equal to zero if no specialization occurs and hospital DRG case proportion increases according to the level of specialization of the hospitals.

weighted[10] measurement for DRG-index for inpatient days (DRG-IID) as the DEA measure tends to give high efficiency scores for the units with a specialized output structure (Nunamaker, 1985). These index variables related only to inpatient days of the hospitals and it is very difficult to get data on DRG adjusted proportions for output visits of the hospitals. Other variables included in the determinant analysis of inefficiency of hospitals costs are the relative number of outpatient visits to all patients, the percentage of total medical personnel working hours to the total working hours of other non-medical personnel, number of beds, and quality of healthcare of hospitals.

An increase of quality of the healthcare in the hospitals always coincides with increase in costs and vice-versa. It implies a low average cost is due to an inadequate provision of drugs and thus would represent poor quality and inefficiency. It is necessary to recognize the quality factors of hospitals in the efficiency analysis. Therefore, Donabedian's framework (1966) of healthcare quality was used in the analysis. It measured quality of the hospitals in terms of structural, process and outcome units. The structural units of the hospital included (1) the availability and adequacy of infrastructure facilities like drugs and sundries, (2) availability of equipments such as thermometer, sterilizer, stethoscope, BP manometer, wound dressing sets, examination beds, vaginal speculums, reflex hammer, and refrigerators, (3) provisions for the waste management in the hospitals, and (4) maintenance of patient medical records. The indicators for the process units of the hospitals are included in the analysis: (5) factors attracting patients to the hospital in terms of efficient delivery of services and good doctor-patients relationship, provision of services with good technical quality, and (6) operating constraints of each hospital's bureaucracy and hierarchy, difficulty in getting a technically qualified staff and the constant availability of supplies and increasing number of non-paying patients, and (7) participation in public health promotion activities such as immunization drives, family planning, leprosy, TB, blindness and HIV/AIDS control programs in the hospitals. The outcome unit of the hospitals is (8) basically reflection of strengthening the policy measures of the public and private hospitals. The private-public partnership (PPP) measures contracting out of government services to private sector, government support to private hospitals including supply of drugs and training of staff, which have direct bearing on hospital costs. The Likert Scaling Method has been used to include all the PPP indicators numerically through ordinal measurement.[11] The number 4 stands for very good, 3 for good, 2 for bad and 1 for very bad. The mean score of 0 has been allotted to

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[10] It is a weighted log of a hospital's DRG proportions in monetary terms (i.e. DRG-IID*) and calculated as the produced quantity of the hospital and multiplied by the marginal cost estimates β_j from the equation 1. The DRG-IID* = $\sum_j \hat{\beta}_j y_{ij} . \ln\left(\frac{\hat{\beta}_j y_{ij}}{\hat{\beta}\bar{y}_j}\right)$.

[1] Any scale obtained by adding together the response scores of its constituent items is referred to as a Likert or summative scale. This method is used in this paper for analyzing a set of items, composed of approximately an equal number of favorable and unfavorable statements concerning the attitude object (that is quality of the hospital), which has been given to a group of subjects (that is, sources of provider). Hospital administers have been asked to respond to each statement in terms of their own degree of agreement or disagreement. They have been instructed to select one of the four responses: very good, good, very bad, and bad. The specific responses to the items have been combined so that hospitals with the most favorable attitudes will have the highest scores while hospitals with the least favorable or most unfavorable attitudes will have the lowest scores.

'no comments'. The average score of each indicator of the sample hospitals has been assumed to have higher quality healthcare if the score value was high and vice-versa (Mathiyazhagan, 2003a).

Three types of input variables (x_i) and related prices (w_i) were used viz., (a) average total working hours of medical personnel, (b) average total working hours of non-medical personnel, and (c) total costs of materials and equipment and other costs. The price variables (w_i) such as average hourly wage rate of medical personnel, average hourly wage rate of the non-medical personnel, and average price of materials, equipments and other costs were also used in the analysis.

For data on hospital cost and its associated determinants, the paper uses two Hospital Facility Surveys (HFS, 2004) in Karnataka State. The first HFS survey had been carried out by the author of this paper as a part of International Health Policy Program (IHPP) in 1993-94. The same hospitals had been revisited (in 1996-97, 1999-2000, 2003-04) and it formed four waves of panel data set of the hospitals in the State. However the paper uses the only recent survey in 2003-04. The revisits of the hospital had been supported by the Asian Foundation of Social and Economic Change (AFSEC) in Tamil Nadu (India). The second HFS (2004) had been carried out by the Karnataka Health System Development Project (KHSDP) with a sponsorship of World Bank, where the author was a member of the research team of the survey. The total sample hospitals for the IHPP-AFSEC survey was around 86 (i.e., 40 and 46 of public and private hospitals respectively). The total sample hospitals for the KHSDP survey was around 161 (i.e., 80 and 81of public and private hospitals respectively). However, this paper uses only 13 hospitals from the KHSDP survey in order to get more representation of the private hospitals. Thus, it forms nearly 99 sample hospitals (i.e. 40 and 59 of public and private hospitals respectively) for the analysis. It is confined only to the multipurpose hospitals with 75-150 beds, which are located at taluk and district levels in the State.

4. Hospitals in Karnataka State, India

Karnataka has been one among the proactive States for health sector reforms in India with introduction of user fee scheme at the secondary level public hospitals in 1994, contracting out of primary health centres to the non-profit private organizations, endorsing the private public partnerships in the delivery of healthcare system, implementation of state subsidized health insurance scheme for farmers in the State and pioneers in decentralized planning in India. A wide network of health care institutions with updated infrastructure was established in the State at all levels- primary, secondary and tertiary. There were around 300 hospitals of public and private sources with bed ratios of 88 beds for every 100,000 population. It provides various aspects of healthcare like outpatient, in-patient and preventive healthcare services, which provides a significant improvement in terms of health indicators over the past few decades.

The descriptive results[12] of the hospital survey demonstrate that the government hospitals were fully financed by the budget outlays of the state government as compared to the

[12] The Tables were not reported in this paper and it will be available by requests to the author.

private hospitals where 88 per cent of the revenue came from patients' direct out –of-pocket payments and 4 per cent from private insurance payment. The estimates of the total average cost of hospitals in Karnataka show that there is a significant difference between the cost of both public and private hospitals. The total average cost of government hospitals in the State was around Rs.80 million (US $ 1.82 million) as compared to the total average cost of private hospitals, which was around Rs.110 million (US $ 2.50 million). The variations of the total average cost between public and private hospitals are better explained by looking at the share of the components or inputs of average total costs. The inputs of total average cost are recurrent cost and capital expenditure. The average recurrent cost is an indicator that explains the efficiency of the hospitals with given outputs. The proportion of the average recurrent cost of private hospitals is much lower than the government hospitals in the State. The average recurrent cost proportion of the private hospitals was only about 40 per cent as compared to the proportion of the government hospitals (70 per cent) in the State. In the case of capital expenditure, private hospitals were spending more than the government hospitals. It accounts for nearly 58 per cent for private hospitals as against the 30 per cent in the government hospitals.

The most common out-patient cares offered by the government hospitals are general medicine, obstetrics and gynecology, and family planning and its average fee (i.e. put together as a group mean) of these services was about Rs.100 (US $ 2.27).[13] In the case of private hospitals, the most common out-patient care services offered were general medicines, pediatrics and obstetrics and gynecology and its average fee for these services were Rs.700 (US $ 15.91). The top three in-patient care services offered by both the public and private hospitals were family planning, obstetrics and gynecology and general medicine. The in-patient care services offered by the government hospitals were nominal as the average mean of these services only accounted for Rs.250 (US $5.68), which is four times lower than the private hospitals (i.e., Rs.1100 or US $ 25). It is also important to note that the most common diagnostic test provided in the government hospitals was blood smear, which has been considered as the third most common diagnostic tests service offered by the private hospitals. The average fee of this diagnostic service of the private hospitals was 15 times higher than the government hospitals. The routine tests of blood, urine and stool were the top most common diagnostic tests offered by the private hospital with the average of Rs.200 (US$ 4.55) and followed by the Radiology (X-ray) with average fee of Rs.250 (US$ 5.68) (Table 4). The nominal average fee of these common diagnostic tests indicate that it is only admission or entry charges for using these services in the government hospitals. It was found that there was no price competition in fixing fee for healthcare services among the hospitals in order to attract more clients and concurrently there is an increasing trend of private hospitals and nursing homes in the State.

5. Results and Discussion

The cost efficiency and its determinants of the hospitals have been estimated by both stochastic frontier and data envelopment analysis. The equations (2), (4) and (5) were solved using liner programming routines of GAMS software (version 148). The frontier model (equation

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[13] 1 US $ equals to Indian Rupees (Rs.) 44 in 2004.

1) and respective inefficiency measures were estimated using FRONTIER subroutine in LIMDEP (version 5.1) (Greene 1993). The algorithm is a maximum likelihood estimator that uses OLS estimates as starting values. The results have been reported in Tables 1 through 9. The results of total sample for frontier cost function reported in the Table 1, demonstrates that among two primary measures of outputs, an increase in outpatient visits resulted in a positive and significant impact on total operational costs of the hospitals. It implies that every one percent change in the outpatient visits of the hospital leads to 18 to 20 per cent change in the operational costs of the hospitals in the State. This means that the hospitals need to spend effectively on wage of the personnel, which is the important input factor of the hospital's operation cost. It is evident from the result that there is a positive and significant relationship between wages of medical and non-medical personnel and operation costs of the hospital (Table 1). However, the quality index, which is the proxy measure for quality of the care services and institutional characteristics of the hospitals, has registered an insignificant relationship with the operational costs of the hospitals. It indicates that hospitals are not proficient enough in providing a quality oriented care services irrespective of a positive relationship between the outpatient visits and the operational costs. It is also true in the case of inpatient days care services of the hospitals, which turns to hold an insignificant association with the costs in the State. It may be due to be the fact that hospitals at the lower levels have low bed occupancy rates in the State (Mathiyazhagan, 2003b).

The results also demonstrate that average cost efficiency score for the total sample was around 0.53 by the stochastic frontier model and the same was between 0.50 and 0.54 by the DEA models (Table 2). It implies that most of the hospitals were cost inefficient in Karnataka State in India, which is due to inappropriate technical and allocative system of resources in the hospitals. It is also evident from the results that the average level of technical inefficiency of the hospitals was around 0.50 with VRS hypothesis and 0.51 with CRS. The allocative inefficiency of the hospitals was around 0.48 and 0.50 with VRS and CRS hypotheses respectively. It implies that, on an average, 2-3 per cent of allocative inefficient added to the hospital costs. Thus, the cost inefficiency of the hospitals was contributed equally by both technical and allocative inefficiency levels in the State.

The average cost efficiency scores for public and private hospitals were 0.40 and 0.60 respectively by the SFM and it was ranging between 0.38 and 0.42 for public hospitals and 0.63 and 0.67 for the private hospitals by the DEA models. The estimations of average cost efficiency scores were not significantly different as is evident from the high correlation coefficient between the average cost efficiency scores by these two models (results are not reported here).[14] It implies that estimations are robust by these two models. Further, the results also show that the private hospitals appear relatively less inefficient than the public hospitals. Nevertheless, the average cost efficiency scores between public and private hospitals demonstrate a vast difference in the State.

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[14] It has been tested by F statistic at 5 per cent level of significance in terms of mean efficiency scores of the different models.

Table 1. Parameter Estimates for the Frontier Cost Function for Total Sample

Variables	*Box-Cox model*	
	OLS model	*Stochastic frontier model*
Constant	4.38	3.20
	(2.87)*	(2.48)*
Inpatient days	0.40	0.31
	(0.12)	(0.16)
Outpatient visits	0.20	0.18
	(2.98)*	(3.12)*
Quality index	0.023	0.019
	(0.49)	(0.53)
Wages (medical & non-medical personnel)	0.17	0.21
	(2.81)**	(2.75)**
R^2	0.80	-
Pseudo R^2	-	0.68
Log L	-	49.20
Heteroscedasticity: Breusch-Pagan X^2 (4)	18.9	-
Chow test: F(40, 59)	1	-
Box-Cox analysis: $H_0{:}\lambda = 0$, LR, $\chi^2(1)$	4.76	-
Endogeneity test: Hausman, χ^2 (1)	0.55	-
Multicollinearity (CI-Index)	35.8	-
N	99	99

Note: Figures in the brackets are't' values.
* refers to 1 per cent level of significance; ** refers to 5 per cent level of significance

As can be seen from the Table 3, the null hypothesis is rejected at 1 per cent level of statistical significance in each hospital category. It provides evidence that the differences in efficiency are statistically significant at 1 per cent level of significance. It is also imperative to note that low average efficiency score of public hospital is also due to the fact that very few public hospitals satisfy the highest level of technical inefficiency score of 1 in VRS and CRS models. It accounts for only 10 - 15 per cent of all the hospitals in the sample from the CRS and VRS models respectively. It may also be due to the competing interests of the government hospitals under the bureaucratic meddling, which may lead to restrictions or mandates in terms of hospital resources. It also supports the public finance arguments to characterize non-profit firms as contributing to social efficiency by providing levels of public goods that could be inadequately financed and do not always have required technology and equipments.

Table 2. Efficiency Scores of the Hospitals by Stochastic Frontier Model and DEA Models

Efficiency measure	*Total sample*	*Public Hospitals*	*Private Hospitals*
	Mean	*Mean*	*Mean*
Stochastic frontier model	0.53	0. 40	0.65
DEA models Cost efficiency:			
DEACE (1)	0.50	0.38	0.67
DEACE (2)	0.51	0.40	0.63
DEA (3)	0.54	0.42	0.66
DEA (4)	0.50	0.41	0.64
Technical efficiency (CRS)	0.51	0.30	0.65
Technical efficiency (VRS)	0.50	0.41	0.61
Allocative efficiency (CRS)	0.48	0.40	0.65
Allocative efficiency (VRS)	0.50	0.39	0.60
Scale efficiency	0.55	0.42	0.66

The average scale efficiency for the total sample was around 0.55, which also varies between public and private hospitals (Table 2). They were 0.42 and 0.66 for public and private hospitals respectively. It is evident from the results that cost inefficiency of the public hospitals was higher than private hospitals and there was no significant difference in the cost inefficiencies attributed to the technical efficiency and allocative efficiency in the State. In the case of private hospitals, allocative inefficiency added an average of 5-6 per cent to hospital costs (Table 2). It implies that allocative inefficiency contributed to a slightly higher scale than the technical inefficiency of the private hospitals in the State.

The results also offer some insights into cost minimizing vector of inputs such as labour and minor capital used in the hospitals (Table 3). The results for the CRS model indicate that all types of hospital under-utilized labour input of medical personnel by an average of 35 per cent and 44 per cent of other inputs of materials and equipments. In the case of inputs of non-medical personnel, all types of hospitals were over utilized by an average of 3 per cent. The use of inputs varied between public and private hospitals. The use of non medical personnel and expenditure on material and equipments were nearly optimal for the private hospitals, while the public hospitals reported over utilization in the use of non-medical personnel by an average of 10 per cent. The results were similar in the case of VRS model. The results demonstrate that there is a need for rationalization of utilization of non-medical personnel of public hospitals in terms of contracting out these services.

The estimated efficiency scores were analyzed by regressing them against a set of observed characteristics of the hospitals. The determinations of parametric and non-parametric efficiency scores were examined by standard OLS regression and censored Tobit model respectively. The results from both the methods are robust and there are no much differences in the coefficient. The outpatient visits and share of medical personnel are statistically significant determinants of cost efficiency for all types of hospitals in the State (Table 4).

Table 3. Technical Efficiency of the Hospitals

Hospital ownership	*Mean (CRS model)*	*Mean (VRS model)*
Total sample:		
Technically efficient or optimal working hours of medical personnel	0.65	0.69
Technically efficient or optimal working hours of non-medical personnel	1.03	1.05
Technically efficient or optimal expenditure on material and equipments	0.56	0.51
Public Hospitals:		
Technically efficient or optimal working hours of medical personnel	0.80	0.82
Technically efficient or optimal working hours of non-medical personnel	1.10	1.12
Technically efficient or optimal expenditure on material and equipments	0.70	0.75
Private Hospitals:		
Technically efficient or optimal hours of medical personnel	0.90	0.91
Technically efficient or optimal working hours of non-medical personnel	0.98	0.98
Technically efficient or optimal expenditure on material and equipments	0.97	0.98

The other determinants such as hospital quality index and location of the hospitals do not have any significant contribution to the cost efficiency of the hospitals. Outpatient index is the only factor that is a statistically significant determinant of the cost efficiency of the public hospitals (Table 5). In the case of private hospitals, both the inpatient days and outpatient visits have turned out to be significant determinants of the cost efficiency in addition to the share of medical personnel and hospital quality index (Table 6).

The results from the analysis of the determinants of the technical, allocative and scale efficiencies of the hospitals demonstrate a significant variation across the type of ownership of the hospitals (Table 7 through Table 9). The analysis from all types of hospitals indicates that the inpatient days care index, outpatient visits and location of the hospitals were positively related with technical, allocative and scale efficiencies (Table 7). The results of the determinants of the technical, allocative and scale efficiencies also differ across the types of ownership of the hospitals. The public hospitals happened to be efficient in terms of technical and allocative systems only in delivering the services of outpatient visits (Table 8). This is due to the high demand of subsidized or free health services provided to the poor people by the public hospitals. It justifies the social role of public hospitals in the State.

Table 4. Determinants of Cost Efficiency Scores for Total Sample

Explanatory variables	Stochastic frontier estimates	DEA estimates			
	Regression co-efficient	Censored Tobit Model co-efficient			
		DEACE (CRS)	DEACE (VRS)	DEA (CRS)	DEA (VRS)
Constant	-0.69	1.22	1.01	0.98	0.76
	(-0.21)*	(0.35)*	(0.42)**	(0.27)*	(0.21)**
Inpatient days index	-0.28	0.67	0.58	0.65	0.61
	(-0.12)**	(0.86)	(1.02)	(1.13)	(0.90)
Outpatient visits	-0.87	1.12	1.28	1.31	1.02
	(-0.23)**	(0.30)*	(0.54)**	(0.68)*	(0.31)*
Share of medical personnel	0.65	0.59	0.43	0.61	0.54
	(0.24)	(0.11)	(0.06)	(0.20)	(0.15)
Beds capacity	0.31	0.24	0.28	0.34	0.22
	(0.15)**	(0.10)**	(0.07)**	(0.12)*	(0.06)**
Hospital quality index	1.23	0.44	0.29	0.35	0.39
	(0.10)*	(0.12)*	(0.11)**	(0.14)*	(0.16)**
Location of the hospitals	0.18	0.20	0.31	0.25	0.24
	(0.29)	(0.40)	(0.37)	(0.81)	(0.55)
σ	R^2=0.41	0.19	0.24	0.16	0.20
		(0.08)*	(0.10)**	(0.05)**	(0.09)**
Log-likelihood	-	23.01	19.32	30.16	23.40

Note: Inefficiency score is the dependent variable for both the models.

Figures in the brackets are't' values.

* refers to 1 per cent level of significance; ** refers to 5 per cent level of significance

The private hospitals has not only been technically efficient but also been efficient in allocation of resources in terms of inpatient days care index, outpatient visits, and share of medical personnel (Table 9). The results also show that in addition to the determinants of technical and allocative efficiencies, the scale efficiency of the private hospitals are correlated with the capacity of beds, and locations of the hospitals. Most of the private hospitals have been located in the urban areas, which affirms a high demand for outpatient visits and inpatient days care services. The hospital quality index indicator did not have any significant relation with technical, allocative and scale efficiencies of the private hospitals. It implies that private hospitals were efficient without any concerns for quality factors of the hospital services in the State as the hospital quality index did not have any significant relationship with cost interventions of technical and allocation of resources.

Table 5. Determinants of Cost Efficiency Scores for Public Hospitals

Explanatory variables	*Stochastic frontier estimates*	*DEA estimates*			
	Regression co-efficient	*Censored Tobit Model co-efficient*			
		DEACE (CRS)	*DEACE (VRS)*	*DEA (CRS)*	*DEA (VRS)*
Constant	0.89	1.42	0.91	1.18	0.96
	(1.20)	(1.15)	(0.66)	(1.32)	(0.91)
Inpatient days index	0.85	0.76	0.92	0.71	0.59
	(0.82)	(0.90)	(1.20)	(0.87)	(0.60)
Outpatient visits	-0.80	-1.10	-0.97	-1.14	-0.86
	(-0.29)*	(-0.61)*	(-0.43)**	(-0.63)*	(-0.32)**
Share of medical personnel	0.65	0.59	0.43	0.61	0.54
	(0.24)	(0.11)	(0.06)	(0.20)	(0.15)
Beds capacity	0.19	0.27	0.32	0.56	0.37
	(0.45)	(0.34)	(0.55)	(0.71)	(0.73)
Hospital quality index	0.11	0.36	0.18	0.29	0.28
	(0.15)	(0.30)	(0.15)	(0.26)	(0.25)
Location of the hospitals	0.13	0.10	0.04	0.08	0.50
	(0.09)	(0.08)	(0.05)	(0.09)	(0.45)
σ	R^2=0.38	0.23	0.32	0.55	0.29
		(0.12)*	(0.10)**	(0.24)**	(0.13)**
Log-likelihood	-	19.12	17.31	24.32	21.30

Note: Inefficiency score is the dependent variable for both the models.

Figures in the brackets are 't' values.

* refers to 1 per cent level of significance; ** refers to 5 per cent level of significance

6. Implications of the Results and Conclusion

This paper used the parametric and nonparametric methods to analyze hospital cost efficiency. The findings indicate that the choice of models did not make any significant differences in the results and they are robust. The analysis infers that (a) hospitals (both public and private together in the analysis) are 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; and (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. It means that standardization of hospitals and improvement in quality of healthcare services need to be attended immediately in the state.

Table 6. Determinants of Cost Efficiency Scores for Private Hospitals

Explanatory variables	Stochastic frontier estimates	DEA estimates			
	Regression co-efficient	Censored Tobit Model co-efficient			
		DEACE (CRS)	DEACE (VRS)	DEA (CRS)	DEA (VRS)
Constant	-1.18	-1.60	-1.23	-1.35	-1.42
	(-0.43)*	(-0.83)**	(-0.45)*	(-0.34)*	(-0.91)**
Inpatient days index	-0.66	-0.59	-0.72	-0.68	-0.52
	(-0.19)	(-0.27)**	(-0.29)*	(-0.25)*	(-0.13)*
Outpatient visits	-0.89	-1.23	-1.12	-1.30	-1.26
	(-0.18)*	(-0.50)*	(-0.55)**	(-0.60)*	(-0.43)**
Share of medical personnel	-0.79	-0.29	-0.10	-0.15	-0.19
	(-0.21)*	(-0.09)**	(-0.03)**	(-0.06)**	(-0.05)**
Beds capacity	-1.10	-1.18	-1.09	-1.17	-1.08
	(-0.43)*	(-0.58)**	(-0.29)	(-0.40)**	(-0.51)**
Hospital quality index	-0.10	-0.18	0.09	-0.17	0.08
	(-0.03)**	(-0.05)**	(0.06)	(-0.05)**	(0.06)
Location of the hospitals	0.09	0.50	0.06	0.17	0.30
	(0.19)	(0.40)	(0.05)	(0.15)	(0.27)
σ	R^2=0.43	0.40	0.28	0.36	0.20
		(0.10)*	(0.09)**	(0.10)**	(0.05)*
Log-likelihood	-	21.05	29.12	20.21	14.20

Note: Inefficiency score is the dependent variable for both the models.

Figures in the brackets are 't' values.

* refers to 1 per cent level of significance; ** refers to 5 per cent level of significance

The results are having serious implications related to emerging vast number of private voluntary and government sponsored health insurance scheme at the State level. The government hospitals will be out of the health insurance schemes as a service provider as it lacks the cost efficiency in general and technical and allocative efficiency in particular. It is also evident from the accreditation of hospitals for "Yeshasvini" health insurance scheme, where only 6 government hospitals were endorsed as a provider in this scheme as against over 100 private hospitals from all over the State.

The public hospitals are financed out of tax resources of the government, and its total outlays have been reduced in real terms due to the stabilization of fiscal monetization by the State (Mathiyazhagan, 2004a). It calls for a change in favour of need based financing and payment mechanism of the public hospitals. Though private hospitals are cost efficient, there is a need to main the quality of care services given the rise in competitive environment of private hospitals in the State. Since most of the private hospitals are highly depending on out-of-packet payments of the patients, it would be subject to financial vulnerability if the care services are not quality oriented.

Table 7. Determinants of Technical, Allocative and Scale Efficiency for the All Types of Hospitals

Explanatory variables	*Censored Tobit Model co-efficient from DEA estimates*				
	Technical efficiency (CRS)	*Technical efficiency (VRS)*	*Allocative efficiency (CRS)*	*Allocative efficiency (VRS)*	*Scale efficiency*
Constant	0.86 (-4.18)*	-1.57 (-4.60)*	0.60 (3.15)*	0.89 (3.21)*	0.32 (4.09)*
Inpatient days index	0.79 (3.17)**	-0.22 (0.29)	-0.32 (-0.25)	-0.36 (-0.33)	0.40 (0.38)
Outpatient visits	-1.10 (-3.50)*	-1.22 (-4.55)*	-1.30 (-3.60)*	-1.36 (-3.43)*	-0.56 (4.12)*
Share of medical personnel	0.68 (0.39)	0.50 (0.23)	0.25 (0.16)	0.19 (0.15)	0.45 (0.12)
Beds capacity	0.28 (0.22)	0.79 (0.29)	0.87 (0.40)	0.88 (0.51)	0.59 (0.021)
Hospital quality index	0.18 (0.12)	0.55 (0.31)	0.55 (0.12)	0.43 (0.10)	0.28 (0.13)
Location of the hospitals	-0.40 (-2.60)**	-0.29 (-2.57)**	-0.17 (-2.65)**	-0.30 (-3.27)*	-0.31 (-2.90)**
σ	0.30 (9.31)*	0.34 (11.20)*	0.45 (10.13)*	0.34 (8.15)*	0.21 (8.14)*
Log-likelihood	19.12	30.31	34.10	23.00	22.32

Note: Inefficiency score is the dependent variable for both the models.

Figures in the brackets are 't' values.

* refers to 1 per cent level of significance; ** refers to 5 per cent level of significance

Table 8. Determinants of Technical, Allocative and Scale Efficiency for the Public Hospitals

Explanatory variables	*Censored Tobit Model co-efficient from DEA estimates*				
	Technical efficiency (CRS)	*Technical efficiency (VRS)*	*Allocative efficiency (CRS)*	*Allocative efficiency (VRS)*	*Scale efficiency*
Constant	-1.35 (-4.12)*	-1.32 (-3.25)*	-1.19 (-3.14)*	-1.41 (-2.91)**	-1.29 (2.89)**
Inpatient days index	0.60 (0.27)	0.56 (0.21)	0.69 (0.34)	0.79 (0.45)	0.53 (0.40)
Outpatient visits	-0.23 (-2.90)**	-0.12 (-3.32)**	-0.40 (-2.89)**	-0.32 (-2.97)**	-0.40 (-3.01)
Share of medical personnel	0.22 (0.19)	0.18 (0.10)	0.25 (0.16)	0.21 (0.19)	0.20 (0.15)
Beds capacity	0.20 (0.19)	0.29 (0.10)	0.32 (0.21)	0.25 (0.19)	0.28 (0.20)
Hospital quality index	0.28 (0.20)	0.31 (0.16)	0.27 (0.15)	0.18 (0.10)	0.19 (0.23)
Location of the hospitals	0.30 (0.12)	0.16 (0.14)	0.29 (0.17)	0.26 (0.20)	22.0 (0.20)
σ	1.40 (2.70)**	1.73 (3.09)*	1.81 (3.17)*	1.20 2.95)*	1.51 (2.81)*
Log-likelihood	24.95	19.79	30.12	34.20	39.00

Note: Inefficiency score is the dependent variable for both the models.

Figures in the brackets are 't' values.

* refers to 1 per cent level of significance; ** refers to 5 per cent level of significance

Table 9. Determinants of Technical, Allocative and Scale Efficiency for the Private Hospitals

Explanatory variables	*Censored Tobit Model co-efficient from DEA estimates*				
	Technical efficiency (CRS)	*Technical efficiency (VRS)*	*Allocative efficiency (CRS)*	*Allocative efficiency (VRS)*	*Scale efficiency*
Constant	-1.65 (-2.93)**	-1.33 (-3.22)*	-1.40 (-3.21)*	-1.32 (-4.12)*	-1.30 (-2.89)**
Inpatient days index	-1.57 (-3.23)*	-1.71 (-2.87)**	-1.79 (-4.25)*	-1.52 (-5.43)*	-1.63 (-5.21)*
Outpatient visits	-2.12 (-5.51)*	-1.98 (-3.27)*	-1.30 (-2.90)**	-1.56 (-2.89)**	-1.76 (-2.93)**
Share of medical personnel	-1.29 (-1.09)	-2.30 (-3.32)**	-1.25 (-1.07)	-2.34 (-2.95)**	-1.87 (-3.71)*
Beds capacity	1.23 (0.65)	1.10 (0.35)	1.31 (0.48)	1.28 (0.63)	1.10 (1.30)
Hospital quality index	0.89 (0.54)	0.59 (0.76)	0.67 (0.94)	0.78 (0.56)	0.67 (0.54)
Location of the hospitals	-2.50 (-3.40)	-1.16 (-3.12)	-2.17 (-4.32)	-2.43 (-3.38)	-2.01 (-3.23)**
σ	0.80 (2.79)*	0.86 (3.12)**	0.72 (2.89)**	0.90 (2.95)**	0.43 (2.89)**
Log-likelihood	36.29	43.16	30.61	19.29	37.34

Note: Inefficiency score is the dependent variable for both the models.

Figures in the brackets are 't' values.

* refers to 1 per cent level of significance; ** refers to 5 per cent level of significance

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