VALUE JUDGMENT IN DATA ENVELOPMENT ANALYSES (DEA) OF THE SECONDARY HEALTH CARE IN PLATEAU STATE, NIGERIA

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ABSTRACT

Most Data Envelopment Analyses (DEA) focus on determining "efficient frontiers" or better still "best practices" for inefficient Decision Making Units (DMUs). For systems that render basically service to the society like the Hotels, Schools, Hospitals, etc., it is possible for a DMU to operate at the inefficient level not necessarily because it has any short comings but because it has excess input and/or limited area of impact. Increasing its output may be practically not possible because its target population is smaller compared to its size. Reducing its input will on the other hand impair its function and would cause to be defeated, the purpose for its establishment. Most times, Management have strong preferences about the relative importance of the different factors and what constitutes best practice, therefore it becomes imperative to incorporate these preferences as Value Judgment in the DEA Model. This study therefore, focuses on measuring the Technical efficiency of Hospitals operating in Plateau State taking into consideration Management Preferences (value judgment) using DEA. The study used Microsoft Excel Solver for the DEA analysis and found that the poor Health Status of the state is not attributable to the Secondary Health Care system only. The study thus recommends among others that Plateau State Government should consider subsidizing the cost of services of her hospitals to encourage patronage from the catchment community who obviously resort to finding substandard help from quacks and other private operators.

Keywords: ***Value Judgment, Efficiency, Healthcare, Management***

INTRODUCTION

Plateau State is located in North Central region of Nigeria. It has a population of about 2.8million, about 49.9% of which are males while 50.1% are females. The state is reasonably covered with health facilities as a result of the active participation of government, individuals and voluntary agencies in the health sector. In all, the Plateau State Government has fifteen Hospitals, forty-eight Maternal and Child Welfare Clinics, fifty-nine General Clinics and 285 Dispensaries. Individuals have forty-seven Hospitals, six Maternal Clinics, sixty-two Child Welfare Clinics, 310 General Clinics and 119 Dispensaries. Voluntary agencies own and operate five Hospitals, three Maternal Clinics, sixty-two General Clinics and forty-five Dispensaries (PLSG, 2004).
The number and variety of health facilities in Plateau State are impressive; unfortunately, the health situation in the state does not seem to reflect this as can be seen from the following UNFPA report:

The maternal mortality ratio in the state is estimated at 1000 deaths per 100,000 live births which is above the national average of 704 deaths per 100,000 live births, while infant mortality rate is 85 deaths per 1000 live births as against the national average of 75 deaths per 1000 live births. The area has a contraceptive prevalence rate of 1.2% which is below the national rate of 9%; this partly explains the high HIV prevalence rate of 8.5% as against national average of 5.4% (UNFPA, 2005).

The effective health care delivery in the state has not been realized, despite the available facilities provided by the various stakeholders. The volume of resources committed into health care provision (as evidenced by the number of institutions/facilities listed above), makes it a serious matter of concern that this does not seem to achieve the goals for which they were intended. The output of services as provided by the health systems are not quantifiable in units consistent with the units of the resources committed into the process. This compounds the problem of determining these efficiencies. Worst still, when we talk of efficiency in systems that render basically service to the society, it is possible for a unit to operate at the inefficient level not necessarily because it has any short comings but because it has excess input and/or limited area of impact. This makes the unit appear inefficient but, increasing the output of services may be practically not possible because its target population is smaller compared to its size. Reducing its input will on the other hand impair its function and would cause to be defeated, the purpose for its establishment. For such systems, it is necessary to determine the nature of their inefficiency. It is worthy of note here that sometimes Management have preferences regarding best practice, which could ordinarily be a cause of inefficiency. Davwar, Adelaiye and Nathan (2010) had in a study using simple DEA, concluded that hospitals operating at this level of health care in Plateau State are generally inefficient.

This study therefore aims at determining what constitutes inefficiency in these inefficient Hospitals taking into consideration Management preferences regarding what constitutes best practice.

THE VALUE JUDGMENTS AND DEA WEIGHT RESTRICTIONS IN HOSPITAL STUDIES

According to Allen, Athanassoupoulos, Dyson and Thanassoulis (1997), Value Judgments concerning the relative importance of inputs and outputs can be incorporated in the CCR model, via weight restrictions, according to three broad approaches having different implications on the assessed relative efficiency of hospitals:

(1) Imposing direct restrictions on the weights of some or all inputs and outputs. This approach can be applied in two ways: (i) Absolute weight restrictions, by imposing lower and upper bounds to weights; (ii) Assurance region methods, which impose constraints on the marginal rates of substitution between inputs or outputs (defined by the ratio between input or output weights);

(2) Adjusting the observed input-output levels (cone-ratio approaches);

(3) Restricting the virtual weights of inputs and/or outputs. For example, the virtual weight for output k of hospital *j* - which defines the proportion of the total virtual output of DMU *j* devoted to output *k*, and expressed as:

$$\frac{(u_{kj}y_{kj})}{\left(\left|\sum_{K=1}^{K}u_{kj}y_{kj}\right|\right)}$$ could be restricted within a given range.

The bounds used in weight restrictions can be either exogenously set according to policy-makers (or top management) objectives, expert opinion and price/cost information (where available) or endogenously derived from the data. In the latter case, running an unbounded DEA at the first stage could provide useful information for definition of the weight restrictions to use in the constrained DEA in the second stage. For example, Chilingerian and Sherman (1997) obtained optimal weights for inputs and outputs of primary care physicians with an unbounded DEA, at the first stage, and then used these weights to define a cone-ratio in a subsequent bounded DEA model based on Management's objectives.

Advantages of using Value Judgement

Imposing weight restrictions have proven beneficial as follows:

1. The analysis would otherwise ignore additional information that cannot be directly incorporated into the model that is used, e.g., the envelopment model;
2. Management has strong preferences about the relative importance of different factors and what determines best practice; and
3. For a small sample of DMUs, the method fails to discriminate, and all are efficient.

The proposed techniques for enforcing these additional restrictions include imposing upper and lower bounds on individual multipliers (Dyson and Thanassoulis, 1988); imposing bounds on ratios of multipliers (Thompson, Langemeier, Lee and Thrall, 1990), appending multiplier inequalities (Wong and Beasley, 1990), and requiring multipliers to belong to given closed cones (Charnes, Cooper and Thrall, 1989).

THE DEMAND AND SCALE EFFICIENCIES IN THE PERFORMANCE OF HOSPITALS

If the set of hospitals under examination includes units with excess supply with respect to demand, then the analysis of efficiency should capture this effect. In a hospital under a common regulatory body, an excess supply of hospital services could be due to past decisions of health care policy-makers. Over-sizing of capacity with respect to actual demand has a negative influence on DEA efficiency scores. This particular source of inefficiency can be defined as demand inefficiency. Moreover, if we consider the hospitals operating within the HMB (which make their decisions according to The State Ministry's guidelines), the Ministry could also be responsible, at least partly, for another source of inefficiency, i.e. scale inefficiency, arising from over- or under-sizing of hospitals with respect to their actual activity levels. In fact, within regulatory body, a hospital could be kept active for reasons regarding broader health care policy, even if it exhibits a non-optimal bed capacity, high levels of potential production and insufficient demand (Rebba and Rizzi, 2006; O'Neill, 1998).

METHODOLOGY

The data used for this study were secondary data. These are records of transactions of the various hospitals covered by this study. These include:

i Total number of admissions in each hospital in the year.
ii Total number of discharges in each hospital in the year.
iii Average number of Physicians in each hospital in the year.
iv Average number of Nurses and Midwives in each hospital in the year.
v Number of beds in each hospital.
vi Number of emergency/casualty cases handled by each hospital in the year.
vii Opinions of top management staff of the Board were sought regarding the relative importance of certain variables to the Health care project.

These data were collected from the records of each of the fourteen hospitals operating under the HMB and the four voluntary agency owned hospitals. See Appendix I

Using DEA, it was possible to provide evidence of the two major sources of external inefficiency namely: External Scale Inefficiency (due to a non-optimal hospital size) which can be measured by introducing the assumption of Variable Returns to Scale (VRS), as in the BCC (Banker, Charnes and Cooper) model. External Demand Inefficiency (due to a shortage of actual demand with respect to supply), takes account of the existence of an additional constraint on the demand side. This can be done by adding to the BCC-DEA model a non-discretionary demand variable (that proxies the actual demand level) among inputs, i.e. an exogenous demand variable that cannot be modified at the discretion of individual hospital managers. The consideration of an additional exogenous demand input in BCC-DEA was made following Cooper-Seiford-Tone's approach to the treatment of a non-controllable (NCN) variable (Cooper, Seiford and Tone, 2000).

In order to measure Demand Inefficiency, we considered a demand variable completely exogenous with respect to hospital management decisions. This should have been the potential demand of admissions for each hospital measured by past hospitalization rates or by a good estimation of the number of in-patients within the hospital's catchment area. Unfortunately these data were not available (in our case). Rebba and Rizzi (2006) suggested that "the non-discretionary demand variable could be proxied either by the hospitalization rate or by the number of residents in the Local Health Authority area where the hospital is located". However, the choice of these non-discretionary variables does not appear appropriate for several reasons. Firstly, hospitals are "point-services" whose demand cannot be easily circumscribed to a specific area (even though the higher percentage of admissions refers to residents within a particular Local Government Area boundary).

Secondly, since more than one hospital operates within the territory of a given LGA, it is difficult to share residential LGA demand between each hospital. To overcome these problems, we used the actual number of hospital admissions to approximate the non-discretionary level of demand. This is clearly an unsatisfactory choice, since the satisfied admissions demand is undoubtedly influenced by the hospital's production process. But Rebba and Rizzi, (2000) argued that the number of admissions (satisfied demand) cannot be larger than the expressed demand and that both are lower than the actual (latent) admissions demand. Therefore, if - after including in the BCC-DEA model the number of admissions among the inputs (as a non- discretionary variable) - we do not find any demand inefficiency, this can be surely considered a robust result. We therefore used the demand variable as input to determine the Internal Efficiency with VRS. It was therefore possible for us to determine:

(a) *Total Technical Efficiency with VR*S: e_j^s

(b) *Internal Technical Efficiency with VR*S, e_j^I which signals the ability of the hospital management to apply the most efficient production technique. These parameters were computed using the Microsoft EXCEL SOLVER.

The Value Judgment of the HMB over the most sensitive variables was inputted into the models as additional constraints as follows:

$$\alpha_i \leq \frac{v_i}{v_{io}} \leq \beta_i,\ \ i = 1,\ldots,m \text{, on input weights and}$$

$$\delta_r \leq \frac{\mu_r}{\mu_{ro}} \leq \gamma_r,\ r = 1,\ldots,s \text{, on output weights}$$

Here, v_{i0} and μ_{r0} represent multipliers which serve as 'numeraries' in establishing the upper and lower bounds α_i, β_i and δ_r, γ_r placed on input and output weights respectively. The above constraints form our Assurance Region constraints as developed by Thompson, et al (1990). The values of α_i, β_i and δ_r, γ_r respectively were determined from Policy specifications and opinions of top management Officers of the HMB. This opinion was determined as simple proportions obtained through responses to a set of Questions (See Appendix II) administered to randomly selected Management Staff of the Board.

The Total Inefficiency of a hospital *j* (1-e_j) was considered as the result of three components:

(a) *Internal Inefficiency* due only to hospital management, computed as (1- e_j^I);

(b) *External Scale Inefficienc*y, computed as the difference between total efficiency with VRS and total efficiency with CRS: (e_j^s - e_j);

(c) *External Demand Inefficienc*y, computed as the difference between internal efficiency with VRS and total efficiency with VRS: (e_j^I - e_j^s).

Determining the Constraints for Value Judgment

The constraints for the Value Judgment were determined from the responses given by randomly selected Management Staff of the Board.

Table 1: The sum of scores for each question item (as calculated)

S/N	Variable	Symbol	Total Score
1	Number of Physicians in the hospital	X_1	27
2	Number of Nurses and Midwives in the hospital	X_2	68
3	Annual Budgetary Allocation to a hospital	-	20
4	Number of Beds	X_3	33
5	Number of discharges made by the hospital	X_4	103
6	Number of Admissions made by a hospital	X_5	33
7	Number of emergency/casualty cases handled	X_6	29

From preliminary discussions with stakeholders in the health services sector, health care provision is basically all about nurses and Doctors admitting, treating and discharging patients. Any other arrangement in the hospital only facilitates the accomplishment of these activities. Therefore, the constraints imposed prevents the DEA model from either over-emphasizing or under-emphasizing any of these variables. From the totals above, it can be seen that:

$$\frac{X_2}{X_1} = 2.5185 \quad \text{And} \quad \frac{X_4}{X_5} = 3.1212$$

Thus; $X_2 - 2.5185X_1 \geq 0$ Thus; $X_4 - 3.1212X_5 \geq 0$

These therefore form the Value Judgment constraints which are appended to the basic DEA models [BCC/CCR].

The models analyzed are therefore;

e_j	e_j^s	e_j^I
Max $z = \sum_{r=1}^{s} \mu_r y_{ro}$ Subject to: $\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0$ $\sum_{i=1}^{m} v_r x_{io} = 1$ $X_{2j} - 2.5185X_{1j} \geq 0$ $X_{4j} - 3.1212X_{5j} \geq 0$ $\mu_r, v_i \geq \varepsilon > 0$	Max $\theta_o = \sum_{r=1}^{s} \mu_{ro} y_{ro} + w$ Subject to: $\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + w \leq 1$, *for all j=1,2,…,n* $\sum_{i=1}^{m} v_i x_{io} = 1$ $X_{2j} - 2.5185X_{1j} \geq 0$ $X_{4j} - 3.1212X_{5j} \geq 0$ $\mu_r, v_i \geq \varepsilon > 0$ w *free*	Max $\theta_o = \sum_{r=1}^{s} \mu_{ro} y_{ro} + w$ Subject to: $\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + w \leq 1$, *for all j=1,2,…,n* $\sum_{i=1}^{m} v_i x_{io} = 1$ $X_{2j} - 2.5185X_{1j} \geq 0$ $X_{4j} - 3.1212X_{5j} \geq 0$ $\mu_r, v_i \geq \varepsilon > 0$ w *free*

These models were solved using EXCEL SOLVER (Zhu, 2003).

RESULTS AND DISCUSSION

From the table, the scores in column eight [8] indicates that all the hospitals have a relatively good Internal Efficiency [in other words, their internal production mechanisms are efficient]. The inefficiency noted in columns 2 and 3 are as a result of External Inefficiencies (Column 7). This implies that they are either Demand Inefficiencies (Column 6) or Scale Inefficiencies (Column 5). A look at column 5 reveals that only one (1) hospital, DMU01 has Scale Inefficiency. This explains the nature of DMU01's Inefficiency as dominantly Scale Inefficiency. Column 6 shows that **all** the hospitals **except** the four hospitals [DMU04, DMU11, DMU15, and DMU16] have cases of Demand Inefficiency. One can also observe that the values in column 6 [the Demand Inefficiency scores], are equal to the values in column 7 [the External Inefficiency scores] except for DMU 01. This implies that the inefficiencies of the thirteen [13] hospitals are External Inefficiencies, and that the type of External Inefficiency is Demand Inefficiency.

Table 3: Comprehensive Table Showing Scale and Demand Effects on Hospital Efficiency Scores

Hospitals*	Total Eff. CRS e_j	Total Eff. VRS e^s_j	Intern Eff. VRS e^i_j	Scale Ineff (e^s_j - e_j)	Dd Ineff. (e^i_j - e^s_j)	Ext Ineff. (e^i_j - e_j)	Int. Ineff (1-e^i_j)	Total Ineff (1-e_j)
DMU01	0.75	0.93	1.00	0.17	0.07	0.25	0.00	0.25
DMU02	0.59	0.59	1.00	0.00	0.40	0.40	0.00	0.41
DMU03	0.95	0.95	1.00	0.00	0.05	0.05	0.00	0.05
DMU04	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00
DMU05	0.73	0.73	1.00	0.00	0.27	0.27	0.00	0.27
DMU06	0.23	0.23	0.98	0.00	0.75	0.75	0.02	0.77
DMU07	0.63	0.64	0.98	0.01	0.35	0.36	0.02	0.37
DMU08	0.25	0.25	0.99	0.00	0.74	0.74	0.01	0.75
DMU09	0.41	0.41	0.99	0.00	0.59	0.59	0.01	0.59
DMU10	0.67	0.66	0.99	0.00	0.32	0.32	0.01	0.33
DMU11	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00
DMU12	0.44	0.44	0.99	0.00	0.55	0.55	0.01	0.56
DMU13	0.27	0.27	0.99	0.00	0.72	0.72	0.01	0.73
DMU14	0.49	0.49	1.00	0.00	0.50	0.50	0.00	0.51
DMU15	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00
DMU16	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00
DMU17	0.41	0.41	0.99	0.00	0.58	0.58	0.01	0.59
DMU18	0.24	0.24	0.99	0.00	0.75	0.75	0.01	0.76
Number of Efficient DMUs								
	4	4	9					

Source: Survey, 2008.

CONCLUSION AND RECOMMENDATIONS

The result of the analyses agrees with Davwar et. al (2010) that there are cases of inefficiency among the hospitals operating under the Hospitals Management Board (HMB) in Plateau State. The worst being those of DMU06, DMU18, DMU08, and DMU13. But these inefficiencies are Demand Inefficiencies. This means that in these inefficient hospitals, there is an excess supply of hospital services with respect to demand and not that it is as a result of any failures of these hospitals to perform. Implying that, the Health Services delivery process is efficient for each of these hospitals. A simple reason for this occurrence could be the high number of private Hospitals and Primary Health care Clinics (PLSG, 2005) which provide cheaper and maybe faster services to the general public resulting in the low demand for Secondary Health Care services. The reason for the poor health status of the state is not attributable to any failures in the performance of the Secondary Health Care system in the state. Based on the findings of this study, this study believes that the following measures would enhance Health Services delivery in Plateau State.

1. The Plateau State Government should consider subsidizing the cost of services of her hospitals to encourage patronage from the catchment community who obviously resort to finding substandard help from quacks and other private operators.
2. DMU01 should be considered for upgrading in terms of manpower resource allocation and facilities to enable it meet the Health Services needs of its catchment area.
3. Supplies of Manpower and material resources to the four DEA Efficient hospitals namely, DMU04, DMU11; DMU15 and DMU16 should be sustained. And the manpower encouraged to ensure sustenance of current standards of service delivery.
4. The Primary and Tertiary Health care levels should be investigated.

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