ARTICLES

Cost Effectiveness of Kuwaiti Hospitals

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Abstract:

The objective of this paper is to estimate the production functions of the Kuwaiti governmental hospitals and their related efficiencies. It is shown that the public hospitals' production technology is of the Cobb-Douglas type, whereas the specialized hospitals have the Translog type technology. Moreover, it is shown that the specialized hospitals are more efficient than the public hospitals.

1. Introduction:

While health care privatization problems have been solved in the developed countries a long time ago, it is still prevailing in the developing countries. Currently, the State of Kuwait aims to privatize the public health sector for most of its hospitals. This economic situation imposes a statistical dilemma in terms of model building, which needs to be solved. However, it requires a robustness analysis, which is one of the old topics that requires any kind of data with gross error violating the statistical model assumptions, such as, normality, independency, and constant variance (Huber (1964,1967), Hampel (1968), Hampel et al.(1986)). Mathematically, it was introduced as M-techniques and modified H1-Ramzy (Hana (1992)).While, economically this statistical framework is evaluated to assess hospitals' efficiency, productivity and cost (Connor 1995, Vitaliano et al.1996, Cutler 1995, Newhouse 1987), by using Kuwaiti hospitals as a case study. Different production functions are examined as the Cobb-Douglas, Translog and the Least Square models. This paper will focus

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on the allocative efficiency rather than the technical efficiency to reflect the best usage of limited resources.

The objective of this paper is to analyze and compare the cost effectiveness between general and specialized Kuwaiti hospitals. The benefits of this investigation are : 1) to develop econometric models that explain the productivity and cost effectiveness in Kuwaiti hospitals 2) to evaluate the potential for successful privatization of health care organizations in Kuwait and its stability 3) to help policy makers in the Ministry of Public Health of Kuwait identify the effective methods that both maximize the employee's productivity and minimize the overall cost, and 4) analyze the robustness and stability of hospitals' efficiency over time.

The importance of the previous points has become an essential requirement recently under the resources' limitation constraint on the part of the Kuwaiti government.

2. Methodology:

This paper is mainly surveying various statistical, econometric and linear or nonlinear models (Creedy and Martin 1997) for increasing public access to the hospitals besides reducing service cost. A comparison among those models will lead us to choose the most appropriate method and model that fits the different Kuwaiti hospitals. For this purpose, the annual statistical data published by the Ministry of Public Health in Kuwait were used (see Appendix B, Al-Omar 2004).

However, the first mathematical representation was first proposed by Philip Wicksteed (1894) as $y = f(x_1, \ldots, x_m)$, where $y = Single\ output,\ x_1, \ldots, x_m = Factors\ of\ production,\quad y = Singleoutput,$ $x_1, \ldots, x_m = Factorsofproduction$ (*note: joint production was excluded). Then, this model has been developed by* Cobb and Douglas (1928) to become $P_i = bL_i^k C_i^{1-k},\ i = 1, \ldots, n,$ where $P_i = Output,\quad L_i = Labour(input),$ $C_i = Capital\ (output),\ b, k =\ Parameters\ should\ be\ estimated.$ Furthermore, another model, which is a generalization of the Cobb-Douglas production function, was used by introducing the Transedental Logarithmic production function (Translog). It has been used including both linear and quadratic logarithmic terms with an arbitrary number of inputs, (Zuckerman et al.(1994), Christensen et al. (1971, 1973)),

$$\ln(Q) = \beta_0 + \sum_{i=1}^{n} \beta_i \ln(x_i) + 0.5 \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} \ln(x_i) \ln(x_j),$$

$\beta_{ij} = \beta_{ji}$(to assure equality of the cross-partial derivations).

Generally, any factors under investigation can utilize the classical linear model which is of the form $Y_i = \underset{\sim}{x} i' \underset{\sim}{\beta} + \in_i$, $i = 1, ..., n$, where $\underset{\sim}{x} i' = (1, x_{i1}, ..., x_{ik})$, $\underset{\sim}{\beta} = (\beta_o, \beta_1, ..., \beta_k)$. As those models should be estimated, they will be of the forms:

1) Cobb-Douglas, $Q = AL^{\alpha} K^{\beta} e^{\in}$, which can be written in the logarithmic form, $\ln(Q) = \ln(A) + \alpha \ln(L) + \beta \ln(K) + \in$.

2) Translog, $\ln(Q) = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + 0.5\beta_3\{\ln(L)\}^2 + 0.5\beta_4\{\ln(K)\}^2 + 0.5\beta_5\{\ln(L)\}\{\ln(K)\} + \in$, where $\beta_0 = \ln(A)$, $\beta_1 = \alpha$, $\beta_2 = \beta$and $\alpha, \beta \geq 0$.

3) Regression model, $\ln(Q) = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + \in$. However, the interact-ion effects may be required for some factors under investigation.

3. The Data:

The structure of the data collected from the Kuwaiti hospitals is of the sort panel data, where its usage has several benefits as follows (Badi (1995)):

- Controlling for individual heterogeneity.
- Giving more informative data, more variability, less collinearity among the variables, more degree of freedom and more efficiency.
- Giving a better ability to study the dynamics of adjustments.
- Giving a better ability to identify and measure effects that are simply not detectable in pure cross-section or pure time-series data.

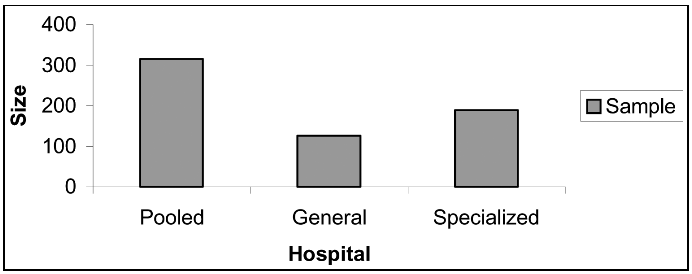
- Allowing, by modeling, to construct and test more complicated behavior models than purely cross-section or time-series data.
- Eliminating the biases resulting from aggregation over firms or individual, which increases the accuracy of measuring variables.
- Generally speaking, the panel data has the following reasonable limitations:
- Design and data collection problems.
- Distortions of measurement errors.
- Selectivity problems (self-selectivity, non-responsiveness, attrition).
- Short time-series dimension.

This type of data was available and collected from three main sources: 1) the Statistics Department of the Ministry of Planning, 2) the Statistics Department in Sharq area , and 3) the Health & Vital Statistics Department in Sabhan area of the Ministry of Public Health in Kuwait covering a period of twenty one year specifically from 1980 to 2000. The data cover 15 governmental hospitals divided into 6 general and 9 specialized hospitals. The latter are specialized according to the type of the disease. However, the number of patients discharged alive was the output variable (Greenfield (1974), Young et al.(1998)), whereas the number of nurses added to the number of doctors as labor and the number of beds as capital were the interested input variables (Cromwell (1974), Baron (1974), Al-Ahmadi (2001)). Some descriptive statistics and bar charts were calculated and plot to study the behavior of the data. Table1 shows the descriptive statistics for the input/output variables either in the pooled format or separated as general or specialized, while Graphs 1 and 2 show only the input variables' behavior.

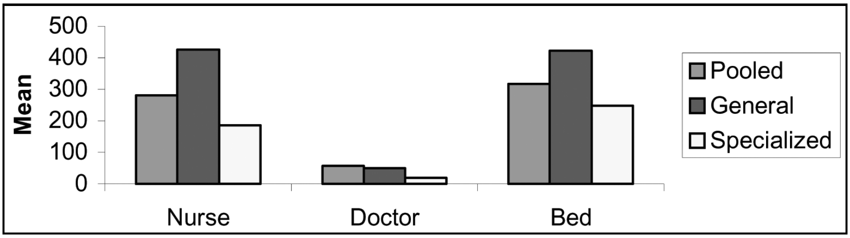
We notice from Graph1 that the specialized hospitals have higher size than the general hospitals, which means that the Kuwaiti government is giving the former higher weight or interest. Furthermore, Graph 2 shows that the specialized hospitals have the lowest mean whenever the input is labor (number of doctors and nurses), or capital (number of beds), while the highest mean in the general hospitals is for the number of nurses and number of beds. Finally, the pooled hospitals have the highest mean in the number of doctors only.

Table (1)
Panel Data Descriptive Analysis of Kuwaiti Hopitals

Variables	Sample size	Mean	Stanared Dividation	Minimum	Maximum
Patient Discharge alive					
Pooled	315	10989.15	10087.302	19	35673
General	126	19476.22	7203.177	2473	35673
Specialized	189	5331.10	7415.678	19	31875
Number of Doctors					
Pooled	315	57.62	54.483	2	222
General	126	109.19	49.222	23	222
Specialized	189	23.24	19.405	2	95
Number of Nurses					
Pooled	315	281.42	156.196	4	851
General	126	425.52	95.404	196	851
Specialized	189	185.35	107.245	4	473
Number of Labor					
Pooled	315	339.04	201.060	6	970
General	126	534.71	125.090	268	970
Specialized	189	208.59	119.787	6	566
Number of Beds					
Pooled	315	318.08	165.624	14	1021
General	126	421.65	114.667	128	879
Specialized	189	249.03	158.405	14	1021



(Graph 1) Panel Data Size Drawn from Kuwaiti Hospitals



(Graph 2) Panel Input Variables Data
(Capital and Labor Mean Level Comparison)

We should note here that this panel data went through a data filtering stage before being used. This stage consists of detecting unnecessary inputs of the labor or the irrelevant information, such as the consultants, emergency doctors, the out-patient and emergency nurses. This insures the only and real staff who is responsible for the real admission and discharge alive of purely healthy patient. Accordingly, the real staff wages were computed from the total cost. However, the ratios of the number of doctors or nurses were constant for the entire period of the twenty one year under study, which insures consistency. This means that the required specifications of labor for each hospital were almost constant. Mainly, this step helped in the reality of the fitting stage as the empirical results show.

4. Empirical results:

The following tables report the results of estimation of the production function for each hospital in Kuwait.

Table (2)
Cobb-Douglas Model for General Hospitals

General Hospital	Cobb-Douglas Production Function
Adan	$Q = L^{0.964919} \times K^{0.909754}$
Amiri	$Q = L^{0.520591} \times K^{1.038903}$
Jahra	$Q = L^{0.824659} \times K^{0.825107}$
Mubarak Al-Kabir	$Q = L^{1.095687} \times K^{0.465315}$
Sabah	$Q = L^{0.965015} \times K^{0.586036}$

Table (3)
Cobb-Douglas Model for Specialized Hospitals

Specialized Hospital	Cobb-Douglas Production Function
Chest	$Q = L^{1.012507} \times K^{0.517933}$
Maternity	$Q = L^{0.881119} \times K^{0.804395}$
Ibin-Sina	$Q = 17.7135 \times L^{0.780831} \times K^{0.227545}$
Cancer	$Q = 7.9582 \times L^{0.37785} \times K^{0.697473}$

Tables 2 and 3 show that the Cobb-Douglas production function fits the majority of the general and some specialized hospitals as:

- General : Adan, Amiri, Jahra, Mubarak Al-Kabir, Sabah
- Specialized : Chest, Maternity, Ibin-Sina, Cancer.

This is with zero p-value which refers to highly significant importance of the labor and capital and their effectiveness in the model description. Moreover, we notice that the technical progress is neutral in the Cobb-Douglas models. It has an impact importance on the labor and capital ($\ln(A) \neq 0$) in specific specialized hospitals (i.e., Ibin-Sina and Cancer), while it has no importance ($A = 1$, $\ln(A) = 0$) or has equal effect on the general hospitals over time. Also, those tables insure the increasing return to scale by notifying the labor and capital elasticity values that sum up to above one ($\alpha + \beta > 1$). On the other hand, the majority of the specialized hospitals and only Farwaniya hospital as general fit the Translog production function, which are:

- General : Farwaniya
- Specialized : Infectious, Allergy, Al-Razi, Rehabilitation, Cancer, Psychological hospital.

Table (4)
Translog Model for General Hospitals

General Hospital	Translog Production Function
Farwaniya	$Q = 1.3724 \times 10^{-31} \times L^{25.64519} \times e^{2.216574 \times \{\ln(L)\}^2} \times e^{-4.238292 \times \{\ln(L) \times \ln(K)\}}$

Table (5)
Translog Model for Specialized Hospitals

Specialized Hospital	Translog Production Function
Infectious	$Q = 1.883 \times 10^{-58} \times L^{31.4906} \times K^{25.28899} \times e^{3.579876\times\{\ln(L)\}^2} \times e^{3.450712\times\{\ln(K)\}^2} \times e^{-12.68079\times\{\ln(L)\times\ln(K)\}}$
Allergy	$Q = 9.2092 \times 10^{-4} \times L^{12.19087} \times e^{-2.773132\times\{\ln(L)\}^2}$
Al-Razi	$Q = 4.9663 \times 10^{-6} \times e^{0.37781\times\{\ln(L)\}^2} \times e^{0.272004\times\{\ln(K)\}}2$
Rehabilitation	$Q = 141.3260 \times e^{-2.319336\times\{\ln(L)\}}2 \times e^{-2.213292\times\{\ln(K)\}^2} \times e^{4.583461\times\{\ln(L)\times\ln(K)\}}$
Cancer	$Q = 96.1142 \times e^{0.038036\times\{\ln(L)\}^2} \times e^{0.078117\times\{\ln(K)\}^2}$
Psychological	$Q = 2.4384 \times 10^{-40} \times L^{34.97149} \times e^{2.839573\{\ln(L)\}^2} \times e^{-5.925898\times\{\ln(L)\times\ln(K)\}}$

If we look at tables 4 and 5, we get the impression of more flexible modeling process for more complicated specialized combination of variables' relationships. This is resembled by the combination of the quadratic and linear variables creating a relaxed model with free return to scale. We notice only Farwaniya general hospital follows this type of models showing the high importance of labor through the quadratic term of $\{\ln(L)\}^2$and the interaction effect with the capital of the $\{\ln(L) \times \ln(K)\}$ term. Moreover, we may notice that the elasticity of the labor of capital is always positive, while the elasticity of the quadratic terms is either negative or positive depending on the nature of the hospital and related type of disease. Obviously, the technical progress has an impact and vital effect on the purity of the discharged alive patient in the Rehabilitation and Cancer hospitals. Whereas, its importance decreases in the other hospitals.

Also, the regression models introduced a useful comparison with the Cobb-Douglas and Translog models declaring and supporting the nature of each hospital over time. They were classified as follows:

Linear:

1) General: Adan, Amiri, Jahra, Mubarak Al-Kabir, Sabah
2) Specialized: Chest, Maternity, Al-Razi, Rehabilitation, Cancer, Ibin-Sina

Quadratic:

1) General: Farwaniya, Sabah
2) Specialized: Infectious, Allergy, Al-Razi, Psychological.

Table (6)
Estimated Regression Models for General Hospitals

General Hospital	Regression Model
Adan	$\ln(Q) = 0.844\ln(L) + 0.749\ln(K)$
Amiri	$\ln(Q) = 0.457\ln(L) + 1.11\ln(K)$
Farwaniya	$\ln(Q) = -77.278 + 27.232\ln(L) - 2.274\{\ln(L)\}^2 + 0.749\{\ln(L)\times\ln(K)\}$
Jahra	$\ln(Q) = 0.780\ln(L) + 0.881\ln(K)$
Mubarak Al-Kabir	$\ln(Q) = 3.0110 + 1.056\ln(L)$
Sabah	$\ln(Q_1) = 1.138\ln(L) + 0.392\ln(K)$
	$\ln(Q_2) = 1.852\ln(L) + 0.84\ln(K) - 0.172\{\ln(K)\}^2$

Table (7)
Estimated Regression Models for Specialized Hospitals

Specialized Hospital	Regression Model
Chest	$\ln(Q) = 1.023\ln(L) + 0.441\ln(K)$
Infectious	$\ln(Q) = -73.738 + 17.505\ln(L) + 15.392\ln(K) - 3.278\{\ln(L)\times\ln(K)\}$
Allergy	$\ln(Q) = -10.315 + 14.926\ln(L) - 3.330\{\ln(L)\}^2$
Maternity	$\ln(Q) = 0.724\ln(L) + 0.980\ln(K)$
Al-Razi	$\ln(Q_1) = -36.41 + 4.527648\ln(L) + 3.429758\ln(K)$ $\ln(Q_2) = -14.324 + 0.406\{\ln(L)\}^2 + 0.308\{\ln(K)\}^2$
Rehabilitation	$\ln(Q) = 2.781 + 0.686\ln(K)$
Cancer	$\ln(Q) = 1.414\ln(L)$
Ibin-Sina	$\ln(Q) = 3.348 + 0.665\ln(L) + 0.273\ln(K)$
Psychological	$\ln(Q_1) = 0.228\ln(L)\times\ln(K)$ $\ln(Q_2) = 2.588 + 0.143\{\ln(K)\}^2$

Note: $Q = e^{\ln(Q)}$

We may notice that the linear regression models are compatible with the Cobb-Douglas production functions in Tables 1 and 2, while the quadratic regression models are compatible with the Translog production functions (see the above Tables 6 and 7). Moreover, some specialized hospitals followed the linear regression and the Translog production function (Al-Razi, Rehabilitation, Cancer), whereas only Sabah general hospital followed the linear or quadratic regression models and the Cobb-Douglas production function. Actually, we can clearly see that the regression coefficients are amazingly compatible, relatively, to the elasticity coefficients of the relevant labor and capital variables. Here, we refer to the usage and the location of the word "compatible" in this content text to describe the same behavior or pattern.

Table (8)
Classifications of the Hospitals' Efficiency Models'

Models Hospitals	Cobb-Douglas	Translog	Linear Regression	Quadratic Regression	Linear-Quadratic-cRegression
General Hospital					
Adan	S-SSE	*	S-SSE	*	*
Amiri	D-SSE	*	D-SSE	*	*
Farwaniya	*	IE	*	*	IE
Jahra	SE	*	SE	*	*
Mubarak Al-Kabir	IE	*	IE	*	*
Sabah	IE	*	IE	*	IE
Specialized Hospital					
Chest	IDE	*	IDE	*	*
Infectious	*	DIE	*	*	DIE
Allergy	*	DE	*	*	DE
Maternity	SE	*	SE	*	*
Al-Razi	*	DE	DE	DE	*
Rehabilitation	*	IE	IE	*	*
Cancer	SE	SE	SE	*	*
Ibin-Sina	SE	*	SE	*	*
Psychological	*	IE	*	IE	*

* Means not efficient (NE).

At this stage to clarify the robustness of the pre-discussed models, it is convenient to calculate the related efficiency indicators according to the following formula:

$$Eff_t = \frac{Cost_t}{Q_t}, t = 1,...,21, \text{ where } Cost_t = Laborwage_t + (50 \times Capital_t),$$

$Capital_t = (\text{ no. of beds})_t, Q_t = (\text{ Discharge alive patients})_t.$

The efficiency scores were classified, according to the graphical behavior of the efficiency plots over time for each hospital, to nine types (see table 8): efficient (E), not-efficient (NE), increasing efficiency (IE), decreasing efficiency (DE), decreasing-increasing efficiency (DIE), increasing-decreasing efficiency (IDE), stable efficiency (SE), stable shifted to stable efficiency (S-SSE), decreasing shifted to stable efficiency (D-SSE).

Those types support the following percentages:

i) Cobb-Douglas : 83% from general, 33.33% from specialized
ii) Translog : 17% from general, 55.56% from specialized
iii) Cobb-Douglas & Translog : 11.11% from specialized
iv) Linear Regression : 60% of all hospitals
v) Quadratic Regression : 6.667%
vi) Linear-Quadratic : 20%
vii) Linear & Quadratic : 6.667%
viii) Linear & Linear-Quadratic : 6.667%

5. Conclusion:

This study was confined to model and evaluate the production line for certain governmental hospitals in the Kuwaiti health sector with different input/output variables' combinations. This may add a new dimension to the policy makers' vision upon the importance and vitality of the health care, which may insure high quality health service. However, the vital data used were carefully chosen, precisely the production inputs (labor and capital) and output the discharge alive patient. The labor (number of nurses and doctors) variable needed to be filtered more to exclude the irrelevant staff not related to the real patient admission and discharge alive. Then, the Cobb-Douglas production function was applied to all hospitals, but it was applicable to 83% of the general and 33.33% of the specialized hospitals. Then, the rest were tested by the Translog production function, where 17% of the general and 55.56% of the specialized hospitals. Finally, the regression models were applied to all hospitals as 60%, 6.667%, 20%, 6.667%, and 6.667% for linear, quadratic, linear-quadratic, linear and quadratic, and linear and linear-quadratic models respectively. The regression coefficients were compatible to the production coefficients for the labor and capital.

To ensure the accuracy sensitivity analysis was used through efficiency scores and the long-run average-marginal cost behavior. However, the efficiency score reflects the allocative efficiency that measures the annual cost/patient discharged alive. This patient is either released from the actual data or the fitted production or regression models.

Mainly, it was found that general hospitals are of Cobb-Douglas type, whereas the specialized hospitals are of Translog type. Moreover, the specialized hospitals were found with higher efficiency scores than the public translating the higher cost of labor in the former. But the public hospital's efficiency is increasing, even if it is lower than the specialized ones' efficiency. While the latter has a steady efficiency, but relatively high, compared to the former. This was the direct reason behind the new policy of the policy makers to change their vision and think about the privatization of the health sector, through the new insurance program for the expatriates as a first step. But, clearly this step didn't help to reduce or minimize the annual cost. Patient ratio, which may give a clue to revise the current policy. This may suggest an alternative policy for allocating or re-allocating resources, which is expected to reduce the wasted time, effort and unproductive use of resources.

Finally, the production functions of the Kuwaiti hospitals are consistent with what is actually found in the production and cost analysis literature, whether the country is developing or developed.

Those conclusions suggest further research work to look for the main reasons of deficiencies and their reduction. This may suggest the need or importance of establishing a quality assurance department that follows and analyses the required data to minimize the annual total cost of each hospital, as well as the total cost of the Ministry of Public Health in Kuwait. This requires a professional computerized network, which links the Ministry with all of the hospitals including the private ones. This network may help to trace the patient's transference route between hospitals or hospitals with dispensaries. Which, may reduce the cost and insures the shortest medical path to the right patient to prevent the disease from reaching the chronic stage. This may reflect the need to establish a preventive medicine program and put strict conditions to reduce the patient's long stay possibility in any hospital or unnecessary medical diagnosis routes.

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