Efficiency of Health Service in Managing Common Diseases Using Data Envelopment Analysis

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Abstract: The objective of this paper is to investigate the level of health facilities and services provided by the Malaysian hospitals across the 14 states. We are inclined to believe that the states of the East Coast of Peninsular Malaysia being less developed are lacking behind in health facilities and service performance in meeting the need of the health demand from the general population. In this study, we will be rating the states availability of registered doctors and provision of hospital beds in both the private and government hospitals throughout Malaysia against the four major types of communicable diseases food poisoning, dengue fever, HIV and tuberculosis whose occurrences are most frequent according to the official health cases reported. This study intends to illustrate whether or not lower income states have the tendency to slack in health services, as health is an important component of the development and environmental agenda.

Keywords: Data Envelopment Analysis, Decision-Making Unit, Health Facility, Services

1 Introduction

The total number of deaths according to medically certified and inspected causes is on the increase from 51.9 thousands in 2000 to 56.3 thousands in 2001 and 57.6 thousands in 2002 (Malaysia, 2006). These figures show a gradual escalation of health condition over the short period of time although they may be expected to decline due to the increased population and better facilities of health service. As more people are coming to live in the cities where business and economic activities flourish with industrial development and urbanisation, congestion begins to worsen following increased transportation. This is a normal trend for the developing economies whereby industrialisation and urbanisation growth in turn give rise to a new dimension of social problem, that is, worsening of health. With the influx of people from the rural areas and foreign immigrants, there is a mixture of the rich and the poor, the educated and the illiterate and the healthy and the sick inhabitants. Air and water pollution are common that may affect health from vehicles discharges, mismanagement of solid wastes and exploitation of natural resources and the environment. Because people are more concerned about their survival and the daily needs of their livings, they tend to neglect their health.

Obviously there is a significant difference in the level of health condition in terms of facilities and services provided to the people between the developed and developing states of Malaysia that is worth investigating, as this issue is related to the state of development.

The objective of this paper is to rank the country's 14 states in accordance with the condition of health service. It is in line with the management performance of the health provision of the registered doctors and hospital beds in treating selected communicable diseases, namely food poisoning, tuberculosis, dengue fever and HIV. These four types of diseases are common among the Malaysians as reported by the official Social Statistics Bulletin (Malaysia, 2006). Studies on rating of health service across the Malaysian states are rarely carried out or perhaps have never been analysed systematically. This study is far from comprehensive but provides a foundation for a detailed gathering of data and information needed for future investigation.

2 Diseases Common to Malaysians

The condition of the communicable diseases that are pervasive of the Malaysian hospitals is presented here showing cases and types of communicable diseases treated in the various states of Malaysia in 2005 (see Table 1).

The total 46,165 cases of the communicable types of diseases shown in Table 1 constituted a large portion of the whole 57,758 cases treated in 2006. This means food poisoning, tuberculosis, dengue fever, viral hepatitis and HIV accounted for about 80.0% of the communicable diseases in Malaysia. As noted, the highest percent of food poisoning treatment took place in Pahang (30.1%), and this is followed by Kedah (10.1%) and Sarawak (9.4%). Tuberculosis is prevalent in Sabah (21.4%), Selangor (12.4%), Sarawak (10.1%), Johor (8.8%), Federal Territory of Kuala Lumpur/Putrajaya (7.9%), Kelantan (7.2%) and Perak (7.2%). It must be aware that many cases of these diseases are referred to the Kuala Lumpur or Selangor general hospitals because of better health facilities available in the cities thus making these advanced states more problematic with the actual reporting of the cases of the communicable diseases.

Dengue fever and haemorrhagic dengue fever are the other communicable diseases which are prevalent particularly in the state of Selangor. Approximately 33.9% cases of dengue fever and 37.4% cases of the haemorrhagic dengue fever were treated in Selangor alone in 2005 making the state foremost on the list of these treated diseases. As for viral hepatitis, the states of Sabah and Pahang evidently leading the list with 31.9 and 22.4%, respectively. For HIV, surprisingly the number of cases treated in 2005 was highest in Kelantan (20.3%) followed by the state of Selangor (13.6%), Pahang (12.8%), Johor (11.0%) and Federal territory of Kuala Lumpur (8.5%).

These figures are virtual data which represent the actual cases that are supposed to represent real cases reported by the states in their respective government and private hospitals. In the current analysis using data envelopment analysis (DEA)-solver, the raw data will be used as outputs with the number of registered doctors and the number of hospital beds as inputs. The number of nurses can be used as input, but such information is not available at the time of the analysis. This study will be able to project the number of doctors and hospital beds required under efficient operational condition. Given the current level of health facilities and the cases of communicable diseases, the objective is to identify states that perform better or more efficiently than the others.

The ultimate exercise as mentioned earlier is to investigate and prognosis how less developed states match up to the developed states in the utilisation of their health services and facilities that can be associated with their development status. These less developed states as revealed in our earlier finding of stochastic frontier efficiency ranking comprise the states of Sabah, Perlis, Kelantan and Terengganu. The concept of less developed state is totally different from the low income state because development assessment had taken into consideration both economic and social indices to form the composite development index.

In the next section, the methodology of DEA will be discussed to broaden the understanding and meaning of the technique. The DEA method is fundamentally a linear programming (LP) base; therefore, it is non-parametric, that is, the outcomes are not testable for the confidence level as in the stochastic frontier's estimated coefficients and equations.

3 Methodology

The analytical framework of DEA begins with identifying and defining output variables and input variables of interest to the economist and business analyst and any other fields of study wishing to find out about relative efficiency of a cluster of entity be it hospitals, individuals, institutions, regions and so forth. In the case of a single output–input relationship, one could easily recognise say between the numbers of sickness treated (y) and the number of doctor (x). In this study, we have several types of diseases as outputs, whereas

Table 1 Percent of types of communicable diseases treated in states of Malaysia 2005

State/region	Food poisoning	Tuberculosis (all types)	Dengue fever	Haemorrhagic dengue fever	Viral hepatitis	HIV	Total
Johor	7.05	8.80	13.43	10.41	12.81	10.96	10.76
Kedah	10.13	5.72	3.99	0.40	1.72	4.38	5.05
Kelantan	6.51	7.19	3.20	9.71	7.64	20.25	7.56
Melaka	3.23	2.14	2.40	8.61	1.02	2.52	2.47
N. Sembilan	4.78	2.90	5.71	3.50	0.82	3.19	3.99
Pahang	30.06	5.03	5.90	4.30	22.41	12.84	9.83
Perak	5.43	7.15	8.44	5.81	4.98	6.52	7.19
Perlis	2.43	0.64	0.59	0.00	0.20	2.11	0.96
Pulau Pinang	5.80	5.06	6.00	6.51	3.06	4.10	5.25
Sabah	3.02	21.24	4.58	2.70	31.86	1.49	11.25
Sarawak	9.39	10.12	2.46	1.00	2.66	1.70	5.69
Selangor	3.60	12.42	33.87	37.44	4.55	13.55	19.16
Terengganu	7.24	3.72	1.53	1.60	2.86	7.94	3.79
K. Lumpur/Putrajaya	1.34	7.87	7.89	8.01	3.41	8.46	7.06
Malaysia (no. of cases)	4,641	15,991	15,862	999	2,552	6,120	46,165
Percent of cases	100	100	100	100	100	100	100

Note: Recalculated from the data of the Department of Statistics, Malaysia (2006).

the number of doctors (private and government) and the number of hospital beds as inputs. If more hospital beds were available, more patients can be admitted for medical treatments, and similarly if more doctors were available, additional cases of sickness can be accommodated. Mathematically this input–output functional relationship can be presented as

$$y_{ij} = \mathrm{f}(x_{kj}), \quad i = 1, 2, \ldots, n, j = 1, 2, \ldots, m, k = 1, 2, \ldots, o, \tag{1}$$

where y_{ij} is the output of ith types of diseases treated by the jth states and x_{kj} is input of kth types (doctors and hospital beds) serving for the jth states.

The mathematical function presented above is to simplify the concept of outputs and inputs used in the current DEA. This functional relationship is needed in the stochastic frontier analysis, and the appropriate statistical tests are required to justify the relevant of the functional form adopted in estimating the parameters. For DEA framework, the virtual outputs and virtual inputs as defined above are required to formulate the programming problem. The virtual outputs are also defined as *the weighted sum of output* and the virtual inputs as *the weighted sum of inputs*. The technical efficiency is derived using the programming technique whose objective is to maximise the objective function of the ratio of virtual outputs over virtual inputs subject to the constraint that this ratio is equal to and less than unity. This fractional programming objective function is shown in Equation (2) and is known as Charnes, Cooper and Rhodes DEA model after Charnes et al. (1978).

$$\max \theta = \frac{\sum_{i=1}^{n} u_i y_{ij}}{\sum_{k=1}^{o} v_k x_{kj}} = \frac{u_1 y_{1j} + u_2 y_{2j} + \cdots + u_n y_{nj}}{v_1 x_{1j} + v_2 x_{2j} + \cdots + v_0 x_{0j}} \tag{2}$$

$$\text{subject to } \frac{u_1 y_{1j} + u_2 y_{2j} + \cdots + u_n y_{nj}}{v_1 x_{1j} + v_2 x_{2j} + \cdots + v_0 x_{0j}} \leq 1 \quad (j = 1, 2, \ldots, m) \tag{3}$$

$$u_1, u_2, \ldots, u_n \geq 0$$
$$v_1, v_2, \ldots, v_0 \geq 0$$

The constraint in (3) is set such that the ratio of virtual outputs over the virtual inputs will not exceed unity for every state, which represents the decision-making unit (DMU) in DEA framework. The output weights u_i and input weights v_k representing the non-negativity constraints are set such that their values will not be negative. The objective of this fractional programming problem is to estimate the numerical values of these input and output weights that will satisfy the maximum value of the objective function θ* whose limit is one.

The fractional programming problem in (2) mathematically can be transformed to the LP problem (Cooper et al., 2006, pp. 23-24). On the assumption that **v** as the row vector input weight and **X** input matrix as non-zero, Equation (2) is obtained, and by multiplying (3) by the denominator, we obtain the objective function for the LP problem by setting the denominator equal to one. The denominator is moved down as a constraint equation as shown in the following LP problem.

$$\max \theta = \mu_1 y_{1j} + \mu_2 y_{2j} + \cdots + \mu_{nj} \tag{4}$$

$$\text{subject to } v_1 x_{1j} + v_2 x_{2j} + \cdots + v_k x_{kj} = 1 \tag{5}$$

$$\mu_1 y_{1j} + \mu_2 y_{2j} + \cdots + \mu_{nj} \leq v_1 x_{1j} + v_2 x_{2j} + \cdots + v_k x_{kj} \quad (j = 1, 2, \ldots, m)$$
$$\mu_1, \mu_2, \ldots, \mu_n \geq 0$$
$$v_1, v_2, \ldots, v_k \geq 0$$

Defining the optimal solution of the objective function θ as θ*, the output weight μ as μ* and input weight ν as ν*, CCR-efficient DMU requires that the optimal value of the objective function θ* = 1 such that 'there exists at least one optimal value of μ^* and ν^* with $\mu^* > 0$ and $\nu^* > 0$ otherwise, DMU is CCR-inefficient' (see Cooper et al., 2006, Chapter 2, p. 24). The above LP problem written in multiplier form becomes (6), which is the primal LP problem. The dual LP problem of Equation (7) yields the same optimal value of θ^* from the primal CCR-efficiency value. This dual optimal value of the LP problem is refereed to as 'Farrell Efficiency' in recognition of Farrell (1957).

$$\begin{aligned} &\text{Maximise } uy_k \\ &\text{subject to } vx_k = 1 \\ &\qquad -vX + uY \le 0 \\ &\qquad v \ge 0,\ u \ge 0 \end{aligned} \tag{6}$$

$$\begin{aligned} &\text{Minimise } \theta \\ &\text{subject to } \theta x_k - X\lambda \ge 0 \\ &\qquad Y\lambda \ge y_k \\ &\qquad \lambda \ge 0 \end{aligned} \tag{7}$$

The DEA-solver uses the dual in (7) as Phase I in solving the objective function of the LP problem, as this is proven to give a more precise result of estimated multipliers. The problem is with the slack of input excess (s−) and slack of output shortage (s+) defined as

$$s- = \theta x_k - X\lambda, \quad s+ = Y\lambda - y_k. \tag{8}$$

Phase II is performed with the objective to eliminate the slacks using the dual LP solution of the primal of maximisation of sum of the input excess and the output shortfall slacks defined as $\omega = (es- + es+)$. This second phase dual LP problem is presented as

$$\begin{aligned} &\text{Minimise } -es- \ - \ es+ \\ &\text{subject to } \theta x_k = X\lambda + s- \\ &\qquad y_k = Y\lambda - s+ \\ &\qquad \theta \ge 0,\ \lambda \ge 0,\ s- \ge 0,\ s+ \ge 0 \end{aligned} \tag{9}$$

An optimal solution (θ^*, λ^*, $s-^*$, $s+^*$) of the second phase is called min-slack solution. 'If the min-slack solution satisfies $s-^* = 0$ and $s+^* = 0$, then it is called zero-slack' (Cooper et al., 2006, p. 45). The CCR-efficiency, radial efficiency and technical efficiency are defined in relation to the conditions of these slacks. 'If an optimal solution to θ^*, λ^*, $s-^*$, $s+^*$ of both phases of LP problems satisfies that $\theta^* = 1$ and all slacks equal zero, that is, $s-^* = 0$, $s+^* = 0$, then the DMU is called CCR-efficiency' (Cooper et al., 2006, p. 45). Otherwise, the DMU is called CCR-inefficient. Hence, CCR-efficient should satisfy both conditions $\theta^* = 1$ and all slacks are zero.

If and only if the first of these two conditions is satisfied, then it is referred to as 'radial efficiency'. In LP, the radial efficiency is referred to the DMU position on the frontier of LP line and distance from the corner point solution. The radial efficiency is also named as 'technical efficiency' whose value should be less than unity, i.e. $\theta^* < 1$. The reference set in DEA-solver is defined as peers in Coelli et al. (1998), which means the distance required for the radial efficient DMU to become completely technical efficient amounting to an equivalent CCR-efficient set if the DMU choose to become efficient.

One of the limitations of DEA applications is that all DMU are assumed to be rationale entities, and they will attempt to attain to the efficient corner point solution closest to their distances. The condition of efficiency performance is only known after the DEA analysis is conducted. Every DMU such as the firm, individual and other entity in the spirit of competition tries to strike for the best of their outcomes that will be rewarded in the production. In DEA although an entity such as the state health care would like to be competitive with the other healthcare services, they would not have the slightest idea about their standings

Table 2 Statistics on input and output data

	Doctor	Hospital beds	Food poisoning	Tuberculosis	Dengue fever	HIV
Maximum	3784	5467	1375	3396	5373	1237
Minimum	147	448	62	102	94	91
Average	1436.071	2771.571	330.0714	1142.214	1133	437
Standard deviation	1012.972	1357.572	311.579	795.4667	1280.317	328.1883

Table 3 Matrix correlation between inputs and outputs

DMU	Doctor	Hospital beds	Food poisoning*	Tuberculosis	Dengue fever	HIV
Doctor	1	0.868385	–0.24905	0.400923	0.72169	0.269097
Hospital beds	0.868385	1	–0.15453	0.666896	0.72532	0.185278
Food poisoning*	–0.24905	–0.15453	1	–0.13607	–0.1093	0.294286
Tuberculosis	0.400923	0.666896	–0.13607	1	0.360806	0.037449
Dengue fever	0.72169	0.72532	–0.1093	0.360806	1	0.40448
HIV	0.269097	0.185278	0.294286	0.037449	0.40448	1

*Only food poisoning exhibits negative correlation to both inputs of doctors and hospital beds implying that with increased doctors and hospital beds food poisoning is expected to decline.

until the result of their performances is known. Furthermore, the performance is only relevant for comparison within the number of DMU analysed for the study.

4 Results and Discussion

The result of basic statistics of inputs and outputs used in this DEA analysis of the 14 Malaysian states health performance using Banker, Charnes and Cooper Input DEA model (BCC-I) is shown in Table 2. The maximum number of doctors is 3784, and the maximum number of hospital beds is 5467. The corresponding minimum numbers are 147 doctors and 448 hospital beds, respectively. On the average, the ratio of hospital bed to doctor is about 2:1 implying that every doctor in Malaysia is assigned to serve two beds. The smaller is this ratio of bed to doctor, the better is the service expected from the health performance.

Table 3 shows the matrix correlation between the inputs and the outputs. As noted, doctor and the hospital beds are highly correlated with coefficient 0.868, which means they are directly associated with one another. If we were to run a simple regression between these two variables, we will find that the number of hospital beds would be directly dependent on the number of doctors and their association is highly significant from the statistical viewpoint. On the other hand, a couple of matrix correlation between the inputs and the outputs show mix results with some degree of association for variables like tuberculosis, dengue fever and hospital beds or doctor while most of them show no sign of correlation at all. However, the capability to run together two inputs, doctor and hospital beds with several outputs in this case food poisoning, tuberculosis, dengue fever and HIV, is a specialty for the DEA technique.

Figure 1 and Table 4 shows the order of efficiency score by state of the health service in communicable diseases. In terms of health service (doctor) and facilities (hospital beds) in meeting the need of communicable diseases, the less developed states such as Kelantan (1.0) and Sabah (1.0) scored exceptionally well according to the efficiency scoring. The Federal Territory of Kuala Lumpur (0.502), Pulau Pinang (0.530), Perak (0.532) and Melaka (0.542) recognised as developed states in Malaysia apparently ranked among the

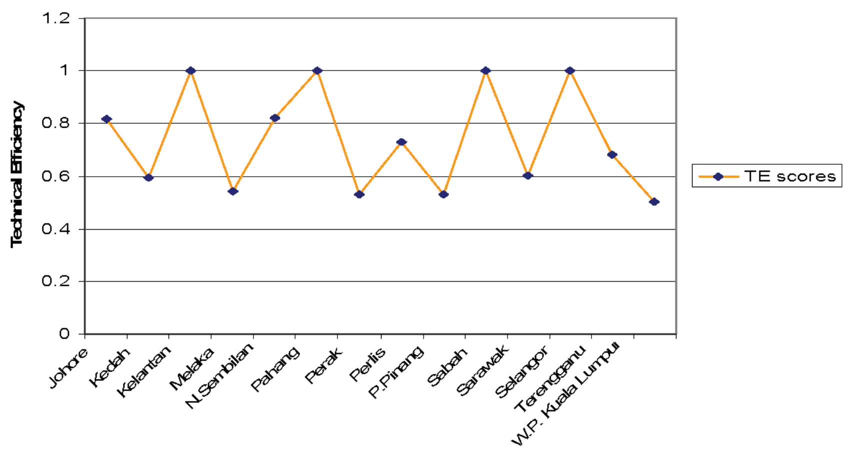

Figure 1 - Technical efficiency scores by states

Table 4 Rank order by states

Rank	DMU	Score
1.00	Kelantan	1
1.00	Pahang	1
1.00	Sabah	1
1.00	Selangor	1
5.00	N. Sembilan	0.820
6.00	Johor	0.819
7.00	Perlis	0.729
8.00	Terengganu	0.680
9.00	Sarawak	0.601
10.00	Kedah	0.595
11.00	Melaka	0.542
12.00	Perak	0.532
13.00	P. Pinang	0.529
14.00	Kuala Lumpur	0.501

least efficient of the 14 states. We may have doubt about the outcomes of this efficiency scoring but the fact shows otherwise. The possible explanation for the underscored inefficiency of the developed states could be due to the fact that these states tend to attract medical specialists and people to the areas because of the availability of up-to-date facilities and better remuneration schemes. Most people with financial ability would prefer their health to be treated by the specialists, in an exclusive way, less expensive but reliable and probably the best hospital around, when seeking for their medical advice and treatments. The influx of patients to the hospitals while servicing a large number of populations makes them less efficient.

The reference set for inefficient states is shown in Table 5. States with highest scoring of 1 considered as highest achievers include Kelantan, Pahang, Sabah and Selangor. They are fully efficient DMU by virtue of the fact that their excesses slack (s–*) and shortfalls slack (S+*) in the reference set of row cells are all zero. For the inefficient DMU Johor, there exists a cluster of reference set to choose to be fully efficient but the shortest distance is *Sabah* (0.110). Likewise DMUs Melaka and Perak each has a cluster of reference

Table 5 Reference set for inefficient DMU states

Decision-making unit	Reference set (lambda)							
Johor	*Kelantan*	0.221	*Pahang*	0.137	*Sabah*	0.110	*Selangor*	0.337
Kedah	*Pahang*	0.320	*Sabah*	0.171	*Selangor*	0.039		
Kelantan	*Kelantan*	1.000						
Melaka	*Kelantan*	0.032	*Pahang*	0.092	*Sabah*	0.041	*Selangor*	0.046
N. Sembilan	*Pahang*	0.142	*Sabah*	0.021	*Selangor*	0.141		
Pahang	*Pahang*	1.000						
Perak	*Kelantan*	0.102	*Pahang*	0.121	*Sabah*	0.158	*Selangor*	0.197
Perlis	*Kelantan*	0.061	*Pahang*	0.069				
P. Pinang	*Pahang*	0.167	*Sabah*	0.122	*Selangor*	0.132		
Sabah	*Sabah*	1.000						
Sarawak	*Pahang*	0.275	*Sabah*	0.411				
Selangor	Selangor	1.000						
Terengganu	*Kelantan*	0.276	*Pahang*	0.180	*Sabah*	0.039		
Kuala Lumpur	*Kelantan*	0.284	*Sabah*	0.167	*Selangor*	0.183		

set open for choice. The shortest distances for these DMUs (Melaka and Perak) to be fully efficient are both *Kelantan*. For the inefficient DMU Terengganu, the state of *Sabah* appears to be the shortest distance to achieve fully efficient. The distance refers to the reduction in input weights that can be achieved by the inefficient DMUs. As noted, all reference sets represent the fully efficient DMUs located on the corner points of the frontier DEA. Any DMU located on the frontier line of DEA is not considered fully efficient because it does not satisfy the conditions for an optimal attainment as mentioned earlier. As such, this non-corner point solution is not an optimal DMU by definition.

One may ask the question in what capacity could the inefficient DMU improves its position after knowing the results of DEA? The answer to this question is explained in the DEA projection results. Table 6 shows the DMU Johor has to reduce the current level of doctor by 20.3% and a corresponding reduction in hospital beds by 18.1% to attain to an optimal efficient DMU. Looking at the existing level of doctors, Johor is one of the states with a large number of doctors and hospital beds while the prevalent of the communicable diseases is reasonable high 10.8% out of the total 46,165 cases treated. A reduction in these inputs other things remained unchanged an optimal use of resource may be attainable. This is needed if Johor were to improve its existing condition of excess inputs from the health care.

Kedah with the efficiency score of 0.596 is much lower than Johor with that of 0.819. To improve the management of DMU, Kedah should not be surprised to hear that it needs to revamp a large portion of doctors and hospital beds that is a reduction of 56.9% for doctors and 45.8% for hospital beds. As an alternative, Kedah also needs to increase its HIV cases by 11.6% of the patients simultaneously with the above reduction of inputs. With efficiency score of 0.542, the state of Melaka health service condition is about half of those best performers such as Kelantan, Sabah, Pahang and Selangor. For this very reason, DEA-solver suggests a big change in the state's inputs combination, that is, a reduction of number of doctors by 56.9% and corresponding reduction in number of hospital beds of about 45.8% with the existing level of outputs of common diseases. This suggestion may look surprising and obviously contradicts to the general belief that Malaysia is in shortage of doctors but the finding revealed otherwise. There are two possibilities: first, the prevalence of communicable diseases in Melaka as reported in Table 1 is relatively small in comparison

Table 6 Projection of inefficient DMU for Johor, Kedah and Melaka

DMU I/O	Score data	Projection	Difference	Percentage
Johor	0.819			
Doctor	1979	1577.9	–401.1	–20.27
Hospital beds	3559	2915.5	–643.5	–18.08
Food poisoning	327	327	0	0.00
Tuberculosis	1407	1407	0	0.00
Dengue fever	2131	2131	0	0.00
HIV	671	671	0	0.00
Kedah	0.595			
Doctor	1054	627.988	–426.011	–40.42
Hospital beds	2566	1461.796	–1104.2	–43.03
Food poisoning	470	470	0	0.00
Tuberculosis	914	914	0	0.00
Dengue fever	633	633	0	0.00
HIV	268	299.204	31.204	11.64
Melaka	0.542			
Doctor	732	315.508	–416.491	–56.90
Hospital beds	1188	643.926	–544.074	–45.80
Food poisoning	150	150	0	0.00
Tuberculosis	343	343	0	0.00
Dengue fever	381	381	0	0.00
HIV	154	154	0	0.00

to percentages reported by other states. Second, it is possible that the services of doctors and hospital beds in relation to common diseases treated for this particular state is underutilised.

The inefficient DMU is also presented in Table 7 for the states of Perak, Terengganu and Federal Territory of Kuala Lumpur. Sarawak with the inefficiency score of 0.602 needs reduction of inputs and increased outputs of specific diseases. The reduction in excess doctor amounts to 39.8%, whereas reduction of excess hospital beds as suggested by DEA-solver is 43.2%. An increase in output of HIV (144.0%) and dengue fever (42.6%) means that for these particular diseases, the service of doctor and hospital beds were underutilised in 2005. It could be due to the fact that these diseases are not common in Sarawak. Referring to the actual percentage of HIV and dengue fever in Table 1, Sarawak had insignificant number of both diseases 1.0 and 2.5%, respectively. For the inefficient DMU, Terengganu with the efficient score of 0.681 appears to have a similar pattern of inputs reduction doctor (32.4%) and hospital beds (31.9%) and an increase in dengue fever of 38.2% as indicated in Table 7.

However, for the Federal Territory of Kuala Lumpur, suggestion for inputs reduction is significantly large with a 72.4% in doctor and 49.8% in hospital beds. Perhaps in Kuala Lumpur, the service of private doctors working in non-government hospitals constitutes a large proportion of the total doctor which may not look fully occupied because of their specialised fields.

Again DEA-solver suggests a big increase in the output of food poisoning of 125.3% to be fully efficient for the territory. This is a familiar case where the number of food poisoning is relatively small for DMU Kuala Lumpur. It is a case of underutilisation of the service of doctor and facilities available for this

Table 7 Projection of inefficient DMU for Sarawak, Terengganu and W.P. Kuala Lumpur

DMU I/O	Score data	Projection	Difference	Percentage
Sarawak	0.601			
Doctor	1236	743.750	–492.249	–39.83
Hospital beds	3532	2007.636	–1524.36	–43.16
Food poisoning	436	436	0	0.00
Tuberculosis	1618	1618	0	0.00
Dengue fever	390	556.142	166.142	42.60
HIV	104	253.744	149.744	143.99
Terengganu	0.680			
Doctor	614	415.138	–198.861	–32.39
Hospital beds	1485	1010.962	–474.038	–31.92
Food poisoning	336	336	0	0.00
Tuberculosis	595	595	0	0.00
Dengue fever	243	336.843	93.843	38.62
HIV	486	486	0	0.00
W.P. Kuala Lumpur	0.501			
Doctor	3784	1042.908	–2741.09	–72.44
Hospital beds	4219	2117.01	–2101.99	–49.82
Food poisoning	62	139.698	77.698	125.32
Tuberculosis	1259	1259	0	0.00
Dengue fever	1251	1251	0	0.00
HIV	518	518	0	0.00

particular communicable disease. For improving the management and efficiency of these DMUs of Kuala Lumpur, Sarawak and to a small extent also Kedah, doctors and hospital beds of these states can be further reduced to the optimal levels as suggested in the DEA-solver.

5 Conclusion

The management of communicable diseases by hospital differs between the states in Malaysia owing to the availability of doctors, hospital beds and medical facilities. The most important of all is the number of occurrences that may affect efficiency scores of those states. For instance, if the number of occurrences is frequent while the number of doctors, nurses and hospital beds is insufficient to attend to these patients, then obviously the hospital management is inefficient. In contrast, inefficiency scores might be relatively lower because there are too many doctors and/or hospital beds under capacity partly due to the fewer number of reported diseases. The efficiency scores as reported in this study are very much related to this kind of problem. Because every state may have experienced quite an unpredictable occurrence of communicable diseases, the efficiency scores of those efficient and inefficient states might not persist constantly over different years. It is therefore necessary to have the study conducted from time to time to see the possible changes.

It is also important to sustain health conditions among the population of the states with necessary measures constantly taken to combat against the causes of these communicable diseases. For instance, food poisoning is primarily concerned with hygienic preparation of food processing and provision. This problem occurs when food preparation is improperly done whereby food safety measures are ignored. Dengue fever is originated from the mosquito which tends to breed in stagnant water due to poor drainage system in the less developed states of Malaysia. Again this is related to the environmental problem depicting the way of living among the poorer people of the population, but the spread of dengue fever is irrespective of the rich or poor. Similarly tuberculosis and HIV are diseases associated with unhealthy environment, which may be related to human or physical condition of the air therefore sustainable health care should come from the clean environment.

References

Charnes, A., Cooper, W.W. & Rhodes, E. (1978). 'Measuring the efficiency of decision making units', *European Journal of Operation Research* Vol. 2, pp. 429-444.

Coelli, T.J., Prasada, R., D.S. & Battese, G.E. (1998). 'An Introduction to Efficiency and Productivity Analysis', Kluwer Academic Publishers, London.

Cooper, W.W., Seiford, L.M. & Kaoru, T. (2006). 'Introduction to Data Envelopment Analysis and Its Uses with DEA-Solver Software and References', Springer (e-book).

Farrell, M.J. (1957). 'The measurement of productive efficiency', *Journal of the Royal Statistical Society, Series A*, CXX, Part 3, pp. 253-290.

Malaysia. (2006). 'Social Statistics Bulletin', Department of Statistics, Putrajaya, Kuala Lumpur.

Wang, Y-M. & Luo, Y. (2006). 'DEA efficiency assessment using ideal and anti-ideal decision-making units', *Applied Mathematics and Computation* Vol. 173, pp. 902-915.