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Efficiency Analysis of Input-Output Measures of Hotel Services

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Abstract:

The efficiency assessment is based on the implementation of the Data Envelopment Analysis DEA in five hotels. This study examined the effectiveness of hotel services. The analysis was conducted by the use of Charnes, Cooper and Rhodes (CCR) model to achieve the objective of identifying efficient and non-efficient hotels. Three and two hotels are found to be efficient and inefficient respectively. It was then concluded that inefficient hotels should emulate the efficient hotels in order to maximize their profit.

Keywords: Data envelopment analysis, efficiency, CCR model, input and output

1. Introduction

Hotels are one of the service-based industries that make up tourism industry of any nation, Nigeria. The industries contribute to the nation economic growth. Thus, there is need to measure the efficiency (performance) of these hotels in order to ensure that the industry is on a good track as it will sustain the hotel management relationship with their customer (Carlos, 2005). The performance to be measured by efficiency, a process that uses a lowest amount of input to create greatest amount of output (Keh et al., 2006). Of the available mechanisms, Data Envelopment Analysis (DEA) is employed to evaluate performance measure of similar organizations, such as hospitals, banks, hotels, schools, and pharmaceutical companies' etc.

The analysis of hotel efficiency is restricted to a small number of studies. Among the earliest, Baker and Riley (1994) propose the use of ratios to analyze the performance of the lodging industry. Wijesinghe (1993) suggests the use of break-even analysis to discern the effectiveness of tourism management. Brotherton and Mooney (1992), Donaghy et al (1995) applied yield management to analyze the efficiency of hotel management.

Nowadays, numerous techniques exist to evaluate performance of a company to determine their long run survival. Data Envelopment Analysis (DEA) serves as a tool to evaluate performance on activity in entity units. The researches on several fields agreed that DEA was an excellent methodology to modeling operational process, such that of hotel industries and the likes.

In this study, the searchlight is on the relative performances of five hotels using Data Envelopment Analysis as the basic tool.

DEA, initially proposed by Charnes et al. (1950) is a specialist application of linear programming (LP) power aggregate comparative method evaluates the relative efficiencies of a set of entities, called decision-making units (DMUs) with the common but incomparable inputs and outputs (Ekinci, 2007). The analysis under review is recommendable in cases when other approaches fail to provide an expected result; but adequate selection of the number of inputs is very significant in terms of producing a dependable result.

The CCR model, a DEA model-type, has proven to produce a good result in terms of comparing input and output for the entire homogeneous units and ability to evaluate performance of other alternative units, named after the authors (Charnes, Cooper and Rhodes, 1978). Hence, it is useful in this study.

DEA and its models have been widely used since its inception in 1950 by researchers to measures efficiency and productivity (Deraman and Saman, 2013). Some of these authors and their works are reviewed as follows:

Nunamaker and Lewin (1983) measure the routine nursing service efficiency using DEA.

Saranga and Phani (2004) used DEA to study the performance of pharmaceutical companies in order to determine the best practices in the Indian pharmaceutical industry.

Malhotra and Malhotra (2008) used DEA where it employs relative efficiency, a concept enabling comparison of companies with a pool of known efficient companies.

Mazumdar et al (2010) used DEA efficiency score of a firm which provides an assessment of its performance based on measurement of output and input efficiencies for Indian pharmaceutical firms.

Sumanta and Patal (2013) used DEA approach to find out the efficiency of firms and peers of inefficient firms. It was discovered that efficiency scores all 24 pharmaceutical companies are above 70%.

Deraman et al (2013) used DEA-CCR model to evaluate the performance of hotels. Their research work revealed that sixteen (16) hotels gave full cooperation out of the twenty (20) hotels under investigation.

Babak and Maryam (2015) used FDEA compare the efficiency score of twenty-two Pharmaceutical Companies; where six Pharmaceutical Companies are more efficient than other sixteen Pharmaceutical Companies but the company with number seven has the first grade.

2. Model Specification

The CCR model from DEA allows comparisons between homogeneous entities (DMU). The model makes a distinction between efficient and non-efficient decision-making units.

Suppose that we have n DMU_s ($DMU_s, j = 1, 2, \dots, n$) which produce s outputs $y_{rj} : r = 1, 2, \dots, s, j = 1, 2, \dots, n$ by consuming m inputs $x_{ij} : i = 1, 2, \dots, m; j = 1, 2, \dots, n$.

Let V_i and u_r be respectively the weights to be determined for input, i and output, r . V_i^* and u_r^* represents the optimal solutions for V_i and u_r .

For the selected decision-making unit, $K(DMU_K)$, the mathematical model for this study being formulated (Cooper et al, 2011).

$$\begin{aligned} \text{Max } \theta_K &= \frac{\sum_{r=1}^S u_r y_{rK}}{\sum_{i=1}^m V_i x_{iK}} \\ \text{Subject to } \frac{\sum_{r=1}^S u_r y_{rj}}{\sum_{i=1}^m V_i x_{ij}} &\leq 1, \quad 1 \leq j \leq n \\ u_r &\geq 0, \quad 1 \leq r \leq S \\ V_i &\geq 0, \quad 1 \leq i \leq m \end{aligned}$$

The solutions to this problem return the values of the variables V_i and u_r which maximize the efficiency of the DMU under analysis. The procedure is repeated for each DMU; in this way, the relative efficiencies of the DMU_s are obtained.

The full formulation is then:

$$\begin{aligned} \text{Max } \theta_K &= \sum_{r=1}^S u_r y_{rK} \\ \text{Subject to } \sum_{i=1}^m V_i x_{iK} &= 1 \\ \sum_{r=1}^S u_r y_{rj} - \sum_{i=1}^m V_i x_{ij} &\leq 0 \\ u_r &\geq 0, V_i \geq 0. \end{aligned}$$

3. Data Analysis

3.1. Illustrative Example

A Hotel Management Company intends to evaluate the performance of five hotels under its supervision. The following information available relates to the input and output measures.

	Input Measures.		
Hotel	Hours of Operation	FTE Staff	Supplies ₹ '000'
A	96	16	850
B	110	22	1400
C	100	18	1200
D	125	25	1500
E	120	24	1600

Table 1: Table of Input Measures

	Output Measures		
Hotel	Weekly profit ₹ '000'	%Market Share	%Growth Rate
A	3800	25	8.0
B	4600	32	8.5
C	4400	35	8.0
D	6500	30	10.0
E	6000	28	9.0

Table 2: Table of Output Measures

HOTEL A

$$\begin{aligned}
 \text{MaX } Z_0 &= \frac{3800u_1 + 25u_2 + 8u_3}{96V_1 + 16V_2 + 850V_3} \\
 \text{Subject to } &\frac{3800u_1 + 25u_2 + 8u_3}{96V_1 + 16V_2 + 850V_3} \leq 1 \\
 &\frac{4600u_1 + 32u_2 + 8.5u_3}{110V_1 + 22V_2 + 1400V_3} \leq 1 \\
 &\frac{4400u_1 + 35u_2 + 8u_3}{100V_1 + 18V_2 + 1200V_3} \leq 1 \\
 &\frac{6500u_1 + 30u_2 + 10u_3}{125V_1 + 25V_2 + 1500V_3} \leq 1 \\
 &\frac{6000u_1 + 28u_2 + 9u_3}{120V_1 + 24V_2 + 1600V_3} \leq 1 \\
 &u_1, u_2, u_3, V_1, V_2 \text{ and } V_3 \geq 0.
 \end{aligned}$$

The full formulation is then:

$$\begin{aligned}
 \text{MaX } Z_0^1 &= 3800u_1 + 25u_2 + 8u_3 \\
 \text{s.t } &96V_1 + 16V_2 + 850V_3 = 1 \\
 &4600u_1 + 32u_2 + 8.5u_3 - 110V_1 - 22V_2 - 1400V_3 \leq 0 \\
 &4400u_1 + 35u_2 + 8u_3 - 100V_1 - 18V_2 - 1200V_3 \leq 0 \\
 &6500u_1 + 30u_2 + 10u_3 - 125V_1 - 25V_2 - 1500V_3 \leq 0 \\
 &6000u_1 + 28u_2 + 9u_3 - 120V_1 - 24V_2 - 1600V_3 \leq 0 \\
 &3800u_1 + 25u_2 + 8u_3 - 96V_1 - 16V_2 - 850V_3 \leq 0 \\
 &u_1, u_2, u_3, V_1, V_2 \text{ and } V_3 \geq 0.
 \end{aligned}$$

HOTEL B

$$\begin{aligned}
 \text{MaX } Z_0^{11} &= 4600u_1 + 32u_2 + 8.5u_3 \\
 \text{s.t } &110V_1 + 22V_2 + 1400V_3 = 1
 \end{aligned}$$

$$\begin{aligned}
4400u_1 + 35u_2 + 8u_3 - 100V_1 - 18V_2 - 1200V_3 &\leq 0 \\
6500u_1 + 30u_2 + 10u_3 - 125V_1 - 25V_2 - 1500V_3 &\leq 0 \\
6000u_1 + 28u_2 + 9u_3 - 120V_1 - 24V_2 - 1600V_3 &\leq 0 \\
3800u_1 + 25u_2 + 8u_3 - 96V_1 - 16V_2 - 850V_3 &\leq 0 \\
4600u_1 + 32u_2 + 8.5u_3 - 110V_1 - 22V_2 - 1400V_3 &\leq 0 \\
u_1, u_2, u_3, V_1, V_2 \text{ and } V_3 &\geq 0.
\end{aligned}$$

HOTEL C

$$\begin{aligned}
\text{MaX } Z_0^{111} &= 4400u_1 + 35u_2 + 8u_3 \\
\text{s.t } 100V_1 + 18V_2 + 1200V_3 &= 1 \\
6500u_1 + 30u_2 + 10u_3 - 125V_1 - 25V_2 - 1500V_3 &\leq 0 \\
6000u_1 + 28u_2 + 9u_3 - 120V_1 - 24V_2 - 1600V_3 &\leq 0 \\
3800u_1 + 25u_2 + 8u_3 - 96V_1 - 16V_2 - 850V_3 &\leq 0 \\
4600u_1 + 32u_2 + 8.5u_3 - 110V_1 - 22V_2 - 1400V_3 &\leq 0 \\
4400u_1 + 35u_2 + 8u_3 - 100V_1 - 18V_2 - 1200V_3 &\leq 0 \\
u_1, u_2, u_3, V_1, V_2 \text{ and } V_3 &\geq 0.
\end{aligned}$$

HOTEL D

$$\begin{aligned}
\text{MaX } Z_0^{IV} &= 6500u_1 + 30u_2 + 10u_3 \\
\text{s.t } 125V_1 + 25V_2 + 1500V_3 &= 1 \\
6000u_1 + 28u_2 + 9u_3 - 120V_1 - 24V_2 - 1600V_3 &\leq 0 \\
3800u_1 + 25u_2 + 8u_3 - 96V_1 - 16V_2 - 850V_3 &\leq 0 \\
4600u_1 + 32u_2 + 8.5u_3 - 110V_1 - 22V_2 - 1400V_3 &\leq 0 \\
4400u_1 + 35u_2 + 8u_3 - 100V_1 - 18V_2 - 1200V_3 &\leq 0 \\
6500u_1 + 30u_2 + 10u_3 - 125V_1 - 25V_2 - 1500V_3 &\leq 0 \\
u_1, u_2, u_3, V_1, V_2 \text{ and } V_3 &\geq 0.
\end{aligned}$$

HOTEL E

$$\begin{aligned}
\text{MaX } Z_0^V &= 6000u_1 + 28u_2 + 9u_3 \\
\text{s.t } 120V_1 + 24V_2 + 1600V_3 &= 1 \\
3800u_1 + 25u_2 + 8u_3 - 96V_1 - 16V_2 - 850V_3 &\leq 0 \\
4600u_1 + 32u_2 + 8.5u_3 - 110V_1 - 22V_2 - 1400V_3 &\leq 0 \\
4400u_1 + 35u_2 + 8u_3 - 100V_1 - 18V_2 - 1200V_3 &\leq 0 \\
6500u_1 + 30u_2 + 10u_3 - 125V_1 - 25V_2 - 1500V_3 &\leq 0 \\
6000u_1 + 28u_2 + 9u_3 - 120V_1 - 24V_2 - 1600V_3 &\leq 0 \\
u_1, u_2, u_3, V_1, V_2 \text{ and } V_3 &\geq 0.
\end{aligned}$$

4. Results

TORA solution of these models gives the following optimal results as shown in the table below.

Hotel	u_1^*	u_2^*	u_3^*	V_1^*	V_2^*	V_3^*	Z_0^i
A	0	0	0	0	0	0	1.00
B	0	0	0.09	0.01	0	0	0.95
C	0	0.01	0	0	0	0	1.00
D	0	0	0	0	0	0	1.00
E	0	0.01	0	0.01	0	0	0.96

Table 3: Optimal Solution

The implementation of CCR-DEA model is based on non-parametric linear programming using TORA Software package. The application is programmed to accept three inputs and three outputs. This program accommodates DEA equations and produces results containing the efficiency scores demonstrated in table 3. The results provide some insight to the efficiency and inefficiency level of the hotels sampled.

As shown in Table3, the average efficiency score is approximately 0.98. A, C and D hotels are rated as most efficient by scoring 1.00 while B and E hotels whose efficiency score is less than the average efficiency score are designated as inefficient.

5. Conclusion

The overarching objective is to improve efficiency of the hotel services in the identified inefficient hotels. The outcome of this study will assist the management of hotels in making a good decision in terms of increasing their revenue and focusing on their strength. A well perform hotels are those that manage all their resources, reducing their expenses and at the same time sustaining relationship with their customers.

To achieve the objective, the research identifies three input and three output variables to measure the performance of the hotels. From this DEA framework, three hotels perform relatively well by scoring above the mean efficiency level of 0.982 and two hotels perform below the mean efficiency level.

Based on these findings, the inefficient hotels are advised to emulate their efficient hotels counterpart.

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