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Research Note

The efficiency of the hotel industry in Singapore

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HIGHLIGHTS

► The Slacks-Based Measure of Efficiency is used on Singapore's hotel industry data.
► The model of super-efficiency is used to rank the efficient years.
► The inefficient years are associated with the occurrence of major world events.

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ABSTRACT

Existing literature related to evaluating the efficiency of the hotel industry, generally, uses different types of radial Data Envelopment Analysis (DEA) to compare the relative efficiency of different hotels in a location. This research note has adopted a different approach by treating years as decision making units (DMUs). This will allow policymakers to evaluate the relative efficiency of a hotel industry as a whole over a specified time period so that the effects of the occurrence of events on the efficiency of hotel industry can be evaluated. This study focuses on the efficiency of hotel industry in Singapore from 1995 to 2010. The analysis is carried out using the non-radial DEA called the Slacks-Based Measure (SBM) to identify the efficient years. Then the efficient DMUs are ranked with the SBM model of super-efficiency.

1. Introduction

Data envelopment analysis (DEA), a performance measurement technique that utilises mathematical programming in the evaluation of the relative efficiency of decision making units (DMUs) with multiple inputs and outputs, was first proposed by Charnes, Cooper, and Rhodes (1978). Subsequently, many authors have extended the works of Charnes et al. (1978) by considering different sets of assumptions. For instance, Banker, Charnes, and Cooper (1984) introduced the assumption of variable return-to-scale. Since DEA is estimated with a nonparametric methodology, the users of DEA do not have to specify the functional form and the distributional assumptions for the inefficiency term. Furthermore, it can be estimated with a small data span. Due to its strengths, DEA has been widely used in different disciplines, including tourism research.

The analysis of hotel efficiency is common in tourism research. Yu and Lee (2009) used Hyperbolic Network Data Envelopment Analysis to examine the performance of 57 international tourist hotels in Taiwan for the year 2004. Their results suggest that the productive efficiency and service effectiveness actually differ across hotel businesses. Hwang and Chang (2003) measure the managerial performance of 45 hotels in 1998 and the efficiency change of 45 hotels from 1994 to 1998 in Taiwan. They find that market conditions, sources of customers and management style influence the quality of managerial efficiency of Taiwanese international hotels. Hsieh and Lin (2010) apply relational network DEA to 57 international tourist hotels in Taiwan in 2006 to evaluate the performance of the different departments and of the hotel overall. Barros and Dieke (2008) use DEA to estimate the technical efficiency of 12 hotels in Angola over 2000–2006. They find efficiency has improved at a declining rate over the time.

DEA uses radial or non-radial measures to evaluate the efficiency of DMUs. The assumption for radial models is there is proportional change of inputs or outputs and they usually disregard the slacks in the efficiency scores. The non-radial measures are the ones that take into account of the slacks of each input and output, and allow for the variations of both inputs and outputs which are non-proportional. The non-radial DEA was first proposed by Färe and Lovell (1978) and was named as the Russell Measure. It has

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been adapted by Pastor, Ruiz, and Sirvent (1999) but Tone (2001) then developed a new non-radial model called the Slacks-Based Measure (SBM). The SBM model works directly with the input excesses and output shortfall slacks, which are accounted in the efficiency measure. Since non-radial DEA is seldom used in tourism research, this research note utilises SBM model to evaluate the efficiency of the hotel industry in Singapore. Currently, to the best of our knowledge, the paper of Sun and Lu (2005) is the only paper which has used SBM model in evaluating the performance of hotel industry. Sun and Lu (2005) assess the performance of 55 Taiwanese hotels in 2001 in terms of managerial, occupancy and catering efficiencies. In this research note, the concept of SBM model of super-efficiency proposed by Tone (2002) is also utilized to rank the efficient DMUs.

This research note evaluates the efficiency of the hotel industry in the island country of Singapore. In 2009, 9.7 million international tourists had visited Singapore even though this was the year hit by the global banking crisis. In the same year, Singapore's tourism industry generated total receipts of S$12.8 billion. The hotel industry of Singapore had 120 gazetted hotels with a total supply of 33,880 rooms at the end of 2009. The average room rate was S$189.60 and revenue per available room was S$143.70. This industry earned S$1.6 billion from gazetted hotel rooms. Although hotel industry performed relatively well in 2009, the average occupancy rate, average room rate, average revenue per available room, and total gazetted hotel room revenue decline significantly in comparison to 2008. For instance, total gazetted hotel room revenue fell by 25.9%, average room rate by 22.7%, and revenue per available room by 27.6%. Brown and Dev (1999) suggest that operation productivity of hotels changes when there is a change in economic condition. Hence, it is important to obtain a measurement of efficiency to evaluate the performance of the hotel industry in Singapore over a given time period. With such a measurement available, information about the hotel sector and its contribution to the country's economy can be obtained. Therefore, this study treats the time periods as DMUs, instead of the individual hotels as DMUs. This approach of treating DMUs in terms of the time period was also utilized by Sueyoshi (1997) in measuring the efficiencies and returns to scale in production and cost analyses of Nippon Telegraph and Telephone. The results of this study may be useful to policymakers in assessing whether the performance of the said industry is dependent on the economic condition.

2. Data and methodology

Annual data from 1995 till 2010 has been collected for this study. The variables considered for the inputs to the SBM model here are standard average room rate, total international visitor arrivals and GDP. The outputs are identified as hotel room revenue, hotel food and beverage revenue, occupancy rate and gross lettings. All these variables are obtained from Singapore Tourism Board, except GDP. GDP is taken from Singapore Economic Development Board.

The SBM model introduced by Tone (2001) and SBM model of super-efficiency (Tone, 2002) are used in this study. The DMUs have input and output matrices, $X = (x_{ij}) \in \Re^{m \times n}$ and $Y = (y_{ij}) \in \Re^{m \times n}$ respectively. We assume that $X > 0$ and $Y > 0$, i.e. the data set is positive. The production possibility set P is defined as

$$P = \{(x, y) | x \geq X\lambda, y \geq Y\lambda, \lambda \geq 0\} \tag{1}$$

Suppose there are n DMUs and each DMU$_j$ (j = 1,2,3,...,n), uses m inputs $x_{ij}(i = 1, 2, ..., m)$ to produce s outputs $y_{ij}(r = 1, 2, ..., s)$. It is assumed that the inputs and outputs are positive. The SBM model, as a non-oriented and non-radial DEA model, that is used to evaluate the efficiency of DMU$_o$ $(o \in \{1, 2, ..., n\})$ under the assumption of constant returns to scale (CRS) is defined as:

$$\rho^* = \min \rho = \frac{1 - \frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{io}}}{1 + \frac{1}{s}\sum_{r=1}^{s}\frac{s_r^+}{y_{ro}}}$$
$$\text{s.t.} \quad x_{io} = \sum_{j=1}^{n}\lambda_j x_{ij} + s_i^-, \quad i = 1, 2, ..., m$$
$$y_{ro} = \sum_{j=1}^{n}\lambda_j y_{rj} - s_r^-, \quad r = 1, 2, ..., s, \tag{2}$$
$$\lambda, s^-, s^+ \geq 0$$

where $\lambda = (\lambda_1, \lambda_2, ..., \lambda_n) \in \Re$ is the intensity vector and the non-negative vectors of $s^- = (s_1^-, s_2^-, ..., s_m^-) \in \Re^m$ and $s^+ = (s_1^+, s_2^+, ..., s_m^+) \in \Re^s$ are the input excess and output shortfall slacks respectively. The optimal solution ρ^* is the SBM efficiency score where $0 < \rho^* \leq 1$. Note that this supports the properties of units invariance and monotonicity.

Definition: A DMU$_o$ is SBM efficient if and only if $\rho^* = 1$.

This is equivalent to $s^- = s^+ = 0$ which translate to no input excesses and output shortfalls in any optimal solution.

The SBM model will find the DMUs that are efficient. In the case of multiple efficient DMUs, the SBM model of super-efficiency (Tone, 2002) is utilised to rank these DMUs based on super-efficient scores generated. The model is defined as follows: the production possibility set $P(x_0, y_0)$ spanned by (X, Y) excluding (x_0, y_0) is defined as

$$P(x_0, y_0) = \left\{ (\bar{x}, \bar{y}) | \bar{x} \geq \sum_{j=1, j \neq 0}^{n} \lambda_j x_j, \bar{y} \leq \sum_{j=1, j \neq 0}^{n} \lambda_j y_j, \bar{y} \geq 0, \lambda \geq 0 \right\} \tag{3}$$

Further, a subset $\bar{P}(x_0, y_0)$ of $P(x_0, y_0)$ is defined as

$$\bar{P}(x_0, y_0) = P(x_0, y_0) \cap \{\bar{x} \geq x_0, \bar{y} \leq y_0\} \tag{4}$$

By assumption of $X > 0$ and $Y > 0$, $\bar{P}(x_0, y_0)$ is not empty. The weighted distance, l_i, from (x_0, y_0) to $(\bar{x}, \bar{y}) \in \bar{P}(x_0, y_0)$ is obtained by using an index, ∂, where

$$\partial = \frac{\frac{1}{m}\sum_{i=1}^{m}\frac{\bar{x}_i}{x_{io}}}{\frac{1}{s}\sum_{r=1}^{s}\frac{\bar{y}_r}{y_{ro}}} \tag{5}$$

Hence the super-efficiency of (x_0, y_0) as an objective function value ∂^* is define as follows:

$$\partial^* = \min \partial = \frac{\frac{1}{m}\sum_{i=1}^{m}\frac{\bar{x}_i}{x_{io}}}{\frac{1}{s}\sum_{r=1}^{s}\frac{\bar{y}_r}{y_{ro}}} \tag{6}$$

subject to

$$\bar{x} \geq \sum_{j=1, j \neq 0}^{n} \lambda_j x_j,$$
$$\bar{y} \leq \sum_{j=1, j \neq 0}^{n} \lambda_j y_j,$$
$$\bar{x} \geq x_0, \bar{y} \leq y_0,$$
$$\bar{y} \geq 0, \lambda \geq 0.$$

Table 1
Coding for the decision making units (DMUs).

1 = 1995	2 = 1996	3 = 1997	4 = 1998	5 = 1999	6 = 2000	7 = 2001	8 = 2002
9 = 2003	10 = 2004	11 = 2005	12 = 2006	13 = 2007	14 = 2008	15 = 2009	16 = 2010

Table 2
Efficiency and super-efficiency scores and ranking.

DMU	Efficiency score	Super-efficiency score	Rank
1	1.0000	1.0610	2
2	1.0000	1.0146	6
3	1.0000	1.0208	4
4	1.0000	1.0106	7
5	1.0000	1.0022	11
6	1.0000	1.0251	3
7	0.9197		12
8	0.8923		13
9	0.8087		15
10	1.000	1.0100	8
11	1.000	1.0075	9
12	1.000	1.0031	10
13	1.000	1.0195	5
14	1.000	1.0770	1
15	0.7577		16
16	0.8122		14

3. Results and discussions

In this study, each year considered by the sample period is a DMU. The codes for all years are reported in Table 1.

The results of the SBM model are reported in Table 2. The ranking of the efficiency of the hotel industry in Singapore from 1995 till 2010 based on the SBM model of super-efficiency is also represented in Table 2. The SBM identified the years of 1995–2000, 2004–2007 and 2008 as efficient DMUs.

From the results obtained, 2008 is the best efficient DMU for the hotel industry in Singapore. This was followed by 1995 and 2000.

4. Conclusion

The results in Section 3 suggest that 2001–2003, 2009 and 2010 are inefficient DMUs. All these years are associated with the occurrence of major events, such as September 11 attacks in year 2001, the outbreak of SARS between November 2002 and July 2003, and the global financial crisis. It is interesting to note that during 1997 Asian financial crisis, the hotel industry was efficient. These suggest not all events will deteriorate the efficiency of this industry. The policymakers have to focus on the occurrence of events which can lead to cancellation or postponement of vacation plans. This information would be useful when trying to look at improving the efficiency for the hotel industry.

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