An Efficiency Analysis of Korean Hotels Measured By Dynamic DEA*
동태적 자료포락분석을 통한 우리나라 호텔산업의 효율성 분석

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ABSTRACT

효율성 문제는 호텔 산업에 있어서 2007년에 있었던 심각한 금융위기 후에 더욱 더 많은 주목을 받게 되었다. 이 논문의 목적은 동태적 DEA 측정방법을 이용하여 2005년부터 2008년까지 한국 39개 호텔의 효율성을 측정하고 분석하는 것이다. 이 연구가 기존 연구와 다른 점은 한국 호텔 산업의 경영 효율성을 측정하는데 있어서 동태적 DEA를 사용한 논문이 거의 없다는 것이다. 뿐만 아니라 이 논문은 Tobit 회귀분석을 사용하여 한국 호텔의 효율성을 결정짓는 특성들을 찾아내는데 중점을 두고 있다는 것이다. 그 결과 한국 호텔의 효율성을 결정짓는 특성들로는 호텔의 규모, 국제화 또는 세계화 정도, 호텔 등급, 호텔 소재지(서울 또는 지방) 등을 들 수 있다. 이 연구의 주요 발견사항은 다음과 같다. 첫째, 호텔의 규모가 클수록 호텔의 효율성을 낮다. 둘째, 국제화의 정도가 큰 호텔일수록 효율성이 높았다. 셋째, 특2급 호텔이 특1급 호텔 보다 효율적인 것으로 나타났다. 끝으로 한국 호텔 산업에서 전통적인 DEA 방법으로 분석한 결과는 동태적 DEA로 분석한 결과 보다 평균 효율성 점수가 과다 계상되고 표준편차에서는 과소 계상되는 것으로 드러났다. 이 연구의 결과와 시사점은 향후 호텔경영에 있어서 유용한 정보를 제공할 수 있을 것이다.

Keywords : 동태적 효율성(Dynamic Efficiency), 자료포락분석(DEA: Data envelopment analysis), 한국 호텔 산업(Korean Hotel Industry)

Ⅰ. Introduction

As economic crisis is pervasive and more deepening in some countries recently, the hotel(tourism) industry is becoming more important nationally as it brings huge foreign exchange income and provides job opportunities. The Korea hotel industry is sometimes criticized area lowers in a botanical greenhouse - there had been no serious foreign competition until the economic crisis's in 1997 and 2008.

At the same time, the issue of efficiency is gathering momentum in the economics field. A non-parametric estimation technique, called DEA(Data Envelopment Analysis) has been widely accepted as in measuring efficiency. However, the models previously used neglected the effects of

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carry-over activities between two consecutive terms. Recent development in the DEA field covers this area, and many softwares in the market made researchers available to analyze this field.[2)] Thus, the purpose of this paper is to measure the efficiency of Korean hotels using a dynamic DEA model.

We are also interested in finding the characteristics determining the efficiency of Korean hotels using Tobit regression analysis. We will use variables size(scale) of the hotel, degree of internationalization(or globalization), level of the hotels, and location(Seoul vs. non-Seoul).

The remainder of the paper is organized as follow: Section II reviews the existing literature on our subject. Section III explains the methodology of the dynamic version of DEA, which was adopted in this paper. The data sources used in this paper also will be discussed in this Section. In Section IV, an empirical analysis is performed based on the estimated results from the models described in Section III. Some concluding remarks are presented in the last Section.

Ⅱ. Review of Literature

1 Estimation of efficiency of hotels with DEA and dynamic DEA

1) DEA-related studies

Many papers on the estimation of efficiency include not only hotels but also hospitals, universities, and countries using DEA. According to <Table 1>, on the estimation of hotel, Wang et al.(2006b) analyzed 49 Taiwan hotel units using number of rooms, number of full-time employees in room departments, total floor area of food and beverage departments, number of full-time employees in food and beverage departments as inputs, and average wage rate of a full-time employee in the room department, average room rates, average price of food and beverage operations, average wage rate of a full-time employee in the food and beverage department as outputs. He tried to estimate the relative cost efficiency in 2001.

Chiang et al.(2004) tried to estimate the efficiency of 25 Taipei hotels using hotel rooms, food and beverage capacity, number of employees, and total costs as inputs and yielding index, food and beverage revenue, miscellaneous revenue and operational costs as outputs. Hwang and Chang(2003) also used DEA to estimate the efficiency of 45 Taiwan hotels with number of full-time employees, number of guest rooms, total area of catering department operating expenses as inputs, and room, food and beverage, and other revenues as outputs.

There are other DEA studies for hotels including Tsaur(2001), Barros(2004), Barros(2005a, b),

2) The new version of DEA-Solver-Pro (7.0) is one of the softwares dealing with dynamic version of efficiency.

Barros and Santos(2006), which used DEA as their estimation technique. Barros and Dieke(2008) used DEA two-stage procedure: The first stage applies the Malmquist model and the second stage applies a bootstrapped Tobit model to estimate 25 Portugues travel agencies in 200-2004.

There are also studies on US hotels: Brown and Ragsdale(2002) used a DEA-CCR method for 46 US hotels rated in a consumer report. Anderson et al.(2000) used 48 US hotels in his study. Morey and Dittman(1995) analyzed 54 US hotels for their efficiency estimation.

<Table 1> Studies on DEA

Study	Method	Units	Inputs	Outputs	Prices
Barros and Dieke(2008)	DEA two-stage procedure: 1st stage Malmquist model;2nd stage a bootstrapped Tobit model	25Portuguese travel agencies 2000-2004	(1) Wages, (2) capital, (3) total costs excluding wages and (3) book value of premises	(1) Sales and (2) profits	
Barros and Santos(2006)	DEA- allocative model	15Hotels observed from 1998 to 2002	(1) Employees and (2)physical capital	(1) Sales,(2)added value and (3) earnings	(1) Price of labor and (2) price of capital
Wang et al.(2006c)	DEA	54 Taiwan hotels	Number of full-time employees, guest room, total area of meal department	Room reenus, food and beverages revenue, other revenues	
Wang et al.(2006a)	Quality-incorporated Malmquist productivity index	29 Taiwan hotels	Guest rooms, food and beverage capacity, number of full-time employees operating expenses	Room revenus, food and beverage revenue, miscellaneous revenue, the ratios for housekeeping staff per guest room, the ratios for food and beverage staff per floor area	
Wang et al.(2006b)	DEA	49 Taiwan hotels	Number of rooms, number of full-time employees in room departments, total floor ara of food and beverage departments, number of full-time employees in food and beverage departments	Average wage rate of a full-time employee in the room department, average room rates, average price of food and beverage operations, average wage rate of a full-time employee in the food and beverage department	

Study	Method	Units	Inputs	Outputs	Prices
Barros (2005a.b)	DEA-CCR and DEA-BCC models	42 Enatur hotels (Portugal), observed from 1999 to 2001	(1)Capital and (2)labor	(1)Sales;(2)number of guests; (3)nights spent	-
Chiang et al.(2004)	DEA	25 Taipei hotels	Hotel rooms food and beverage capacity, number of employees total cost	Yielding index, food and beverage revenue, miscellaneous revenue	
C.P.Barros and Alves(2004)	DEA-Malmquist index	42 Enatur hotels, observed from 1999 to 2001	(1)Full-time workers; (2) cost of labor; (3) book value of property; (4)operating costs and (5)external costs	(1) Sales; (2)number of guests; (3)nights spent	-
Hwang and Chang(2003)	DEA-CCR model; superefficiency model; Malmquist	45Hotels in Taiwan	(1) Number of full-time employees; (2)number of guestrooms; (3) total diension of meal department; (4) operating expenses	(1)Room revenue; (2) food and beverage revenue; (3) other revenue	-
Reynolds (2003)	DEA CCR and BCC model	38 Restaurants	(1) Front-of-house hours worked per day during lunchtime; (2)front-of-hours worked during dinner per day; (3) average wages; uncontrollable input (4) number of competitors within a 2-mile radius; (5)seating capacity	(1) Sales; (2) customer satisfaction	-
Brown and Ragsdale (2002)	DEA-CCR model and cluster analysis	46 US hotels rated in comsumer report	(1) Median price; (2) problems(defined in a 4-point scale);(3)service; (4)upkeep;(5)hotels and (6)rooms	(1) Satisfaction value (defined on a 100-point scale); (2)value(defined in a 5-point scale)	-
Tsaur (2001)	DEA	53 Taiwan hotels	Total operating expenses, the number of employees, the number of guest rooms, the total floor space of catering division, the number of employees in the room division, the number of employees in the catering division, catering cost	Total operating revenues, the number of rooms occupied, the average production value per employee in the catering division, tatal operating revenues of the room division, total operating revenues of the catering division	

Study	Method	Units	Inputs	Outputs	Prices
Anderson et al. (2000)	DEA(technical and allocative)	48 Hotels	(1)Full-time equivalent employees; (2)the number of rooms;(3)total gaming-related expenses;(4)total food and leverage expenses;(5)other expenses	(1)Total revenue; (2)other revenue	(1)Wagees proxied by the hotel revenue per full-time employee;(2)rooms price proxied by hotel revenue divided by the product of rooms times occupancy rate and day per-year)
Johns et al. (1997)	DEA	15 UK hotels over a 12-month period	(1)Number of room nights available; (2) total labor hours; (3) total food and beverage costs and (4) total utilities cost	(1)Number of room-nights sold; (2)total covers served; and (3)total beverage revenue	
Bell and Morey (1995)	DEA	31 Units of corporate travel departments	(1)Actual level of travel expenditure; (2)nominal level of other expenditure; (3)level of environment factors(ease of negotiating discounts, percentage of legs with commuters, flights required; (4)actual level of labor costs	(1)Level of service provided, qualified as excellent and average	-
Morey and Dittman (1995)	DEA	54 Hotels	(1) Room division expenditure; (2)energy costs; (3)salaries; (4)non-salary expenditure for property; (5) salaries and related expenditure for advertising; (6)non-salary expenses for advertising; (7) fixed marked expenditure for administrative work	(1)Total revenue; (2)level of service delivered; (3) market share; (4) rate of growth	

2) Dynamic DEA-related studies

Färe and Grosskopf(1996) first showed a dynamic version of DEA model in the 1990s. Recently, Tone and Tsutsop(2010) explained a slacks-based measore of dynamic DEA. According to Tone and Tsutsop(2010), the previous DEA models did not account for the effect of carry-s er activities between two consecutive terms. For each term these models htiv inputs and outputs, but the connecting activities between terms are not accounted for explicitly.

There have been so far few papers using the dynamic models of DEA. Yang and Lu(2006) proposed an alternative DEA for assessing the operational performance of 46 international tourist hotels(ITHs) in Taiwan over the period 1997-2002. The paper used a two-stage procedure: The first stage contains the slacks-based measurement(SBM) model and the dynamic view of window analysis in applying DEA. In the second stage, a Tobit regression analysis was employed to analyze the operating characteristics for exploring the variation of managerial performance among ITHs. There have been several efforts to use the dynamic version of DEA such as De Mateo et. al(2006-7). De Mateo et. al(2006-7) applied the dynamic version of DEA to analyze the optimal paths and costs of adjustment in Chilean department stores.

2. Efficiency of Korean Hotels

There are a number of papers estimating the efficiency of hotels in Korea. K. J. Kim, S. Y. Bae, and Y. H. Lee(2008) employed the DEA method to estimate the efficiency of 17 first-special, 14 second-special, and 18 first-tourist levels of hotels in Korea. They utilized Input-oriented CCR and BCC models for the efficiency measure in 2005, and the Malmquist index method was used for the productivity change from 2002 to 2005.

B. Y. Hong and E. K. Kang(2005) also tried to estimate the efficiency and productivity from 1999 to 2003 by the method introduced by Ray and Delsi(1997). Their findings illustrate that efficiency and productivity changes were decreasing during the estimation periods. K. J. Kim(2004)'s results showed that the productivity has increased in the 1997-2002 period, but the efficiency had decreased.

D. H. Shim(2001) used the DEA method with inputs of number of employees, fixed assets, number of rooms, and outputs of sales. He found that the efficiency of second-special level hotels was higher than that of the first-special level hotels. The result is quite different from past findings. For example, B. Y. Hong and K. J. Kim(2004) assumed the CRS and VRS then performed DEA: Their findings suggest the higher efficiency of the first-special level hotels rather than the second-special with CRS assumption. However, assuming VRS resulted in the exactly opposite estimation, higher efficiency of the second-special level of hotels than the first-special level hotels. References to these Korean literature are given in Korean in reference section.

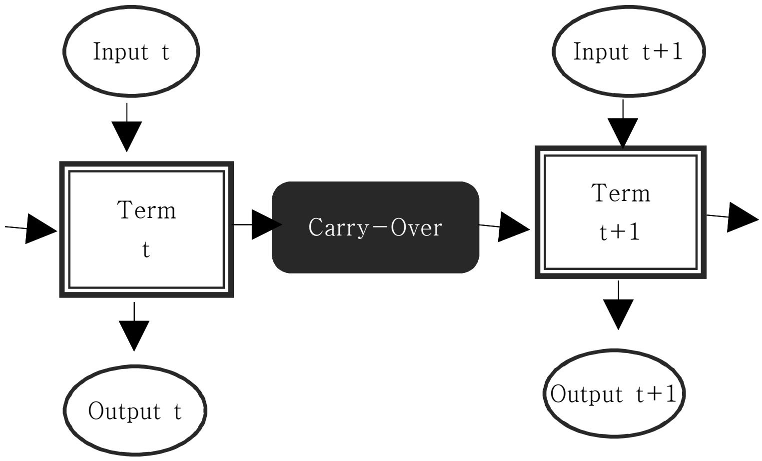
Ⅲ. Methodology and Data

Two main methods have previously been used in efficiency and productivity estimation. These are data envelopment analysis(DEA), a linear programming and non-parametric estimation technique to estimate the efficiency, and stochastic frontier approach(SFA). DEA assumes that the efficiency frontier has no random fluctuations. It does not require knowledge in a functional form, and it is prevalent in the literature. Another advantage of DEA is that it can decompose overall efficiency into multiple allocative and technical components. However, its disadvantages are no-random-fluctuation assumption and a lack of statistical analysis foundation.

1 Concepts of Dynamic version of DEA

Traditional DEA models deal with efficiency of input resources vs. output products of associated decision making units(DMUs) within cross sectional data. <Figure 1> illustrates the dynamic version of DEA. We observe n DMUs over T terms. At each term t, each DMU has its own inputs and outputs along with the carry-over(sometimes called link) to the next term t+1. We assume that we have a homogeneous panel data through terms. What distinguishes dynamic DEA from the traditional ones is the existence of carry-overs that connect two consecutive terms, and these terms have been neglected in ordinary DEA, and resulted inefficient estimates.

Further, carry-over activities, or links, are classified into four categories: (1) desirable links, (2) undesirable links, (3) discretionary(free) link, and (4) non-discretionary(fixed) link. A desirable (Undesirable) link such as profit(loss) carries forward to the next term. A discretionary(or free) link is a link that DMU can handle freely. Its value can be increased or decreased from the observed one. On the other hand, a non-discretionary(fixed) links is a link that is beyond the control of DMU. Its value is fixed at the observed level.



<Figure 1> Dynamic Structure

There are three models in the dynamic DEA: Input-oriented, output- oriented and non-oriented. Thus, applying these models to the dynamic SBM models can make the following six models:

① Dynamic SBM input-oriented with constant returns-to-scale model
② Dynamic SBM input-oriented with variable returns-to-scale model
③ Dynamic SBM output-oriented with constant returns-to-scale model
④ Dynamic SBM output-oriented with variable returns-to-scale model
⑤ Dynamic SBM non-oriented with constant returns-to-scale model
⑥ Dynamic SBM non-oriented with variable returns-to-scale model

In this paper, since we are not interested in any of the oriented models, we will use models ⑤ and ⑥ for our analyses.

The background theories of non-oriented cases of dynamic SBM models are presented in the following sections of 3.2 and 3.3.

2. Non-oriented Case[3)]

As the combination of input-and output-oriented cases, we define the non-oriented efficiency measure by solving program below:

$$\rho_0^* = \min \frac{\frac{1}{T}\sum_{t=1}^{T} w^t \left[1 - \frac{1}{m+nbad}\left(\sum_{i=1}^{m} \frac{w_i^- s_-}{x_{iot}} + \sum_{i=1}^{nbad} \frac{s_{bad}}{z_{iot}^{bad}}\right)\right]}{\frac{1}{T}\sum_{t=1}^{T} w^t \left[1 - \frac{1}{s+ngood}\left(\sum_{i=1}^{s} \frac{w_i^+ s_+}{y_{iot}} + \sum_{i=1}^{ngood} \frac{s_{good}}{z_{iot}^{good}}\right)\right]} \quad (3\text{-}1)$$

subject to (3-2) and (3-3).

$$x \geq \sum_{j=1}^{n} x_{ijt}\lambda_j^t, \ (i=1, K, m; t=1, K, T) \quad (3\text{-}2)^{4)}$$
$$x^{fix} = \sum_{j=1}^{n} x_{ijt}^{fix}\lambda_j^t, \ (i=1, K, p; t=1, K, T)$$
$$y \leq \sum_{j=1}^{n} y_{ijt}\lambda_j^t, \ (i=1, K, s; t=1, K, T)$$
$$y^{fix} = \sum_{j=1}^{n} y_{ijt}^{fix}\lambda_j^t, \ (i=1, K, r; t=1, K, T)$$

3) Section 3.2 is the summary from User's Guide to DEA-Solver-Pro 7.0, Appendix O, pp. 73-74.

4) We deal with n DMUs(j=1...n) over T terms (t=1...T). At each term, DMUs have common m inputs $(i=1, K, m)$, p non-discretionary (fixed) inputs $(i=1, K, p)$, s outputs $(i=1, K, s)$ and r non-discretionary (fixed) outputs $(i=1, K, r)$. Let $x_{ijt}(i=1, K, m)$, $x_{ijt}^{fix}(i=1, K, p)$, $y_{ijt}(i=1, K, s)$ and $y_{ijt}^{fix}(i=1, K, r)$ denote the observed(discretionary) input, non-discretionary input, (discretionary) output and non-discretionary output values of DMU j at term t, respectively. We symbolize the four category links as Z^{good}, Z^{bad}, Z^{free} and Z^{fix}. In order to identify them by term (t), DMU (j) and item (i), we employ, for example, the notation $z_{ijt}^{good}(i=1, K, ngood; j=1, K, n; t=1, K, T)$ for denoting good link values where ngood is the number

$$z^{bad} \geq \sum_{j=1}^{n} z_{ijt}^{bad} \lambda_j^t, \ (i=1, K, nbad; t=1, K, T)$$
$$z^{free} : free, \ (i=1, K, nfree; t=1, K, T)$$
$$z^{fix} = \sum_{j=1}^{n} z_{ijt}^{fix} \lambda_j^t, \ (i=1, k, nfix; t=1, K, T)$$
$$\lambda_j^t \geq 0, (j=1, k, n : t=1, K, T)$$
$$\sum_{j=1}^{n} \lambda_j^t = 1, \ (t=1, K, T),$$

$$\sum_{j=1}^{n} z_{ijt}^{\alpha} \lambda_j^t = \sum_{j=1}^{n} z_{ijt}^{\alpha} \lambda_j^{t+1}, \ (\forall i; t=1, K, T-1), \quad (3\text{-}3)$$ [5]

This objective function is an extension of the non-oriented SBM model and deals with excesses in both input resources and undesirable (bad) links, and shortfalls in both output products and desirable (good) links in a single unified scheme. The numerator is the average input efficiency and the denominator is the inverse of the average output efficiency. We define the non-oriented overall efficiency as their ratio which ranges between 0 and 1, and attains 1 when all slacks are zero. This objective function value is also units-invariant.

Using an optimal solution $\left(\{\tau_0^{t*}\}, \{s_{ot}^{-*}\}, \{s_{ot}^{+*}\}, \{s_{ot}^{good*}\}, \{s_{ot}^{bad*}\}, \{s_{ot}^{free*}\}, \{s_{ot}^{fix*}\}\right)$ to (3-1) we define the non-oriented term efficiency as follows.

$$\rho_{ot} = \frac{1 - \frac{1}{m + nbad}\left(\sum_{i=1}^{m} \frac{w_i^- s_{iot}^{-*}}{x_{iot}} + \sum_{i=1}^{nbad} \frac{s_{iot}^{bad*}}{z_{iot}^{bad}}\right)}{1 + \frac{1}{s + ngood}\left(\sum_{i=1}^{s} \frac{w_i^+ s_{iot}^{+*}}{y_{iot}} + \sum_{i=1}^{ngood} \frac{s_{iot}^{good*}}{z_{iot}^{good}}\right)} \ (t=1, K, T) \quad (3\text{-}4)$$

[Definition 1] (Non-oriented overall efficient)

If all optimal solutions of (3-1) satisfy $\rho_0^* = 1, DMU_0$, this is called non-oriented overall efficient.

of good links. These are all observed values up to the term T. The production possibilities $\{x\}, \{x^{fix}\}, \{y\}, \{y^{fix}\}, \{z^{good}\}, \{x\}, \{x^{fix}\}\{z^{bad}\}, \{z^{free}\}$ and $\{z^{fix}\}$ are defined by (3-2). In (3-2), $\lambda^t \in R^n (t=1, K, T)$ is the intensity vector for the term t, and nbad, nfree and nfix are respectively the number of bad, free and fixed links. The last constraint corresponds to the variable returns-to-scale assumption. If we delete this constraint, we have the constant returns-to-scale model. We notice that $x_{ijt}, x_{ijt}^{fix}, y_{ijt}, y_{ijt}^{fix}, z_{ijt}^{good}, z_{ijt}^{bad}$ and z_{ijt}^{fix} on the left are variables connected by the intensity variable λ_j^t.

5) The continuity of link flows (carry-overs) between terms t and t+1 can be guaranteed by the above condition (3-2). In (3-2) the symbol α stands for good, bad, free or fix. This constraint is critical for the dynamic model, since it connects term t and term t+1 activities.

This means $s_{iot}^{-*}=0(\forall i,t), s_{iot}^{bad*}=0(\forall i,t)s_{iot}^{+*}=0(\forall i,t)$ and $s_{iot}^{good*}=0(\forall i,t)$, and hence $\rho_{ot}^{*}=1(\forall t)$.

[Definition 2] (Non-oriented term efficient)

If all optimal solutions of (012) satisfy $\rho_{ot}^{*}=1, DMU_0$, this is called non-oriented term efficient for the term t.

This implies that the optimal slacks for term t in (3-1) are all zero, $i.e.$ $s_{iot}^{-*}=0(\forall i)$, $s_{iot}^{bad*}=0(\forall i), s_{iot}^{+*}=0(\forall i)$ and $s_{iot}^{good*}=0(\forall i)$ for all optimal solutions of (3-1).

We will try to solve the term efficient for each term, and overall efficiency as well.

3. Data Used

In order to estimate the cost frontier, we used 39 hotels, 17 first-special level hotels and 22 second-special level hotels in 2007. The hotels considered in the analysis are listed in <Table 2>. The data used in this study were obtained from *Audit Report(2005-2008)* by the Financial Supervisory Service(http://fss.or.kr) and *Performance of Tourist Hotels (2005-2008)*, published by the Korea Hotel Association. Total revenues from rooms and other operations, price of labor, and price of other operations are deflated by CPI.

<Table 2> Names of Hotels and Their Division

Division	Name of Hotels
First-Special	Hotel Shilla, Sharaton Grande Walkerhill, Hotel Inter-Burgo, Haeundae Grand Hotel, Lotte Hotel Busan, Paradiase Hotel Busan, Commodor Hotel, Grand Intercontinental Seoul, Renaissangce Seoul Hotel, Mayfield Hotel & Resort, Millennium Seoul Hotel, Imperial Palace, Lotte Hotel & Resort, JW Marriott, Paradise Hotel Inchon, Jeju Grand Hotel, Oriental Hotel 17
Second-Special	Hotel Sorakpark, Hotel Capital, Changwon Hotel, Daegu Prince Hotel, Koreana Hotel, Onyang Hotel, Dongbang Hotel, Hotel International, Gumi century, Saint Western, J's Hotel, Hotel Riviera Seoul, Yousung Hotel, Hotel Paragon, Novotel Gangnam, Novotel Doksan, Seoul Royal Hotel, Pacific Hotel, Hotel PJ, Hotel Prima, Hotel Concorde, Palace Hotel

Ⅳ. Empirical Analysis

1. Descriptive Statistics

<Table 3> illustrates the descriptive statistics of the variables used: Average, maximum,

minimum, and standard deviation: Inputs are number of employees (EMP) and total operating expenses(TOE), and outputs are number of guest rooms sold(ROOMS), total revenues from guest rooms(TREV), and other revenues(OREV), and a link variable is fixed assets (LF(FA)).

<Table 4> reports uniqueness of the linked variable, fixed assets. This analysis checks uniqueness of link values. If a difference of more than 0.001 exists, then the value of (max - min) appears as non-zero number for DMUs, and the cell is colored.. Although the overall efficiency is uniquely determined as the optimum value of the respective objective function, the term efficiency me have multiple optima. In this cien, the number of non-unique links is 23, average {(max-min)/max} is 1.148%, and average {(max-min)/max} in non-unique cases is 7.789%, which is almost 7 times higher than unique cases.

<Table 3> Descriptive Statistics of Data Used

Term	Term1					
HOTEL	(I)EMP	(I)TOE	(O)ROOMS	(O)TREV	(O)OREV	(LF)FA
Average	482.1282	73444191.34	76104.1282	11155619.1	23390484.13	235148939.1
Max	4647	1209430331	357570	66851967	256645966	4960453631
Min	40	2945797.797	10745	963830	403176	5613905
St Dev	811.6598	202862957	67842.4191	14116050	45120631.99	794268412.6
Term	Term2					
HOTEL	(I)EMP	(I)TOE	(O)ROOMS	(O)TREV	(O)OREV	(LF)FA
Average	479.5641	76862817.69	74594.3077	10103410.3	28245146.9	251736069.2
Max	4580	1270657994	330707	55981348	274761011	5590183665
Min	30	3043190.883	6187	1076147	167378	7312309
St Dev	814.2682	213016636.1	62454.1194	11810383.9	54156704.45	893369114.3
Term	Term3					
HOTEL	(I)EMP	(I)TOE	(O)ROOMS	(O)TREV	(O)OREV	(LF)FA
Average	455.3333	81070893.78	76058.4872	10214786.46	22761633.26	268652484.3
Max	4288	1318193538	311542	50646824	188207620	6103204566
Min	35	2722550.579	11287	1066505	235789	8760698
St Dev	768.1307	222596016.8	62169.8028	11654483.57	36223514.71	974224439.3
Term	Term4					
HOTEL	(I)EMP	(I)TOE	(O)ROOMS	(O)TREV	(O)OREV	(LF)FA
Average	437.8718	99297759	79307.2308	11220078.92	22638067.08	305999061.2
Max	3325	1525279223	295030	54604977	184012449	6554136524
Min	12	2798250.973	11372	916090	171835	9594681
St Dev	666.7303	275328011.6	64505.7188	12976123.78	36036804.76	1055526295

<Table 4> Uniqueness Test

No.	DMU	Term	Term1	Term2	Term3	Term4
1	A	Max-Min	0	0	0	0
2	B	Max-Min	0	0	0	0
3	C	Max-Min	0	0	0	0
4	D	Max-Min	0	0	0	0
5	E	Max-Min	0	0	0	0
6	F	Max-Min	0.00377	0.00383	0.00407	0.00525
7	G	Max-Min	0	0	0	0
8	H	Max-Min	0	0	0	0
9	I	Max-Min	0	0	0	0.00058
10	J	Max-Min	0	0	0	0
11	K	Max-Min	0	0.00001	0.00001	0.00064
12	L	Max-Min	0	0	0	0
13	M	Max-Min	0	0	0	0
14	N	Max-Min	0.00002	0.00003	0.00003	0.00015
15	O	Max-Min	54720.65503	315745.867	321941.3516	238731.955
16	P	Max-Min	0	0	0	0
17	Q	Max-Min	23072.80268	259238.333	270776.2647	195173.9179
18	R	Max-Min	0.00006	0.00004	0.00002	0.00002
19	S	Max-Min	515605.3462	3930648.55	6940939.195	18453515.64
20	T	Max-Min	0.00212	0.00014	0.00015	0.00011
21	U	Max-Min	0	0	0	0
22	V	Max-Min	0	0	0	0
23	W	Max-Min	0	0	0	0.00173
24	X	Max-Min	0	0	0	0
25	Y	Max-Min	0.00107	0.00014	0	0
26	Z	Max-Min	0	0	0	0
27	AA	Max-Min	432432901.1	564274093	616796713.8	1297301924
28	AB	Max-Min	0.001	0.00127	0.00131	0.00136
29	AC	Max-Min	0	0	0	0
30	AD	Max-Min	0	0	0	0
31	AE	Max-Min	0	0	0	0
32	AF	Max-Min	0	0	0	0
33	AG	Max-Min	395372.6853	7974546	8340119.729	11978919.51
34	AH	Max-Min	0	0	0	0
35	AI	Max-Min	0.00005	0.00005	0	0
36	AJ	Max-Min	0	0	0	0
37	AK	Max-Min	0.00033	0.00034	0.00035	0.00043
38	AL	Max-Min	0.00134	3403019.04	3555995.768	5107479.085
39	AM	Max-Min	0.00459	0.00552	0.00567	0.01291

No. of Non Unique Link = 23
Average (Max-Min)/Max = 1.148%
Average (Max-Min)/Max in Non Unique case =7.789%

<Table 5> shows correlation coefficients among inputs and outputs used. It seems that EMP and TOE, ROOMS and TREV, and EMP and $LF(FA)$ are highly correlated - the coefficients are higher than 0.9. Except OREV and $LF(FA)$, the other correlation coefficients among the variables are higher than 0.579.

<Table 5> Correlation Coefficients among inputs and outputs

평균	EMP	TOE	ROOMS	TREV	OREV	LF
EMP	1.000					
TOE	0.948	1.000				
ROOMS	0.826	0.756	1.000			
TREV	0.879	0.776	0.956	1.000		
OREV	0.652	0.579	0.618	0.694	1.000	
LF(FA)	0.901	0.954	0.723	0.717	0.353	1.000

4.2 Results from Dynamic DEA Models

<Table 6> reports efficiency scores by non-oriented SBM model with constant returns to scale(N-C, hereafter). According to <Table 6>, 8 out of 39 DMUs show 1.000 for efficiency. Average overall score is 0.634, and the DMU S's score is the lowest at 0.038. Standard deviation is 0.293. Weighted average mean is similar to the overall scores, but not the same figures.

<Table 7> illustrates the efficiency scores by non-oriented SBM model with variable returns to scale assumption(N-V, hereafter). According to <Table 7>, 13 out of 39 DMUs show 1.000 for efficiency. It seems that the assumption of VRS results in higher value of efficiency for hotels. Average overall score is 0.753, and the DMU S's score is the lowest at 0.039. Standard deviation is 0.259, lower than the figure from the previous model.

<Table 8> shows average and standard deviation of the inputs, outputs and overall scores for the first-special and second-special level of hotels for the period of 2005-2008. In fixed assets, one can imagine that the size of the hotel of the first-special hotels is 15 times larger than second-special hotels, and the deviation of the fixed assets is also 55 times higher for first-special hotels. In overall scores, it seems that the second-special hotels(0.690) are more efficient than the first-special hotels(0.570). This finding is quite similar to the findings of D. H. Shim(2001).

<Table 6> Efficiency Scores by Non-oriented SBM Model with CRS

No.	DMU	Overal Scorel	term1(1)	term2(1)	term3(1)	term4(1)	W. A. Mean
1	A	0.614	0.511	0.650	0.478	1	0.659
2	B	1	1	1	1	1	1
3	C	1	1	1	1	1	1
4	D	1	1	1	1	1	1
5	E	0.234	1	0.362	0.156	0.112	0.408
6	F	0.218	0.299	0.233	0.167	0.216	0.229
7	G	1	1	1	1	1	1
8	H	1	1	1	1	1	1
9	I	0.897	1	1	1	0.674	0.919
10	J	0.491	0.454	0.725	0.450	0.440	0.517
11	K	1	1	1	1	1	1
12	L	0.716	0.324	1	1	1	0.831
13	M	0.244	0.217	0.361	0.242	0.225	0.261
14	N	0.543	0.548	0.882	0.531	0.352	0.578
15	O	0.504	0.373	0.615	0.562	0.631	0.545
16	P	0.872	0.823	0.857	0.825	1	0.876
17	Q	0.670	0.491	0.743	0.766	0.788	0.697
18	R	0.455	0.483	0.517	0.414	0.420	0.459
19	S	0.038	0.313	0.170	0.384	0.016	0.221
20	T	0.620	0.449	0.678	0.698	0.804	0.658
21	U	0.267	0.254	0.327	0.281	0.239	0.275
22	V	0.708	0.494	0.594	1	1	0.772
23	W	0.995	1	1	1	0.981	0.995
24	X	0.256	0.356	0.172	0.337	0.261	0.282
25	Y	0.820	0.728	0.928	0.687	1	0.836
26	Z	0.713	0.383	1	1	1	0.846
27	AA	0.115	0.137	0.114	0.110	0.108	0.117
28	AB	0.779	0.709	0.797	0.761	0.867	0.783
29	AC	1	1	1	1	1	1
30	AD	0.922	1	1	1	0.726	0.932
31	AE	0.642	0.530	0.672	0.659	0.792	0.663
32	AF	0.908	0.662	1	1	1	0.916
33	AG	0.448	0.323	0.560	0.495	0.544	0.480
34	AH	0.529	1	1	0.242	0.651	0.723
35	AI	0.793	0.623	0.863	0.745	1	0.808
36	AJ	0.628	0.485	0.701	0.684	0.717	0.647
37	AK	0.148	0.119	0.158	0.156	0.181	0.153
38	AL	0.515	0.391	0.586	0.601	0.595	0.543
39	AM	0.439	0.430	0.460	0.402	0.475	0.442
	Average	0.634	0.613	0.711	0.662	0.688	
	Max	1	1	1	1	1	
	Min	0.038	0.119	0.114	0.110	0.016	
	St Dev	0.293	0.298	0.296	0.311	0.330	

<Table 7> Efficiency Scores by Non-oriented SBM Model with VRS

No.	DMU	Overall Score	term1(1)	term1(1)	term1(1)	term1(1)	W.A.Meanores
1	A	1	1	1	1	1	1
2	B	1	1	1	1	1	1
3	C	1	1	1	1	1	1
4	D	1	1	1	1	1	1
5	E	0.599	1	1	0.377	0.292	0.667
6	F	0.862	1	0.985	0.496	1	0.870
7	G	1	1	1	1	1	1
8	H	1	1	1	1	1	1
9	I	0.900	1	1	1	0.683	0.921
10	J	0.560	0.573	0.716	0.499	0.476	0.566
11	K	1	1	1	1	1	1
12	L	0.833	0.530	1	1	1	0.883
13	M	0.253	0.221	0.359	0.248	0.231	0.265
14	N	0.603	0.618	1	0.586	0.432	0.659
15	O	0.538	0.394	0.604	0.583	0.705	0.571
16	P	1	1	1	1	1	1
17	Q	0.713	0.574	0.752	0.775	0.797	0.725
18	R	0.473	0.524	0.516	0.429	0.448	0.479
19	S	0.038	0.274	0.183	0.312	0.015	0.196
20	T	0.690	0.499	0.681	0.731	1	0.728
21	U	0.466	0.490	0.453	0.453	0.467	0.466
22	V	0.750	0.542	0.645	1	1	0.797
23	W	1	1	1	1	1	1
24	X	1	1	1	1	1	1
25	Y	0.856	0.807	0.945	0.718	1	0.868
26	Z	0.716	0.386	1	1	1	0.847
27	AA	1	1	1	1	1	1
28	AB	0.852	0.809	0.846	0.839	0.916	0.852
29	AC	1	1	1	1	1	1
30	AD	0.922	1	1	1	0.726	0.932
31	AE	1	1	1	1	1	1
32	AF	0.917	0.712	1	1	1	0.928
33	AG	0.549	0.445	0.570	0.568	0.675	0.565
34	AH	0.545	1	1	0.257	0.679	0.734
35	AI	0.834	0.732	0.825	0.805	1.000	0.841
36	AJ	0.765	0.708	0.750	0.796	0.809	0.766
37	AK	0.159	0.128	0.167	0.178	0.177	0.163
38	AL	0.521	0.393	0.583	0.616	0.621	0.553
39	AM	0.447	0.437	0.460	0.412	0.483	0.448
	Averag	0.753	0.738	0.822	0.761	0.786	
	Max	1	1	1	1	1	
	Min	0.039	0.128	0.167	0.178	0.015	
	St Dev	0.259	0.279	0.249	0.276	0.286	