國立交通大學

經營管理研究所

碩 士 論 文

影響台灣地區國際觀光旅館成本效率之因素：
隨機邊界法之應用

Efficiency Analysis of International Tourist Hotels in Taiwan:
An Application of the Stochastic Frontier Approach

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摘要

本論文採用一階段隨機邊界分析法（Battese and Coelli, 1995）衡量 1997-2006 年間台灣地區 66 家國際觀光旅館之成本效率，同時探討造成無效率之因素。本模型中使用三產出項，分別為觀光旅館客房收入、餐飲部收入和其他營運收入，而三投入價格則是勞動價格、其他營運價格和餐飲部價格，同時也納入五項環境變數：位處風景區之虛擬變數、加入連鎖飯店系統之虛擬變數、導遊人數、到桃園國際機場的最短距離、及到高雄國際機場的最短距離。由實證結果顯示，台灣地區國際觀光旅館平均營運的成本效率值為 91.15%。加入連鎖飯店系統、增加導遊人數、鄰近國際機場，皆與國際觀光旅館之成本效率具有顯著正向影響，而有助於觀光產業之發展。

關鍵詞：國際觀光旅館、成本效率、隨機邊界、橫縱面資料、時間變動效率

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ABSTRACT

A one-stage stochastic frontier approach (SFA) is used in this study to simultaneously estimate cost efficiency scores and factors of cost inefficiency for 66 international tourist hotels in Taiwan during 1997-2006. An SFA model with three outputs and three inputs is defined. The three outputs are room revenue, food and beverage revenue, and other operation revenue while the three inputs are price of labor, price of other operation, and price of food and beverage. This model also takes into account five environmental variables, including dummy variable of the hotels located in non-metropolitan area, dummy variable of chain hotels, the number of tourist guides, the minimum distance from each hotel to Taoyuan international airport and the minimum distance from each hotel to Kaohsiung international airport. Empirical results show that international tourist hotels in Taiwan are on average operating at 91.15% cost efficiency. All nominal variables are transformed into real variables in 1997 prices by GDP deflators. Chain systems, tourist guides, and international transportation can significantly improve the cost efficiency of international tourist hotels in Taiwan.

Keywords: International Tourist Hotel; Cost Efficiency; Stochastic Frontier; Panel Data; Time-varying Efficiency

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1. Introduction

The demand for recreational traveling has increased as quickly as peoples' incomes have in Taiwan's history. This has caused intensified competition among the hospitality industry, and in particular the hotel industry. The tourism industry not only brings in huge foreign exchange income, but also provides job opportunities in the tourism sector as well as many other industries. In order to promote the hotel industry and attract more international tourists, the government is administering a "Doubling Tourist Arrivals Plan" in an effort to achieve the goal of increasing annual tourists to Taiwan. Over the past six years, total tourism receipts have risen rather quickly and the tourism industry has become a major source of foreign exchange earnings for Taiwan. Up to the year 2006, Taiwan had a total of 89 hotels, of which 60 were international tourist hotels and 29 were general tourist hotels. As the hotel industry is one of the most important industries in Taiwan, it is worth paying more attention to the evaluation of hotel operation efficiency.

The issue of efficiency is gathering momentum in the economics field. This study uses the stochastic frontier approach to measure average and firm-specific efficiency levels in the hotel industry. The process permits a manager to decide if the optimal amount of resources has been employed given the revenues realized. Any resources employed over the optimal quantity indicate a deviation from efficiency or X-inefficiencies as they are termed in finance and economics literature (Leibenstein, 1966).

The two main methods that have previously been used in efficiency estimation are data envelopment analysis (DEA) and stochastic frontier approach (SFA). Although the SFA has been used in miscellaneous empirical studies in the literature, few papers implement the SFA on Taiwan's hotel sector. There is still no study on Taiwan's hotel sector using the SFA for panel data. In the past, most researchers applied DEA to estimate efficiency in the hotel industry, as DEA is a linear programming technique to estimate the efficiency and a non-parametric technique. DEA assumes that the efficiency frontier has no random fluctuations. It does not require knowledge in a functional form, and therefore it is prevalent in the literature. In addition, it can readily deal with multiple inputs and outputs. The advantage of the DEA approach is that it can easily decompose overall efficiency into multiple allocative and technical components. Its disadvantage is, due to the no-random-fluctuation assumption, a lack of statistical analysis foundation. In most cases, SFA is better than DEA. The advantages of SFA are a well-developed statistical test to identify the effectiveness of the model description and its ability to decompose the deviations from efficiency levels into noise and pure inefficiency (Barros, 2004).

Only a few previous studies on Taiwan's hotel industry (e.g., Tsaur 2001; Hwang and Chang 2003; and Chiang et al. 2004) have used the DEA method to estimate hotel efficiency. Chen (2007) took the stochastic frontier approach to analyze data from a single year. This study tries to adopt the panel data, stochastic frontier approach, in order to estimate and analyze the efficiency of Taiwan's international tourist hotels.

2. Background of the hotel industry in Taiwan

According to the latest UNWTO World Tourism Barometer (2008), there were approximately 898 million international tourist arrivals globally in 2006 and the number grew by 6% in 2007. The World Tourism Organization (WTO, 2008) reported 52 million more international arrivals than in 2006, and of the overall number, Europe received some 19 million and Asia and the Pacific took 17 million. The Americas were up by around 6 million, Africa by 3 million and the Middle East by 5 million. All the different regions registered increases above their long-term average, with the Middle East leading the regional growth ranking (+13%), followed by Asia and the Pacific (+10%), Africa (+8%), the Americas (+5%), and Europe (+4%). In Taiwan, the number of foreign visitors has also been increasing continuously. Therefore, the tourism industry has been one of the most important sources of foreign exchange earnings for Taiwan. In fact, since the tourism industry is a non-smokestack industry, it is deemed environmentally significant and important by countries all over the world. The tourism industry is also considered one of the star industries of the 21^{st} century since it brings along such great benefits as creating jobs and increasing foreign exchange earnings. The World Travel and Tourism Council (WTTC) reports that over the next ten years the global tourism industry will enjoy a rise in tourism expenditure from US$4.21 trillion to US$8.61 trillion, an expansion of its share of global GDP (Gross Domestic Product) from 3.6% to 3.8%, and an increase in job opportunities, from 198 million to 250 million positions added. Therefore, this indicates that the tourism industry will play an important role in future global economic development. According to the 2006 annual report on tourism, published by the Taiwan Tourism Bureau, there are 89 tourist hotels in Taiwan, with a total of 21,095 suites and rooms. They can be classified into two groups: international-class tourist hotels and domestic, regular hotels. Of the total number of tourist hotels, 60 are international-class tourist hotels with a total of 17,830 rooms and 29 are regular hotels with 3265 rooms. These hotels employ a total of 19,667 persons. Because of its unique traits in geographic environment, Taiwan possesses plentiful and diverse cultural and natural resources. Therefore, it has great potential for the development of tourism.

In order to achieve the annual visitor goals of the Doubling Tourist Arrivals Plan, Taiwan's government is targeting to double the number of international tourist arrivals, to improve the tourism environment, and to reach the international standards. The government not only wants to attract more foreign tourists, but also to allow people to enjoy their holidays in Taiwan.

Table 1 and Figure 1 respectively show the tabular and figurative numbers of the international tourist hotels in Taiwan during the ten-year period from 1997 to 2006.

Table 1. Numbers of international hotels and rooms in Taiwan from 1997 to 2006

Year	Number of international tourist hotels	Number of rooms
1997	54	16845
1998	53	16558
1999	56	17403
2000	56	17057
2001	58	17815
2002	62	18790
2003	62	18776
2004	61	18709
2005	60	18385
2006	60	17830

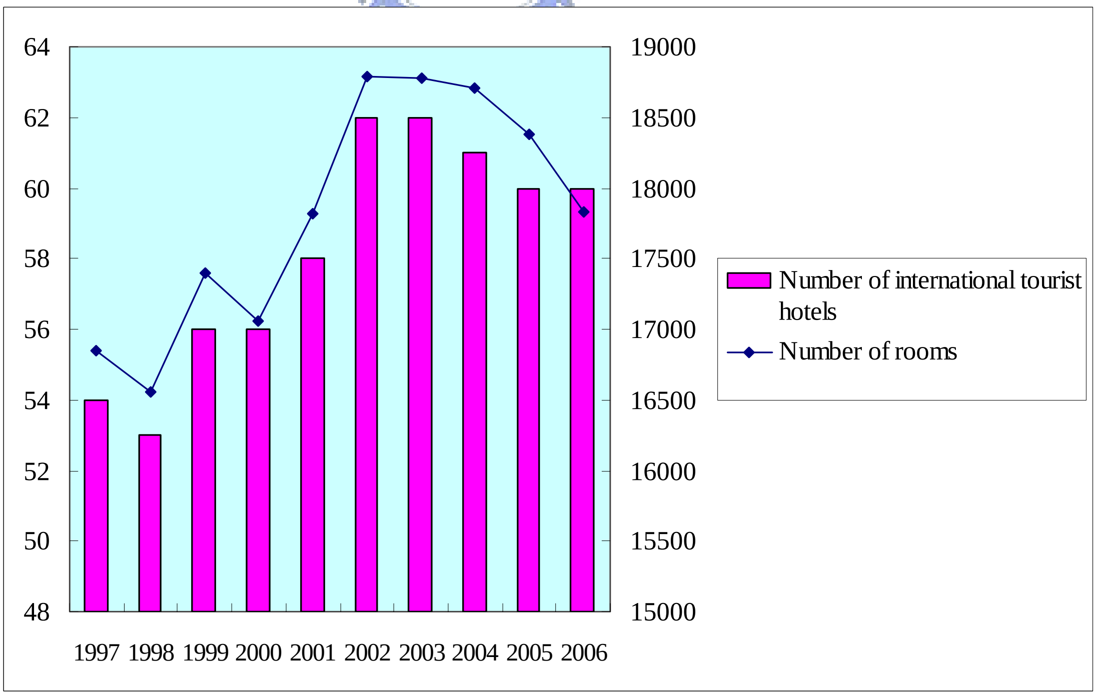

Figure 1. Numbers of international hotels and rooms in Taiwan from 1997 to 2006

3. Review of the literature

Farrell (1957) pioneered dividing cost efficiency into technical efficiency and allocative efficiency. The technical efficiency evaluates the ability of a firm to obtaining maximal output from a given set of inputs and the allocative efficiency the ability of a firm to use the inputs in optimal proportions, given their respective prices and the production technology. These two measures are combined to provide a measure of total economic efficiency. The theories of efficiency measurement are very important in economics, and also commonly and extensively used for other industrial applications. For example, studies of hotel efficiency are currently being conducted. In general, the two primary methods that have been used in efficiency estimation are the stochastic frontier approach (SFA) and data envelopment analysis (DEA). The literatures reviewed are grouped according to these two methods.

3.1 Papers based on SFA

A few papers that used SFA in the hotel industry are summarized as follows: Anderson et al. (1999) employed a stochastic frontier technique to estimate managerial efficiency of 48 hotels in the United States in 1994. They defined inputs as the number of full-time equivalent employees, the number of rooms, total gaming related expenses, total food and beverage expenses, and other expenses, while defining output as the total revenue generated from rooms, gaming, food and beverages, and others. The price of labor was calculated as the total hotel revenue per full-time equivalent employee. The room price was measured by hotel revenues divided by the product of the number of rooms, the occupancy rate, and days per year. The price of gaming, food and beverages, and other expenses were all calculated by measuring each as a percentage of total revenue. They found the hotel industry to be operating at an 89% efficiency level. In particular, the average efficiency was estimated at 89.4%, with the most and least efficient hotels operating at 92.1% and 84.3% efficiency levels, respectively.

Anderson et al. (1999) applied both DEA and SFA to estimate the efficiency of 31 corporate travel management departments. They defined three inputs: the total expense of air, hotel, and car; labor expense, which includes the cost of exempt labor, hourly labor, and part-time labor; and other expenses, which include fee expense, technology costs, and building and occupancy expense. Their inputs were transformed into prices by dividing the three input categories by the number of trips. The output was the number of trips.

Barros (2004) employed a stochastic cost frontier in Portugal's hotel industry. He used a balanced-panel data during 1999-2001 to estimate a stochastic generalized Cobb-Douglas cost function with three inputs and two outputs. Those three inputs were prices of labor, capital and food while the two outputs were sales and nights occupied. In addition, a dummy variable was used to account for the distinction between historical Pousadas and regional Pousadas. The research found that the results were at best mixed, since the efficiency scores were low and not time-varying. For this reason, the author suggested an alteration of management procedures to enable an increase in efficiency, based on a governance environment framework.

Wang et al. (2007) used a one-stage stochastic frontier approach to measure the relative efficiency of 66 international tourist hotels in Taiwan during 1992-2002 and to investigate the determinants of technical efficiency. They also added the Malmquist productivity index to estimate the range and the cause of the productivity change. They used the following four inputs, salaries, the area of food and beverage, the number of rooms, and other operating expenses, and the following three outputs, the number of room occupied, food and beverage revenue, and other operating revenue. Their empirical results revealed that the government policy increasing weekend vacation time has fostered domestic travel and expanded hotel industry. The local government's other expenditures had a significantly positive effect on international tourist hotel's efficiency.

Chen (2007) adopted a stochastic cost frontier to analyze the cost efficiency of 55 international tourist hotels in Taiwan. He used three inputs (labor, food and beverage, and materials) and one output (the total revenue) to measure hotel efficiency. In his result, the factor of operation type not only can affect hotel efficiency significantly, but also can be used to analyze whether the efficiency of the chain hotels is higher than that of independent hotels.

3.2 Papers based on DEA

DEA has been employed by a good number of studies. They are summarized as follows:

Bell and Morey (1995) adopted DEA to analyze the efficiency of 31 corporate travel departments. The inputs used are the actual levels of expenditure for travel, i.e., air, hotel and rental cars, nominal levels of other expenditure, the level of environmental factors, i.e., ease of negotiating discounts, percentage of legs with commuter flights required and actual levels of support cost for labor, technology, fees, space, etc. One output used is the level of service provided, which is either excellent or average.

Morey and Dittman (1995) also used DEA with nine inputs and four outputs to analyze the efficiency of 54 hotels in the United States. The nine inputs used are room division expenditure, energy costs, salaries, non-salary expenses for property, salaries and related expenses for variable advertising, non-salary expenses for variable advertising, fixed market expenditures, payroll and related expenses for administrative work, and non-salary expenses for administrative work. The four outputs used are total revenue, level of service delivered, market share, and the rate of growth.

Anderson et al. (2000) employed DEA with their input-output data to analyze the efficiency of 48 hotels in the United States and to estimate the allocative, technical, pure technical levels. The inputs used are full-time equivalent employees, the number of rooms, total gaming-related expenses, total food and beverage expenses, and other expenses. One output used is total revenue, which is generated from rooms, gaming, food and beverages, and other revenues. Their results indicated that the hotel industry was inefficient with a mean overall efficiency measure of approximately 42%.

Literatures that adopted DEA to analyze the efficiency of the hotel industry in Taiwan included Tsaur (2001), Hwang and Chang (2003), and Chiang et al. (2004). These papers are reviewed as follows:

Tsaur (2001) employed DEA with seven inputs and six outputs to analyze 53 international tourist hotels in Taiwan during 1996-1998. The seven inputs used were total operating expenses, the number of employees, the number of guest rooms, the total floor space of the catering division, the number of employees in the room division, the number of employees in the catering division, and catering cost. The six outputs used were total operating revenues, the number of rooms occupied, average daily rate, the average production value per employee in the catering division, total operating revenues of the room division, and total operating revenues of the catering division. Their results showed that the average operating efficiency score is 0.8733. However, 71.7% of the international tourist hotels in Taiwan present relative inefficiency.

Hwang and Chang (2003) adopted DEA and added the Malmquist productivity index to measure and analyze the managerial performance in 45 Taiwanese hotels in 1998. They also explored the cause of efficiency change during 1994-1998. Their results revealed that the managerial efficiency of Taiwan's international tourist hotels was related to the level of internationalization of the hotels.

The research of Chiang et al. (2004) was aimed at using DEA to measure hotel performance under three operational styles of international tourist hotels commonly seen in Taiwan since 2000: independently owned and operated, franchise licensed, and managed by international hotel operators. The four inputs chosen by the hoteliers were hotel rooms, food and beverage capacity, number of employees, and total cost of the hotel. The three outputs were yielding index, food and beverage revenue, and miscellaneous revenue. They expected their results to provide hoteliers with a basis for constructing strategies and promotion plans. In addition, these results illustrated that not all of Taipei's franchised or managed international tourist hotels performed more efficiently than the independent ones.

3.3 Tabular Summary

It is apparent that the above-mentioned bibliography is quite thin for such a major tourism issue. This paper departs from the previous literature in that it uses panel data of international tourist hotels in Taiwan, related to the years 1997–2006. Table 2 summarizes the previous studies on hotel efficiency.

Table 2. Recapitulation of studies on the hotel frontier efficiency

Paper	Method	Units	Inputs	Outputs
Bell and Morey (1995)	DEA	31 corporate travel departments	Actual level of travel expenditure nominal level of other expenditure level of environmental factors actual level of labor costs	Level of service provided, qualified as excellent and average
Morey and Dittman (1995)	DEA	54 U.S. hotels	Room division expenditure energy costs Salaries non-salary expenditure for property salaries and related expenditure for advertising non-salary expenses for advertising fixed marked expenditure for administrative work	Total revenue level of service delivered market share rate of growth
Anderson et al. (1999a)	Stochastic frontier approach	48 U.S. hotels	Number of full-time equivalent employees number of rooms total gaming-related expenditure total food and beverage expenses other expenses	Total revenue
Anderson et al. (1999b)	DEA and stochastic translog frontier	31 corporate travel departments	Total air expenses hotel expenses car expenses labor expenses hourly labor part-time labor fee expenses technology costs building and occupancy expenses	Number of trips
Anderson et al. (2000)	DEA	48 U.S. hotels	Full-time equivalent employees the number of rooms total gaming-related expenses total food and beverage expenses other expenses	Total revenue other revenue
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 total operating revenues of the room division total operating revenues of the catering division
Hwang and Chang (2003)	DEA	45 Taiwan hotels	Number of full time employees number of guest rooms total area of catering department operating expenses	Room revenue food and beverage revenue other revenue
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
Barros (2004)	Stochastic Cobb-Douglas cost frontier	43 Portuguese hotels	Number of employees amount of capacity food and beverage expenses	Operational cost
Wang et al. (2007)	Stochastic frontier approach	66 Taiwan hotels	Salaries the area of food and beverage the number of rooms other operating expenses.	The number of rooms occupied food and beverage revenue other operating revenue
Chen (2007)	Stochastic Cobb-Douglas cost frontier	55 Taiwan hotels	Price of labor price of food and beverage price of materials	Total revenue of hotel

4. The stochastic frontier approach

The efficiency measurement begins with Farrell (1957), who drew upon the work of Debreu (1951) and Koopmans (1951) to define a simple measure of firm efficiency that could account for multiple inputs. He illustrated his ideas using a simple example involving firms that use two inputs to produce a single output, under the assumption of constant returns to scale. Given the measure of technical efficiency, the overall cost efficiency (*CE*) can be expressed as a product of technical and allocative efficiency measures:

$$TE \times AE = CE. \tag{1}$$

Even though a cost function can be deterministically specified to account for many factors, a stochastic cost function that includes a random error in the formulation is frequently needed. Because the error reflects both the cost inefficiency and the white noise, a zero mean error term is theoretically incorrect. There has been a large amount of research to extend and apply this model ever since the stochastic frontier production function was taken up by Aigner et al. (1977) and Meeusen and van den Broeck (1977). They proposed models with a composite error structure. The composite error structure permits the measurement of efficiency in spite of white noise. This is created with seminal contributions to the stochastic frontier approach. The stochastic frontier cost function for panel data, for the *i*-th hotel (i=1,2, …,N) at the *t*-th period (t=1,2,…,T), is as follows:

$$\ln TC_{it} = C\left(X_{it}, Y_{it}, \beta_i\right) + V_{it} + U_{it}. \tag{2}$$

where TC_{it} is the total cost for the *i*-th hotel at the *t*-th period; X_{it} is a 1×k vector containing values of known functions of inputs of cost and other explanatory variables related to the *i*-th hotel at the *t*-th period; Y_{it} is a 1×k vector containing values of known functions of output of revenue and other explanatory variables related to the *i*-th hotel at the t-th period; and β_i is a k×1 vector of unknown parameters to be estimated. The V_{it}s are assumed to be independent and identically distributed as $N(0, \sigma_V^2)$. They are also independent of the U_{it}s, which are non-negative random variables corresponding to technical inefficiency of cost. Moreover, U_{it}s are assumed to be independently distributed and truncated at zero of $Half\ N\left(\mu, \sigma_U^2\right)$.

In order to assist the maximum likelihood estimation, the variance terms are parameterized as σ_U^2 and σ_V^2, respectively. Several more terms are defined based on them.

$$\sigma^2 = \sigma_U^2 + \sigma_V^2 \text{ and } \gamma = \sigma_U^2 / \sigma^2. \tag{3}$$

Many scholars in the early empirical literature, such as Pitt and Lee (1981) and Kalirajan (1981), engaged in the illustration of these inefficiency effects. They took a two-stage approach. In the first stage, the stochastic frontier production function is estimated and the technical inefficiency effects are predicted based on the assumption that these inefficiency effects are caused by appropriate distributions. In addition, the models for technical inefficiency effects of the stochastic frontier functions have been proposed by Kumbhakar et al. (2003) and Reifschneider and Stevenson (1991).

Battese and Coelli (1995) also proposed a model for technical inefficiency effects in a stochastic frontier production function for panel data. The model assumes that the inefficiency effects are stochastic. It also allows for the measurement of both technical changes in the stochastic frontier and time-varying technical inefficiencies. In the stochastic model of the frontier cost function, it is assumed that any deviation of the observed cost from the theoretical microeconomic cost function is simply due to random disturbances and inefficiency. The deviation is accounted for as the composite error term in the stochastic frontier model. In this case, the model of stochastic frontier function for panel data is as follows:

$$Y_{it} = \exp\left(X_{it}\beta + V_{it} - U_{it}\right). \tag{4}$$

where Y_{it} is the production at the t-th period (t = 1,2,⋯,T) for the i-th firm (i = 1,2,…,N); x_{it} is a 1×k vector of known values, equal to functions of inputs of product and other explanatory variables corresponding to the i-th firm at the t-th period; β is a 1×k vector of unknown parameters to be computed; V_{it}s are assumed to be iid N $(0,\sigma_V^2)$ random errors, independently distributed from U_{it}s; and U_{it}s are non-negative random variables, corresponding to the technical inefficiency of production. Additionally, the technical inefficiency effect, U_{it}, in the stochastic frontier model (1) can be specified as follows:

$$U_{it} = Z_{it}\delta + \theta_{it}. \tag{5}$$

where θ_{it} is a random variable defined by the truncation of the normal distribution with zero mean and variance of σ^2, such that the point of truncation is at $-Z_{it}\delta$. This model is a one-stage model that permits the simultaneous estimation by the two-stage procedure. However, the simple random component cannot very accurately model the effect of variables that are farther away from the control of the production unit being analyzed. Decomposition techniques go back to Jondrow et al. (1982) and take advantage of the conditional distribution to provide firm-specific inefficiency estimates, not purely overall averages.

The cost efficiency (CE), a value between zero and one, reveals the extent to which a hotel succeeds in minimizing cost given input and output prices. It can be formulated as follows:

$$CE_{it} = \frac{C^{\min}}{C} = \frac{C\left(Y_{it}, X_{it}, \beta\right)\exp\left(V_{it}\right)}{C\left(Y_{it}, X_{it}, \beta\right)\exp\left(U_{it} + V_{it}\right)} = \exp\left(-U_{it}\right). \tag{6}$$

5. Data and empirical model

5.1 Sample and data sources

In order to estimate the cost frontier, the panel data used in this study consisted of data obtained from the annual report of international tourist hotels published by Taiwan Tourism Bureau during 1997~2006 concerning 66 different international hotels. Although the original data contained a total of 660 (66×10) samples, only hotels with complete data were chosen to be samples in this research. In addition, all nominal variables are transformed into real variables in 1997 prices by GDP deflators. The change in the GDP deflator provides the most general measure of overall price change, taking into account changes in total cost, price of labor, price of other operations, price of food and beverage, room revenue, other operation revenue, and food and beverage revenue.

5.2 Variables

There are two main businesses for international tourist hotels. One is the renting of rooms and the other the service of food and beverage. A stochastic generalized translog cost frontier function was used as the empirical model. The cost frontier function used has three inputs and three outputs. The three inputs are the price of labor, the price of food and beverage, and the price of other operations. The three outputs are room revenue, food and beverage revenue, and other operation revenue. The function involves five environmental variables, including the hotels located in non-metropolitan areas, chain hotels, number of tourist guides, the minimum distance from each hotel to Taoyuan international airport and the minimum distance from each hotel to Kaohsiung international airport. Moreover, the total operating cost comprises labor cost, fuel and energy, materials, and circumstantial services as the dependent variables. All those variables are detailed as follows.

- Input variables:

1. Price of labor (W_l): measured by dividing the total salary expenditure by the number of equivalent employees.

2. Price of other operations (W_o): measured by dividing the other operations expenditure by the number of rooms.

3. Price of food and beverage (W_c): measured by dividing the total food and beverage expenditure by the area of equivalent food and beverage.

- Output variables:

1. Room revenue (R_r): the room revenue of an international hotel.
2. Other operation revenue (R_o): measured by the total revenue minus the room revenue and the food and beverage revenue.
3. Food and beverage revenue (R_c): the food and beverage revenue of an international hotel.

- Environmental variables:

1. Non-metropolitan area (D_R): a dummy variable, with a value of one when a hotel is located in a non-metropolitan area and zero for a metropolitan area.
2. Chain hotel (D_I): a dummy variable, with a value of one for a chain hotel and zero for an independent hotel.
3. Tourist guides (G): the number of tourist guides.
4. Distance from Taoyuan international airport (MD_{TIA}): the minimum distance from each hotel to Taoyuan international airport.
5. Distance from Kaohsiung international airport (MD_{KIA}): the minimum distance from each hotel to Kaohsiung international airport.

The characteristics of the variables are summarized in Table 3.

5.3 Empirical model

The model used in this study is a translog cost function with three inputs, three outputs, and five environmental variables (two of these are dummy variables). More specifically, the model can be expressed as follows:

$$
\begin{aligned}
\ln(TC_{it}) &= \beta_0 + \beta_1 \ln(W_{lit}) + \beta_2 \ln(W_{oit}) + \beta_3 \ln(W_{cit}) + \beta_4 \ln(R_{rit}) + \beta_5 \ln(R_{oit}) + \beta_6 \ln(R_{cit}) \\
&+ \frac{1}{2}\beta_7 \left[\ln(W_{lit})\right]^2 + \frac{1}{2}\beta_8 \left[\ln(W_{oit})\right]^2 + \frac{1}{2}\beta_9 \left[\ln(W_{cit})\right]^2 + \frac{1}{2}\beta_{10} \left[\ln(R_{rit})\right]^2 + \frac{1}{2}\beta_{11} \left[\ln(R_{oit})\right]^2 \\
&+ \frac{1}{2}\beta_{12} \left[\ln(R_{cit})\right]^2 + \beta_{13} \ln(W_{lit})\ln(W_{oit}) + \beta_{14} \ln(W_{lit})\ln(W_{cit}) + \beta_{15} \ln(W_{lit})\ln(R_{rit}) + \beta_{16} \ln(W_{lit})\ln(R_{oit}) \\
&+ \beta_{17} \ln(W_{lit})\ln(R_{cit}) + \beta_{18} \ln(W_{oit})\ln(W_{cit}) + \beta_{19} \ln(W_{oit})\ln(R_{rit}) + \beta_{20} \ln(W_{oit})\ln(R_{oit}) + \beta_{21} \ln(W_{oit})\ln(R_{cit}) \\
&+ \beta_{22} \ln(W_{cit})\ln(R_{rit}) + \beta_{23} \ln(W_{cit})\ln(R_{oit}) + \beta_{24} \ln(W_{cit})\ln(R_{cit}) + \beta_{25} \ln(R_{rit})\ln(R_{oit}) + \beta_{26} \ln(R_{rit})\ln(R_{cit}) \\
&+ \beta_{27} \ln(R_{oit})\ln(R_{cit}) + V_{it} + U_{it} \qquad (7)
\end{aligned}
$$

and

$$U_{it} = \delta_0 + \delta_1 D_{Ri} + \delta_2 D_{Ii} + \delta_3 G_{it} + \delta_4 MD_{TIAi} + \delta_5 MD_{KIAi} + \theta_{it} \qquad (8)$$

where i represents the number of international hotels, i =1,2,⋯,N;

t is time, t = 1,2,⋯,T;

TC is the total cost;

W_l is the price of labor;

W_o is the price of other operations;

W_c is the price of F&B;

R_r is the room revenue;

R_o is the other operation revenue;

R_c is the food and beverage revenue;

D_R is the dummy variable of non-metropolitan area;

D_I is the dummy variable of the chain hotel;

G is the number of tourist guides;

MD_{TIA} is distance from Taoyuan international airport; and

MD_{KIA} is distance from Kaohsiung international airport.

Equation (7) specifies the stochastic cost frontier function. The deviation from the frontier occurs because of the random shocks and statistical noise (V_{it}) as well as technical inefficiency (U_{it}). Equation (8) is a one-sided term reflecting technical inefficiency. The characteristics of the variables are summarized in Table 3.

Table 3. Descriptive statistics of variables

Variable	Description	Mean	Maximum	Minimum	Standard deviation
TC	Total cost	536244279	2394250681	17760321	482328259
W_l	Price of labor measured in dividing total salary expenditure by the number of equivalent employees	497864	902741	82963	147731
W_o	Price of other operation measured in dividing total revenue minus the room revenue and the food and beverage revenue by the number of rooms	731001	2741308	83304	493151
W_c	Price of F&B measured in dividing total F&B expenditure by the area of equivalent F&B	100138	785254	2283	65663
R_r	Room revenue	227696937	1359688456	7082913	206559883
R_o	Other operation revenue	97698159	702209043	263111	132501554
R_c	Food and beverage revenue	270546313	1313060839	5581527	271353292
D_R	Dummy (1 for located in non-metropolitan and 0 for metropolitan)	0.1413	1	0	0.3486
D_I	Dummy (1 for chain hotel and 0 for independent hotel)	0.5156	1	0	0.5002
G	Number of tourist guides	2823.4624	5113	2138	846.8952
MD_{TIA}	minimum distance from each hotel to Taoyuan international	41.3305	499.63	0.01	95.3040

	airport				
MD_{KIA}	minimum distance from each hotel to Kaohsiung international airport	256.9486	400.97	7.33	134.9411

6. Empirical results

In this study, Frontier 4.1 is applied to estimate the parameters of the translog cost frontier function. The results of the stochastic frontier estimation are shown in Tables 4 and 5.

Table 4 summarizes the estimation results obtained for the stochastic frontier approach, showing that the translog cost function specified in the previous chapter fits the data well. The coefficients of most inputs and outputs are statistically significant. That means the selection of inputs and outputs is appropriate for the cost frontier estimation. The coefficients with respect to output variables, room revenue β_4 and other operation revenue β_5, are 3.0028, and 1.1477, respectively. The positive signs indicate that an increase in output will lead to an increase in the total cost.

Except for the hotel located in the non-metropolitan area, the coefficients of all environmental variables are negative. That means these four environments can decrease cost inefficiency. The results also show that δ_1 is significantly positive while δ_2, δ_3, δ_4, and δ_5 are significantly negative. A positive value indicates that an increase in environmental variables will lead to an increase in cost inefficiency. A negative value indicates that an increase in environmental variables will lead to a decrease in cost inefficiency. The environmental variable of operation type, such as chain hotels, is significant at the 1% level. The environmental variable for the number of tourist guides is also significant at the 1% level. The environmental variables of international transportation, such as international airports, are significant at the 1% level. In addition to all of the above, the environmental variables significantly affect hotel cost efficiency.

The ratio of the variability for U and V can be used to estimate the relative inefficiency in a hotel. It is an estimate of the amount of variation stemming from inefficiency relative to noise for the sample. The values of λ and γ, where

$\lambda = \sigma_U / \sigma_V$ and $\gamma = \sigma_U^2 / \sigma_V^2$, are 4.3916 and 0.9507, respectively. Therefore, γ is significant at 1% level. The fact that γ is close to one reveals that a significant proportion of variance in the composite error term comes from the inefficiency effect. For this reason, it is appropriate to use the stochastic frontier approach in this study.

Table 4. Parameter estimates of the translog cost frontier function

Variable	Coefficient	Estimate	t-ratio
Constant in the cost frontier	β_0	-5.8367	-1.4392*
$\ln\left(W_{l_{it}}\right)$	β_1	0.8708	1.2094
$\ln\left(W_{o_{it}}\right)$	β_2	-1.8648	-2.4460***
$\ln\left(W_{c_{it}}\right)$	β_3	1.8716	7.0492***
$\ln\left(R_{rit}\right)$	β_4	3.0028	4.6875***
$\ln\left(R_{oit}\right)$	β_5	1.1477	2.9881***
$\ln\left(R_{cit}\right)$	β_6	-2.7331	-4.4940***
$1/2\left[\ln\left(W_{l_{it}}\right)\right]^2$	β_7	0.0957	1.2259
$1/2\left[\ln\left(W_{o_{it}}\right)\right]^2$	β_8	-0.0030	-0.0544
$1/2\left[\ln\left(W_{c_{it}}\right)\right]^2$	β_9	-0.1124	-5.7028***
$1/2\left[\ln\left(R_{rit}\right)\right]^2$	β_{10}	0.1275	2.7615***
$1/2\left[\ln\left(R_{oit}\right)\right]^2$	β_{11}	0.0207	1.8111**
$1/2\left[\ln\left(R_{cit}\right)\right]^2$	β_{12}	0.1265	4.0857***
$\ln\left(W_{l_{it}}\right)\ln\left(W_{o_{it}}\right)$	β_{13}	0.0809	1.5648*
$\ln\left(W_{l_{it}}\right)\ln\left(W_{c_{it}}\right)$	β_{14}	-0.1001	-3.4926***
$\ln\left(W_{lit}\right)\ln\left(R_{rit}\right)$	β_{15}	-0.2021	-3.9752***
$\ln\left(W_{lit}\right)\ln\left(R_{oit}\right)$	β_{16}	-0.0612	-2.3663***
$\ln\left(W_{lit}\right)\ln\left(R_{cit}\right)$	β_{17}	0.1508	3.1287***
$\ln\left(W_{oit}\right)\ln\left(W_{cit}\right)$	β_{18}	-0.0472	-1.6610**
$\ln\left(W_{oit}\right)\ln\left(R_{rit}\right)$	β_{19}	0.0504	1.5382*
$\ln\left(W_{oit}\right)\ln\left(R_{oit}\right)$	β_{20}	0.0547	2.3250***
$\ln\left(W_{oit}\right)\ln\left(R_{cit}\right)$	β_{21}	-0.0194	-0.6941
$\ln\left(W_{cit}\right)\ln\left(R_{rit}\right)$	β_{22}	0.0055	0.2282

$\ln(W_{cit})\ln(R_{oit})$	β_{23}	-0.0537	-3.4682***
$\ln(W_{cit})\ln(R_{cit})$	β_{24}	0.1127	5.2784***
$\ln(R_{rit})\ln(R_{oit})$	β_{25}	-0.0501	-2.6018***
$\ln(R_{rit})\ln(R_{cit})$	β_{26}	-0.1243	-3.8589***
$\ln(R_{oit})\ln(R_{cit})$	β_{27}	0.0106	0.7358
Constant in the equation of cost inefficiency	δ_0	0.4452	2.2094***
D_{Ri}	δ_1	0.6962	2.4567***
D_{Ii}	δ_2	-0.3203	-2.5843***
G_{it}	δ_3	-0.0005	-2.3733***
MD_{TIAi}	δ_4	-0.0014	-2.1235***
MD_{KIAi}	δ_5	-0.0009	-3.1403***
σ_V^2		0.0071	
σ_U^2		0.1374	
$\sigma^2 = \sigma_U^2 + \sigma_V^2$	sigma-squared	0.1445	3.2927***
$\gamma = \sigma_U^2 / (\sigma_U^2 + \sigma_V^2)$	Gamma	0.9507	57.7196***
log likelihood function	389.9759		
LR test of the one-sided error	75.2766		
Total number of observations	545		

Note: ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 5 shows the efficiency scores measured from the residuals. The mean efficiency is 91.15%. This value indicates that, to operate efficiently, hotels could only reduce their input costs by 8.85% without decreasing their outputs. In this study, the hotel outputs are defined as room revenue, food and beverage revenue, and other operation revenue. The score of the maximum hotel efficiency is 97.79% while the minimum efficiency score is 71.29%. The median efficiency is 92.39% and the standard deviation is 5.11%. These efficiency scores are higher than those listed in previous literatures in the same industry. For example, the corresponding values are 21.6%, 80.29%, and 89.4% in Portugal (Barros, 2004), Taiwan (Chen, 2007), and the United States (Anderson et. al, 1999), respectively. Tables 6 to 15 are efficiency scores of individual international tourist hotels, one table for each year from 1997 to 2006.

Table 5. Average cost efficiency rankings of Taiwanese international tourist hotels

ID	Hotel	Cost efficiency	Ranking	ID	Hotel	Cost efficiency	Ranking
1	Grand Hotel	0.8322	62	34	Hotel National	0.9149	37
2	Ambassador Hotel	0.9463	18	35	Plaza International Hotel	0.9506	13
3	Mandarina Crown Hotel	0.8707	55	36	Evergreen Laurel Hotel	0.9370	29
4	Imperial Taipei	0.8499	59	37	Howard Plaza Hotel Taichung	0.9636	6
5	Gloria Prince Hotel	0.9383	27	38	Splendor Taichung	0.9019	45
6	Emperor Hotel	0.9423	22	39	Hotel Royal Chiao-His	0.9779	1
7	Hotel Riverview Taipei	0.9395	26	40	Marshal Hotel	0.9139	39
8	Caesar Park Taipei	0.9636	6	41	Chinatrust Hotel Hualien	0.9373	28
9	Golden China Hotel	0.9648	5	42	Parkview Hotel	0.9266	33
10	San Want Hotel	0.9114	42	43	Taroko	0.9473	17
11	Brother Hotel	0.9432	20	44	Hotel Landis China Yangmingshan	0.9164	36
12	Santos Hotel	0.9118	41	45	The Grand Hotel Kaohsiung	0.8965	47
13	The Ritz Landis Hotel	0.9439	19	46	Caesar Park Hotel Kending	0.8919	49
14	United Hotel	0.9546	9	47	Hotel Royal Chihpen Spa	0.9080	43
15	Sheraton Taipei Hotel	0.8845	50	48	Grand Formosa Hotel	0.8065	64
16	Taipei Fortuna Hotel	0.9123	40	49	Howard Beach Resort Kending	0.9140	38
17	Holiday Inn Asiaworld Taipei	0.8356	60	50	Hibiscus Resorts	0.7129	66
18	Hotel Royal Taipei	0.9699	2	51	Lalu Sun Moon Lake	0.9404	25
19	Howard Plaza Hotel	0.9272	32	52	Taoyuan Holiday Hotel	0.9211	34
20	Rebar Crowne Plaza Taipei	0.8655	56	53	Hotel Tainan	0.9498	15
21	Grand Hyatt Taipei	0.8756	54	54	Ta Shee Resort Hotel	0.9545	10
22	Grand Formosa Regent Taipei	0.9687	3	55	Hotel Royal Hsinchu	0.9411	24
23	Sherwood Hotel Taipei	0.9617	8	56	Ambassador Hotel Hsinchu	0.9424	21
24	Far Eastern Plaza Hotel Taipei	0.9503	14	57	Formosan Naruwan Hotel	0.8812	51
25	Westin Hotel	0.9539	11	58	Tayih Landis Tainan Hotel	0.9498	15
26	Hotel Kingdom	0.8796	52	59	Jen Dow International Hotel	0.9033	44
27	Holiday Garden Kaohsiung	0.8945	48	60	Plaza Hotel	0.7612	65
28	Ambassador Hotel Kaohsiung	0.8553	58	61	Le Midi Hotel Chitou	0.8762	53
29	Han-Hsien international Hotel	0.8966	46	62	Royal Less Hotel	0.9678	4
30	Grand Hi-Lai Hotel	0.9370	29	63	Miramar Garden Taipei	0.8560	57
31	Howard Plaza Hotel Kaohsiung	0.9370	29	64	Chinatrust Hotel Sun Moon Lake	0.9515	12
32	Splendor Kaohsiung	0.8351	61	65	EI Dorado Hotel	0.8295	63
33	Park Hotel	0.9418	23	66	Evergreen Plaza Hotel Tainan	0.9186	35
Mean efficiency		0.9115					
Highest efficiency		0.9779					
Lowest efficiency		0.7129					
Median efficiency		0.9239					
Standard deviation		0.0511					

Table 6. The efficiency scores of international tourist hotels in Taiwan (1997)

ID	Hotel	Cost efficiency	ID	Hotel	Cost efficiency
1	The Grand Hotel	0.6244	28	The Ambassador Hotel Kaohsiung	0.7802
2	The Ambassador Hotel	0.9326	29	Han-Hsien international Hotel	0.9131
3	Mandarina Crown Hotel	0.7960	30	Grand Hi-Lai Hotel	0.9497
4	Imperial Taipei	0.3994	31	Howard Plaza Hotel Kaohsiung	0.9211
5	Gloria Prince Hotel	0.9575	33	Park Hotel	0.9562
6	Emperor Hotel	0.9631	34	Hotel National	0.8566
7	Hotel Riverview Taipei	0.9369	35	Plaza International Hotel	0.9412
8	Caesar Park Taipei	0.9234	36	Evergreen Laurel Hotel	0.8894
9	Golden China Hotel	0.9623	37	Howard Plaza Hotel Taichung	0.9591
10	San Want Hotel	0.8078	40	Marshal Hotel	0.9264
11	Brother Hotel	0.9383	41	Chinatrust Hotel Hualien	0.9411
12	Santos Hotel	0.8976	42	Parkview Hotel	0.9449
13	The Ritz Landis Hotel	0.9452	44	Hotel Landis China Yangmingshan	0.8954
14	United Hotel	0.9530	45	The Grand Hotel Kaohsiung	0.8447
15	Sheraton Taipei Hotel	0.9261	46	Caesar Park Hotel Kending	0.9294
16	Taipei Fortuna Hotel	0.9336	47	Hotel Royal Chihpen Spa	0.9478
17	Holiday Inn Asiaworld Taipei	0.7561	48	Grand Formosa Hotel	0.6214
18	Hotel Royal Taipei	0.9712	52	Taoyuan Holiday Hotel	0.9377
19	Howard Plaza Hotel	0.9471	53	Hotel Tainan	0.9613
20	Rebar Crowne Plaza Taipei	0.8906	54	Ta Shee Resort Hotel	0.9599
21	Grand Hyatt Taipei	0.9022	59	Jen Dow International Hotel	0.9279
22	Grand Formosa Regent Taipei	0.9690	61	Le Midi Hotel Chitou	0.9234
23	The Sherwood Hotel Taipei	0.9620	63	Miramar Garden Taipei	0.8569
24	Far Eastern Plaza Hotel Taipei	0.9494	64	Chinatrust Hotel Sun Moon Lake	0.9577
26	Hotel Kingdom	0.8937	65	EI Dorado Hotel	0.8295
27	Holiday Garden Kaohsiung	0.9182			
	Mean efficiency	0.8947			
	Highest efficiency	0.9712			
	Lowest efficiency	0.3994			
	Median efficiency	0.9294			
	Standard deviation	0.1042			

Table 7. The efficiency scores of international tourist hotels in Taiwan (1998)

ID	Hotel	Cost efficiency	ID	Hotel	Cost efficiency
1	The Grand Hotel	0.7562	28	The Ambassador Hotel Kaohsiung	0.7325
2	The Ambassador Hotel	0.9331	29	Han-Hsien international Hotel	0.9057
3	Mandarina Crown Hotel	0.8482	30	Grand Hi-Lai Hotel	0.9388
4	Imperial Taipei	0.9039	31	Howard Plaza Hotel Kaohsiung	0.9331
5	Gloria Prince Hotel	0.9509	33	Park Hotel	0.9261
6	Emperor Hotel	0.9388	34	Hotel National	0.8909
7	Hotel Riverview Taipei	0.8025	35	Plaza International Hotel	0.9647
8	Caesar Park Taipei	0.9645	36	Evergreen Laurel Hotel	0.9192
9	Golden China Hotel	0.9596	37	Howard Plaza Hotel Taichung	0.9621
10	San Want Hotel	0.8830	40	Marshal Hotel	0.9204
11	Brother Hotel	0.9348	41	Chinatrust Hotel Hualien	0.9294
12	Santos Hotel	0.9081	42	Parkview Hotel	0.9432
13	The Ritz Landis Hotel	0.9346	44	Hotel Landis China Yangmingshan	0.9224
14	United Hotel	0.8973	45	The Grand Hotel Kaohsiung	0.8331
15	Sheraton Taipei Hotel	0.9242	46	Caesar Park Hotel Kending	0.9518
16	Taipei Fortuna Hotel	0.8387	47	Hotel Royal Chihpen Spa	0.9477
17	Holiday Inn Asiaworld Taipei	0.8464	48	Grand Formosa Hotel	0.8132
18	Hotel Royal Taipei	0.9622	49	Howard Beach Resort Kending	0.8815
19	Howard Plaza Hotel	0.9412	52	Taoyuan Holiday Hotel	0.9327
20	Rebar Crowne Plaza Taipei	0.8815	53	Hotel Tainan	0.9634
21	Grand Hyatt Taipei	0.9217	54	Ta Shee Resort Hotel	0.9394
22	Grand Formosa Regent Taipei	0.9660	59	Jen Dow International Hotel	0.9365
23	The Sherwood Hotel Taipei	0.9573	60	Plaza Hotel	0.6475
24	Far Eastern Plaza Hotel Taipei	0.9610	61	Le Midi Hotel Chitou	0.9606
26	Hotel Kingdom	0.9443	63	Miramar Garden Taipei	0.8700
27	Holiday Garden Kaohsiung	0.8956	64	Chinatrust Hotel Sun Moon Lake	0.9654
	Mean efficiency	0.9074			
	Highest efficiency	0.9660			
	Lowest efficiency	0.6475			
	Median efficiency	0.9311			
	Standard deviation	0.0648			

Table 8. The efficiency scores of international tourist hotels in Taiwan (1999)

ID	Hotel	Cost efficiency	ID	Hotel	Cost efficiency
1	The Grand Hotel	0.7008	30	Grand Hi-Lai Hotel	0.9370
2	The Ambassador Hotel	0.9425	31	Howard Plaza Hotel Kaohsiung	0.9353
3	Mandarina Crown Hotel	0.8112	33	Park Hotel	0.9653
4	Imperial Taipei	0.8532	34	Hotel National	0.8859
5	Gloria Prince Hotel	0.9004	35	Plaza International Hotel	0.9463
6	Emperor Hotel	0.9489	36	Evergreen Laurel Hotel	0.9325
7	Hotel Riverview Taipei	0.9463	37	Howard Plaza Hotel Taichung	0.9463
8	Caesar Park Taipei	0.9607	38	The Splendor Taichung	0.8635
10	San Want Hotel	0.8973	40	Marshal Hotel	0.9222
11	Brother Hotel	0.9450	41	Chinatrust Hotel Hualien	0.8958
12	Santos Hotel	0.9217	42	Parkview Hotel	0.9185
13	The Ritz Landis Hotel	0.9376	44	Hotel Landis China Yangmingshan	0.9433
14	United Hotel	0.9368	45	The Grand Hotel Kaohsiung	0.8777
15	Sheraton Taipei Hotel	0.9224	46	Caesar Park Hotel Kending	0.9331
16	Taipei Fortuna Hotel	0.9100	47	Hotel Royal Chihpen Spa	0.9404
17	Holiday Inn Asiaworld Taipei	0.8987	48	Grand Formosa Hotel	0.7553
18	Hotel Royal Taipei	0.9698	49	Howard Beach Resort Kending	0.9444
19	Howard Plaza Hotel	0.9414	52	Taoyuan Holiday Hotel	0.9006
20	Rebar Crowne Plaza Taipei	0.8759	53	Hotel Tainan	0.9675
21	Grand Hyatt Taipei	0.9230	54	Ta Shee Resort Hotel	0.9510
22	Grand Formosa Regent Taipei	0.9633	55	Hotel Royal Hsinchu	0.8215
23	The Sherwood Hotel Taipei	0.9616	59	Jen Dow International Hotel	0.8545
24	Far Eastern Plaza Hotel Taipei	0.9593	60	Plaza Hotel	0.7808
26	Hotel Kingdom	0.9218	61	Le Midi Hotel Chitou	0.9405
27	Holiday Garden Kaohsiung	0.9171	63	Miramar Garden Taipei	0.8410
28	The Ambassador Hotel Kaohsiung	0.8168	64	Chinatrust Hotel Sun Moon Lake	0.9314
29	Han-Hsien international Hotel	0.9018			
	Mean efficiency	0.9079			
	Highest efficiency	0.9698			
	Lowest efficiency	0.7008			
	Median efficiency	0.9230			
	Standard deviation	0.0567			

Table 9. The efficiency scores of international tourist hotels in Taiwan (2000)

ID	Hotel	Cost efficiency	ID	Hotel	Cost efficiency
1	The Grand Hotel	0.8866	28	The Ambassador Hotel Kaohsiung	0.8270
2	The Ambassador Hotel	0.9323	29	Han-Hsien international Hotel	0.8525
3	Mandarina Crown Hotel	0.8372	30	Grand Hi-Lai Hotel	0.9294
4	Imperial Taipei	0.8813	31	Howard Plaza Hotel Kaohsiung	0.9264
5	Gloria Prince Hotel	0.9096	32	The Splendor Kaohsiung	0.8952
6	Emperor Hotel	0.9439	33	Park Hotel	0.9321
7	Hotel Riverview Taipei	0.9536	34	Hotel National	0.8826
8	Caesar Park Taipei	0.9668	35	Plaza International Hotel	0.9359
9	Golden China Hotel	0.9683	36	Evergreen Laurel Hotel	0.9347
10	San Want Hotel	0.9096	37	Howard Plaza Hotel Taichung	0.9526
11	Brother Hotel	0.9516	38	The Splendor Taichung	0.9390
12	Santos Hotel	0.9089	40	Marshal Hotel	0.8859
13	The Ritz Landis Hotel	0.9404	41	Chinatrust Hotel Hualien	0.9134
14	United Hotel	0.9736	42	Parkview Hotel	0.9331
15	Sheraton Taipei Hotel	0.9322	44	Hotel Landis China Yangmingshan	0.9406
16	Taipei Fortuna Hotel	0.9129	45	The Grand Hotel Kaohsiung	0.9079
17	Holiday Inn Asiaworld Taipei	0.9085	46	Caesar Park Hotel Kending	0.8113
18	Hotel Royal Taipei	0.9674	47	Hotel Royal Chihpen Spa	0.9163
19	Howard Plaza Hotel	0.9448	48	Grand Formosa Hotel	0.5931
20	Rebar Crowne Plaza Taipei	0.8597	49	Howard Beach Resort Kending	0.9013
21	Grand Hyatt Taipei	0.8643	52	Taoyuan Holiday Hotel	0.9073
22	Grand Formosa Regent Taipei	0.9658	53	Hotel Tainan	0.9637
23	The Sherwood Hotel Taipei	0.9608	54	Ta Shee Resort Hotel	0.9612
24	Far Eastern Plaza Hotel Taipei	0.9645	55	Hotel Royal Hsinchu	0.9629
25	The Westin Hotel	0.9411	59	Jen Dow International Hotel	0.8208
26	Hotel Kingdom	0.8320	60	Plaza Hotel	0.9600
27	Holiday Garden Kaohsiung	0.8274	61	Le Midi Hotel Chitou	0.6806
	Mean efficiency	0.9058			
	Highest efficiency	0.9736			
	Lowest efficiency	0.5931			
	Median efficiency	0.9279			
	Standard deviation	0.0693			

Table 10. The efficiency scores of international tourist hotels in Taiwan (2001)

ID	Hotel	Cost efficiency	ID	Hotel	Cost efficiency
1	The Grand Hotel	0.8360	29	Han-Hsien international Hotel	0.8816
2	The Ambassador Hotel	0.9354	30	Grand Hi-Lai Hotel	0.8880
3	Mandarina Crown Hotel	0.8968	31	Howard Plaza Hotel Kaohsiung	0.9136
4	Imperial Taipei	0.8710	32	The Splendor Kaohsiung	0.8153
5	Gloria Prince Hotel	0.9274	33	Park Hotel	0.9220
6	Emperor Hotel	0.9052	34	Hotel National	0.8939
7	Hotel Riverview Taipei	0.9622	35	Plaza International Hotel	0.9473
8	Caesar Park Taipei	0.9589	36	Evergreen Laurel Hotel	0.9238
9	Golden China Hotel	0.9617	37	Howard Plaza Hotel Taichung	0.9500
11	Brother Hotel	0.9303	38	The Splendor Taichung	0.9174
12	Santos Hotel	0.9074	40	Marshal Hotel	0.8398
13	The Ritz Landis Hotel	0.9362	41	Chinatrust Hotel Hualien	0.9362
14	United Hotel	0.9586	42	Parkview Hotel	0.9336
15	Sheraton Taipei Hotel	0.9091	44	Hotel Landis China Yangmingshan	0.9006
16	Taipei Fortuna Hotel	0.9245	45	The Grand Hotel Kaohsiung	0.8511
17	Holiday Inn Asiaworld Taipei	0.8581	46	Caesar Park Hotel Kending	0.7797
18	Hotel Royal Taipei	0.9654	47	Hotel Royal Chihpen Spa	0.9181
19	Howard Plaza Hotel	0.9373	48	Grand Formosa Hotel	0.7519
20	Rebar Crowne Plaza Taipei	0.8147	49	Howard Beach Resort Kending	0.9261
21	Grand Hyatt Taipei	0.8327	50	The Hibiscus Resorts	0.6169
22	Grand Formosa Regent Taipei	0.9676	52	Taoyuan Holiday Hotel	0.8920
23	The Sherwood Hotel Taipei	0.9574	53	Hotel Tainan	0.9278
24	Far Eastern Plaza Hotel Taipei	0.9281	54	Ta Shee Resort Hotel	0.9523
25	The Westin Hotel	0.9277	55	Hotel Royal Hsinchu	0.9498
26	Hotel Kingdom	0.7504	56	The Ambassador Hotel Hsinchu	0.8639
27	Holiday Garden Kaohsiung	0.8124	59	Jen Dow International Hotel	0.9765
28	The Ambassador Hotel Kaohsiung	0.8405	60	Plaza Hotel	0.6563
	Mean efficiency	0.8915			
	Highest efficiency	0.9765			
	Lowest efficiency	0.6169			
	Median efficiency	0.9178			
	Standard deviation	0.0747			

Table 11. The efficiency scores of international tourist hotels in Taiwan (2002)

ID	Hotel	Cost efficiency	ID	Hotel	Cost efficiency
1	The Grand Hotel	0.9185	29	Han-Hsien international Hotel	0.9186
2	The Ambassador Hotel	0.9470	30	Grand Hi-Lai Hotel	0.9087
3	Mandarina Crown Hotel	0.9014	31	Howard Plaza Hotel Kaohsiung	0.9374
4	Imperial Taipei	0.8596	32	The Splendor Kaohsiung	0.7848
5	Gloria Prince Hotel	0.9625	33	Park Hotel	0.9491
6	Emperor Hotel	0.9313	34	Hotel National	0.9038
7	Hotel Riverview Taipei	0.9532	35	Plaza International Hotel	0.9196
8	Caesar Park Taipei	0.9608	36	Evergreen Laurel Hotel	0.9455
9	Golden China Hotel	0.9619	37	Howard Plaza Hotel Taichung	0.9626
11	Brother Hotel	0.9520	38	The Splendor Taichung	0.8931
12	Santos Hotel	0.9213	40	Marshal Hotel	0.8875
13	The Ritz Landis Hotel	0.9410	41	Chinatrust Hotel Hualien	0.9476
14	United Hotel	0.9571	42	Parkview Hotel	0.9212
15	Sheraton Taipei Hotel	0.8775	44	Hotel Landis China Yangmingshan	0.8492
16	Taipei Fortuna Hotel	0.9132	45	The Grand Hotel Kaohsiung	0.8605
17	Holiday Inn Asiaworld Taipei	0.9378	46	Caesar Park Hotel Kending	0.8764
18	Hotel Royal Taipei	0.9696	47	Hotel Royal Chihpen Spa	0.9387
19	Howard Plaza Hotel	0.9260	48	Grand Formosa Hotel	0.8477
20	Rebar Crowne Plaza Taipei	0.8150	49	Howard Beach Resort Kending	0.9249
21	Grand Hyatt Taipei	0.7955	50	The Hibiscus Resorts	0.7076
22	Grand Formosa Regent Taipei	0.9697	52	Taoyuan Holiday Hotel	0.8765
23	The Sherwood Hotel Taipei	0.9587	53	Hotel Tainan	0.9153
24	Far Eastern Plaza Hotel Taipei	0.9341	54	Ta Shee Resort Hotel	0.9483
25	The Westin Hotel	0.9344	55	Hotel Royal Hsinchu	0.9583
26	Hotel Kingdom	0.7812	56	The Ambassador Hotel Hsinchu	0.9562
27	Holiday Garden Kaohsiung	0.8665	57	Formosan Naruwan Hotel	0.7540
28	The Ambassador Hotel Kaohsiung	0.8800	58	Tayih Landis Tainan Hotel	0.9149
	Mean efficiency	0.9062			
	Highest efficiency	0.9697			
	Lowest efficiency	0.7076			
	Median efficiency	0.9213			
	Standard deviation	0.0586			

Table 12. The efficiency scores of international tourist hotels in Taiwan (2003)

ID	Hotel	Cost efficiency	ID	Hotel	Cost efficiency
1	The Grand Hotel	0.8794	29	Han-Hsien international Hotel	0.9100
2	The Ambassador Hotel	0.9559	30	Grand Hi-Lai Hotel	0.9564
3	Mandarina Crown Hotel	0.9373	31	Howard Plaza Hotel Kaohsiung	0.9468
4	Imperial Taipei	0.9208	32	The Splendor Kaohsiung	0.8192
5	Gloria Prince Hotel	0.9642	34	Hotel National	0.9669
6	Emperor Hotel	0.9445	35	Plaza International Hotel	0.9540
7	Hotel Riverview Taipei	0.9551	37	Howard Plaza Hotel Taichung	0.9748
8	Caesar Park Taipei	0.9725	38	The Splendor Taichung	0.8809
9	Golden China Hotel	0.9675	40	Marshal Hotel	0.9280
10	San Want Hotel	0.9501	41	Chinatrust Hotel Hualien	0.9477
11	Brother Hotel	0.9432	42	Parkview Hotel	0.9199
12	Santos Hotel	0.9122	43	Taroko	0.9530
13	The Ritz Landis Hotel	0.9446	44	Hotel Landis China Yangmingshan	0.9731
14	United Hotel	0.9656	45	The Grand Hotel Kaohsiung	0.9264
15	Sheraton Taipei Hotel	0.7560	46	Caesar Park Hotel Kending	0.8859
16	Taipei Fortuna Hotel	0.9066	47	Hotel Royal Chihpen Spa	0.9095
17	Holiday Inn Asiaworld Taipei	0.7665	48	Grand Formosa Hotel	0.8366
18	Hotel Royal Taipei	0.9720	49	Howard Beach Resort Kending	0.9191
19	Howard Plaza Hotel	0.9044	50	The Hibiscus Resorts	0.7077
20	Rebar Crowne Plaza Taipei	0.8638	51	The Lalu Sun Moon Lake	0.9572
21	Grand Hyatt Taipei	0.8704	52	Taoyuan Holiday Hotel	0.9208
22	Grand Formosa Regent Taipei	0.9737	53	Hotel Tainan	0.9537
23	The Sherwood Hotel Taipei	0.9666	54	Ta Shee Resort Hotel	0.9544
24	Far Eastern Plaza Hotel Taipei	0.9415	55	Hotel Royal Hsinchu	0.9535
25	The Westin Hotel	0.9664	56	The Ambassador Hotel Hsinchu	0.9541
26	Hotel Kingdom	0.9084	57	Formosan Naruwan Hotel	0.8937
27	Holiday Garden Kaohsiung	0.9010	58	Tayih Landis Tainan Hotel	0.9550
28	The Ambassador Hotel Kaohsiung	0.9071	66	Evergreen Plaza Hotel(Tainan)	0.8946
	Mean efficiency	0.9209			
	Highest efficiency	0.9748			
	Lowest efficiency	0.7077			
	Median efficiency	0.9424			
	Standard deviation	0.0557			

Table 13. The efficiency scores of international tourist hotels in Taiwan (2004)

ID	Hotel	Cost efficiency	ID	Hotel	Cost efficiency
1	The Grand Hotel	0.8794	30	Grand Hi-Lai Hotel	0.9564
2	The Ambassador Hotel	0.9559	31	Howard Plaza Hotel Kaohsiung	0.9468
3	Mandarina Crown Hotel	0.9373	32	The Splendor Kaohsiung	0.8192
4	Imperial Taipei	0.9208	34	Hotel National	0.9374
5	Gloria Prince Hotel	0.9642	35	Plaza International Hotel	0.9647
6	Emperor Hotel	0.9445	36	Evergreen Laurel Hotel	0.9573
7	Hotel Riverview Taipei	0.9551	37	Howard Plaza Hotel Taichung	0.9747
8	Caesar Park Taipei	0.9725	38	The Splendor Taichung	0.8708
9	Golden China Hotel	0.9675	40	Marshal Hotel	0.9280
10	San Want Hotel	0.9501	41	Chinatrust Hotel Hualien	0.9516
11	Brother Hotel	0.9432	42	Parkview Hotel	0.9125
12	Santos Hotel	0.9122	43	Taroko	0.9525
13	The Ritz Landis Hotel	0.9446	44	Hotel Landis China Yangmingshan	0.9715
14	United Hotel	0.9656	45	The Grand Hotel Kaohsiung	0.9120
15	Sheraton Taipei Hotel	0.7560	46	Caesar Park Hotel Kending	0.8980
16	Taipei Fortuna Hotel	0.9066	47	Hotel Royal Chihpen Spa	0.9111
17	Holiday Inn Asiaworld Taipei	0.7665	48	Grand Formosa Hotel	0.8421
18	Hotel Royal Taipei	0.9720	49	Howard Beach Resort Kending	0.9142
19	Howard Plaza Hotel	0.9044	50	The Hibiscus Resorts	0.6964
20	Rebar Crowne Plaza Taipei	0.8638	51	The Lalu Sun Moon Lake	0.9609
21	Grand Hyatt Taipei	0.8704	52	Taoyuan Holiday Hotel	0.9309
22	Grand Formosa Regent Taipei	0.9737	53	Hotel Tainan	0.9508
23	The Sherwood Hotel Taipei	0.9666	54	Ta Shee Resort Hotel	0.9599
24	Far Eastern Plaza Hotel Taipei	0.9415	55	Hotel Royal Hsinchu	0.9530
25	The Westin Hotel	0.9664	56	The Ambassador Hotel Hsinchu	0.9542
26	Hotel Kingdom	0.9084	57	Formosan Naruwan Hotel	0.8807
27	Holiday Garden Kaohsiung	0.9010	58	Tayih Landis Tainan Hotel	0.9571
28	The Ambassador Hotel Kaohsiung	0.9071	66	Evergreen Plaza Hotel(Tainan)	0.8944
29	Han-Hsien international Hotel	0.9100			
	Mean efficiency	0.9208			
	Highest efficiency	0.9747			
	Lowest efficiency	0.6964			
	Median efficiency	0.9415			
	Standard deviation	0.0562			

Table 14. The efficiency scores of international tourist hotels in Taiwan (2005)

No.	Hotel	Cost efficiency	No.	Hotel	Cost efficiency
1	The Grand Hotel	0.9090	30	Grand Hi-Lai Hotel	0.9414
2	The Ambassador Hotel	0.9591	31	Howard Plaza Hotel Kaohsiung	0.9515
4	Imperial Taipei	0.9445	32	The Splendor Kaohsiung	0.8428
5	Gloria Prince Hotel	0.9342	34	Hotel National	0.9675
6	Emperor Hotel	0.9465	35	Plaza International Hotel	0.9664
7	Hotel Riverview Taipei	0.9606	36	Evergreen Laurel Hotel	0.9627
8	Caesar Park Taipei	0.9759	37	Howard Plaza Hotel Taichung	0.9765
9	Golden China Hotel	0.9668	38	The Splendor Taichung	0.9332
10	San Want Hotel	0.9314	40	Marshal Hotel	0.9514
11	Brother Hotel	0.9448	41	Chinatrust Hotel Hualien	0.9534
12	Santos Hotel	0.8726	42	Parkview Hotel	0.9096
13	The Ritz Landis Hotel	0.9533	43	Taroko	0.9476
14	United Hotel	0.9696	44	Hotel Landis China Yangmingshan	0.9475
15	Sheraton Taipei Hotel	0.8979	45	The Grand Hotel Kaohsiung	0.9368
16	Taipei Fortuna Hotel	0.9395	46	Caesar Park Hotel Kending	0.9175
17	Holiday Inn Asiaworld Taipei	0.7819	47	Hotel Royal Chihpen Spa	0.9145
18	Hotel Royal Taipei	0.9715	48	Grand Formosa Hotel	0.8996
19	Howard Plaza Hotel	0.9057	49	Howard Beach Resort Kending	0.9125
20	Rebar Crowne Plaza Taipei	0.8752	50	The Hibiscus Resorts	0.6878
21	Grand Hyatt Taipei	0.8734	51	The Lalu Sun Moon Lake	0.8754
22	Grand Formosa Regent Taipei	0.9730	52	Taoyuan Holiday Hotel	0.9570
23	The Sherwood Hotel Taipei	0.9601	53	Hotel Tainan	0.9256
24	Far Eastern Plaza Hotel Taipei	0.9599	54	Ta Shee Resort Hotel	0.9661
25	The Westin Hotel	0.9665	55	Hotel Royal Hsinchu	0.9606
26	Hotel Kingdom	0.9210	56	The Ambassador Hotel Hsinchu	0.9602
27	Holiday Garden Kaohsiung	0.9471	57	Formosan Naruwan Hotel	0.9408
28	The Ambassador Hotel Kaohsiung	0.9265	58	Tayih Landis Tainan Hotel	0.9586
29	Han-Hsien international Hotel	0.8745	66	Evergreen Plaza Hotel(Tainan)	0.9387
	Mean efficiency	0.9294			
	Highest efficiency	0.9765			
	Lowest efficiency	0.6878			
	Median efficiency	0.9447			
	Standard deviation	0.0498			

Table 15. The efficiency scores of international tourist hotels in Taiwan (2006)

ID	Hotel	Cost efficiency	ID	Hotel	Cost efficiency
1	The Grand Hotel	0.9316	32	The Splendor Kaohsiung	0.8696
2	The Ambassador Hotel	0.9691	34	Hotel National	0.9639
4	Imperial Taipei	0.9447	35	Plaza International Hotel	0.9656
5	Gloria Prince Hotel	0.9120	36	Evergreen Laurel Hotel	0.9683
6	Emperor Hotel	0.9559	37	Howard Plaza Hotel Taichung	0.9777
7	Hotel Riverview Taipei	0.9700	38	The Splendor Taichung	0.9176
8	Caesar Park Taipei	0.9798	39	Hotel Royal Chiao-His	0.9779
9	Golden China Hotel	0.9675	40	Marshal Hotel	0.9500
10	San Want Hotel	0.9619	41	Chinatrust Hotel Hualien	0.9569
11	Brother Hotel	0.9488	42	Parkview Hotel	0.9294
12	Santos Hotel	0.9562	43	Taroko	0.9403
13	The Ritz Landis Hotel	0.9617	44	Hotel Landis China Yangmingshan	0.8863
14	United Hotel	0.9684	45	The Grand Hotel Kaohsiung	0.9591
15	Sheraton Taipei Hotel	0.9439	46	Caesar Park Hotel Kending	0.9289
16	Taipei Fortuna Hotel	0.9373	47	Hotel Royal Chihpen Spa	0.9204
18	Hotel Royal Taipei	0.9782	48	Grand Formosa Hotel	0.9146
19	Howard Plaza Hotel	0.9193	49	Howard Beach Resort Kending	0.9327
20	Rebar Crowne Plaza Taipei	0.9146	50	The Hibiscus Resorts	0.8606
21	Grand Hyatt Taipei	0.9027	51	The Lalu Sun Moon Lake	0.9682
22	Grand Formosa Regent Taipei	0.9653	52	Taoyuan Holiday Hotel	0.9558
23	The Sherwood Hotel Taipei	0.9658	53	Hotel Tainan	0.9687
24	Far Eastern Plaza Hotel Taipei	0.9633	54	Ta Shee Resort Hotel	0.9528
25	The Westin Hotel	0.9749	55	Hotel Royal Hsinchu	0.9694
26	Hotel Kingdom	0.9343	56	The Ambassador Hotel Hsinchu	0.9658
27	Holiday Garden Kaohsiung	0.9585	57	Formosan Naruwan Hotel	0.9368
28	The Ambassador Hotel Kaohsiung	0.9354	58	Tayih Landis Tainan Hotel	0.9635
29	Han-Hsien international Hotel	0.8986	62	Royal Less Hotel	0.9678
30	Grand Hi-Lai Hotel	0.9647	66	Evergreen Plaza Hotel(Tainan)	0.9468
31	Howard Plaza Hotel Kaohsiung	0.9578			
	Mean efficiency	0.9466			
	Highest efficiency	0.9798			
	Lowest efficiency	0.8606			
	Median efficiency	0.9562			
	Standard deviation	0.0272			

Table 16 shows a summary of the mean efficiency scores of 1997-2006. From Table 16, we can draw a tendency figure such as Figure 2. The figure indicates that the average cost efficiency scores are relatively stable from 1998 to 2000 and then grow higher from 2004 to 2006. In 2001, there is a dip in the average cost efficiency score. This may be explained by the 9/11 attacks that occurred in the United States in 2001. These deadly terrorist attacks created a sluggish market not only in the international aviation industry but also in the global tourism and hotel industry. In later years (2002 to 2006), the efficiency scores returned to the normal growth trend. The growth rate is a value of 1.85% for hotel cost efficiency in 2006. Furthermore, the international tourist hotel business can be expected to have an increase in efficiency in the future.

Table 16. The yearly cost efficiency scores in Taiwan international hotels

Year	Efficiency scores
1997	0.8947
1998	0.9074
1999	0.9079
2000	0.9058
2001	0.8915
2002	0.9062
2003	0.9209
2004	0.9208
2005	0.9294
2006	0.9466

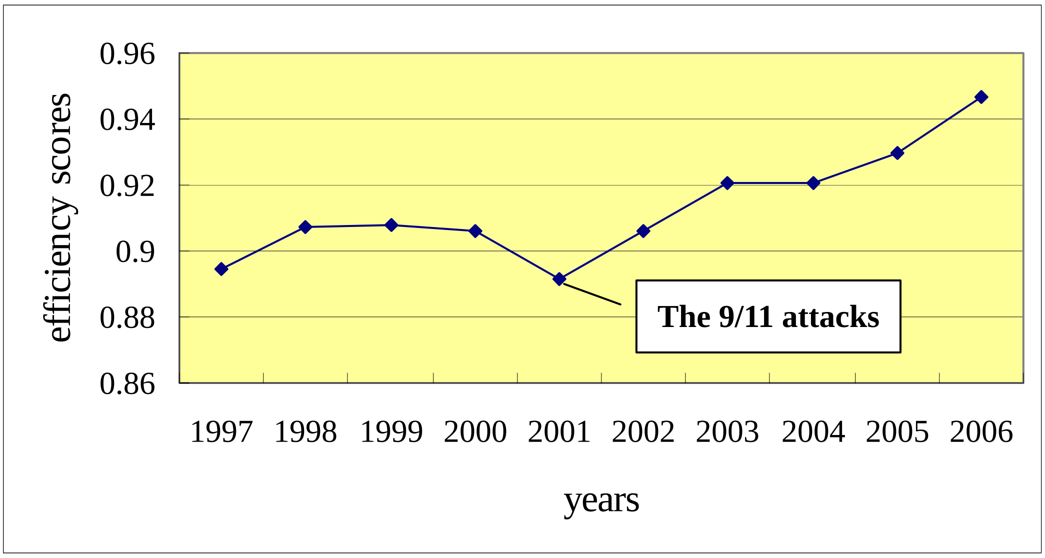

Figure 2. The yearly cost efficiency scores for international hotels

Table 17 is the cost efficiency for six areas of international hotels in Taiwan from 1997 to 2006. Figure 3 is the average cost efficiency for six areas in Taiwan over ten years. The highest average cost efficiency is for other international hotel with a value of 0.9356 while the lowest average cost efficiency is for non-metropolitan international hotel with a value of 0.8779.

Table 17. The cost efficiency scores of international hotels in six areas

	Year									
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Taipei	0.8841	0.9074	0.9112	0.9274	0.9171	0.9250	0.9240	0.9240	0.9322	0.9519
Kaohsiung	0.8917	0.8981	0.8977	0.8638	0.8598	0.8682	0.9070	0.9070	0.9150	0.9358
Taichung	0.9205	0.8851	0.9030	0.9338	0.8872	0.9289	0.9441	0.9410	0.9613	0.9586
Hualien	0.9374	0.9310	0.9199	0.9108	0.9032	0.9187	0.9372	0.9361	0.9405	0.9441
Non-metropolitan	0.8743	0.9095	0.9033	0.8216	0.8206	0.8579	0.8894	0.8883	0.8864	0.9276
Other	0.9530	0.9451	0.9102	0.9488	0.9172	0.9034	0.9350	0.9351	0.9509	0.9574

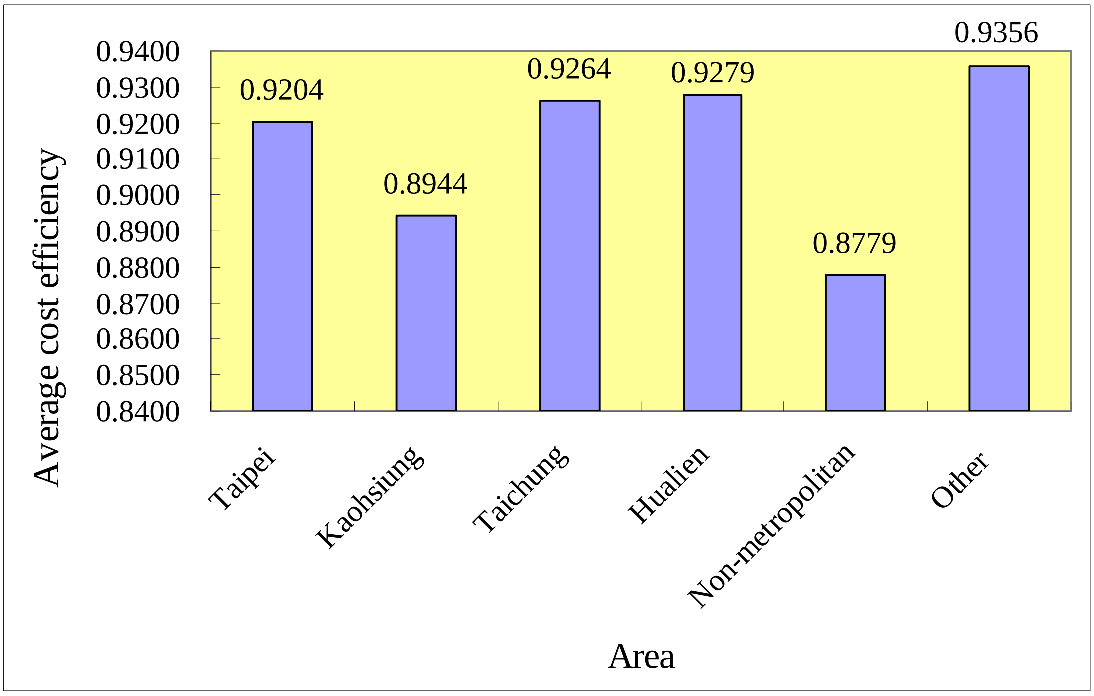

Figure 3. The international hotel's average cost efficiency in six areas

Table 18 is the statistics of tourist guides in Taiwan from 1997 to 2006 and Figure 4 is the tendency figure of tourist guides during those ten years. That set of data is one of the environmental variables used in this study.

Table 18. The number of tourist guides

Year	Number of tourist guides
1997	2206
1998	2256
1999	2312
2000	2360
2001	2723
2002	2925
2003	2925
2004	3058
2005	5113
2006	6750

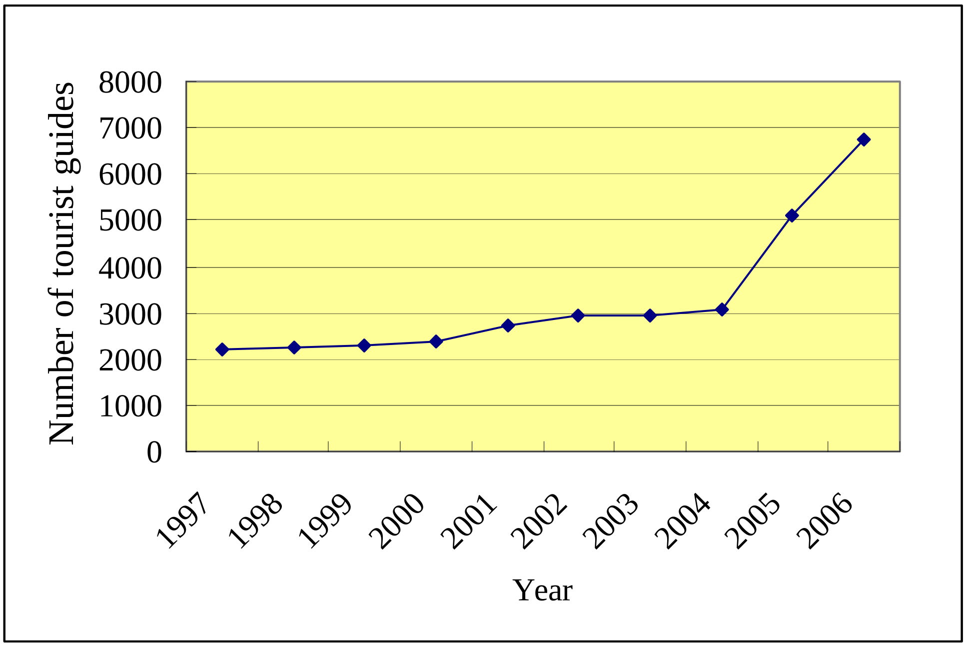

Figure 4. The tendency for number of tourist guides in 1997-2006

7. Conclusions

Facing strong competition in the global hotel industry, the cost efficiency of international hotels plays an important role in determining the profitability of international hotels and even their survival. While the focus of the past literatures is on internal management and different business models in the hotels, this thesis is about hotel cost efficiency analysis. It is based on an econometrics frontier model that permits the incorporation of multiple inputs in terms of various prices and multiple outputs in terms of various revenues while determining the relative efficiency. The external environmental variables are considered, and the time-varying cost efficiency for panel data is analyzed.

By applying the approach proposed by Battese and Coelli (1995), this thesis simultaneously estimates the cost efficiencies and factors of inefficiency of 66 international tourist hotels in Taiwan from 1997 to 2006. The factors of technical inefficiency and the reasons for the well performing international tourist hotels are also analyzed. The study has the following major findings:

- On the whole, the average cost efficiency of Taiwan's international tourist hotels from 1997 to 2006 is 91.15%, which implies that those hotels can reduce their input costs by 8.85%. Moreover, the market is generally competitive.
- The contributions of cost efficiency in the hotel industry are significantly dependent on environmental variables. The empirical results reveal that the efficiency of chain hotels is higher than that of independent hotels, which means that the chain hotel systems can be a significant positive impact on average efficiency in the international tourist hotels in Taiwan. The fact of the existence of a large number of tourist guides, as published by the Tourism Bureau, makes the tourism market much more competitive. Therefore, the number of tourist guides is a significant factor influencing international tourist

hotel efficiency. In addition, the international tourist hotels closer to international transportation, such as international airports, are more cost efficient than those farther away, revealing that international transportation has a significant impact on the average efficiency. Except for the variable about hotels located in non-metropolitan areas, all the other environmental variables are significant at 1% level and can reduce cost inefficiency.

- The international tourist hotels have been ranked in this study based on their cost efficiencies. The ranking permits inefficient hotels not only to ponder about their positions in the ranking list but also to develop strategies to improve their efficiency in the future. The highest performing international tourist hotels are identified and constitute reference points for the less efficient hotels.

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