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A stochastic cost efficiency analysis of international tourist hotels in Taiwan

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ABSTRACT

The 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.

1. Introduction

The demand for recreational traveling has increased quickly as local people's income as well as the number of foreign visitors increase in Taiwan. This intensifies competition in hospitality industries, particularly 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. In 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 realized revenues. 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. Moreover, there is a need to study 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; Chiang et al., 2004) have used the DEA method to estimate hotel efficiency. Chen (2007)

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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.

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 (UNWTO, 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 as one of the star industries of the 21st 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 (Fig. 1).

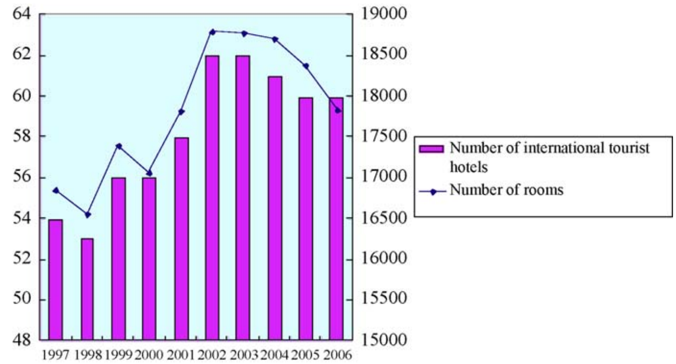

Fig. 1. Numbers of international tourist hotels and rooms in Taiwan from 1997 to 2006.

2. Literature review

Farrell (1957) pioneered dividing cost efficiency into technical efficiency and allocative efficiency. The technical efficiency evaluates the ability of a firm to obtain maximal output from a given set of inputs and the allocative efficiency evaluates 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) (Coelli et al., 1998). These papers reviewed are grouped according to these two methods.

2.1. Papers based on SFA

A few papers that used SFA in the hotel industry are summarized as follows: Anderson et al. (1999a) 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 divided by the number of full-time equivalent employees. 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. (1999b) 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.

2.2. 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%.

The literature applying DEA to compute the efficiency of the hotel industry in Taiwan included Tsaur (2001), Hwang and Chang (2003), and Chiang et al. (2004). These papers are summarized 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 the 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 the 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. The 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.

Wang et al. (2006a,b,c) employed the four-stage DEA procedure to calculate the pure managerial efficiency of 54 international tourist hotels in Taiwan. They used the following input variables: number of full-time employees, number of guest rooms, and total dining area. Outputs variables were room revenue, food and beverage revenue, and other revenue. Their results revealed that there is no significance in pure managerial efficiency due to differences in management style. The pure managerial style of resort hotels is no longer more efficient than that of city hotels.

Wang et al. (2006a,b,c) adopted the quality-incorporated Malmquist productivity index and applied data from the Annual Operations Report of International Tourist Hotels from 1992 to 2002 to evaluate productivity in the hotel sector. The study examined productivity changes in 29 hotels as a result of technological changes, efficiency changes, or changes in service quality. Four inputs selected were the number of guest rooms, food and beverage capacity, the number of full-time employees, and the operating expenses. Five outputs used were room revenue, food and beverage revenue, miscellaneous revenue, the ratio of housekeeping staff per guest room, and the ratio of food and beverage staff per square meter. Their results showed that the reason for decreased efficiency changes and lowered service quality in Taiwan's hospitality management profession was because it was not viewed as a creditable field. This mentality may be influenced by negative attitudes toward service positions in Chinese culture. In addition, to accommodate peak seasons, a significant number of part-time employees are hired. However, they lack in both training and experience, which adversely impacts efficiency and service quality.

Wang et al. (2006a,b,c) used the DEA model to measure the relative cost efficiency of 49 international tourist hotels in Taiwan in 2001. However, they used the single year data to analyze the cost efficiency of international tourist hotels in Taiwan. Four inputs were identified: number of rooms, number of full-time employees in room departments, number of full-time employees in food and beverage departments, and total area of food and beverage departments. Based on the four selected input variables, the input prices in this study were the average wage rate of a full-time employee in the room department, average room rates, average price of food and beverage operations, and average wage rate of full-time employees in the food and beverage department. Results from the Tobit regression indicate that the proportion of foreign individual travelers, online transaction functions, and franchising are positively correlated with efficiency in international tourist hotels in Taiwan. However, the number of years a hotel has been operating is not significantly related to any of these efficiency measures.

2.3. 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 1 summarizes the previous studies on hotel efficiency.

3. The stochastic cost frontier approach

Fried et al. (1993) asserted that the econometric approach to (a) the construction of production frontiers, and (b) the measurement of efficiency relative to the constructed frontiers, differed from the mathematical programming approach. The two approaches adopted different techniques to envelop data more or less tightly in different ways. With respect to their differences, each approach has distinct advantages and disadvantages. The econometric approach is stochastic and so attempts to distinguish the effects of noise from the effects of inefficiency. This method enables more accurate results based on real-time data. In contrast, the programming approach is non-stochastic and lumps noise and inefficiency together—also referred to as combination efficiency. However, the econometric approach is parametric and confuses the effects of misspecification of function form with inefficiency, while the programming approach is non-parametric and less prone to this type of specification error.

The efficiency measurement began with Farrell (1957), who defined 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

Table 1
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 environment 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. (2006c)	DEA	54 Taiwan hotels	Number of full-time employees, guest room, total area of meal department	Room revenue, 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 revenue, 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 area 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
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

be expressed as a product of technical and allocative efficiency measures:

$$TE \times AE = CE \quad (1)$$

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:

$$\ln TC_{it} = C(X_{it}, Y_{it}, \beta_i) + V_{it} + U_{it} \quad (2)$$

where TC_{it} is the total cost for the i-th hotel at the t-th period; X_{it} is a $1 \times k$ 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 $1 \times k$ vector containing values of known functions of outputs of revenue and other explanatory variables related to the i-th hotel at the t-th period; and β_i is a $k \times 1$ 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 $N(\mu, \sigma_U^2)$.

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.

$$\sigma^2 = \sigma_U^2 + \sigma_V^2 \text{ and } \gamma = \frac{\sigma_U^2}{\sigma^2} \quad (3)$$

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 and Lovell (2003) and Reifschneider and Stevenson (1991).

Färe et al. (1994) suggested that stochastic frontier analysis has been used to estimate cost and production frontiers. In a cost frontier, the units on the frontier are efficient, whereas the units belonging to the area above the frontier are inefficient. Moreover, the area below the frontier is not preferred, since the most cost-efficient unit is located on the frontier. For reading purposes, frontier models are the standard for efficient scores—the best performing (efficient frontiers) units are equal to one, and the underperforming units (inefficient frontiers) are less than one. The econometric frontier estimates the performance of the units statistically and measures the difference between the inefficient units and the frontier by the residuals. This is an intuitive approach. However, when assuming that the residuals have two components – noise and inefficiency – the result is the stochastic frontier model. Therefore, the main issue in the econometric frontier model is the decomposition of the error terms.

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:

$$Y_{it} = \exp(X_{it}\beta + V_{it} - U_{it}) \quad (4)$$

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 $1 \times k$ 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 $1 \times k$ 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:

$$U_{it} = Z_{it}\delta + \theta_{it} \quad (5)$$

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:

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

4. Data and empirical model

4.1. 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 tourist 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.

4.2. Variables

There are two main businesses for international tourist hotels. One is the renting of rooms and the other is 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.

O'Neill (2004) created an automated valuation model (AVM) for hotels. The model adopted nine environmental variables: occupancy, average daily rate (ADR), number of guest rooms, net operating income (NOI), the region, location in a metropolitan area, type of hotel, age of property, and date of sale. He found that the AVM has a high level of validity even though the average accuracy is not quite as good as an actual hotel appraisal. Therefore, the AVM possesses the greatest degree of accuracy when used to estimate the value of hotels that have relatively more guest rooms, and higher occupancy, ADR, and NOI. For this reason, we select a metropolitan area as the location variable. Furthermore, Earnhart (2004) asserted that his paper improved the value of time costs and transportation costs related to recreational demand. Therefore, we consider the minimum distance from each hotel to Taiwan's international airport as environmental variables.

We chose our environmental variables based on the resources-based theory, which asserts that, in general, international tourist hotels gain competitive advantages by accumulating resources that are economically valuable, relatively scarce, and not easily replicable. According to Lamminmaki (2005), who employed Williamson's (1985, 1988, 1991) typology of the seven asset specificity dimensions (asset specificity, physical asset specificity, site specificity, dedicated asset specificity, brand capital, temporal specificity, human asset specificity), site specificity and brand capital appear are the most pertinent dimensions of asset specificity, based on his experiment. Studies indicate that hotels with unique business models and requirements prefer in-house resources.

- 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.

4.3. The 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). According to Weng and Wang (2006), the prices of input factors, which we also applied to our model, are defined by the following parameters. The price of labor is defined as the average annual wage per employee, and the value is measured by dividing the total salary by the total number of employees. The price of capital is measured as dividing capital expenses (rent, interest cost, etc.) by the number of guest rooms. The price of materials is measured as dividing the total operating revenues by material expenses such as the expenditures on food and beverage. The quantities of output of accommodation, food and beverage and the other services were, respectively, the revenue of accommodation, food and beverage, and the other services. Similar to Weng and Wang, we defined the outputs and total cost as the sum of labor expenses, capital expenses, and material expenses.

More specifically, the model can be expressed as follows:

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

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 tourist 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 tourist hotel.

and

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

where i represents the number of international hotels, $i = 1, 2, \ldots, N$; t is time, $t = 1, 2, \ldots, T$; 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; MD_{KIA} is distance from Kaohsiung international airport; and θ_{it} is a non-negative random variable following the truncated normal distribution.

Eq. (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}). Eq. (8) is a one-sided term reflecting technical inefficiency. The characteristics of the variables are summarized in Table 2.

Table 2
Descriptive statistics of variables.

Variable	Description	Mean	Maximum	Minimum	Standard deviation
TC	Total cost	536,244,279	2,394,250,681	17,760,321	482,328,259
W_l	Price of labor measured in dividing total salary expenditure by the number of equivalent employees	497,864	902,741	82,963	147,731
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	731,001	2,741,308	83,304	493,151
W_c	Price of F&B measured in dividing total F&B expenditure by the area of equivalent F&B	100,138	785,254	2,283	65,663
R_r	Room revenue	227,696,937	1,359,688,456	7,082,913	206,559,883
R_o	Other operation revenue	97,698,159	702,209,043	263,111	132,501,554
R_c	Food and beverage revenue	270,546,313	1,313,060,839	5,581,527	271,353,292
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 airport	41.3305	499.63	0.01	95.3040
MD_{KIA}	Minimum distance from each hotel to Kaohsiung international airport	256.9486	400.97	7.33	134.9411

5. 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 3 and 4.

Table 3
Parameter estimates of the translog cost frontier function.

Variable	Coefficient	Estimate	t-ratio
Constant in the cost frontier	β_0	−5.8367	−1.4392*
$\ln(W_{lit})$	β_1	0.8708	1.2094
$\ln(W_{oit})$	β_2	−1.8648	−2.4460***
$\ln(W_{cit})$	β_3	1.8716	7.0492***
$\ln(R_{rit})$	β_4	3.0028	4.6875***
$\ln(R_{oit})$	β_5	1.1477	2.9881***
$\ln(R_{cit})$	β_6	−2.7331	−4.4940***
$1/2[\ln(W_{lit})]^2$	β_7	0.0957	1.2259
$1/2[\ln(W_{oit})]^2$	β_8	−0.0030	−0.0544
$1/2[\ln(W_{cit})]^2$	β_9	−0.1124	−5.7028***
$1/2[\ln(R_{rit})]^2$	β_{10}	0.1275	2.7615***
$1/2[\ln(R_{oit})]^2$	β_{11}	0.0207	1.8111**
$1/2[\ln(R_{cit})]^2$	β_{12}	0.1265	4.0857***
$\ln(W_{lit})\ln(W_{oit})$	β_{13}	0.0809	1.5648*
$\ln(W_{lit})\ln(W_{cit})$	β_{14}	−0.1001	−3.4926***
$\ln(W_{lit})\ln(R_{rit})$	β_{15}	−0.2021	−3.9752***
$\ln(W_{lit})\ln(R_{oit})$	β_{16}	−0.0612	−2.3663***
$\ln(W_{lit})\ln(R_{cit})$	β_{17}	0.1508	3.1287***
$\ln(W_{oit})\ln(R_{cit})$	β_{18}	−0.0472	−1.6610**
$\ln(W_{oit})\ln(R_{rit})$	β_{19}	0.0504	1.5382*
$\ln(W_{oit})\ln(R_{oit})$	β_{20}	0.0547	2.3250***
$\ln(W_{oit})\ln(R_{cit})$	β_{21}	−0.0194	−0.6941
$\ln(W_{cit})\ln(R_{rit})$	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 3 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 environmental variables 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 estimation of the amount of variation stemming from inefficiency relative to noise for the sample. The values of γ, where $\gamma = \sigma_U^2/(\sigma_U^2 + \sigma_V^2)$, is 0.9507 and 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 shows the efficiency scores measure 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 derivation is 5.11%. These efficiency scores are higher than those listed in the 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., 1999a,b), respectively.

Table 5 summarizes the annual average cost efficiency scores from 1997 to 2006. The cost efficiency scores from 1997 to 2006

Table 4
Average cost efficiency rankings of international tourist hotels in Taiwan.

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 5
Annual average cost efficiency.

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

show stable growth. The 911 attacks in the United States in 2001 resulted in a sluggish market not only for the international aviation industry, but also in global tourism and the hotel industry.

6. Conclusion

Based on our study, we employ a stochastic cost frontier model to analyze panel data and to estimate the cost efficiency of international tourist hotels in Taiwan. Moreover, we adopted a time-varying model proposed by Battese and Coelli (1995) which simultaneously estimates the stochastic cost frontier and the equation of inefficiency with panel data. Previous studies largely focused on production frontier of the DEA and used data from only a single year. By using the time-varying model and panel data, we trended the international tourism hotel in Taiwan from 1997 to 2006. In addition, some of our environmental variables differ from the past papers. All of the environmental variables are statistically significant such that they can provide a reasonable forecast for the inefficiency of international tourist hotels in Taiwan.

Facing strong competition in the global hotel industry, the cost efficiency of international tourist hotels plays an important role in determining the profitability of international tourist hotels and even their survival. While the focus of the past literatures is on internal management and different business models in the hotels, this study 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, in 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 study simultaneously estimates the cost efficiencies and factors of inefficiency of 66 international tourist hotels in Taiwan from 1997 to 2006. We also analyze the factors of technical inefficiency and the reasons for the well performing international tourist hotels. The study has the following major findings:

- On the whole, the average cost efficiency of international tourist hotels in Taiwan from 1997 to 2006 is 91.15%, which implies that those hotels can reduce their input costs by 8.85%. Moreover, the market is competitive in general.
- 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 the international tourist hotels' efficiency. In addition, the international tourist hotels closer to the international conveyance, such as international airports, are more cost efficient than those farther away, revealing that the international conveyance has a significant impact on the average efficiency. Except for the variable about hotel located in non-metropolitan, all the other environmental variables are very significant and they 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 for their efficiency improvement in the future. The best performing international tourist hotels are identified and constitute reference points for the inefficient hotels.

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