國立交通大學

經營管理研究所

博士論文

No. 111

整合財務資訊之績效標竿分析－

國際觀光旅館產業之應用

Benchmarking with Financial Information for International Tourist Hotel Industry in Taiwan

研 究 生：盧文民

指導教授：楊 千 教授

中華民國九十五年四月

國立交通大學

經營管理研究所

博士論文

No. 111

整合財務資訊之績效標竿分析－國際觀光旅館產業之應用

Benchmarking with Financial Information for International Tourist Hotel Industry in Taiwan

研　究　生：盧文民

研究指導委員會：楊　千　教授

丁　承　教授

胡均立　教授

指導教授：楊　千　教授

中華民國九十五年四月

整合財務資訊之績效標竿分析－國際觀光旅館產業之應用

Benchmarking with Financial Information for International Tourist Hotel Industry in Taiwan

研 究 生：盧文民　　　　Student：Wen-Min Lu
指導教授：楊　千　教授　　Advisor：Dr. Chyan Yang

國 立 交 通 大 學
經 營 管 理 研 究 所
博 士 論 文

A Dissertation

Submitted to Institute of Business and Management

College of Management

National Chiao Tung University

in Partial Fulfillment of the Requirements

for the Degree of

Doctor of Philosophy

in

Business and Management

April, 2006

Taipei, Taiwan, Republic of China

中華民國九十五年四月

整合財務資訊之績效標竿分析－國際觀光旅館產業之應用

Benchmarking with Financial Information for International Tourist Hotel Industry in Taiwan

研 究 生：盧文民　　　　　　　　　　　　　指導教授：楊　千　教授

國立交通大學經營管理研究所博士班

中文摘要

本篇論文使用財務/非財務指標來勾勒出台灣國際觀光旅館的經營績效。效率評等應該被視為達成較好經營績效暨較佳市場位置的一種關鍵要素。本論文藉由資料包絡分析法(DEA)整合財務/非財務指標的績效模型來衡量台灣國際觀光旅館之效率評等。本研究也進一步整合傳統的資料包絡分析、投入擁擠測度、標竿分享測度及差額變數為基礎的窗口分析來延伸資料包絡分析在績效標竿的應用。這項研究的結果能為國際觀光旅館的管理者提供對資源配置的瞭解和探究競爭優勢所在，並且幫助經營者在競爭激烈的環境下擬定適當的經營策略。

首先就橫斷面研究(cross sectional study)而言，本研究探討台灣國際觀光旅館的「整體管理績效」、「住房部門績效」和「餐飲部門績效」，使用「臺灣地區國際觀光旅館營運分析報告」中的 2002 年作業資料。數個實證結果說明如下：(1)大部份的國際觀光旅館呈現規模報酬遞減的情境，此結果意謂台灣國際觀光旅館正面對著競爭激烈的經營環境；(2)加入國際連鎖的國際觀光旅館，整體而言，經營績效是優於獨立經營的國際觀光旅館；(3)休閒區域的國際觀光旅館，平均而言，經營績效是優於都會區的國際觀光旅館

；(4)靠近中正機場的國際觀光旅館，平均而言，經營績效是差於遠離中正機場的國際觀光旅館；(5)擁擠分析 (congestion analysis) 指出無管理績效之國際觀光旅館缺乏資源整合的能力，尤其在「餐飲部門的面積」及「客房數」此二個投入變項；(6)標竿分享測度 (benchmark-share measure) 呈現出有效率的國際連鎖觀光旅館較容易成為無效率國際觀光旅館的標竿。此結果可推論出，加入國際連鎖的國際觀光旅館有較佳的競爭優勢。本研究也進一步使用「住房部門績效」和「餐飲部門績效」來建構管理決策矩陣，以協助經營者擬訂相關績效改善策略。

次之就跨期研究 (cross-period study) 而言，本研究使用兩階段的方式來分析國際觀光旅館跨期 (1997-2002) 的管理績效。第一階段將差額變數為基礎的測度 (slack-based measure) 模式和窗口分析 (window analysis) 模式整併，用來衡量國際觀光旅館的跨期效率。第二階段藉由 Tobit 迴歸模式來找出影響國際觀光旅館經營績效的作業特徵。數個實證結果說明如下：(1)國際觀光旅館整體經營績效逐漸成長，同時國際觀光旅館之間的績效差異也逐漸趨向穩定；(2)大部份的國際觀光旅館呈現規模報酬遞減的情境，此結果意謂台灣國際觀光旅館正面對著競爭激烈的經營環境；(3)台灣的921地震、美國911恐怖攻擊和政府主導的軍公教強迫性休假補助政策，對不同作業特徵下的國際觀光旅館在短期時間上造成明顯的影響；(4)結果也指出管理形式之差異顯著影響國際觀光旅館跨期的管理績效。

最後，本研究的發現可以視為處理國際觀光旅館相關議題的指引。我們也希望在本研究所使用的數量模型暨方法論可廣泛應用到不同產業，探究不同的議題。

關鍵詞：資料包絡分析、績效測度、投入擁擠測度、標竿分享測度、標竿、窗口分析、國際觀光旅館

Benchmarking with Financial Information for International Tourist Hotel Industry in Taiwan

Student：Wen-Min Lu **Advisor：Dr. Chyan Yang**

Institute of Business and Management
National Chiao Tung University

Abstract

This dissertation reconciles diverse financial/non-financial measures to characterize the business performances of Taiwan's International Tourist Hotel (ITHs). Efficiency ratings should be considered as a key element for achieving greater business performance and better market position. The technology of data envelopment analysis (DEA) is employed to determine a multi-factor business performance model which inherently recognizes tradeoffs among various financial/non-financial measures. This study also presents an extension to the DEA, by incorporating the traditional DEA, input congestion measure, benchmark-share measure, and slack-based measure (SBM) DEA window analysis for assessing the performance of ITHs. The results of this study can provide ITHs' operations with insights into resource allocation and competitive advantage and help with strategic decision-making, especially regarding operational styles under an intense competitive environment through high ITH density.

Firstly, this study evaluates the performance of ITHs in terms of managerial, occupancy and catering efficiencies, using 2002 operating data. Several empirical results are shown: (1) most ITHs operate at decreasing returns to scale, indicating that ITHs are facing a highly competitive environment; (2) the international chain ITHs are generally more efficient than

independent-owned ones; (3) ITHs located in resort areas operate slightly better on average than ones located in metropolitan areas; (4) ITHs that are close to CKS international airport operate slightly worse on average than ones far from CKS international airport; (5) congestion analysis reveals that inefficient ITHs lack the ability to integrate their resources, especially in the total area of the catering division and the number of guest rooms; and finally, (6) the benchmark-share measure shows that efficient international chain ITHs are able to more easily become benchmarks. The findings show that efficient international chain ITHs are more competitive and they should provide examples of operating practice.

Secondly, this study examines the managerial performance of ITHs for the period 1997–2002, using a two-stage procedure. In the first-stage analysis, the slack-based measure model and the window analysis are combined in order to sharpen the efficiency estimates over the period (1997-2002) with multiple operating data in both inputs and outputs. In the second stage, a Tobit regression analysis is employed to analyze the operating characteristics for exploring the variation of managerial performance among ITHs. Several empirical results are shown: (1) the trend of mean managerial efficiency is increasing, whereas the variation converges; (2) most ITHs operate at decreasing returns to scale, indicating that ITHs are facing a highly competitive environment; (3) Taiwan's 921 earthquake in 1999, the 911 incident in 2001, and the compulsory government subsidies all play key roles which affect the ITHs' managerial performance for different operating characteristics in the short term; (4) results also indicate that differences in management style do have a very significant influence upon ITHs' performance over time (1997-2002).

Finally, our findings can serve as a guideline in the tourism industry for coping with issues relating to ITHs. It is also hoped that the models and methods implemented in this study can bring about other related research to a variety of industry.

Keywords: Data envelopment analysis; Benchmarking; Financial information; Input congestion measure; Benchmark-share measure; Window analysis; International Tourist Hotel

Acknowledgement

First, I would like to express my gratitude and indebtedness to my thesis advisor, Professor Chyan Yang, for his sincere supervision, fruitful guidance and valuable advice thoughtfully throughout my academic work. Words are inadequate to express my thanks to him that I have yet to see the limits of his wisdom, patience, and selfless concern for his students, and especially his pleasant characteristics as a mentor. He is the most erudite and kindest person I have ever met.

Next, I would like to express special thanks to Professor Cherng G. Ding and Professor Jin-Li Hu, for their kindness and helps with my graduate study. After that, I would also like to express my gratitude to Professor Wei-Tzen Yang, Professor Gwo-Hshiung Tzeng, Professor Shean-Bii Chiu, and Professor Tzong-Chen Wu for their valuable comments which have enriched this dissertation for a great extent.

In addition, special thanks should be given to others who accompany me but not being mentioned for their friendship and helps during my Ph.D. study. This work is dedicated to my parents for their love and support. Finally, I would like to share my pleasure of graduation with my wife and two lovely children.

Table of Contents

List of Tables

List of Figures

Chapter 1 Introduction

1.1 Research Motivation

The World Tourism Organization reported that the number of outbound trips reached 760 million in 2004 and the global tourism trips will exceed 1.56 billion by 2020. The World Travel & Tourism Council also presented that global travel and tourism in 2005 produced about US$6.2 trillion in economic activity that has US$1.7 trillion on direct economic impact, i.e., 3.8% of global GDP.

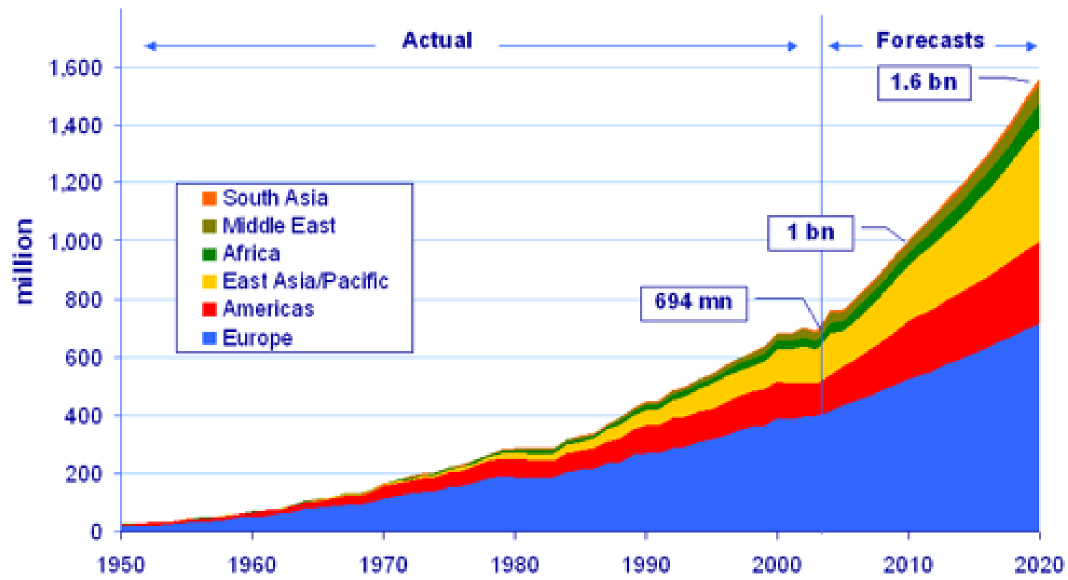

Figure 1 Tourism 2020 Vision

Source: World Tourism Organization

According to the annual report on tourism (2004), hotel bill takes 48.5% out of daily spending from the global travel and tourism. Because the hotel spending takes the most part of the spending in the travel and tourism that can produce the direct economic impact, therefore a country's international tourist hotel industry plays a key role in her economic development and should be further studied.

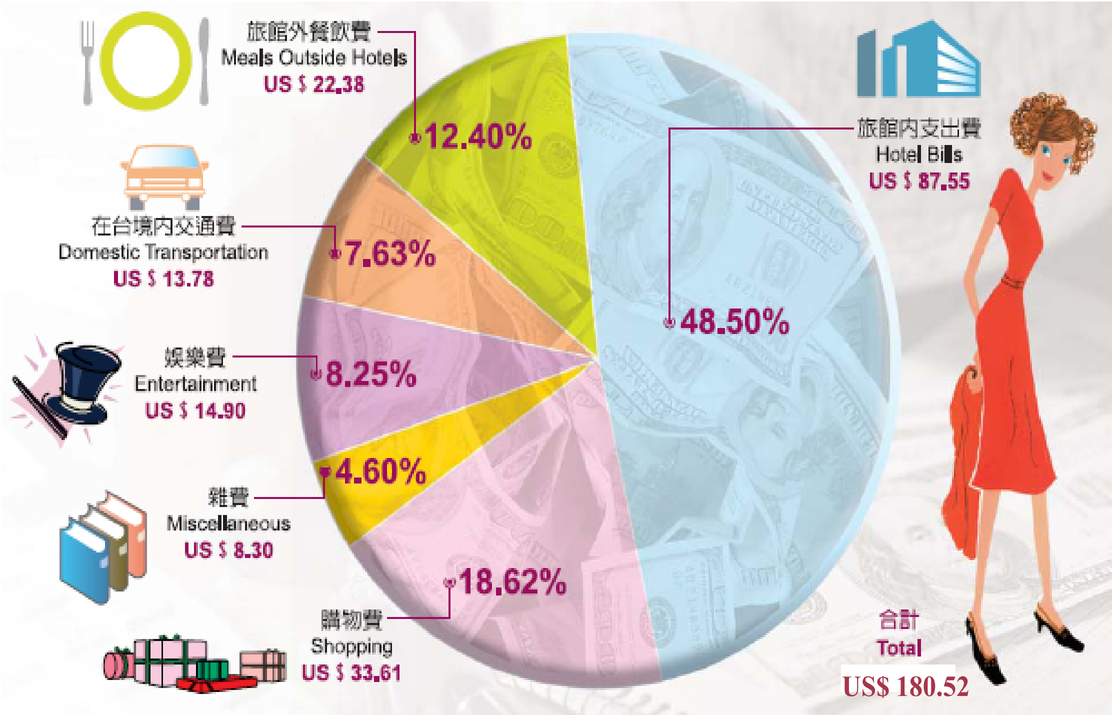

Figure 2 Average Daily Spending by Each Inbound Traveler, 2004

Source: Annual Report on Tourism 2004

Taiwan's international tourist hotel (ITH) industry is experiencing competitive pressure due to the rapid growth of new ITHs, deteriorating economic conditions, and inefficient management. The total number of Taiwan's ITHs has increased from 44 to 62 within the period of 1985 to 2004, while the total number of ordinary tourist hotels has decreased from 79 in 1985 to 25 in 2004. Moreover, as a result of the Asia Financial Crisis in 1997, Taiwan's 921 earthquake in 1999, the 911 terrorist act in 2001, the Second Persian Gulf War in 2003, and the SARS epidemic in 2003, the growth rate of foreign tourists visiting Taiwan are decreasing.

Due to the above external reasons and inefficient management, 8 four-star ITHs closed in 1998. The ITHs in Taiwan need to improve their efficiency in management to survive in the serious situation. They have to identify the critical input/output factors to enhance their operating efficiency and managerial performance. In addition, the differences among hotel operating characteristics, such as closeness to the international airport, location, and management style also may affect the efficiency and performance for ITHs. Hence, an examination of impacts of these factors on hotel performance does have the value for the international hotel industry.

According to the report of Taiwan Tourism Bureau (TTB), the hotel industry in Taiwan can be divided into ITHs and standard tourist hotels. The plum grading system is issued by TTB for hotel grading. This plum-grading system is similar to the star- grading system used by many countries in the world. A hotel with more plums means that it has more quantity of hotel facilities. By 2004, TTB has not used any grading system to measure the quality of hotel services. An ITH is a hotel with five or four plums, which provides many services and facilities to its guests, such as various types of guest rooms and restaurants, recreation (e.g. bars, night clubs, shopping stores), exercise facilities (e.g. swimming pools, gyms), children's nursery, in-house medical consultation, and valet services, and business-related needs (convention venues, business center, and internet services). A standard tourist hotel is a medium size hotel with two or three plums, which only offers guests services such as accommodation and catering. The focus of this study is on ITHs because the degree of competitiveness in this marketplace is high and the amount of resources those hotels consumed to create outputs of services is considerable.

This operational performance study is conducted from hotel manager's perspective. The results of this study can provide Taiwan ITHs' operations with insights into resource allocation and competitive advantage and help with strategic decision-making, especially regarding operational styles under an intense competitive environment through high ITH density.

1.2 Research Purpose

Due to the importance of ITH efficiency measurement, the main interest of this study is therefore to address the issues related to the performance benchmarking analysis and the potential applications and strengths of DEA in assessing the ITHs. This study should provide additional managerial insights into hotel industry in Taiwan. The purposes of this study are fivefold:

The first purpose of this study is to provide a benchmarking analysis based on DEA to investigate hotel industry in Taiwan and assist the managers in improving the operational management of these hotels. Furthermore, we also design a decision-making matrix in terms of the occupancy and catering performances to help the manager and/or authorities to improve their operating efficiencies.

The second purpose concerns the different operational characteristics. The various ITHs' characteristics are evaluated to determine their relationships to the ITH industry's efficiency. The key ITH operating characteristics (i.e., international chain or independent-owned, metropolitan areas or resort areas, closeness to international airport or not) are needed to be figured out and to provide insight into what factors cause imperfectly competitive conditions for some ITHs. The results will also aid operation managers in improving their ITHs by benchmarking their ITHs against similar ITHs.

The third purpose is related to the so-called input congestion. By definition, input congestion (Cooper et al., 2001) means that there are increments in inputs which, however, result in a decrease in output. An excessive amount of labor or capital input can be a major source of inefficiency. The problem of input congestion thus far is less discussed in the literature regarding the hotel industry. We will use herein a slack-based approach (Cooper et al., 2001) to measure the input congestion. This method not only detects congestion, but also determines the amount of congestion and simultaneously identifies factors responsible for causing congestion in an inefficient ITH.

The fourth purpose concerns a situation whereby using the DEA model may produce many ITHs with a full efficient status denoted by unity. These efficient ITHs are worthy of further analysis to identify the real benchmark for each input/output. To discriminate these efficient ITHs, this study applies the benchmark-share measure (Zhu, 2000) defining a ranking measure by combining the factor-specific measure and VRS (variable returns-to-scale) / BCC (Banker et al., 1984) model.

The fifth purpose of this study focuses on the dynamic window analysis. Most DEA analysis is cross sectional which compares the performance of decision making units (DMUs) in the same time period. One window analysis approach performing the longitudinal design is used to compare cross-sectional running across the number of time periods in this study. This approach introduces variability into the analysis because it treats the performance of DMU in each time period as independent from the previous period. Such an approach would allow a dynamic view of the multidimensional performance of ITHs in Taiwan.

1.3 Organization of the Dissertation

This dissertation is organized in the following manner as Figure 3 shows: Chapter 1 presents the motives and purposes of the study, and briefly introduces the structure of this work. Prior studies which have influenced this study are discussed in Chapter 2. Chapter 3 proposes a research design that includes the criteria for performance evaluation, the data selection and description, and the introduction of DEA methodology. The empirical results and interpretations are provided in Chapter 4. Finally, Chapter 5 concludes this dissertation.

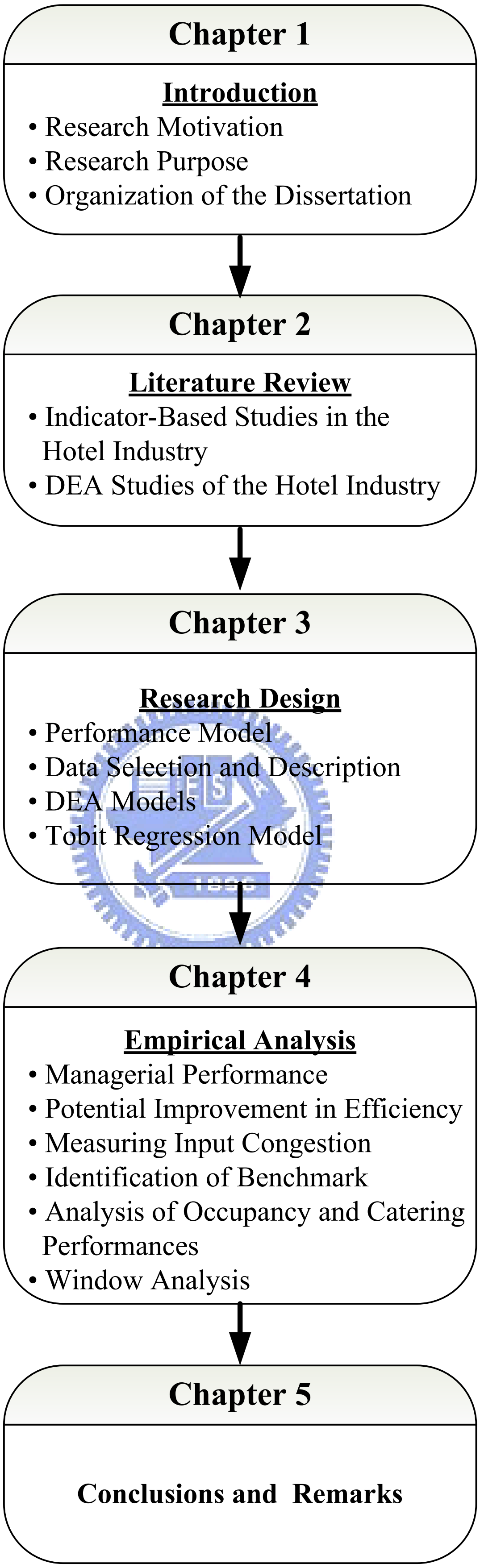

Figure 3 Research Flow Chart

Chapter 2 Literature Review

Many researchers have conducted much of research to measure efficiency and performance in the hotel industry. According the methodology used by researchers, previous studies can be divided into two streams of research: one stream of research using simple performance indicator and the other stream of research using DEA. To provide a detailed review of many works in is beyond the scope of this dissertation. We shall only explore some important research works in the hotel management literature relevant to our study. A survey of literature on performance measurement in the hotel industry follows.

2.1 Indicator-Based Studies in the Hotel Industry

The hotel management literature is rich in studies that attempt to measure efficiency and performance in hotel industry. Most of the limited research on performance measurement in the hotel industry has used a variant of performance indicators. These studies mostly focus on single indicators such as cost-volume-profit (Fay et al., 1971; Jaedicke and Robichek, 1975; Coltman, 1978), the lodging industry's sales receipt information (Van Doren and Gustke, 1982), the concept of perishable asset revenue management to measure performance (Kimes, 1989), lodging index (Wassenaar and Stafford, 1991), a revenue performance indicator (Baker and Riley, 1994), and an efficiency indicator (Wijeysinghe, 1993).

Cost-volume-profit analysis, or breakeven analysis, is used to compute the volume level at which total revenues are equal to total costs. When total costs and total revenues are equal, the business organization is said to be "breaking even." The analysis is based on a set of linear equations for a straight line and the separation of variable and fixed costs. It can not only be used to analyze the performance of an individual firm, but it can be applied at a regional level for the purpose of comparing various types of firms (Fay et al., 1971; Jaedicke and Robichek, 1975; Coltman, 1978). Van Doren and Gustke (1982) use lodging industry sales receipt information to gauge industry performance. This technique does not examine cost efficiency issues and does not provide a method of determining optimal performance.

Kimes (1989) utilizes the basic concept of perishable asset revenue management (PARM) to measure performance in the hotel industry. PARM allows management to determine the optimal trade-off between the average daily rates and the occupancy rates. The basic idea of PARM techniques involves charging the right price in order to select the right customers to fill each room, while achieving the highest possible revenues. The benefits of PARM are generally attributed to three main categories: overbooking, proper allocations among the numerous rate classes, and length of stay.

Wassenaar and Stafford (1991) advocate the use of a lodging index indicator for the hotel/motel industry. The lodging index is defined as the average revenue realized from each room, vacant or occupied, within a region or city during a given time period. They suggest that the index is particularly effective for local travel destinations where average occupancy and room rates are not available. While it combines average occupancy and room rates into a single indicator, this method does not examine how efficiently firms are controlling costs.

Another common indicator is the labor-cost ratio, the ratio of payroll expenses to sales, which is commonly referred to as the labor-cost percentage. However, this index is easily distorted by changes in sales revenue, and it is not necessarily a reflection of efficiency and productivity. In addition, it is of limited value because it is an aggregate, nonspecific figure. In order to illustrate a complete picture of payroll efficiency, total labor hours, sales per labor hour and labor cost per labor hour are needed. Multiple measurements provide an accurate index of labor productivity. When used as a weekly basis to analyze payroll costs, these measurements offer far better tools for forecasting and adjusting labor costs.

Wijeysinghe (1993) suggests a method for calculating breakeven room occupancy that provides accurate calculations together with a system of effective management. He suggests that general indicator to hotel efficiency can be used to analyze the source of loss and, therefore, give a better control of the business. Other common economic indicators of the lodging industry performance measure revenue (Baker and Riley, 1994) such as revenue/wage cost, gross profit/revenue, and net profit/revenue.

Although these accounting and financial indicators in terms of simple ratios provide important and useful information for benchmarking a hotel's financial performance, there are in fact many factors relative to hotel performance, and obviously these techniques have not taken into account the mix and nature of services provided. As suggested by Anderson et al. (1999), measuring the relative efficiency of a hotel requires methods that are more sensitive than accounting and ratio measures and that can explicitly consider the mix of service outputs produced.

2.2 DEA Studies of the Hotel Industry

To overcome the drawbacks mentioned above, DEA has been used to measure hotel performance over the last decade. DEA has many desirable features (Charens et al., 1994) which may explain why researchers are interested in using it to investigate the efficiency of converting multiple inputs into multiple outputs. Furthermore, DEA is also a theory-based, transparent, and reproducible computational procedure. In comparison to the traditional approaches such as ratio analysis and regression analysis (Sherman, 1986), DEA has gained several more advantages. These characteristics include (Lewin et al., 1982):

- capable of deriving a single aggregate measure of the relative efficiencies of uints in terms of their utilization of input factors to produce desired outputs;

- able to handle non-commensurate multiple outputs and multiple input factors;
- able to adjust for factors outside the control of the unit being evaluated;
- not dependent on a set of a priori weights or prices for the inputs or the outputs;
- able to handle qualitative factors such as consumer satisfaction, quality of employees, etc.;
- able to provide insights on the possibilities for increasing outputs and/or conserving inputs for the inefficient unit to become efficient;
- able to maintain equity in performance assessment.

One major advantage is that DEA has emerged as the leading method for efficiency evaluation in terms of both the number of research papers published and the number of applications to real world problems (Seiford, 1997; Gattoufi et al., 2004; Yang et al., 2006; Yang and Lu, 2006). Previous studies that used DEA to investigate the relative efficiency of the hotel industry are now described as follows.

Bell and Morey (1995) employ DEA to measure the relative efficiency of 31 travel departments in the United States. Morey and Dittman (1995) implement DEA to probe the general-manager performances of 54 owner-managed hotels of a nationally known chain, geographically dispersed over the continental United States. This study provides the owners of single properties with the ability to benchmark a manager's performance. By using the stochastic frontier approach, Anderson et al. (1999) evaluate the managerial efficiency of 48 hotels using operating data in the year 1997. Anderson et al. (2000) employ DEA to re-evaluate the managerial efficiency of 48 hotels using the data in Anderson et al. (1999). This study contradicts previous studies, which find the hotel industry to be nearly perfectly competitive and efficient. The major reason is that they use a more comprehensive efficiency measure and are able to capture more inefficiency.

Tsaur (2000) uses DEA to measure the operating efficiency of 53 ITHs in Taiwan using operating data from 1996-1998. The study reports that the market for lodging services seems to be operating efficiently in Taiwan. Hwang and Chang (2003) utilize DEA and the Malmquist productivity index (Färe et al., 1992) to measure the managerial performance of 45 Taiwanese hotels in 1998 and the efficiency change of them from 1994 to 1998. This study shows that the entire industry can be partitioned into six clusters based on relative managerial efficiency and efficiency change. Effective management strategies are developed specifically to each of the six clusters of hotels.

Chiang et al. (2004) implement DEA to measure 25 Taipei ITHs' performances under three operational styles of ITHs using operating data from 2000. The finding shows that not all of Taipei's franchised or managed ITHs performed more efficient than the independent-owned ones. Barros and Alves (2004) analyze the efficiency of Portugal's public-owned hotel chain, Enatur, with the Malmquist productivity index for the period 1999-2001. The study reports that few hotels achieved total productivity improvements in that period. Table 1 presents the characteristics of these main studies using DEA.

This study contributes four extensions to the existing research. Firstly, this study presents a very good review of previous research in this important sector of the economy. Despite the significant work already done in this area, we rightly point to the fact that many elements have not been covered in that previous work. Moreover, we also provide a good discussion of our findings and make concrete recommendations regarding the direction for improvement. Secondly, the problem of input congestion thus far is less discussed in the literature regarding the hotel industry. We will use herein a slack-based approach (Cooper et al., 2001) to measure the input congestion. This method not only detects congestion, but also determines the amount of congestion and simultaneously identifies factors responsible for causing congestion in an inefficient ITH.

Thirdly, this study concerns a situation whereby using the DEA model may produce many ITHs with a full efficient status denoted by unity. These efficient ITHs are worthy of further analysis to identify the real benchmark for each input/output. To discriminate between these efficient ITHs, this study firstly applies the benchmark-share measure (Zhu, 2000) defining a ranking measure by combining the factor-specific measure and VRS (variable returns-to-scale) / BCC (Banker et al., 1984) model in hotel industry. Lastly, this study is the first research that has combined the discriminant power of SBM model (Tone, 2001) and the dynamic view of window analysis (Charnes et al., 1985) in applying DEA to measure the productivity growth of ITHs in Taiwan over the years of 1997-2002.

Table 1 Literature Survey of the DEA Model on the Hotel Industry

Authors	Model	Units	Inputs	Outputs
Bell and Morey (1995)	DEA-CCR	31 travel departments in the United States, 1993.	(1) actual levels of support costs, (2) actual levels of expenditure on travel, (3) level of environmental factors, (4) nominal levels of other expenditures.	(1) level of service provided.
Morey and Dittman (1995)	DEA-CCR	54 owner-managed hotels of the continental United States, 1993.	(1) number of rooms, (2) average occupancy rate, (3) average daily rate, (4) number of employees, (5) resource expenditures.	(1) total room revenue, (2) facilities-satisfaction index, (3) services-satisfaction index.
Anderson, Fish, Xia, and Michello (1999)	Stochastic Frontier Approach	48 hotels/motels of the United States, 1994.	(1) average employee annual wage, (2) average price of a room, (3) average price of food and beverage operations, (4) average price of casino operations, (5) average price of hotel operations, (6) average price of other expenses.	(1) total revenues generated from various hotel services.
Anderson, Fok, and Scott (2000)	DEA-CCR and DEA-BCC	48 hotels/motels of the United States, 1994.	(1) average employee annual wage, (2) average price of a room, (3) average price of food and beverage operations, (4) average price of casino operations, (5) average price of hotel operations, (6) average price of other expenses.	(1) total revenues generated from various hotel services.
Tsaur (2000)	DEA-CCR	53 international tourist hotels of Taiwan, 1996-1998.	(1) total operating expenses, (2) number of employees, (3) number of rooms, (4) total floor space of the catering division.	(1) total operating revenues, (2) number of rooms occupied, (3) average daily rate, (4) average production value per employee in the catering division.
Hwang and Chang (2003)	DEA-CCR and Malmquist productivity index	45 international tourist hotels of Taiwan, 1994, 1998.	(1) number of full-time employees, (2) guest rooms, (3) total area of meal department, (4) operating expenses.	(1) room revenue, (2) food beverages revenue, (3) other revenues.
Chiang, Tsai, and Wang (2004)	DEA-BCC	25 hotels of Taipei, 2000.	(1) hotel rooms, (2) food and beverage capacity, (3) number of employees, (4) total cost of the hotel.	(1) Yielding index, (2) F&B revenue, (3) miscellaneous.
Barros and Alves (2004)	DEA-Malmquist productivity index	42 hotels of Portuguese, 1999-2001	(1) full-time workers, (2) cost of labor, (3) book value of property, (4) external costs.	(1) sales, (2) number of guests, (3) nights spent in the hotel.

Chapter 3 Research Design

Firstly, this study utilizes a production approach to design three performance models, namely, managerial performance, occupancy performance and catering department performance in section 3.1. Data selection and description are given in section 3.2. Section 3.3 presents an extension to the DEA, by incorporating the traditional DEA, input congestion measure, benchmark-share measure, slack-based measure, and window analysis for assessing the relative efficiency in current-period and the efficiency variation in cross-period for ITHs. Finally, the tobit regression analysis is employed to analyze the operating characteristics for exploring the variation of managerial performance among ITHs in section 3.4.

3.1 Performance Models

The hotel industry provides guests such services as accommodation, catering, entertainment, convention venues, social activities, and shopping. Among these services, accommodation and catering have been two main revenue sources for international tourist hotels in Taiwan since 1991. As reported by TTB (2003), these two services contributed more than 84 percent of total revenues of 56 ITHs in 2002; and catering revenues amounting to 45.93% of total revenues, had surpassed that of room revenues (38.89% of total revenues). Therefore, it may be necessary to assess the ITH performance on various dimensions, thus guiding managerial action. In this study, we use a production approach to design three performance models, namely, managerial performance, occupancy performance and catering department performance.

The managerial performance model is to measure the managerial efficiency of hotel operations. The production model consists of four inputs: total operating expenses, the number of employees, the number of guest rooms, and total area of the catering department; and five outputs: total operating revenues, average occupancy rate, average room rate, average production value per employee in the catering department, and average production value of catering department (See Figure 4).

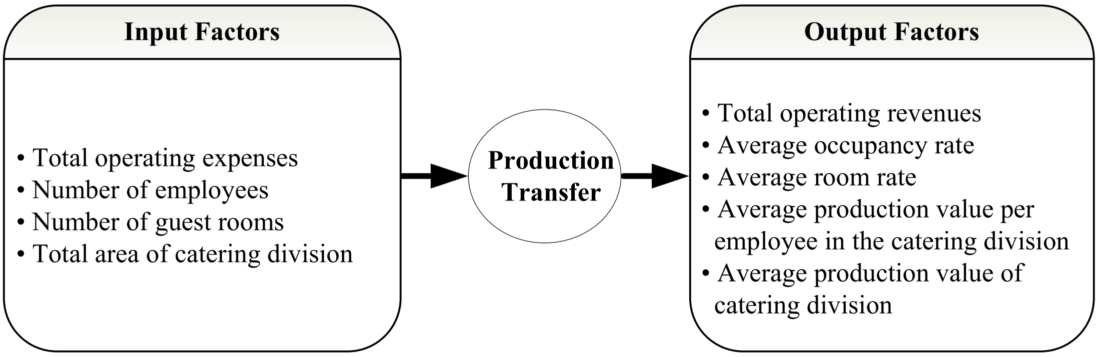

Figure 4 Managerial Performance Model

The occupancy performance model is designed to explore the operational efficiency of room departments. The production model consists of two inputs (the number of guest rooms and the number of employees in room division) and three outputs (the total operating revenues of room division, average occupancy rate, and average room rate) (See Figure 5).

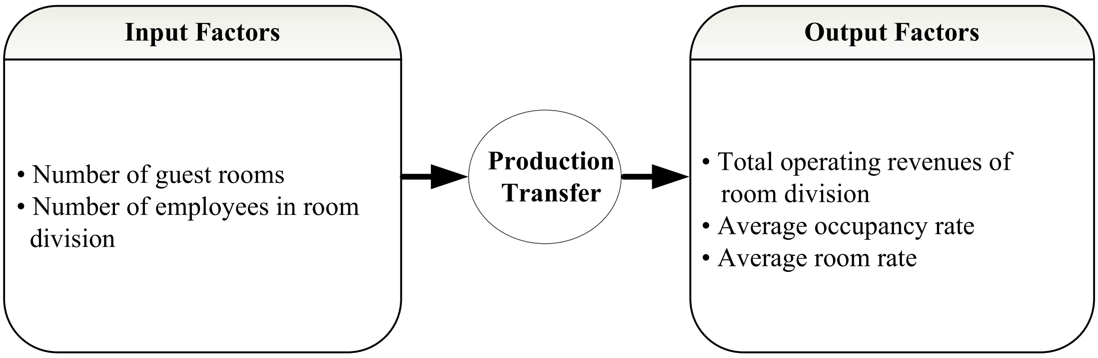

Figure 5 Occupancy Performance Model

The catering performance model is to measure the operational efficiency of the catering departments. The production model consists of three inputs (total area of catering division, the number of employees in the carting department and catering-related expenses) and three outputs (total operating revenues of the catering department, average production value per employee in the catering department, and average production value of the catering division) (See Figure 6).

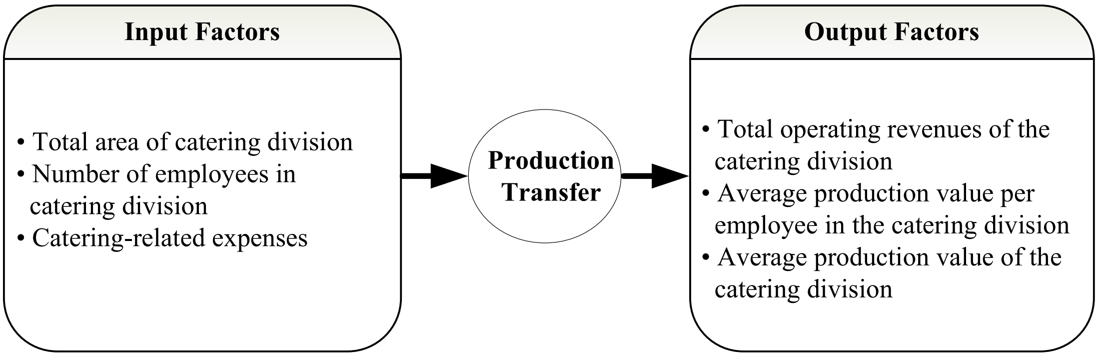

Figure 6 Catering Performance Model

The choice of input and output variables used in the performance models can be traced to the literature (see Table 1) and the hotel operating reports are published by Taiwan Tourism Bureau (TTB). For instance, the total area of the catering department appears as an input measurement in Tsaur (2000) and Hwang and Chang (2003). Similarly, the average production value per employee in the catering division appears as an output measurement in Tsaur (2000). Information on qualitative indices including the physical-facilities-satisfaction index and the service-satisfaction index are not available. Therefore, these input/output factors are excluded from our performance model. The input and output factors used in this study are defined as follows.

Input factors

- Total operating expenses (x_1): the items of operation expenses of ITHs; as a whole, they include salary and relating expenses, catering costs, water and electricity fuel expenses, depreciation expenses, maintenance and repair costs, rent and so forth, measured in units of thousand NT$.

- Number of employees (x_2): refers to the number of individual employees who are involved in the operation of ITHs, including medium- and high-ranking executives, guest rooms and catering staff, cooks, maintenance crews, and repairmen.
- Number of guest rooms (x_3): refers to the amount of guest rooms that can be provided for rent by an ITH. Accordingly, the unit of measurement is simply 'room', without any subsequent adjustment being made for size or quality.
- Total area of catering division (x_4): refers to the total floor space used by the operational units of all the ITH's catering facilities, measured in square feet.
- Number of employees in catering division (x_5): refers to the number of individual employees that are involved in the operation of ITHs in their catering divisions, such as the medium- and high-ranking executives, catering staff and cooks.
- Catering-related expenses (x_6): refers to the cost of food and beverages sold, measured in NT$.
- Number of employees in room division (x_7): refers to the number of individual employees that are involved in the operation of ITHs in the room division, such as the medium- and high-ranking executives, housekeeper and reservation clerk and front desk clerk.

Output factors

- Total operating revenues (y_1): the operational revenue of ITHs includes the income from guest rooms, catering services, laundry, stores, attached operating income, and service fees, measured in units of thousand NT$.
- Average occupancy rate (y_2): refers to the ratio between the actual number of

guestrooms let and those available to be let.

- Average room rate (y_3): refers to the ratio between the income from guest rooms and the actual number of guest rooms, measured in NT$/room.
- Average production value per employee in the catering division (y_4): refers to the ratio between total revenues from the catering division and the number of employees in the catering division, measured in NT$/individual.
- Average production value of the catering division (per 36 square feet) (y_5): refers to the ratio between total revenues from the catering division and the total floor space of catering division, measured in NT$/ (per 36 square feet).
- Total operating revenues of the catering division (y_6): refers to income from food and beverage sales, measured in NT$.
- Total operating revenues of room division (y_7): refers to the income from room rental, measured in NT$.

3.2 Data Selection and Description

This study investigates 56 ITHs in Taiwan based on the ITHs' operation data shown in the period 2002. Each of these ITH is treated as a decision making unit (DMU) in the DEA analysis. The 56 ITHs of various sizes and geographical dispersement are selected since they are officially ranked as being either four or five 'plums'. Note that in Taiwan the highest rating of an ITH with five 'plums' is equivalent to five 'stars' in the U.S. The performances of the ITHs are accessed based on the data obtained for the year 2002. The data are extracted from the annual report of the TTB. Table 2 presents descriptive statistics for our dataset. Input/output data are reported as the total number throughout the year and can be found in *The Operating Report of International Tourist Hotel in Taiwan* (2003) published by the TTB, the newest published document. This report is commonly deemed as valid, reliable, and available to the public.

Table 3 shows the correlation matrix of inputs x_i and outputs y_i. Notice that all the correlation coefficients are positive. Therefore, these inputs and outputs hold 'isotonicity' relations, and thus these variables are justified to be included in the model. Cooper et al. (2001) suggested that the number of ITHs should be at least triple the number of inputs and outputs considered. In this study the number of ITHs is fifty-six, at least triple the selected nine factors for the managerial performance model. We hence conclude that the developed DEA model of the managerial performance model holds high construct validity. Following the above rules, the occupancy/catering performance model also achieves high construct validity. In addition, we used panel data covering observations on the outputs and inputs of 46 ITHs, which are marked with a * in Table 4, for 1997-2002 to measure managerial efficiency changes for those ITHs.

Table 2 Descriptive Statistics for the 56 ITHs in Taiwan

	Mean	Minimum	Maximum	Std. Dev.	Valid N
Input Factors					
x_1	491,393,382	24,091,643	2,180,044,201	434,942,789	56
x_2	334	26	989	242	56
x_3	313	50	873	164	56
x_4	1,039	48	3,727	784	56
x_5	152	2	509	127	56
x_6	90,816,114	827,577	315,654,445	80,191,181	56
x_7	91	4	270	63	56
Output Factors					
y_1	529,329,810	15,379,118	2,550,224,684	515,597,340	56
y_2	60	11	83	15	56
y_3	2,726	866	5,917	1,105	56
y_4	1,504,250	263,379	3,172,857	537,354	56
y_5	237,197	1,194	572,844	142,569	56
y_6	243,141,430	526,757	985,649,421	236,062,687	56
y_7	205,853,918	7,153,742	1,105,255,609	195,470,617	56

Table 3 Correlation Coefficients among Input Variables and Output Variables

Input/Output Factors		Output Factors						
		y_1	y_2	y_3	y_4	y_5	y_6	y_7
Input Factors	x_1	0.9664	0.5311	0.5620	0.4534	0.5696	0.9547	0.9275
		p=0.00	p=.000	p=.000	p=.001	p=.000	p=0.00	p=0.00
	x_3	0.9004	0.5214	0.4261	0.2789	0.5197	0.9138	0.8314
		p=0.00	p=.000	p=.001	p=.041	p=.000	p=0.00	p=.000
	x_3	0.7452	0.2416	0.1200	0.2199	0.2652	0.6893	0.7246
		p=.000	p=.078	p=.388	p=.110	p=.053	p=.000	p=.000
	x_4	0.6176	0.3115	0.1363	0.2174	0.0224	0.6703	0.5077
		p=.000	p=.022	p=.326	p=.114	p=.872	p=.000	p=.000
	x_5	0.8577	0.4762	0.3793	0.2053	0.4940	0.8994	0.7602
		p=.000	p=.000	p=.005	p=.136	p=.000	p=0.00	p=.000
	x_6	0.8980	0.4674	0.4711	0.4107	0.5640	0.9559	0.7862
		p=0.00	p=.000	p=.000	p=.002	p=.000	p=0.00	p=.000
	x_7	0.8818	0.5336	0.4069	0.3205	0.4945	0.8713	0.8144
		p=.000	p=.000	p=.002	p=.018	p=.000	p=.000	p=.000

3.3 Data Envelopment Analysis Model

3.3.1 Efficiency Measurement Concepts

DEA is known as a mathematical programming method for assessing the comparative efficiencies of a DMU. DEA is a non-parametric method that allows for an efficient measurement, without specifying either the production functional form or weights on different inputs and outputs. This methodology defines a non-parametric best practice frontier that can be used as a reference for efficiency measurement which can be found in Cooper et al. (2000).

The input-oriented technical efficiency implies "by how much can input quantities be proportionally reduced without changing the output quantities produced?" The efficiency frontier presents that each DMU minimizes its inputs, keeping the output level constant. DMUs on the frontier are efficient, while DMUs inside the frontier are inefficient. Consider the case of a single input x and a single output y. In Figure 7, the constant returns to scale (*CRS*) frontier is a simple ray (ray *0C*) through the origin that envelops the data. The efficient DMU at point *C* lies on this frontier and its technical efficiency (*TE*) score equals one. The other four DMUs (*B, E, D, F*) operating inside the frontier are inefficient. The *TE* score for the DMU operating at point *E* is defined by $\overline{PQ}/\overline{PE}$. However, the CRS assumption is only appropriate when all DMUs are operating at an optimal scale. Many realistic factors, such as imperfect competition, financial constraints, etc., may cause a DMU not to operate at optimal scale. Thus, there is also a variable returns to scale (VRS) DEA model. In Figure 7, the VRS frontier is the piecewise linear frontier *ABCD*. This general form envelops the data more closely. The DMUs at *B*, *C*, and *D* lying on this frontier are efficient with a score of one. The relative inefficient DMU *E* is given by a pure technical efficiency (PTE) score ($\overline{PR}/\overline{PE}$). The TE is decomposed into PTE and scale efficiency (SE). The *SE* can be estimated by dividing PTE into TE.

To investigate the current operating region to scale inefficient DMUs, this may be determined by running an additional DEA problem with non-increasing returns to scale (*NIRS*) imposed. This may be determined by running an additional DEA problem with non-increasing returns to scale (*NIRS*) imposed. The *NIRS* DEA frontier is also plotted in Figure 7. The nature of the scale inefficiencies (i.e. due to increasing or decreasing returns to scale) for a particular DMU can be determined by seeing whether the *NIRS TE* score is equal to the *VRS TE* score. If they are unequal (as will be the case for the point *E* in Figure 7), then increasing returns to scale (*IRS*) exist for the DMU. If they are equal (as is the case for point *F* in Figure 7), then decreasing returns to scale (*DRS*) apply.

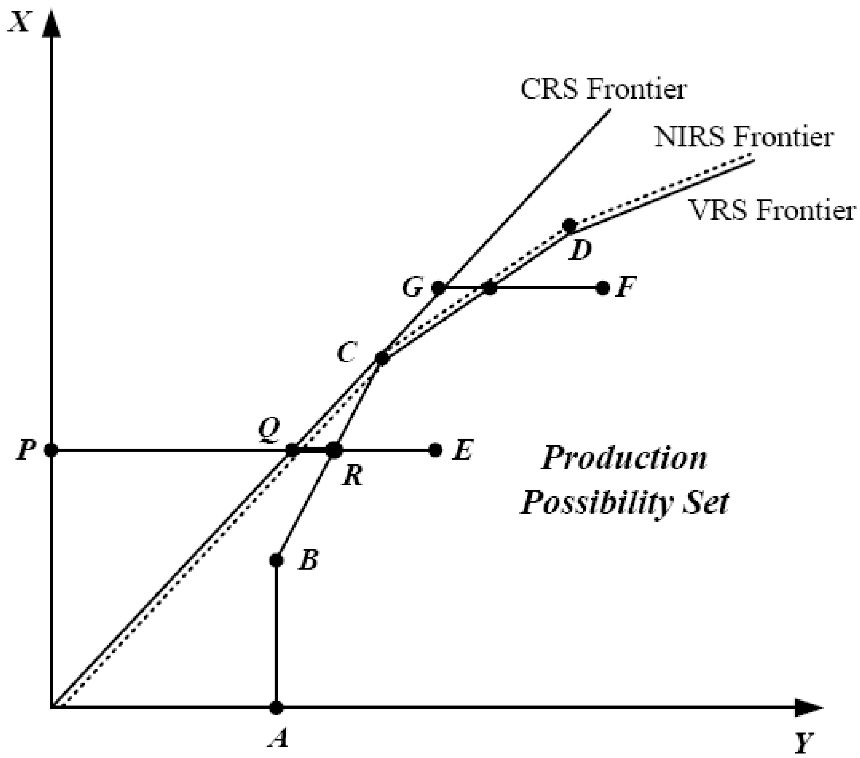

Figure 7 Graphical Illustration of Measuring Technical Efficiency (Input-Oriented DEA Using a Single Input to Produce a Single Output)

3.3.2 Multiplier Model of the CCR/BCC Model

DEA is a mathematical model that measures the relative efficiency of decision-making units with multiple inputs and outputs but with no obvious production function to aggregate the data in its entirety. Relative efficiency is defined as the ratio of total weighted output to total weighted input. By comparing n units with s outputs denoted by y_{ro}, $r = 1,\ldots,s$, and m inputs denoted by x_{io}, $i =,\ldots,m$, the efficiency measure for the target DMU_o ($o = 1,\ldots,n$) is

$$h_o = Max \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}},$$

where the weights, u_r and v_i, are non-negative. A second set of constraints requires that the same weights, when applied to all DMUs, do not provide any unit with efficiency greater than one. This condition appears in the following set of constraints:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \text{ for } j = 1,\ldots,n.$$

The efficiency ratio ranges from zero to one, with the target DMU_o being considered relatively efficient if it receives a score of one. Thus, each unit will choose weights so as to maximize self-efficiency, given the constraints. The result of the DEA is the determination of the hyperplanes that define an envelope surface or Pareto frontier. DMUs that lie on the surface determine the envelope and are deemed efficient, whilst those that do not are deemed inefficient. The formulation described above can be translated into a linear program, which can be solved relatively easily and a complete DEA solves n linear programs, one for each

DMU.

$$
\begin{aligned}
h_o = \ & Max \ \sum_{r=1}^{s} u_r y_{ro} \\
& s.t. \\
& \quad \sum_{i=1}^{m} v_i x_{io} = 1, \\
& \quad \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, \quad j = 1, \ldots, n, \\
& \quad u_r, v_i \ge 0; \quad i = 1, \ldots, m; \quad r = 1, \ldots s,
\end{aligned} \tag{1}
$$

Eq. (1), often referred to as the CCR model (Charnes et al., 1978), assumes that the production function exhibits constant returns to scale. The BCC model (Banker et al., 1984) adds an additional constant variable, u_o, in order to permit variable returns to scale:

$$
\begin{aligned}
h_o = \ & Max \ \sum_{r=1}^{s} u_r y_{ro} - u_o \\
& s.t. \\
& \quad \sum_{i=1}^{m} v_i x_{io} = 1, \\
& \quad \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - u_o \le 0, \quad j = 1, \ldots, n, \\
& \quad u_o \ \text{free in sign}, \\
& \quad u_r, v_i \ge 0; \quad i = 1, \ldots, m; \quad r = 1, \ldots s.
\end{aligned} \tag{2}
$$

It should be noted that the results of the CCR input-minimized or output-maximized formulations are the same, which is not the case in the BCC model. Thus, in the output-oriented BCC model, the formulation maximizes the outputs given the inputs and vice versa.

3.3.3 The Dual Program of the CCR/BCC Model

If a DMU proves to be inefficient, a combination of other efficient units can produce either greater outputs for the same composite of inputs, use fewer inputs to produce the same composite of outputs or some combination of the two. A hypothetical decision making unit can be composed as an aggregate of the efficient units, referred to as the efficient reference set for inefficient DMU_o. The solution to the dual problem of the linear program directly computes the multipliers required to compile efficient units. The pure technical efficiency (PTE) of the target DMU_o ($o = 1, \ldots, n$) in the BCC model can be computed as a solution to the following linear programming (LP) problem.

$$
\begin{aligned}
& Min \;\; \theta_o \\
& s.t. \\
& \quad \sum_{j=1}^{n} \lambda_j x_{ij} \le \theta_o x_{io}, \qquad i = 1, \ldots, m, \\
& \quad \sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{ro}, \qquad r = 1, \ldots, s, \\
& \quad \sum_{j=1}^{n} \lambda_j = 1, \qquad j = 1, \ldots, n, \\
& \quad \theta_o,\ \lambda_j \ge 0;\ \forall\ i\ and\ r.
\end{aligned}
\tag{3}
$$

In the case of an efficient DMU, all dual variables will equal zero except for λ_o and θ_o, which reflect the DMU_o's efficiency, both of which will equal one. If DMU_o is inefficient, θ_o will equal the ratio solution of the primal problem. The remaining variables, λ_j, if positive, represent the multiples by which DMU_o's inputs and outputs should be multiplied in order to compute the composite efficient DMU. If $\sum_{j=1}^{n} \lambda_j = 1$ is dropped from Eq.(3), then the technology is said to exhibit constant returns to scale (CRS). The technical efficiency (TE) of the target DMU_o is defined as $TE = \theta_o$ under the input-oriented CRS model (Charnes et al., 1978).

3.3.4 The Slack-Adjusted CCR/BCC Model

In the slack-adjusted DEA models, see for example model (3), a weakly efficient DMU will now be evaluated as inefficient, due to the presence of input and output oriented slacks s_i^- and s_r^+, respectively. The pure technical efficiency (PTE) of the target DMU_o ($o = 1,\ldots,n$) in the BCC model can be computed as a solution to the following linear programming (LP) problem.

$$
\begin{aligned}
& Min \;\; \theta_o - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right) \\
& s.t. \\
& \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta_o x_{io}, \quad i = 1,\ldots,m, \\
& \sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{ro}, \quad r = 1,\ldots,s, \\
& \sum_{j=1}^{n} \lambda_j = 1, \\
& \theta_o,\ \lambda_j,\ s_i^-,\ s_r^+ \geq 0;\ \varepsilon > 0;\ \forall\ i \ and\ r.
\end{aligned} \tag{4}
$$

The PTE of the target DMU_o is defined as PTE $= \theta_o$. By varying the index 'o' over all DMUs, we arrive at the PTE in each DMU. If PTE $= 1$ and all input and output slacks, s^- and s^+, are equal to zero, then the DMU_o is technically efficient. If PTE is smaller than one, then DMU_o is technically inefficient. The solution value of λ_j indicates whether DMU_j serves as a role model or peer for DMU_o. If $\lambda_j = 0$, then DMU_j is not a peer. However, if $\lambda_j > 0$, say $\lambda_j = 0.4$, then DMU_j is a peer DMU with a 40 percent weight placed on deriving the target efficient output and input levels for DMU_o. For an inefficient DMU_o, we have the expression in Eq. (5).

$$\theta_o x_{io} = \sum_{j=1}^{n} x_{ij}\lambda_j^* + s_i^{-*}, \quad i = 1,\ldots,m,$$
$$y_{ro} = \sum_{j=1}^{n} y_{rj}\lambda_j^* - s_r^{+*}, \quad \mathrm{r} = 1,\ldots,s, \tag{5}$$

where θ_{jo}, s_i^{-*}, s_r^{+*} and λ_j^* are optimal slacks and weights obtained from Eq. (4). The $DMU_o\left(x_{io}, y_{ro}\right)$ can be improved and become efficient by deleting its excess input and augmenting the shortfall output as follows:

$$\hat{x}_{io} = \theta_o x_{io} - s_i^{-*} = \sum_{j=1}^{n} x_{ij}\lambda_j^*, \quad i = 1,\ldots,m,$$
$$\hat{y}_{ro} = y_{ro} + s_r^{+*} = \sum_{j=1}^{n} y_{rj}\lambda_j^*, \quad \mathrm{r} = 1,\ldots,s. \tag{6}$$

This operation is called BCC-projection.

If $\sum_{j=1}^{n} \lambda_j = 1$ is dropped from Eq.(4), then the technology is said to exhibit constant returns to scale (CRS). The technical efficiency (TE) of the target DMU_o is defined as $TE = \theta_o$ under the input-oriented CRS model (Charnes et al., 1978). The scale efficiency (SE) for the target DMU_o is then obtained as.

$$SE = TE / PTE. \tag{7}$$

The SE represents the proportion of inputs that can be further reduced after pure technical inefficiency is eliminated if scale adjustments are possible. It has a value of less than or equal to one. If the target DMU_o has a value equal to one, then it is operating at the constant returns to scale size. If SE is less than one, then the target DMU_o is scale inefficient and there is potential input savings through the adjustment of its operational scale. Whether the scale inefficient DMU_o should be either downsizing or expanding depends on its current operating scale.

3.3.5 Returns to Scale

There are at least three different basic methods of testing a DMU's returns to scale (RTS) nature which have appeared in the DEA literature. Banker (1984) shows that the CCR model can be employed to test for DMUs' RTS using the concept of most productive scale size (MPSS), i.e. the sum of the CCR optimal lambda values can determine the RTS classification. This method is called the CCR RTS method. Banker et al. (1984) report that a new free BCC dual variable (u_o) estimates RTS by allowing variable returns to scale (VRS) for the CCR model, i.e. the sign of u_o determines the RTS. We call this method the BCC RTS method. Finally, Färe et al. (1985) provide the scale efficiency index method for the determination of RTS using DEA. These three RTS methods, in fact, are equivalent but different presentations (Banker et al., 1996; Färe et al., 1994; Zhu et al., 1995).

The three basic RTS methods have been widely employed in real world situations (Byrnes et al., 1984; Charnes et al., 1989; Zhu, 1996a). However, it has been noted that the CCR and BCC RTS methods may fail when DEA models have alternate optima, i.e. the original CCR and BCC RTS methods assume unique optimal solutions to the DEA formulations. In contrast to the CCR and BCC RTS methods, the scale efficiency index method does not require information on the primal and dual variables and, in particular, is robust even when there exist multiple optima. Since it may be impossible or at least unreasonable to generate all possible multiple optima in many real world applications, a number of modifications or extensions of the original CCR and BCC methods have been developed to deal with multiple optima.

Banker and Thrall (1992) generalize the BCC RTS method by exploring all alternate optima in the BCC dual model, i.e. RTS in their extended technique is measured by intervals for u_o. Banker et al. (1995) further modified the technique to avoid the need for examining all alternate optima. Using the same technique, Banker et al. (1996) introduce a modification to the CCR RTS method by determining the maximum and minimum values of $\sum_{j=1}^{n} \lambda_j$ in the CCR model in order to reach a decision. On the other hand, by the scale efficiency index method, Zhu and Shen (1995) suggest a remedy for the CCR RTS method under possible multiple optima.

According to the recent result of Zhu and Shen (1995), one can easily estimate the returns to scale (RTS) by the CCR and BCC scores and $\sum_{j=1}^{n} \lambda_j$ in any optimal solution to the CCR model without exploring all possible multiple optimal solutions. That is, if CCR score is equal to the BCC score, then CRS (constant return to scale) prevails; otherwise, if the CCR and BCC scores are not equal, then $\sum_{j=1}^{n} \lambda_j < 1$ indicates IRS (increasing returns to scale) and $\sum_{j=1}^{n} \lambda_j > 1$ indicates DRS (decreasing returns to scale).

3.3.6 Input Congestion Measure

The input congestion is next measured. 'Input congestion' was first defined in Cooper et al. (2001) as "increasing in one or more inputs associated with decreasing in one or more outputs." A slack-based approach (Cooper et al., 2001) is defined as a congestion measure to capture input congestion and identifies its sources and amounts by the BCC model in Eq. (1). This method not only detects congestion, but also determines the amount of congestion and simultaneously identifies factors responsible for congestion. This study measures the congestion of operating expenses, employees, guest rooms, and the area of the catering division for the managerial performance model.

Input congestion for the target DMU_o can be computed as a solution to the following linear programming (LP) problem (Cooper et al., 2001).

$$
\begin{aligned}
& Max \ \sum_{i=1}^{m} \delta_i^+ \\
& s.t. \\
& \sum_{j=1}^{n} \lambda_j x_{ij} - \delta_i^+ = \theta_o^* x_{io} - s_i^{-*} = \hat{x}_{io}, \quad i = 1, \ldots, m, \\
& \sum_{j=1}^{n} \lambda_j y_{rj} = y_{ro} + s_r^{+*} = \hat{y}_{ro}, \qquad r = 1, \ldots, s, \\
& \sum_{j=1}^{n} \lambda_j = 1, \\
& \lambda_j \geq 0, \ s_i^{-*} \geq \delta_i^+,
\end{aligned} \tag{8}
$$

where θ_o^*, s_i^{-*}, and s_r^{+*} are obtained from Eq. (4) and all variables are constrained to be non-negative. Notice that the inequality in Eq. (8) for the inputs implied in the first $i = 1, \ldots, m$ constraints is reversed from the usual form exhibited in Eq. (4). The objective in Eq. (8) is to maximize the sum of the input slacks with the additional constraint $s_i^{-*} \geq \delta_i^+$ limiting each slack to the maximum value obtained in the preceding solution to Eq. (4). The amount of congestion in each input for DMU_o can then be determined by the difference between each pair of s_i^{-*} and δ_i^{+*}, where δ_i^{+*} are optimal values in Eq. (8). That is,

$$
s_i^c = s_i^{-*} - \delta_i^{+*} \geq 0, \ i = 1, \ldots, m, \tag{9}
$$

where s_i^c in Eq. (9) are then called input congestion slacks. These s_i^c values, when positive, represent the congesting amounts in each of the $i = 1, \ldots, m$ inputs, while $\delta_i^{+*} \geq 0$ represent the corresponding technical inefficiency components.

3.3.7 Benchmark-Share Measure

For an inefficient decision making unit, what is even more important is to find out a benchmark peer to improve the technical inefficient. There are numerous studies devoted to developing methods to identify a benchmark in the DEA models (see Andersen and Petersen, 1993; Seiford and Zhu, 1999; Li and Reeves, 1999; Tone, 2002). However, a difficulty occurs pervasively in those studies in that the contribution which an efficient DMU makes to the potential input (output) improvement in inefficient DMUs cannot be measured.

To identify the inputs/outputs that are most important or to distinguish those efficient ITHs which can be treated as benchmarks, the benchmark-share measure (Zhu, 2000) is defined as a ranking measure by combining the factor-specific measure in Eqs. (5) and (6) and the BCC model in Eq. (1). Lewin et al. (1982) and Torgersen et al. (1996) report the application for output-specific efficiency measures which are derived from the radial component and non-zero slacks. Here, for a particular inefficient ITH_d, the factor-specific (kth input-specific and qth output-specific) measure comes via the following two linear programming problems and the existing BCC model's best practice frontier.

The kth input-specific DEA model can be written as follows.

$$
\begin{aligned}
&\theta_d^{k*} = Min\ \theta_d^k, \quad d \in N, \\
&s.t. \\
&\sum_{j \in E} \lambda_j^d x_{ij} = \theta_d^k x_{kd,} \quad k \in \{1,\ldots,m\}, \\
&\sum_{j \in E} \lambda_j^d x_{ij} \le x_{id,} \qquad i \ne k, \\
&\sum_{j \in E} \lambda_j y_{rj} \ge y_{rd}, \quad r = 1,\ldots,s, \\
&\sum_{j \in E} \lambda_j^d = 1, \\
&\theta_d^k,\ \lambda_j^d \ge 0,\ j \in E.
\end{aligned}
\tag{10}
$$

The qth output-specific DEA model can be written as follows.

$$
\begin{aligned}
&\phi_d^{q*} = Max\ \phi_d^q, \quad d \in N, \\
&s.t. \\
&\sum_{j\in E} \lambda_j^d y_{qj} = \phi_d^q y_{qd}, \quad q \in \{1,\ldots,s\}, \\
&\sum_{j\in E} \lambda_j^d y_{rj} \ge y_{rd},\ r \ne q, \\
&\sum_{j\in E} \lambda_j^d x_{ij} \le x_{id},\ \ i = 1,\ldots,m, \\
&\sum_{j\in E} \lambda_j^d = 1, \\
&\phi_d^q, \lambda_j^d \ge 0, j \in E.
\end{aligned} \tag{11}
$$

Here, E and N respectively represent the index sets for the efficient and inefficient *ITHs* identified by Eq. (1). The factor-specific measures in Eq. (10) and Eq. (11) determine the maximum potential decrease of an input and increase of an output while keeping other inputs and outputs at current levels. These factor-specific measures are still multi-factor performance measures, since all related factors are considered in a single model.

On the basis of Eq. (10), the kth input-specific, benchmark-share measure for each efficient ITH, $j \in E$, is

$$
\Delta_j^k = \sum\nolimits_{d\in N} \lambda_j^{d*}\left(1-\theta_d^{k*}\right)x_{kd} \Big/ \sum\nolimits_{d\in N}\left(1-\theta_d^{k*}\right)x_{kd}, \tag{12}
$$

where λ_j^{d*} and θ_d^{k*} are optimal values in Eq. (10). On the basis of Eq. (11), the qth output-specific benchmark-share measure for each efficient ITH, $j \in E$, is

$$
\Pi_j^q = \sum\nolimits_{d\in N} \lambda_j^{d*}\left[1-\left(1/\phi_d^{q*}\right)\right]y_{qd} \Big/ \sum\nolimits_{d\in N}\left[1-\left(1/\phi_d^{q*}\right)\right]y_{qd}, \tag{13}
$$

where λ_j^{d*} and ϕ_d^{q*} are optimal values in Eq. (11).

The benchmark-share Δ_j^k (or Π_j^q) depends on the values of $\lambda_j^{d^*}$ and $\theta_d^{k^*}$ (or $\lambda_j^{d^*}$ and $\phi_d^{k^*}$). Note that $\left(1-\theta_d^{k^*}\right) x_{kd}$ and $\left[1-\left(1/\phi_q^{d^*}\right)\right] y_{qd}$ characterize the potential decrease on the *kth* input and increase on the *qth* output, respectively. Therefore, the benchmark-share here measures the contribution that an efficient *ITH* makes to the potential input (output) improvement in inefficient *ITHs*.

Terms Δ_j^k and Π_j^q are weighted optimal lambda values across all the inefficient *ITHs*. The weights,

$$\left[\left(1-\theta_d^{k^*}\right)x_{kd} \Big/ \sum\nolimits_{d\in N}\left(1-\theta_d^{k^*}\right)x_{kd}\right] \text{ and } \left\{\left[1-\left(1/\phi_d^{k^*}\right)\right]y_{qd} \Big/ \sum\nolimits_{d\in N}\left[1-\left(1/\phi_d^{k^*}\right)\right]y_{qd}\right\},$$

are normalized and therefore we have $\sum_{j\in E}\Delta_j^k = 1$ and $\sum_{j\in E}\Pi_j^q = 1$. It is very clear from Eq. (12) and Eq. (13) that an efficient *ITH* which does not act as a referent *ITH* for any inefficient *ITH* will have a zero benchmark-share measure. The larger the benchmark-share measure is, the more important an efficient *ITH* is in benchmarking.

3.3.8 Dynamic Extensions of DEA

A DEA window analysis works on the principle of moving averages (Charnes et al., 1985) and is useful to detect performance trends of a unit over time. Each unit in a different period is treated as if it was a different unit. In doing so, the performance of a unit in a particular period is contrasted with its own performance in other periods in addition to the performance of other units. This increases the number of data points in the analysis, which can be useful when dealing with small sample sizes. Varying the window width, that is the number of time periods included in the analysis, means covering the spectrum from contemporaneous analysis, which include only observations from one time period, to intertemporal analysis, which includes observations from the whole study period.

A 'real' window analysis, with a window width somewhere between one and all periods in the study horizon, can be viewed as a special case of a sequential analysis. In a sequential analysis it is assumed, however, that what was feasible in the past remains feasible, and therefore all previous observations are included. This is not the case in the window analysis, where only observations within a certain number of time periods (i.e., a window) are considered, whereby the number of observations in each analysis remains constant. Once the window is defined the observations within that window are viewed in an intertemporal manner and the analysis is therefore better referred to as locally intertemporal.

To formalize, consider n DMUs ($j = 1,\ldots,n$) which are observed in p periods ($t = 1,\ldots,p$) and which all use m inputs to produce s outputs. The sample thus has input $n \times p$ observations, and an observation j in period t, DMU_j^t has a $m-$dimensional input vector $X_j^t = \left(x_{1j}^t, x_{2j}^t, \ldots, x_{mj}^t\right)'$ and a $s-$dimensional output vector $Y_j^t = \left(y_{1j}^t, y_{2j}^t, \ldots, y_{sj}^t\right)'$.

The window starting at time q, $1 \le q \le p$ and with the width w, $1 \le w \le p-q$, is denoted by qw and has $n \times w$ observations. The matrix of inputs for this window analysis is given by

$$X_{qw} = \left(x_{1j}^q, x_{2j}^q, \ldots, x_{mj}^q, x_{1j}^{q+1}, x_{2j}^{q+1}, \ldots, x_{mj}^{q+1}, \ldots, x_{1j}^{q+w-1}, x_{2j}^{q+w-1}, \ldots, x_{mj}^{q+w-1}\right),$$

and the matrix of outputs is

$$Y_{qw} = \left(y_{1j}^q, y_{2j}^q, \ldots, y_{sj}^q, y_{1j}^{q+1}, y_{2j}^{q+1}, \ldots, y_{sj}^{q+1}, \ldots, y_{1j}^{q+w-1}, y_{2j}^{q+w-1}, \ldots, y_{sj}^{q+w-1}\right).$$

The slack-based measure (SBM) DEA window problem for DMU_o^t under a variable returns to scale assumption is given by

$$\theta_o^{t*} = Min \ \frac{1 - (1/m)\sum_{i=1}^{m} s_i^- / x_{io}^t}{1 + (1/s)\sum_{i=1}^{s} s_i^+ / y_{ro}^t}$$
$$s.t.$$
$$X_o^t = X_{qw}\Lambda + S^-,$$
$$Y_o^t = Y_{qw}\Lambda - S^+, \qquad (14)$$
$$\sum_{j=1}^{n\times w} \lambda_j = 1,$$
$$\Lambda \geq 0,\ S^- \geq 0,\ S^+ \geq 0.$$

Λ be a ($nw \times 1$) vector of intensity or weight variables. $S^- \in R^m$ and $S^+ \in R^s$ indicate the input excess and output shortfall of this expression, respectively. In Figure 8 input oriented DEA window analysis is illustrated with two inputs and fixed output.

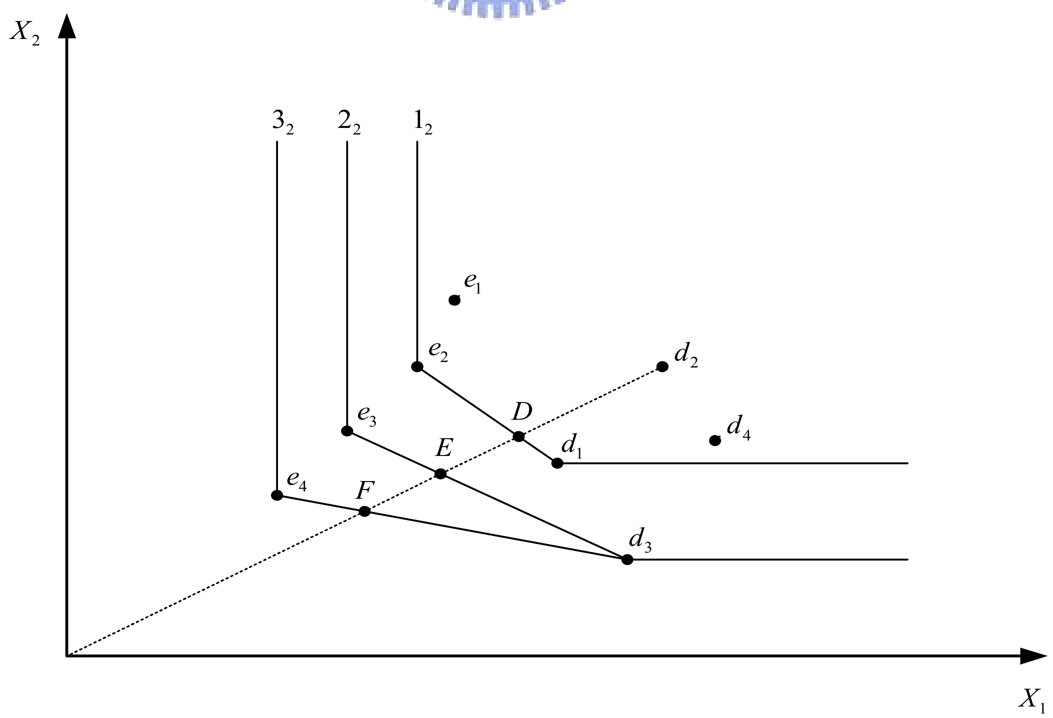

Figure 8 Illustration of DEA Window Analysis.

The figure shows two DMU's, d and e, each observed at four different times, $t = 1,\ldots,4$. The window l_2 is the window starting at times 1 and with a window width of 2, and thus contains the observations $d_1, d_2, e_1,$ and e_2 and has the frontier here simply indicated as l_2.

3.4 Tobit Regression Model

Although the efficiency scores obtained from solving linear programming problems for the SBM models represent the ability of management to convert inputs into outputs at the current scale of operation, it is possible that some differences in operating characteristics may affect the ITHs' performance. Therefore, it is important for this study to determine which ITH characteristics have an influence upon variations in managerial efficiency across ITHs. Tobit regression analysis is employed to estimate the relationship between managerial efficiency scores and ITHs' operating characteristics unrelated to the inputs used in the VRS model. Specifically, the following model is estimated:

$$TE^{mean} = \alpha + Z\beta + \varepsilon , \tag{15}$$

where TE^{mean} is a vector $(n \times 1)$ of mean managerial efficiency for all n ITHs; the scalar α and the $(d \times 1)$ vector β are unknown parameters to be estimated; Z is an $(n \times d)$ matrix of operating characteristics, and e is an $(n \times 1)$ vector of residuals. Past approaches that have employed DEA to measure managerial efficiency followed up by regression techniques to assign variation in efficiency include Berger et al. (1997) and Carrington et al. (1997).

Chapter 4 Empirical Analysis

4.1 Managerial Performance

Based on the controllable aspect from a manager's point of view, the performance model in this study is run under the assumption of input minimization (also known as input orientation). The technical efficiency (TE, Mean=0.848) is decomposed into pure technical efficiency (PTE, Mean=0.876) and scale efficiency (SE, Mean=0.969), and the nature of returns to scale (RTS) is reproduced in Table 4. The result reveals that the overall technical inefficiencies of Taiwanese ITHs are primarily due to the pure technical inefficiencies rather than the scale inefficiencies. This implies that the number of ITHs is approaching market saturation. This also suggests that managers should focus firstly on removing the technical inefficiency of ITHs, and then ITHs can be subject to improving their scale efficiencies.

As regards to the pure technical efficiency (PTE), it is found that, on average, ITHs can produce the same level of measured output with 12.67% less inputs, holding the current input ratios constant. Using a Z-test, we reject the null hypothesis that the sample mean is one at the 5% level of significance. Approximately 54% of ITHs need to reduce their inputs if they are to become efficient. The rest of the ITHs are regarded as efficient. This indicates that overall ITHs still have room for improving their pure technical efficiencies.

This study further investigates the status of returns to scale for ITHs. From Table 4, approximately 30% of the ITHs are constant returns to scale (CRS). Nearly 61% of the ITHs operate at decreasing returns to scale (DRS). The rest of the ITHs operate at increasing returns to scale (IRS). This result implies that ITHs are facing a highly competitive environment in Taiwan. The total number of Taiwan's ITHs increased from 43 to 62 (31% growth rate) within the period of 1989-2003; this created a somewhat oversupply situation.

As a result, too many ITHs competing for a limited number of foreign tourists made most ITHs operate at DRS and they exhibited diseconomies of scale. With existing inputs as sunk costs or fixed costs to business operations, the ITHs are consequently facing greater competition. They will try to minimize their losses by serving tourists whenever they can so as to cover their variable costs.

To determine whether differences exist in various operating characteristics including management type (either international chain or independent-owned), location (either metropolitan area or resort area), and closeness to international airport (either close or far) for managerial efficiency, a non-parametric statistical analysis (Mann-Whitney test) is used (Brockett et al., 1996) for unknown distribution scores. A non-parametric statistical analysis is presented in Table 5. It is discovered that the international chain ITHs are more efficient on average than independent-owned ones. This finding is consistent with the finding by Hwang and Chang (2003). However, the gap of efficiency score in management type is less than the previous study (Hwang and Chang, 2003), because using a Mann-Whitney test shows no significant difference at the 5% level. The result shows that gradually independent-owned ITHs, like international chain ITHs, have achieved managerial know-how in efficiently operating an ITH.

Table 4 Effficiency Scores of the 56 ITHs

Code	ITH Name	TE	PTE	SE	$\sum\lambda$	RTS	MS	Location	CKS
H01	*Grand Hotel Taipei	0.761	0.765	0.994	1.080	DRS	I	MA	Close
H02	*Ambassodor Hotel	0.803	1.000	0.803	1.385	DRS	C	MA	Close
H03	* Mandarina Crown Hotel	0.845	0.884	0.955	1.214	DRS	I	MA	Close
H04	*Imperial Hotel Taipei	0.652	0.682	0.956	1.112	DRS	I	MA	Close
H05	*Gloria Prince Hotel	0.905	0.941	0.962	1.269	DRS	C	MA	Close
H06	*Emperor Hotel	1.000	1.000	1.000	1.000	CRS	I	MA	Close
H07	* Riverview Hotel	1.000	1.000	1.000	1.000	CRS	I	MA	Close
H08	*Caesar Park Hotel Taipei	0.826	0.858	0.962	1.287	DRS	C	MA	Close
H09	*Gold China Hotel	0.918	1.000	0.918	1.792	DRS	I	MA	Close
H10	*Brother Hotel	0.983	1.000	0.983	1.337	DRS	I	MA	Close
H11	*Santos Hotel	0.789	0.862	0.916	1.399	DRS	I	MA	Close
H12	*Landis Ritz Hotel	0.985	1.000	0.985	2.248	DRS	C	MA	Close
H13	*United Hotel	1.000	1.000	1.000	1.000	CRS	I	MA	Close
H14	*Sheraton Taipei Hotel	0.662	0.665	0.996	1.051	DRS	C	MA	Close
H15	*Fortuna Hotel	0.808	0.839	0.963	1.385	DRS	I	MA	Close
H16	*Holiday Inn Asiaworld Taipei	0.717	0.720	0.995	0.707	IRS	C	MA	Close
H17	* Royal Hotel Taipei	0.912	1.000	0.912	1.856	DRS	C	MA	Close
H18	*Howard Plaza Hotel Taipei	0.926	1.000	0.926	1.397	DRS	I	MA	Close
H19	*Rebar Crowne Plaza Hotel	0.800	0.834	0.960	1.500	DRS	C	MA	Close
H20	*Grand Hyatt Taipei	1.000	1.000	1.000	1.000	CRS	C	MA	Close
H21	*Grand Formosa Regent Taipei	1.000	1.000	1.000	1.000	CRS	C	MA	Close
H22	*Sherwood Hotel Taipei	1.000	1.000	1.000	1.000	CRS	C	MA	Close
H23	*Far Eastern Plaza Hotel	1.000	1.000	1.000	1.000	CRS	C	MA	Close
H24	The Westin Taipei	1.000	1.000	1.000	1.000	CRS	C	MA	Close
H25	*Hotel Kingdom	0.685	0.686	0.999	0.938	IRS	I	MA	Far
H26	*Holiday Garden Kaohsiung	0.750	0.759	0.988	1.055	DRS	I	MA	Far
H27	*Ambassador Hotel Kaohsiung	0.647	0.654	0.989	1.119	DRS	C	MA	Far
H28	*Linden Hotel Kaohsiung	0.708	0.734	0.965	1.370	DRS	I	MA	Far
H29	*Grand Hi-Lai Hotel	0.646	0.649	0.995	1.072	DRS	I	MA	Far
H30	*Howard Plaza Hotel Kaohsiung	0.796	0.923	0.863	1.711	DRS	I	MA	Far
H31	Splendor Kaohsiung	0.550	0.550	1.000	0.856	IRS	I	MA	Far
H32	*Park Hotel	1.000	1.000	1.000	1.000	CRS	I	MA	Far
H33	*Hotel National	0.669	0.681	0.982	1.232	DRS	I	MA	Far
H34	*Plaza International Hotel	0.713	0.729	0.978	1.332	DRS	I	MA	Far
H35	*Evergreen Laurel Hotel Taichung	0.877	0.878	0.999	1.060	DRS	I	MA	Far

Table 4 Continued

Code	ITH Name	TE	PTE	SE	$\sum\lambda$	RTS	MS	Location	CKS
H36	*Howard Prince Hotel Taichung	0.908	1.000	0.908	1.594	DRS	I	MA	Far
H37	Splendor Taichung	0.932	0.981	0.950	1.304	DRS	I	MA	Far
H38	*Astar Hotel Hualine	0.889	1.000	0.889	0.388	IRS	I	RA	Far
H39	*Marshal Hotel	0.743	0.768	0.968	1.206	DRS	I	RA	Far
H40	*China Trust Hotel Hualien	1.000	1.000	1.000	1.000	CRS	I	RA	Far
H41	*Parkview Hotel	0.786	0.808	0.974	1.094	DRS	I	RA	Far
H42	*Hotel Landis China Yangmingshan	1.000	1.000	1.000	1.000	CRS	C	RA	Far
H43	*Grand Hotel Kaohsiung	1.000	1.000	1.000	1.000	CRS	I	RA	Far
H44	*Caesar Park Hotel Kenting	1.000	1.000	1.000	1.000	CRS	C	RA	Far
H45	* Royal Chihpen Resort Hotel	1.000	1.000	1.000	1.000	CRS	C	RA	Far
H46	*Grand Formosa Taroko	1.000	1.000	1.000	1.000	CRS	C	RA	Far
H47	Howard Beach Resort Kenting	0.918	1.000	0.918	1.138	DRS	I	RA	Far
H48	The Hibiscus Resort	0.664	0.671	0.989	0.847	IRS	I	RA	Far
H49	*Taoyuan Holiday Hotel	0.713	0.738	0.966	1.223	DRS	I	MA	Close
H50	Hotel Nanhwa	1.000	1.000	1.000	1.000	CRS	I	MA	Far
H51	*Hotel Tainan	1.000	1.000	1.000	1.000	CRS	I	MA	Far
H52	*Ta Shee Resort Hotel	0.737	0.799	0.923	1.522	DRS	C	MA	Close
H53	Hotel Royal Hsinchu	0.789	0.854	0.924	1.569	DRS	C	MA	Far
H54	Ambassador Hsinchu	0.914	0.977	0.935	1.496	DRS	C	MA	Far
H55	Formosan Naruwan Hotel	0.512	0.515	0.994	1.093	DRS	I	MA	Far
H56	Tayih Landis	0.646	0.649	0.995	1.245	DRS	C	MA	Far
	Mean	0.848	0.876	0.969					

Note: 1. An ITH with * was operated during 1997-2002.
2. TE = PTE × SE.
3. RTS: IRS denotes increasing returns to scale; CRS denotes constant returns to scale; DRS denotes decreasing returns to scale.
4. Management style (MS): C: international chain including franchise, management contract, and membership.
5. I: independently owned and operated.
6. Location: RA: resort area; MA: metropolitan area.
7. CKS: Closeness to Chiang Kai-Shek (CKS) International Airport (1 hour driving).

Table 5 Non-Parametric Statistical Analysis of Management Style, Location, and Closeness to CKS

Characteristics		Number of ITHs	Mean	Mann-Whitney Test (p-value)
Management Type	Independent-owned (Mean)	34	0.856	0.314
	International chain (Mean)	22	0.907	
Location	Metropolitan area (Mean)	45	0.862	0.110
	Resort area (Mean)	11	0.932	
Closeness to CKS	Far (Mean)	30	0.907	0.168
	Close (Mean)	26	0.849	

Note: * Statistically significant at 0.05 level.

In order to explain the result of the other two characteristics, some influential events are provided. Due to Taiwan's 921 earthquake in 1999 and the 911 terrorist act in 2001, the number of foreign tourists visiting Taiwan started decreasing, especially for resort areas. To help the ITHs located in resort areas, the government provided government subsidies and discount native tour packages to government employees in 2001. Government subsidies provided support to government employees for domestic tours of up to seven days with a ceiling of NT$16,000 annually. It is estimated that there are nearly 570,000 government employees including military personnel. Table 5 presents that ITHs located in resort areas operate slightly better on average than ones located in metropolitan areas. The result reveals that ITHs located in resort areas regained their advantage in 2002 since the government provided subsidies to government employees in 2001. The performances of ITHs near the CKS international airport were mainly influenced by the decreasing steam of foreign visitors after Taiwan's 921 earthquake in 1999 and the 911 terrorist act in 2001. The majority of the ITHs far from CKS international airport are less influenced by the decreasing number of foreign tourists. These rural ITHs benefited from the annual government subsidiary policy to civil service employees.

4.2 Potential Improvement in Efficiency

In order to find information indicating by how much and in what areas an inefficient ITH needs to improve, a non-zero slack analysis in Eq. (6) is used to find potential improvement for the inefficient ITHs. Such an analysis can identify marginal contributions in efficiency ratings with either an additional increase in specific output amounts or a decrease in specific input amounts. Table 6 reports the results of our potential improvement analysis.

By referring to Table 6, the 'Potential Improvement Percent' column shows, in percentage terms, the use of inputs or production of outputs that are needed by an inefficient

ITH to become an efficient one. For example (see Figure 9), the inefficient Grand Hotel Taipei (H01) can decrease its total operating expenses (x_1) by -23.5%, number of employees (x_2) by -33.9%, number of guest rooms (x_3) by -23.5%, total area of catering division (x_4) by -59%, while simultaneously increasing its average room rate (y_3) by 50.4% and average production value of catering division (y_5) by 112%. Thus, it can be as efficient as its peer group. This result means that Grand Hotel Taipei (H01) is seriously over-utilizing the number of employees (x_2) and total area of catering division (x_4) and should enhance the management ability of the room departments and catering divisions.

The overall potential improvement also indicates that the thirty inefficient ITHs have the major potential in decreasing their number of employees (x_2), number of guest rooms (x_3), total area of catering division (x_4) and in increasing average production value of catering division (see Figure 10). Therefore, managers should expect to spend most of their efforts in these areas. In summary, from the above analysis one can find that inefficient ITHs occurs more frequently in independent-owned ones. On the contrary, the inefficient ITHs are rarely observed in international chain ones, which mean that those international chain ITHs are more able to integrate their resources (employees, assets, etc.) and to operate more efficiently.

Table 6 Potential Improvements Percent for the Thirty Inefficient ITHs

Unit name	PTE	Improvement Percent								
		x_1	x_2	x_3	x_4	y_1	y_2	y_3	y_4	y_5
Grand Hotel Taipei (H01)	0.765	-23.50	-33.90	-23.50	-59.00	0.00	0.00	50.40	0.00	112.00
Mandarina Crown Hotel (H03)	0.884	-11.60	-18.90	-11.60	-45.70	0.00	0.00	1.10	0.00	0.00
Imperial Hotel Taipei (H04)	0.682	-31.80	-31.80	-31.80	-42.10	0.00	0.00	0.00	15.60	93.00
Gloria Prince Hotel (H05)	0.941	-5.90	-12.20	-5.90	-5.90	0.00	0.00	25.20	0.00	0.00
Caesar Park Hotel (H08)	0.858	-14.20	-35.60	-22.90	-26.80	0.00	0.00	0.00	29.80	0.00
Santos Hotel (H11)	0.862	-13.80	-23.80	-30.50	-13.80	0.00	0.00	0.00	50.10	62.30
Sheraton Taipei Hotel (H14)	0.665	-33.50	-64.90	-58.30	-57.70	0.00	0.00	43.90	74.50	42.70
Fortuna Hotel (H15)	0.839	-16.10	-41.30	-43.70	-33.10	0.00	0.00	8.30	0.00	6.90
Holiday Inn Asiaworld Taipei (H16)	0.720	-28.00	-38.50	-65.60	-28.00	0.00	15.70	20.60	30.70	6.40
Rebar Crowne Plaza Hotel (H19)	0.834	-22.60	-18.10	-16.60	-16.60	0.00	0.00	44.20	16.10	0.00
Hotel Kingdom (H25)	0.686	-31.40	-59.40	-54.80	-65.90	0.00	0.00	45.40	17.40	0.00
Holiday Garden Kaohsiung (H26)	0.759	-24.10	-34.80	-51.80	-24.10	0.00	0.00	31.90	0.00	9.60
Ambassador Hotel Kaohsiung (H27)	0.654	-34.60	-39.30	-45.90	-41.40	0.00	0.10	0.00	0.00	0.00
Linden Hotel Kaohsiung (H28)	0.734	-26.60	-38.30	-26.60	-33.40	0.00	0.00	9.50	10.70	0.00
Grand Hi-Lai Hotel (H29)	0.649	-35.10	-48.70	-35.10	-65.40	0.00	0.00	91.80	2.90	50.60
Howard Plaza Hotel Kaohsiung (H30)	0.923	-23.00	-7.70	-7.70	-57.80	0.00	0.00	35.50	6.00	116.10
Splendor Kaohsiung (H31)	0.550	-45.00	-46.30	-56.00	-71.10	0.00	0.00	5.00	22.60	68.20
Hotel National (H33)	0.681	-31.90	-40.20	-53.80	-54.10	0.00	0.00	1.80	0.00	3.60
Plaza International Hotel (H34)	0.729	-27.10	-34.00	-27.30	-32.70	0.00	0.00	6.60	0.00	0.00
Evergreen Laurel Hotel Taichung (H35)	0.878	-17.40	-12.20	-19.20	-62.20	0.00	0.00	6.90	43.00	120.00

Table 6 Continued

Unit name	PTE	Improvement Percent								
		x_1	x_2	x_3	x_4	y_1	y_2	y_3	y_4	y_5
Splendor Taichung (H37)	0.981	-19.20	-13.50	-1.90	-28.20	0.00	0.00	34.90	19.60	74.40
Marshal Hotel (H39)	0.768	-23.20	-35.80	-37.70	-41.40	0.00	0.00	48.50	0.00	0.00
Parkview Hotel (H41)	0.808	-19.20	-19.30	-27.20	-19.20	0.00	0.00	0.00	0.00	12.70
The Hibiscus Resort (H48)	0.672	-32.90	-36.10	-32.90	-32.90	0.00	15.00	13.70	0.00	26.50
Taoyuan Holiday Hotel (H49)	0.738	-26.20	-36.10	-60.50	-33.70	0.00	0.00	3.70	0.00	17.70
Ta Shee Resort Hotel (H52)	0.799	-20.10	-20.90	-20.10	-35.70	0.00	0.00	61.80	0.00	26.30
Hotel Royal Hsinchu (H53)	0.854	-14.60	-14.60	-14.60	-40.10	0.00	0.00	4.60	0.00	69.00
Ambassador Hsinchu (H54)	0.977	-22.20	-2.30	-2.30	-7.70	0.00	0.00	0.00	0.00	0.00
Formosan Naruwan Hotel (H55)	0.515	-48.50	-49.60	-48.50	-48.50	0.00	0.00	8.10	0.00	32.90
Tayih Landis (H56)	0.649	-35.10	-40.30	-35.10	-60.30	0.00	0.00	35.60	0.00	42.10

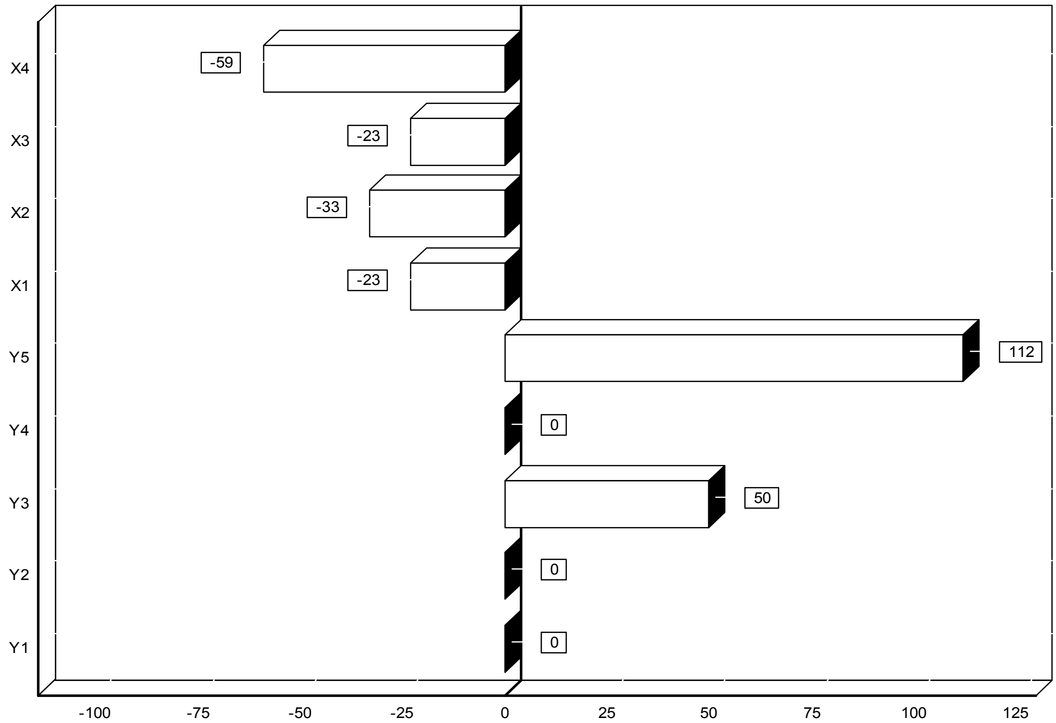

Figure 9 Potential Improvements for Grand Hotel Taipei

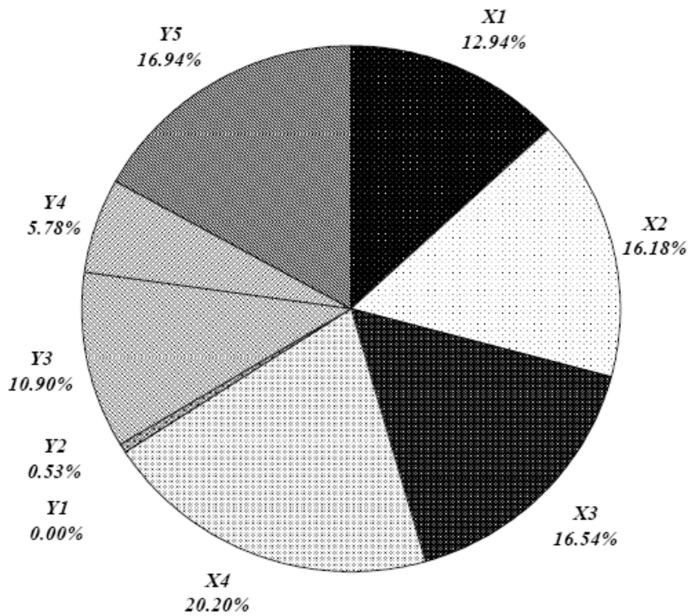

Figure 10 Summaries of Overall Potential Improvements for Thirty Inefficient ITHs.

4.3 Measuring Input Congestion

Input congestion, a concept from the areas of transportation and agriculture, refers to the situation that, when holding the usage of other inputs constant, reductions in the usage of a proper subset of inputs may generate an increase in one or more outputs. In this section we use a slack-based approach following Cooper et al. (2001) to capture input congestion and identify its sources and amounts. The congestion of total operating expenses, number of employees, number of guest rooms, and total area of catering division are measured.

Table 7 reports the non-zero input slacks for thirty inefficient ITHs. In Mandarina Crown Hotel (H03), Gloria Prince Hotel (H05), Grand Hi-Lai Hotel (H29), Splendor Taichung (H37), and Ambassador Hsinchu (H54), the amounts of operating expenses (x_1)'s congestion are 5.21%, 15.28%, 5.94%, 17.36% and 19.58%, respectively, of the current total operating expenses (x_1) input levels. Formosan Naruwan Hotel (H55), Taoyuan Holiday Hotel (H49), Caesar Park Hotel (H08), Santos Hotel (H11), and Hotel Kingdom (H25) have an input congestion of employees in top five ranking. The amounts of employees (x_2)' congestion are 31.38%, 28.02%, 25.23%, 21.43% and 13.64%, respectively, of the current employees' input levels. Holiday Garden Kaohsiung (H26), Tayih Landis (H56), Ta Shee Resort Hotel (H52), Caesar Park Hotel Taipe (H08), and Formosan Naruwan Hotel (H55) have an input congestion of guest rooms in top five ranking. The amounts of guest rooms (x_3)' congestion are 37.64%, 34.32%, 27.68%, 27.60% and 24.78%, respectively, of the current guest rooms' input levels. Gloria Prince Hotel (H05), Mandarina Crown Hotel (H03), Parkview Hotel (H41), Taoyuan Holiday Hotel (H49), and Howard Plaza Hotel Kaohsiung (H30) have an input congestion of area of catering division in top five ranking. The area of catering division (x_4)' congestion are 50.07%, 50.05%, 35.53%, 34.52% and

34.11%, respectively, of the current area of catering division' input levels. Compared to the congestion of operating expenses (x_1), employees (x_2), the number of guest rooms (x_3), and area of catering division (x_4), the congestion of area of catering division (x_4) is relatively serious over input for inefficient ITHs.

Table 8 presents a summary of inputs' congestion after radial technical inefficiency is removed. Holding the level of ITHs' operations constant, on average, five ITHs could reduce their use of total operating expense by NT$76,988,616; 24 ITHs could reduce the number of employees by 45 persons; 14 ITHs could reduce the number of guest rooms by 86 rooms; and 22 ITHs could reduce the total area of the catering division by 392 (36 square feet). Their excessive use of inputs accounts for about 13.61% to 25.84% of total inputs. Almost 40% of ITHs underutilize the employees and the total area of the catering division. The input congestion slacks, the total area of the catering division and number of guest rooms, are larger (20.9% and 25.84%) than other input factors. The result denotes that inefficient ITHs lack the ability to integrate their resources, especially in the total area of the catering division and the number of guest rooms.

We therefore suggest that ITHs' managers may take some actions to improve the performance of the room departments and catering divisions, such as the quality of room service, booking through the internet, internet service in guest rooms, various themed restaurants, and special smart deals. To help the Taiwanese hotel industry, the government can play an important role by organizing more international conferences and business exhibitions in Taiwan as well as providing better tourism environments and various tour packages. In doing so, it may attract more foreign guests to visit Taiwan and hence increase the occupancy rate of ITHs and the production value of catering divisions.

Table 7 Input Congestion for Thirty Inefficient ITHs

Code	DMU Name	Input Congestion Slacks							
		x_1		x_2		x_3		x_4	
H01	Grand Hotel Taipei	0	0.00%	11	6.86%	0	0.20%	44	5.59%
H03	Mandarina Crown Hotel	**27,006,060**	**5.21%**	0	0.00%	25	7.08%	**884**	**50.05%**
H04	Imperial Hotel Taipei	0	0.00%	19	5.18%	0	0.00%	443	25.18%
H05	Gloria Prince Hotel	**66,377,872**	**15.28%**	0	0.00%	0	0.00%	**890**	**50.07%**
H08	Caesar Park Hotel	0	0.00%	**57**	**25.23%**	**84**	**27.60%**	129	16.98%
H11	Santos Hotel	0	0.00%	**112**	**21.43%**	34	8.75%	173	12.64%
H14	Sheraton Taipei Hotel	0	0.00%	13	6.27%	0	0.00%	0	0.00%
H15	Fortuna Hotel	0	0.00%	2	0.82%	0	0.00%	124	15.61%
H16	Holiday Inn Asiaworld Taipei	0	0.00%	16	4.68%	51	11.25%	77	6.78%
H19	Rebar Crowne Plaza Hotel	0	0.00%	24	12.58%	42	14.53%	112	18.17%
H25	Hotel Kingdom	0	0.00%	**101**	**13.64%**	0	0.00%	914	30.38%
H26	Holiday Garden Kaohsiung	0	0.00%	50	10.56%	**284**	**37.64%**	0	0.00%
H27	Ambassador Hotel Kaohsiung	0	0.00%	0	0.00%	0	0.00%	283	25.50%
H28	Linden Hotel Kaohsiung	0	0.00%	0	0.00%	0	0.00%	119	10.34%
H29	Grand Hi-Lai Hotel	**26,000,374**	**5.94%**	5	1.49%	0	0.00%	0	0.00%
H30	Howard Plaza Hotel Kaohsiung	0	0.00%	34	7.29%	0	0.00%	**486**	**34.11%**
H31	Splendor Kaohsiung	0	0.00%	21	8.25%	89	21.92%	311	22.19%
H33	Hotel National	0	0.00%	7	1.28%	65	11.02%	852	26.07%
H34	Plaza International Hotel	0	0.00%	4	3.27%	0	0.00%	0	0.00%
H35	Evergreen Laurel Hotel Taichung	0	0.00%	23	10.01%	51	16.68%	0	0.00%
H37	Splendor Taichung	**139,718,333**	**17.36%**	48	11.66%	0	0.00%	426	26.35%
H39	Marshal Hotel	0	0.00%	38	11.67%	0	0.00%	63	6.80%
H41	Parkview Hotel	0	0.00%	80	10.43%	0	0.00%	**1,324**	**35.53%**
H48	The Hibiscus Resort	0	0.00%	3	1.09%	0	0.00%	0	0.00%
H49	Taouan Holiday Hotel	0	0.00%	**76**	**28.02%**	71	23.38%	**285**	**34.52%**
H52	Ta Shee Resort Hotel	0	0.00%	15	10.68%	**76**	**27.68%**	0	0.00%
H53	Hotel Royal Hsinchu	0	0.00%	0	0.06%	27	8.00%	0	0.00%
H54	Ambassador Hsinchu	**125,840,439**	**19.85%**	0	0.00%	0	0.00%	54	5.41%
H55	Formosan Naruwan Hotel	0	0.00%	**307**	**31.38%**	**170**	**24.78%**	561	24.16%
H56	Tayih Landis	0	0.00%	14	9.88%	**134**	**34.32%**	60	7.56%

Table 8 Descriptive and Summary Statistics for Inputs Congestion

	Number of ITHs with slack	Mean	Total slack as percent of total inputs
Input factors			
Total operating expenses(x_1)	5	76,988,616	13.61
Number of employees (x_2)	24	45	12.39
Number of guest rooms (x_3)	14	86	20.59
Total area of catering division (x_4)	22	392	25.84

4.4 Identification of Benchmark

For an efficient decision making unit (DMU/ITH in our case), the role it plays to be benchmarked by other inefficient DMUs is also important. One may want to know the importance of each efficient DMU by measuring the extent of inefficiencies of other inefficient DMUs. The first way to accomplish such a task is to count the number of times a particular efficient *DMU* acts as a referent *DMU* (Smith and Mayston, 1987). The second way is to compare the *DMU* under evaluation with all other *DMUs* in the sample, i.e., the *DMU* itself is excluded (Andersen and Petersen, 1993). The third method to increase discrimination among efficient DMUs is by using cross-evaluation (Doyle and Green, 1994). The fourth way presents the infeasibility of super-efficiency DEA models (Seiford and Zhu, 1999) in which the unit under evaluation is excluded from the reference set. The fifth way is a multiple criteria approach called Multiple Criteria DEA (Li and Reeves, 1999), which focuses on solving two key problems: lack of discrimination and inappropriate weighting schemes. The sixth way is the super-efficiency model using the slacks-based measure of efficiency (Tone, 2002). The seventh way is Context-dependent DEA (Zhu, 2003; Yang et al, 2006) which refers to a DEA approach where a set of DMUs are evaluated against a particular evaluation context. Each evaluation context represents an efficient frontier composed by DMUs in a specific performance level. To summarize the above previous studies, the contribution which an efficient DMU makes to the potential input (output) improvement in inefficient DMUs cannot be measured.

In the current study the benchmark-share measure (Zhu, 2000; Yang and Lu, 2006) defines a ranking measure by using the factor-specific measure and the BCC model. We can now identify the inputs/outputs that are most important or distinguish those ITHs which can be treated as benchmarks. This section gives the ranking list of the performance model for all those efficient ITHs. In Table 9 the benchmark-share measures are reported for the performance model, with the ranking in parenthesis and ordered by the average ranking of the efficient ITHs. There are 26 pure technical efficient ITHs in the performance model. Of the total 234 benchmark-share measures, 32 benchmark-share measures are greater than 10%.

Grand Formosa Regent Taipei (H21), which is a particular technically efficient ITH, has the biggest benchmark-share in total operating expenditure (x_1) and total operating revenues (y_1). Grand Formosa Regent Taipei (H21) is therefore an important benchmark as the above factors are concerned, while for other input/output factors Grand Formosa Regent Taipei (H21) is still efficient, but not in the leading place. As for the number of employees (x_2) and average production value per employee in the catering division (y_4) are concerned, Grand Formosa Taroko (H46) plays a leading role in terms of the number of employees (x_2) and average production value per employee in the catering division (y_4), given the current levels of other inputs/outputs. Hotel Landis China Yangmingshan (H42) has a leading role in terms of number of guest rooms (x_3) and average room rate (y_3), given the current levels of other inputs/outputs. Sherwood Hotel Taipei (H22) leads in terms of the total area of the catering division (x_4) given the current levels of other inputs/outputs. Royal Hotel Taipei (H17) plays a leading role in terms of average occupancy rate (y_2) given the current levels of other inputs/outputs. China Trust Hotel Hualien (H40) has a leading role in terms of average production value of the catering division (y_5) given the current levels of other inputs/outputs.

Those ITHs which have a benchmark-share measure of zero are self-evaluators in Table 9. Even if these ITHs are efficient, they are revealed as being too different in the input/output space to be either a reference to other units or to be referenced. In summary, efficient international chain ITHs (H17, H21, H22, H42, and H46) are frequently referenced and efficient independent-owned ITHs can hardly become benchmarks. This result is quite reasonable since international chain ITHs have a better reputation, a brand image, internet marketing, an efficient reservation system, and economies of scale. The findings show that the international chain ITHs are more competitive and they should provide examples of operating practice.

Although the benchmark-share measures give a different ranking list in terms of input/output factors measured, the result of this analysis is robust. The ranking lists are all very similar, with ranking correlation coefficients ranging from 0.60 to 0.83 at the 5% level of significance. Therefore, the ranking list shows a clear and stable indication of the ITHs that may be pointed out as benchmarks to be referred by others.

Table 9. Benchmark-Share Measure for Efficient ITHs.

ITH	Input Factors				Output Factors					Average Rank
	x_1	x_2	x_3	x_4	y_1	y_2	y_3	y_4	y_5	
H17	5.08% (6)	1.53% (8)	15.35% (4)	4.55% (6)	2.69% (8)	**36.49%** (1)	7.72% (6)	3.41% (7)	3.06% (6)	5.8 (1)
H21	**21.56% (1)**	19.40% (2)	4.04% (5)	0.12% (12)	**34.17%** (1)	10.98% (4)	1.67% (8)	2.27% (9)	0.47% (11)	5.9 (2)
H40	3.01% (9)	19.07% (3)	0.26% (13)	4.81% (5)	3.82% (7)	9.00% (5)	0.38% (12)	17.58% (2)	**32.38%** (1)	6.3 (3)
H42	5.21% (5)	0.85% (10)	**28.95%** (1)	0.66% (11)	4.23% (6)	0.68% (11)	**35.40%** (1)	0.50% (12)	1.78% (7)	7.1 (4)
H46	2.12% (12)	**34.99%** (1)	3.43% (6)	4.24% (7)	2.28% (9)	0.29% (12)	8.16% (5)	**48.94%** (1)	0.34% (13)	7.3 (5)
H23	0.59% (14)	0.73% (11)	1.41% (10)	1.71% (9)	1.25% (11)	1.74% (8)	11.13% (3)	5.23% (5)	6.56% (5)	8.4 (6)
H45	2.19% (10)	0.58% (13)	1.24% (11)	17.54% (2)	1.04% (13)	0.75% (10)	15.58% (2)	0.08% (15)	11.37% (3)	8.8 (7)
H24	1.84% (13)	0.63% (12)	23.04% (2)	0.87% (10)	4.87% (5)	0.17% (15)	6.27% (7)	0.91% (11)	1.16% (9)	9.3 (8)
H22	2.19% (11)	0.28% (15)	0.00% (20.5)	**40.45%** (1)	2.00% (10)	2.40% (7)	10.24% (4)	0.19% (14)	28.60% (2)	9.4 (9)
H06	18.63% (2)	1.06% (9)	2.22% (7)	8.87% (4)	13.34% (3)	1.36% (9)	0.00% (20.5)	0.00% (21)	0.00% (20.5)	10.7 (10)
H07	15.39% (3)	0.07% (18)	0.78% (12)	0.00% (19.5)	9.81% (4)	14.89% (2)	1.10% (10)	0.00% (21)	0.00% (20.5)	12.2 (11)
H32	13.59% (4)	0.00% (23)	0.12% (14)	0.00% (19.5)	17.52% (2)	0.00% (21.5)	0.07% (14)	5.90% (4)	0.00% (20.5)	13.6 (12)
H47	0.00% (21.5)	2.42% (6)	0.00% (20.5)	0.00% (19.5)	0.11% (17)	6.68% (6)	1.39% (9)	6.91% (3)	0.00% (20.5)	13.7 (13)
H43	0.00% (21.5)	0.01% (19)	15.93% (3)	0.00% (19.5)	0.41% (15)	0.20% (14)	0.00% (20.5)	2.33% (8)	0.91% (10)	14.5 (14)
H51	0.38% (16)	0.43% (14)	1.67% (8)	0.00% (19.5)	0.81% (14)	0.00% (21.5)	0.00% (20.5)	0.32% (13)	1.69% (8)	14.9 (15)
H09	3.89% (7)	0.07% (17)	0.00% (20.5)	0.00% (19.5)	0.41% (16)	13.99% (3)	0.79% (11)	0.00% (21)	0.00% (20.5)	15.1 (16)
H44	0.00% (21.5)	4.05% (5)	0.00% (20.5)	14.31% (3)	0.00% (22.5)	0.25% (13)	0.10% (13)	0.00% (21)	0.00% (20.5)	15.6 (17)
H20	0.00% (21.5)	0.00% (23)	0.00% (20.5)	1.86% (8)	0.00% (22.5)	0.00% (21.5)	0.00% (20.5)	4.07% (6)	0.27% (14)	17.5 (18)
H13	3.78% (8)	0.00% (23)	0.00% (20.5)	0.00% (19.5)	1.23% (12)	0.00% (21.5)	0.00% (20.5)	0.00% (21)	0.34% (12)	17.6 (19)
H36	0.00% (21.5)	0.08% (16)	1.56% (9)	0.00% (19.5)	0.03% (18)	0.11% (16)	0.00% (20.5)	0.00% (21)	0.00% (20.5)	18.0 (20)
H12	0.00% (21.5)	0.00% (23)	0.00% (20.5)	0.00% (19.5)	0.00% (22.5)	0.00% (21.5)	0.00% (20.5)	1.35% (10)	11.07% (4)	18.1 (21)
H38	0.00% (21.5)	11.46% (4)	0.00% (20.5)	0.00% (19.5)	0.00% (22.5)	0.00% (21.5)	0.00% (20.5)	0.00% (21)	0.00% (20.5)	19.1 (22)
H50	0.00% (21.5)	2.29% (7)	0.00% (20.5)	0.00% (19.5)	0.00% (22.5)	0.00% (21.5)	0.00% (20.5)	0.00% (21)	0.00% (20.5)	19.4 (23)
H02	0.54% (15)	0.00% (23)	0.00% (20.5)	0.00% (19.5)	0.00% (22.5)	0.00% (21.5)	0.00% (20.5)	0.00% (21)	0.00% (20.5)	20.4 (24)
H10	0.00% (21.5)	0.00% (23)	0.00% (20.5)	0.00% (19.5)	0.00% (22.5)	0.00% (21.5)	0.00% (20.5)	0.00% (21)	0.00% (20.5)	21.2 (25)
H18	0.00% (21.5)	0.00% (23)	0.00% (20.5)	0.00% (19.5)	0.00% (22.5)	0.00% (21.5)	0.00% (20.5)	0.00% (21)	0.00% (20.5)	21.2 (26)
SUM	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	

Notes: Ranks are given in parenthesis, and ties are assigned mid-rank.

4.5 Analysis of Occupancy and Catering Performances

To have a closer view of the performance of the sampled ITHs, we further assessed the performances of room and catering departments across the 56 ITHs. Results of the occupancy and catering efficiencies of the sampled ITHs are reported in Table 10. The mean catering efficiency score is 0.820 and the mean occupancy efficiency score is 0.747 and, indicating the fact that these ITHs were not operated at the respective levels of occupancy and catering efficiencies in Taiwan. 12 out of the 56 ITHs identified in Table 10 were found to be efficient with a catering efficiency score of one. High variation in the catering efficiency ratings indicates that these inefficient 44 ITHs are unstable under their operations. Table 10 also shows that 14 out of the 56 ITHs achieved occupancy efficiency. High variation in the occupancy efficiency ratings indicates that these inefficient 42 ITHs are unstable under operation.

We also find that the operating efficiency of the catering departments is better than the operating efficiency of the room server departments. This finding is consistent with the finding by Tsaur (2000). Therefore, we suggests that managers take some actions to improve the operational efficiency of the room service departments, such as the quality of room service, booking through internet, internet service in guest rooms, special smart deals packages. To help the Taiwan's hotel industry, the government can play an important role by organizing more international conferences and business exhibitions in Taiwan as well as providing better tourism environments and various tour packages. In doing so, it may attract more foreign guests to visit Taiwan and, hence, increase the occupancy rate of hotels.

The catering and occupancy efficiencies give a two-dimensional view of the performance of each ITH. A good ITH should perform well both at the levels of catering and occupancy efficiencies. Looking at all hotels the correlation coefficient between catering efficiency and occupancy efficiency is 0.477 which is significant at the 0.05%. Thus, there is a medium tendency for an ITH with relative high catering performance to go with good occupancy performance. ITHs have been split subjectively in four groups plotted respectively in areas I, II, III and IV in Figure 11. The performance of the ITHs in each group can be summarized as follows.

The zone of I: These ITHs enjoy high efficiency in both catering and occupancy efficiency dimensions. Ten ITHs are included here: Emperor Hotel (H06), Grand Hyatt Taipei (H20), Grand Formosa Regent Taipei (H21), Sherwood Hotel Taipei (H22), Far Eastern Plaza Hotel (H23), Park Hotel (H32), Astar Hotel Hualine (H38), China Trust Hotel Hualien (H40), Caesar Park Hotel Kenting (H44), and Royal Chihpen Resort Hotel (H45). These ITHs appear to be good role model, which can be treated as benchmarks to others.

The zone of II: Those ITHs experience a higher level of catering efficiency, but a lower occupancy efficiency. Eights ITHs are included: Ambassodor Hotel (H02), Mandarina Crown Hotel (H03), Brother Hotel (H10), Ritz Taipei Hotel (H12), Taipei Fortuna Hotel (H15), Howard Plaza Hotel Taipei (H18), Grand Formosa Taroko (H46), and Hotel Royal Hsinchu (H53). It is possible to suggest that ITHs in area II, especially those with very low occupancy efficiencies, could be achieving good average occupancy rate by adopting appropriate marketing strategy; providing special offers (e.g. net direct rates); and developing smart deals packages (e.g. free tour to National Palace Museum).

The zone of III: These ITHs have low catering efficiency and low occupancy efficiency. There are thirty ITHs in this category, Grand Hotel Taipei (H01), Imperial Hotel Taipei (H04), Gloria Prince Hotel (H05), Caesar Park Hotel (H08), Santos Hotel (H11), United Hotel (H13), Sheraton Taipei Hotel (H14), Holiday Inn Asiaworld Taipei (H16), Rebar Rebar Crowne Plaza Hotel (H19), Hotel Kingdom (H25), Holiday Garden Kaohsiung (H26), Ambassador Hotel Kaohsiung (H27), Linden Hotel Kaohsiung (H28), Grand Hi-Lai Hotel (H29), Howard Plaza Hotel Kaohsiung (H30), Splendor Kaohsiung (H31), Hotel National (H33), Plaza International Hotel (H34), Evergreen Laurel Hotel Taichung (H35), Splendor Taichung (H37), Marshal Hotel (H39), Parkview Hotel (H41), The Hibiscus Resort (H48), Taoyuan Holiday Hotel (H49), Hotel Nanhwa (H50), Hotel Tainan (H51), Ta Shee Resort Hotel (H52), Ambassador Hsinchu (H54), Formosan Naruwan Hotel (H55), and Tayih Landis (H56). They need to improve efficiency in at least one and preferably both dimensions.

The zone of IV: These ITHs which have high occupancy efficiency, but low catering efficiency. We have eights ITHs in this area, Riverview Hotel (H07), Gold China Hotel (H09), Royal Hotel Taipei (H17), The Westin Taipei (H24), Howard Prince Hotel Taichung (H36), Hotel Landis China Yangmingshan (H42), Grand Hotel Kaohsiung (H43), and Howard Beach Resort Kenting (H47). These ITHs need to improve catering performance. It is possible to suggest that ITHs (H07, H09, H17, H24, and H36) located in metropolitan areas adopt appropriate pricing strategy for delivering better catering services to attract more guests, provide various choices of food, special food delivery service to customers who want to hold a festival party outside the hotel, and offers discount on special occasions. As for Hotel Landis China Yangmingshan (H42), Grand Hotel Kaohsiung (H43), and Howard Beach Resort Kenting (H47) located in the resort areas, possible suggestions for the general managers of these ITHs could be efficiently using the area of catering department and adopting appropriate pricing strategy. In addition, general managers could reduce the current size of catering operations from pessimistic perspective.

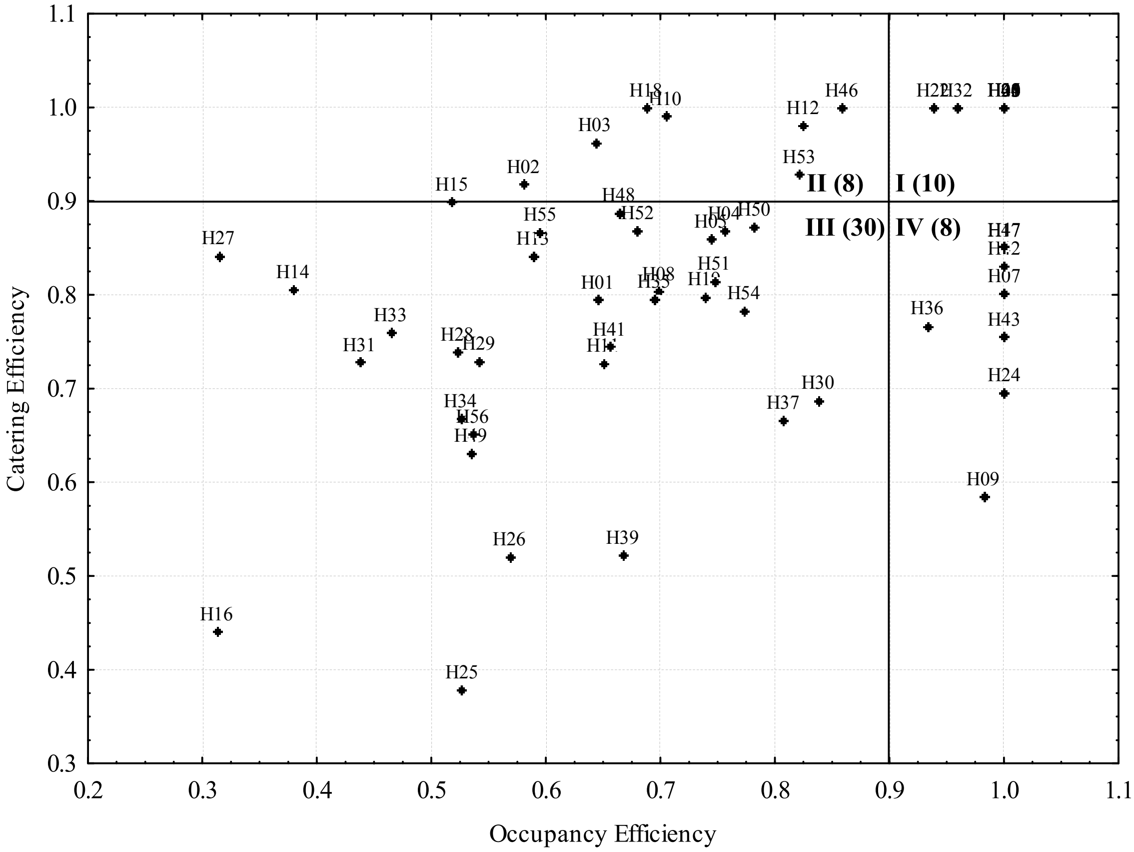

Figure 11 Assessing Separately Occupancy and Catering Efficiencies

Table 10 Catering Efficiency and Occupancy Efficiency for 56 ITHs

ITHs Name	Code	Catering	Occupancy	Style	Position	CKS
Grand Hotel Taipei	H01	0.795	0.645	I	MA	Close
Ambassodor Hotel	H02	0.918	0.580	C	MA	Close
Mandarina Crown Hotel	H03	0.963	0.642	I	MA	Close
Imperial Hotel Taipei	H04	0.869	0.756	I	MA	Close
Gloria Prince Hotel	H05	0.860	0.744	C	MA	Close
Emperor Hotel	H06	1.000	1.000	I	MA	Close
Riverview Hotel	H07	0.802	1.000	I	MA	Close
Caesar Park Hotel	H08	0.804	0.698	C	MA	Close
Gold China Hotel	H09	0.586	0.982	I	MA	Close
Brother Hotel	H10	0.991	0.704	I	MA	Close
Santos Hotel	H11	0.728	0.650	I	MA	Close
Landis Ritz Hotel	H12	0.981	0.824	C	MA	Close
United Hotel	H13	0.842	0.589	I	MA	Close
Sheraton Taipei Hotel	H14	0.806	0.379	C	MA	Close
Fortuna Hotel	H15	0.900	0.518	I	MA	Close
Holiday Inn Asiaworld Taipei	H16	0.441	0.312	C	MA	Close
Royal Hotel Taipei	H17	0.850	1.000	C	MA	Close
Howard Plaza Hotel Taipei	H18	1.000	0.687	I	MA	Close
Rebar Crowne Plaza Hotel	H19	0.799	0.738	C	MA	Close
Grand Hyatt Taipei	H20	1.000	1.000	C	MA	Close
Grand Formosa Regent Taipei	H21	1.000	1.000	C	MA	Close
Sherwood Hotel Taipei	H22	1.000	0.938	C	MA	Close
Far Eastern Plaza Hotel	H23	1.000	1.000	C	MA	Close
The Westin Taipei	H24	0.697	1.000	C	MA	Close
Hotel Kingdom	H25	0.379	0.526	I	MA	Far
Holiday Garden Kaohsiung	H26	0.521	0.568	I	MA	Far
Ambassador Hotel Kaohsiung	H27	0.843	0.314	C	MA	Far
Linden Hotel Kaohsiung	H28	0.740	0.522	I	MA	Far
Grand Hi-Lai Hotel	H29	0.730	0.541	I	MA	Far
Howard Plaza Hotel Kaohsiung	H30	0.688	0.837	I	MA	Far
Splendor Kaohsiung	H31	0.728	0.437	I	MA	Far
Park Hotel	H32	1.000	0.958	I	MA	Far
Hotel National	H33	0.760	0.464	I	MA	Far
Plaza International Hotel	H34	0.669	0.525	I	MA	Far

Table 10 Continued

ITHs Name	Code	Catering	Occupancy	Style	Position	CKS
Evergreen Laurel Hotel Taichung	H35	0.796	0.694	I	MA	Far
Howard Prince Hotel Taichung	H36	0.767	0.933	I	MA	Far
Splendor Taichung	H37	0.667	0.807	I	MA	Far
Astar Hotel Hualine	H38	1.000	1.000	I	RA	Far
Marshal Hotel	H39	0.523	0.667	I	RA	Far
China Trust Hotel Hualien	H40	1.000	1.000	I	RA	Far
Parkview Hotel	H41	0.745	0.655	I	RA	Far
Hotel Landis China Yangmingshan	H42	0.831	1.000	C	RA	Far
Grand Hotel Kaohsiung	H43	0.756	1.000	I	RA	Far
Caesar Park Hotel Kenting	H44	1.000	1.000	C	RA	Far
Royal Chihpen Resort Hotel	H45	1.000	1.000	C	RA	Far
Grand Formosa Taroko	H46	1.000	0.858	C	RA	Far
Howard Beach Resort Kenting	H47	0.851	1.000	I	RA	Far
The Hibiscus Resort	H48	0.889	0.663	I	RA	Far
Taouan Holiday Hotel	H49	0.631	0.534	I	MA	Close
Hotel Nanhwa	H50	0.873	0.782	I	MA	Far
Hotel Tainan	H51	0.815	0.747	I	MA	Far
Ta Shee Resort Hotel	H52	0.869	0.680	C	MA	Close
Hotel Royal Hsinchu	H53	0.929	0.821	C	MA	Far
Ambassador Hsinchu	H54	0.784	0.773	C	MA	Far
Formosan Naruwan Hotel	H55	0.868	0.595	I	MA	Far
Tayih Landis	H56	0.652	0.536	C	MA	Far
Mean		0.820	0.747			

Note:
Catering = Catering Efficiency.
Occupancy: Occupancy Efficiency.
Management style (MS): C: international chain including franchise, management contract, and membership;
I: independently owned and operated.
Location: RA: resort area; MA: metropolitan area.
CKS: Closeness to Chiang Kai-Shek (CKS) International Airport (1 hour driving).

4.6 Window Analysis

In order to observe the managerial performance trends of an ITH over the six-year period, a DEA window analysis based on the principle of moving averages is performed. In essence, each moving average is covered by a sliding window. An ITH performance in a particular period is contrasted with its own performance in other periods as well as to the performance of other ITHs. Charnes, et al. (1985) illustrated the best procedure of window analysis in their work. The data used in this study are obtained for 46 ($n = 46$) ITHs/DMUs over six ($p = 6$) yearly periods. To perform the analysis using a three-year ($w = 3$) window, we proceed as follows.

Each ITH is represented as if it is a different ITH for each of the three successive years in the first window (1997, 1998, and 1999), and an analysis of the 138 ($= nw = 3 \times 46$) ITHs is performed by using slack-based measure (SBM) model to obtain sharper and more realistic efficiency estimates. The window is then shifted one period, and an analysis is performed on the second three-year set (1998, 1999, and 2000) of the 138 ITHs. The process continues in this manner, shifting the window forward one period each time and concluding with a final (fourth) analysis of 138 ITHs for the last three years (2000, 2001, and 2002). In general, one performs $p - w + 1$ separate analyses, where each analysis examines nw ITHs.

This section reports the results obtained using the methods outlined in Section 3.3.8. First, the composition of the efficient frontier, the RTS, and the number of references to this ITH as a peer in each window are given in section 4.6.1, and this is followed by the managerial efficiency of ITHs in Section 4.6.2. This part analyzes trends and potential stability of managerial efficiency over the six-year period. Section 4.6.3 sheds light on the characteristics contributing to managerial efficiency, and Tobit regression analysis is used to determine which characteristics may influence the variations of managerial efficiency across ITHs.

4.6.1 Efficient Frontier, Returns to Scale, and Benchmark

The efficient frontier is the frontier (envelope) representing ‘best performance’ and is made up of the ITHs in every window which are most efficient in transforming their inputs into outputs. The composition of the efficient frontier for each window over the period 1997-2002 is shown in Table 11. The ITHs with unity efficiency are those at the frontier. An ITH not on the frontier line indicates that its efficiency is less than one.

Of the total 46 ITHs in the sample, 25 IHTs are efficient at least once in a sliding window during the time period 1997-2002. Twenty out of the 25 ITHs are below the 5th room-scale size (400<number of room<500). Emperor Hotel (H06) and Park Hotel (H32) are on the frontier for every window. Notice that Emperor Hotel (H06) and Park Hotel (H32) are on 8th room-scale size and 7th room-scale size, respectively. Twelve out of the 17 international chain ITHs are on the frontier at least once for the time period 1997-2002. This implies that aside from the scale of ITHs, management type is also an important factor affecting the performance of ITHs.

The distribution of RTS in Table 11 shows that 1% of the ITHs are operating at increasing returns to scale (IRS), 24% of ITHs are operating at constant returns to scale (CRS), and the remaining 75% of ITHs are at decreasing returns to scale (DRS). This result also reveals that ITHs are facing a highly competitive environment in Taiwan. Of particular interest here is to find out the best ITH which can serve as the benchmark of these efficient ITHs. A counting method counts the number of times an efficient ITH appears in the peer group of the inefficient ones. For instance, Park Hotel (H32) has a count of 21 in the last column of Table 11 (Refs). An efficient ITH with a high count may be considered to be a genuinely efficient ITH (Smith and Mayston, 1987; Charnes et al., 1985).

On the basis of market segmentation and geographical location variation (Ismail et al., 2002), the benchmarks of metropolitan ITHs and resort ITHs are examined separately. Table 11 shows that among the 37 metropolitan ITHs in Taiwan, the Sherwood Hotel Taipei (H22) is the efficient ITH that is referred to the most by others. Hotel Landis China Yangmingshan (H42) is the efficient ITH that is referred to the most by others among the 9 resort ITHs. In other words, the Sherwood Hotel Taipei (H22) and Hotel Landis China Yangmingshan (H42) are benchmarks for metropolitan ITHs and resort ITHs, respectively.

Table 11 Efficiencies of ITHs of the Three-Year Windows During 1997-2002

ITHs	Time						Row Average	Mean	Std. Dev.	Column Range	Total Range	RTS			Frontier Freq.	Refs.
	1997	1998	1999	2000	2001	2002						IRS	CRS	DRS		
H01	0.434	0.451	0.569				0.485	0.542	5.88%	0.036	0.171	0	2	10	0	
		0.460	0.590	0.581			0.544									
			0.605	0.590	0.535		0.577									
				0.605	0.539	0.543	0.562									
H02	0.879	0.934	1.000				0.938	0.951	4.45%	0.043	0.121	0	0	12	4	15
		0.952	1.000	0.957			0.970									
			1.000	0.984	0.925		0.970									
				1.000	0.896	0.889	0.928									
H03	0.272	0.497	0.498				0.423	0.605	18.87%	0.210	0.728	0	0	12	1	0
		0.519	0.521	0.567			0.536									
			0.527	0.586	1.000		0.704									
				0.591	0.790	0.889	0.757									
H04	0.157	0.411	0.510				0.359	0.518	12.75%	0.090	0.499	0	0	12	0	
		0.455	0.553	0.567			0.525									
			0.596	0.642	0.550		0.596									
				0.657	0.555	0.569	0.594									
H05	0.786	0.706	0.740				0.744	0.751	3.45%	0.051	0.136	0	3	9	0	
		0.757	0.737	0.697			0.730									
			0.781	0.748	0.745		0.758									
				0.742	0.740	0.833	0.772									
H06	1.000	1.000	1.000				1.000	1.000	0.00%	0.000	0.000	2	10	0	12	1
		1.000	1.000	1.000			1.000									
			1.000	1.000	1.000		1.000									
				1.000	1.000	1.000	1.000									
H07	0.518	0.437	0.566				0.507	0.666	18.12%	0.124	0.563	0	1	11	2	1
		0.498	0.586	0.598			0.560									
			0.624	0.654	1.000		0.760									
				0.630	0.876	1.000	0.835									
H08	0.335	0.715	0.707				0.586	0.710	11.74%	0.067	0.493	0	0	12	0	
		0.743	0.735	0.761			0.746									
			0.744	0.776	0.717		0.746									
				0.828	0.733	0.728	0.763									
H09	1.000	0.624	0.693				0.772	0.836	12.96%	0.116	0.376	0	1	11	4	11
		0.695	0.750	1.000			0.815									
			0.810	1.000	0.817		0.876									
				1.000	0.817	0.830	0.882									
H10	0.758	0.824	1.000				0.861	0.910	9.22%	0.026	0.242	0	1	11	6	9
		0.850	1.000	1.000			0.950									
			1.000	1.000	0.832		0.944									
				1.000	0.830	0.827	0.886									
H11	0.251	0.568	0.631				0.483	0.609	13.02%	0.103	0.484	0	1	11	0	
		0.646	0.690	0.687			0.674									
			0.733	0.732	0.551		0.672									
				0.735	0.543	0.540	0.606									
H12	0.779	0.773	0.860				0.804	0.894	7.88%	0.075	0.227	0	0	12	2	21
		0.791	0.872	0.989			0.884									
			0.935	1.000	0.914		0.949									
				1.000	0.921	0.899	0.940									
H13	0.430	0.409	0.618				0.486	0.723	21.63%	0.038	0.591	0	7	5	3	3
		0.447	0.627	1.000			0.691									
			0.631	1.000	0.858		0.830									
				1.000	0.860	0.791	0.884									

Table 11 Continued

ITHs	Time 1997	1998	1999	2000	2001	2002	Row Average	Mean	Std. Dev.	Column Range	Total Range	RTS IRS	CRS	DRS	Frontier Freq.	Refs.
H14	0.713	0.605	0.706				0.675	0.667	7.75%	0.025	0.307	0	1	11	0	
		0.625	0.681	0.665			0.657									
			0.681	0.665	0.773		0.706									
				0.653	0.771	0.466	0.630									
H15	0.458	0.377	0.433				0.423	0.498	5.96%	0.096	0.221	0	0	12	0	
		0.440	0.484	0.512			0.479									
			0.529	0.538	0.529		0.532									
				0.565	0.517	0.598	0.560									
H16	0.434	0.362	0.355				0.384	0.420	6.64%	0.015	0.187	0	7	5	0	
		0.371	0.363	0.393			0.376									
			0.369	0.402	0.542		0.438									
				0.408	0.541	0.499	0.483									
H17	1.000	0.805	0.872				0.892	0.929	7.57%	0.053	0.195	0	0	12	6	15
		0.820	0.863	1.000			0.894									
			0.917	1.000	1.000		0.972									
				1.000	1.000	0.869	0.956									
H18	1.000	0.979	1.000				0.993	0.968	5.28%	0.021	0.152	0	5	7	8	46
		1.000	1.000	1.000			1.000									
			1.000	1.000	0.893		0.964									
				1.000	0.896	0.848	0.915									
H19	1.000	0.855	0.834				0.896	0.888	9.01%	0.145	0.270	0	0	12	4	6
		1.000	0.848	0.890			0.913									
			0.907	1.000	0.795		0.901									
				1.000	0.799	0.730	0.843									
H20	1.000	1.000	1.000				1.000	0.984	3.09%	0.045	0.103	0	4	8	9	103
		1.000	0.955	1.000			0.985									
			0.956	1.000	1.000		0.985									
				1.000	1.000	0.897	0.966									
H21	1.000	1.000	1.000				1.000	0.878	21.16%	0.500	0.500	0	11	1	9	84
		0.536	0.500	1.000			0.679									
			0.500	1.000	1.000		0.833									
				1.000	1.000	1.000	1.000									
H22	1.000	0.982	1.000				0.994	0.986	2.81%	0.018	0.077	0	7	5	9	**190**
		1.000	1.000	1.000			1.000									
			1.000	1.000	0.923		0.974									
				1.000	0.926	1.000	0.975									
H23	0.777	1.000	1.000				0.926	0.955	7.20%	0.144	0.223	0	2	10	8	26
		1.000	0.856	1.000			0.952									
			0.892	1.000	1.000		0.964									
				1.000	0.934	1.000	0.978									
H25	0.451	0.485	0.434				0.456	0.495	2.85%	0.079	0.100	0	0	12	0	
		0.533	0.486	0.499			0.506									
			0.513	0.525	0.492		0.510									
				0.529	0.492	0.497	0.506									
H26	1.000	0.549	0.556				0.702	0.575	13.41%	0.043	0.533	0	1	11	1	0
		0.572	0.577	0.500			0.550									
			0.599	0.532	0.467		0.533									
				0.532	0.467	0.546	0.515									
H27	0.509	0.474	0.572				0.518	0.606	7.39%	0.063	0.233	0	1	11	0	
		0.492	0.606	0.634			0.577									
			0.635	0.664	0.707		0.669									
				0.649	0.663	0.670	0.661									

Table 11 Continued

ITHs	Time						Row Average	Mean	Std. Dev.	Column Range	Total Range	RTS			Frontier Freq.	Refs.
	1997	1998	1999	2000	2001	2002						IRS	CRS	DRS		
H28	0.508	0.649	0.630				0.596	0.627	4.38%	0.053	0.175	0	0	12	0	
		0.677	0.662	0.592			0.644									
			0.683	0.615	0.623		0.640									
				0.619	0.626	0.638	0.628									
H29	0.607	0.587	0.575				0.589	0.570	3.15%	0.028	0.093	0	1	11	0	
		0.609	0.594	0.562			0.588									
			0.603	0.571	0.516		0.563									
				0.572	0.518	0.533	0.541									
H30	0.476	0.576	0.593				0.548	0.561	4.25%	0.034	0.151	0	1	11	0	
		0.590	0.608	0.547			0.582									
			0.627	0.567	0.505		0.566									
				0.568	0.512	0.564	0.548									
H32	1.000	1.000	1.000				1.000	1.000	0.00%	0.000	0.000	1	10	1	12	21
		1.000	1.000	1.000			1.000									
			1.000	1.000	1.000		1.000									
				1.000	1.000	1.000	1.000									
H33	0.477	0.528	0.535				0.513	0.530	3.47%	0.074	0.131	0	0	12	0	
		0.570	0.555	0.490			0.539									
			0.608	0.532	0.507		0.549									
				0.537	0.511	0.505	0.517									
H34	0.523	0.683	0.652				0.619	0.634	6.98%	0.085	0.214	0	1	11	0	
		0.737	0.704	0.593			0.678									
			0.737	0.621	0.589		0.649									
				0.652	0.589	0.529	0.590									
H35	0.519	0.540	0.548				0.535	0.599	4.63%	0.069	0.147	0	0	12	0	
		0.565	0.582	0.594			0.581									
			0.617	0.634	0.637		0.629									
				0.645	0.646	0.666	0.652									
H36	0.688	1.000	0.630				0.773	0.701	9.43%	0.259	0.370	0	0	12	1	0
		0.741	0.642	0.667			0.683									
			0.666	0.689	0.651		0.668									
				0.689	0.660	0.687	0.679									
H38	1.000	0.396	0.313				0.570	0.732	31.80%	0.034	0.687	2	6	4	7	0
		0.414	0.316	1.000			0.577									
			0.347	1.000	1.000		0.782									
				1.000	1.000	1.000	1.000									
H39	0.512	0.483	0.508				0.501	0.525	2.29%	0.057	0.081	0	6	6	0	
		0.526	0.542	0.515			0.527									
			0.564	0.535	0.509		0.536									
				0.535	0.509	0.562	0.535									
H40	0.750	0.711	0.682				0.714	0.786	12.50%	0.020	0.318	0	4	8	3	11
		0.728	0.688	0.712			0.709									
			0.702	0.727	1.000		0.810									
				0.727	1.000	1.000	0.909									
H41	0.414	0.648	0.351				0.471	0.536	14.89%	0.085	0.395	0	4	8	0	
		0.712	0.407	0.406			0.508									
			0.436	0.436	0.714		0.529									
				0.436	0.719	0.747	0.634									
H42	1.000	1.000	1.000				1.000	0.989	3.81%	0.138	0.138	1	11	0	11	**234**
		1.000	1.000	1.000			1.000									
			1.000	1.000	1.000		1.000									
				1.000	0.862	1.000	0.954									

Table 11 Continued

ITHs	Time						Row Average	Mean	Std. Dev.	Column Range	Total Range	RTS			Frontier Freq.	Refs.
	1997	1998	1999	2000	2001	2002						IRS	CRS	DRS		
H43	0.584	0.547	0.638				0.590	0.615	3.39%	0.020	0.106	0	1	11	0	
		0.567	0.640	0.653			0.620									
			0.640	0.644	0.598		0.627									
				0.650	0.601	0.617	0.623									
H44	1.000	0.813	0.786				0.866	0.879	8.76%	0.214	0.223	0	3	9	4	74
		1.000	0.841	0.777			0.872									
			1.000	0.830	0.828		0.886									
				0.835	0.839	1.000	0.891									
H45	1.000	1.000	1.000				1.000	0.988	2.68%	0.083	0.083	0	8	4	10	227
		1.000	1.000	0.917			0.972									
			1.000	1.000	1.000		1.000									
				1.000	1.000	0.942	0.981									
H46	0.497	0.832	0.744				0.691	0.697	16.03%	0.049	0.537	0	5	7	1	22
		0.845	0.743	0.463			0.684									
			0.747	0.511	0.749		0.669									
				0.505	0.722	1.000	0.742									
H49	0.447	0.437	0.381				0.422	0.435	2.33%	0.052	0.101	0	2	10	0	
		0.482	0.425	0.416			0.441									
			0.433	0.425	0.450		0.436									
				0.425	0.450	0.446	0.440									
H51	1.000	0.776	0.824				0.867	0.880	8.85%	0.048	0.225	0	2	10	4	49
		0.775	0.809	1.000			0.861									
			0.856	1.000	0.846		0.901									
				1.000	0.854	0.816	0.890									
H52	0.706	0.614	0.683				0.667	0.738	9.16%	0.082	0.299	0	3	9	0	
		0.633	0.732	0.875			0.746									
			0.765	0.912	0.714		0.797									
				0.850	0.717	0.657	0.741									
Mean	0.688	0.696	0.711	0.760	0.755	0.758	**0.730**	0.730	0.085	0.081	0.265	6	133	413		
Std. Dev.	0.261	0.203	0.195	0.211	0.186	0.190						1%	24%	75%		

RTS: IRS denotes increasing returns to scale; CRS denotes constant returns to scale; DRS denotes decreasing returns to scale.
Std. Dev.: the standard deviation x 100.
Refs: the number of references to this ITH as a peer.

4.6.2 Trend of Managerial Performance

Figure 12 shows the mean managerial efficiencies and corresponding standard deviations for ITHs. Notice that the trend of mean managerial efficiency is increasing whereas the variation converges. These results indicate that the overall managerial performance of the ITHs improved over the period.

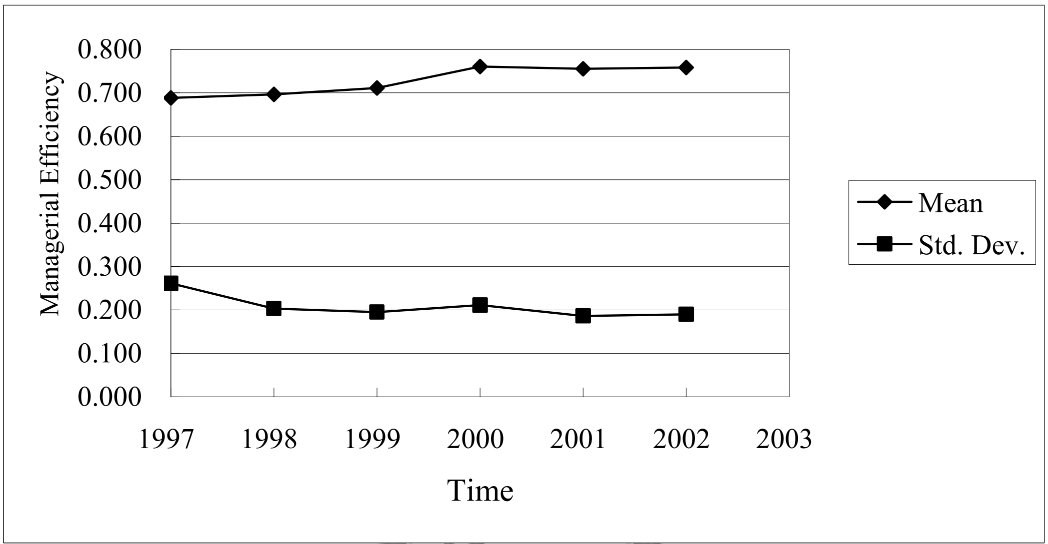

Figure 12 Managerial Efficiency of ITH Industry, 1997-2002

To help interpret the result we note that the "Row Average" and "Std. Dev." (Table 11) are other useful ways of analyzing the trends and potential stability problems in terms of managerial efficiency among ITHs. Totally, Table 11 shows that 11 out of the 46 ITHs exhibit improving behavior and the same improvement continues to be manifested with different datasets. These include Mandarina Crown Hotel (H03), Gloria Prince Hotel (H05), Riverview Hotel (H07), Caesar Park Hotel (H08), Gold China Hotel (H09), United Hotel (H13), Fortuna Hotel (H15), Far Eastern Plaza Hotel (H23), Evergreen Laurel Hotel Taichung (H35), Astar Hotel Hualine (H38), and Caesar Park Hotel Kenting (H44). Four out of the 46 ITHs exhibit deteriorating behavior and the same deterioration continues to be manifested with different datasets. These include Grand Hyatt Taipei (H20), Holiday Garden Kaohsiung

(H26), Grand Hi-Lai Hotel (H29), and Parkview Hotel (H41). However, Mandarina Crown Hotel (H03), Riverview Hotel (H07), Gold China Hotel (H09), United Hotel (H13), Holiday Garden Kaohsiung (H26), Astar Hotel Hualine (H38), and Parkview Hotel (H41) have a higher variance. Such an outcome may be due to the unusually low or high managerial efficiency. These ITHs desire further examination in a future study.

The mean window analysis score is 0.73, indicating the fact that the market for lodging services is not operating efficiently in Taiwan. According to Table 11, 11 out of the 46 ITHs are found to have managerial efficiencies over 0.9%. This means that each of these eleven ITHs are more efficient than the remaining 35 ITHs. From Table 11, one might find that high efficiency is associated with a low standard deviation. Among the eleven ITHs, six ITHs having an average efficiency score over 0.98 indicate that these ITHs were operating efficiently and stably over the six-year period. These ITHs are Emperor Hotel (H06), Grand Hyatt Taipei (H20), Sherwood Hotel Taipei (H22), Park Hotel (H32), Hotel Landis China Yangmingshan (H42), and Royal Chihpen Resort Hotel (H45). Among the six ITHs, Emperor Hotel (H06) and Park Hotel (H32) have the highest mean managerial efficiency and the lowest standard deviation.

To determine whether differences exist in various ITH characteristics (i.e., international chain or independent-owned, metropolitan area or resort area, closeness to CKS international airport or not) for managerial efficiency, a non-parametric statistical analysis (Mann-Whitney test) is used (Brockett and Golany, 1996) for unknown distribution scores. Bold-faced figures in Table 12 indicate statistical significance. Notice that there is a consistent significant, statistical difference on managerial efficiency between independent-owned and international chain ITHs. Moreover, the international chains consistently outperform the locals (Figure 13). This might be due to them having a better reputation, a brand image, internet marketing, an efficient reservation system, and economies of scale.

Figure 14 shows the major dip of the 921 earthquake (year 1999) to resort-type ITHs. These ITHs have regained their advantage since the year 2001 mainly due to government subsidies to government employees. Government subsidies provide support to government employees for domestic tours up to seven days with a ceiling of NT$16,000 annually. It is estimated that there are 570,000 government employees including military personnel.

Table 12 Non-Parametric Statistical Analysis of Management Style, Location, and Closeness to CKS

Characteristics			1997	1998	1999	2000	2001	2002
Management Type	Independent-owned	(Mean)	0.628	0.622	0.640	0.700	0.697	0.703
	International chain	(Mean)	0.790	0.821	0.832	0.863	0.853	0.853
	Mann-Whitney test	(p-value)	**0.012***	**0.001***	**0.001***	**0.022***	**0.005***	**0.006***
Location	Resort area	(Mean)	0.751	0.734	0.690	0.734	0.814	0.874
	Metropolitan area	(Mean)	0.673	0.686	0.716	0.767	0.740	0.730
	Mann-Whitney test	(p-value)	0.438	0.533	0.771	0.515	0.251	**0.034***
Closeness to CKS	Far	(Mean)	0.681	0.676	0.660	0.686	0.697	0.723
	Close	(Mean)	0.695	0.716	0.761	0.835	0.813	0.793
	Mann-Whitney test	(p-value)	0.725	0.613	0.073	**0.012***	**0.038***	0.213

Note: * Statistically significant at 0.05 level.

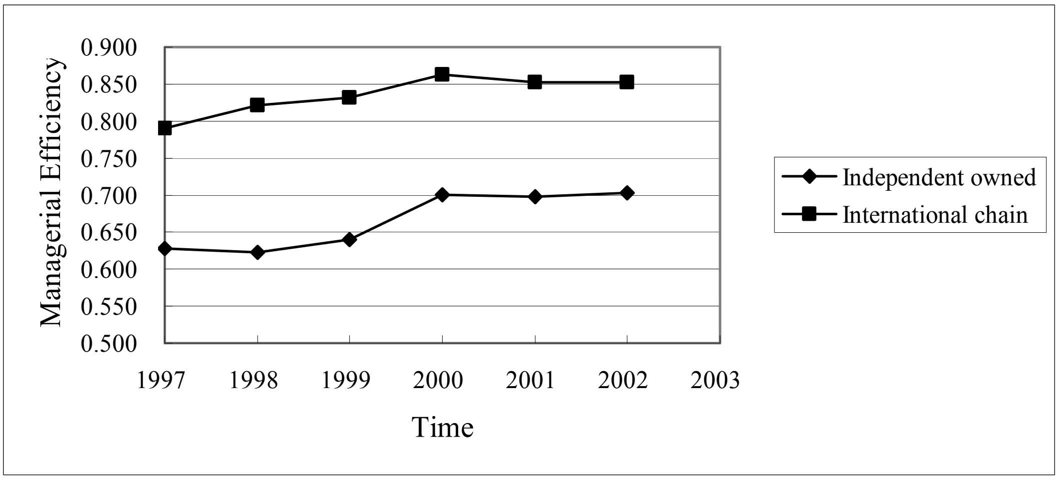

Figure 13 Managerial Efficiency with Management Type of ITHs

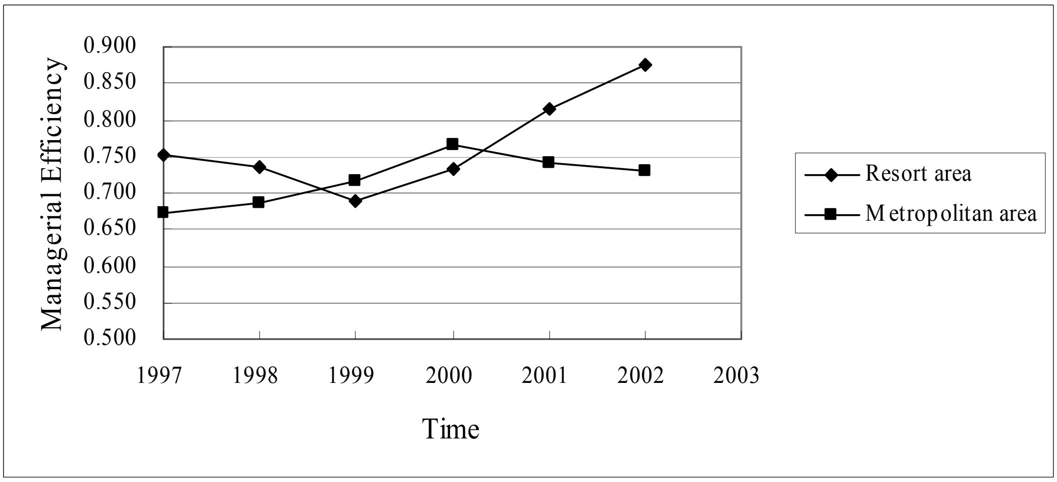

Figure 14 Managerial Efficiency with Location of ITHs

Figure 15 shows that the managerial efficiency with closeness of ITHs to CKS international airport is steady until the 911 incident in 2001 triggered a dip for the next two years. Notice also that due to the occurrence of the 921 earthquake in 1999 in Taiwan more foreigners come to Taiwan for business instead of leisure. The compulsory government subsidies also showed that they helped those ITHs far from CKS international airport.

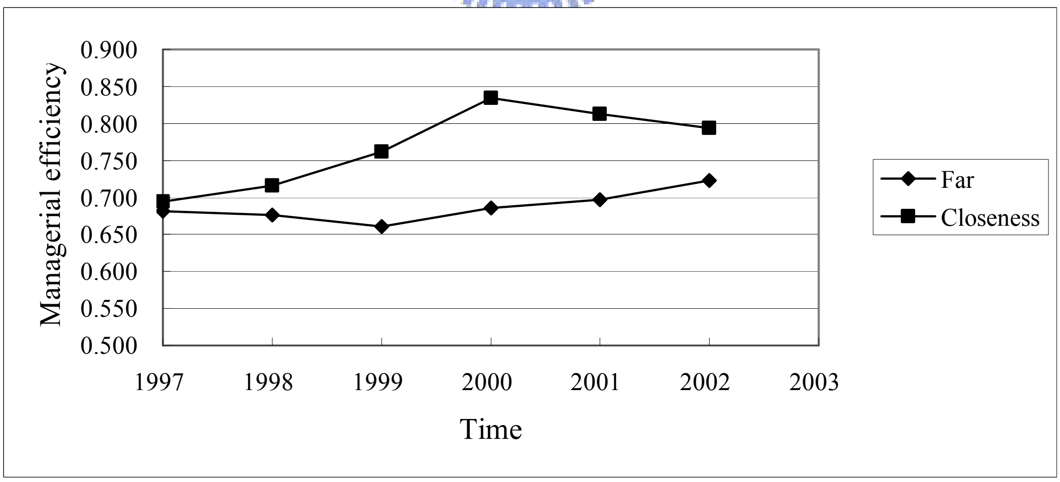

Figure 15 Managerial Efficiency with Closeness of ITHs to CKS International Airport

4.6.3 Characteristics Affecting Hotel Managerial Performance

We identify four key characteristics that may affect the ITHs' performances. One can use a dummy variable to indicate different management styles: 1 for international chain and 0 for independent-owned. Likewise, a dummy variable is used to specify the location of an ITH: 1 for metropolitan and 0 for those located in a resort area. Another dummy variable is used to specify accessibility to CKS international airport (1 hour driving), where a value 1 indicates an ITH is located near it and 0 if it is not located near it. Finally, an ITH with a larger proportion of foreigner guests is likely to have more distinctive competencies than an ITH with a small proportion of foreigner guests.

To determine whether operating characteristics affect the managerial performance of the ITHs, the obtained mean managerial efficiencies are regressed against the management style, location, and closeness to CKS international airport. The tobit regression results in Table 13 explain about 24.53% of the variation in managerial efficiency and the coefficient of management style is significant at the 5% level. The significance of management style confirms our prior finding based on the Mann-Whitney test. Consequently, we conclude that the managerial performance of ITHs is influenced by the management style over the period 1997-2002.

Table 13 Results of Tobit Regression

	Coefficient	Std. Error	Z-Statistic	P-level
Constant	0.702	0.067	10.404	0.000
Management style*	0.158	0.053	2.956	0.005
Location	-0.014	0.086	-0.163	0.872
Closeness to CKS	0.091	0.083	1.100	0.278
Proportion of Foreigner Guests	-0.001	0.002	-0.700	0.488
R-squared				0.2453

Note: * Statistically significant at 0.05 level.

Chapter 5 Conclusions and Remarks

While service industries have become increasingly important in the global economy in recent years, the issue of the international tourism industries is especially valuable for a small open economy like Taiwan, because tourism has not only become one of the largest sources of income for Taiwan, but also has an effective means to stimulate global economic development. Although the international tourism industry's efficiency has been widely discussed in the previous literature and the DEA technique is frequently used to explore this topic, there are still some important points not touched. This paper therefore aims to explore the current-period efficiency (using 2002 operating data) and the cross-period efficiency (using 1997-2002 operating data) from a more complete viewpoint. The results of this study can provide ITHs' operations with insights into resource allocation and competitive advantage and help with strategic decision-making, especially regarding operational styles under intense competition caused by high ITH density.

As regards to the cross sectional study (using 2002 operating data), the findings can briefly be concluded as follows. Firstly, the overall technical inefficiencies of Taiwanese ITHs are primarily due to pure technical inefficiencies rather than scale inefficiencies. This also suggests that managers should focus firstly on removing the pure technical inefficiency of ITHs, and then ITHs can be subject to improving their scale efficiencies. Secondly, most ITHs are operating at decreasing returns to scale (DRS), indicating that ITHs are facing a highly competitive environment in Taiwan. Thirdly, the international chain ITHs are generally more efficient than independent-owned ones. This finding is consistent with the finding by Hwang and Chang (2003). Fourthly, ITHs located in resort areas operate slightly better on average than ITHs located in metropolitan areas. The primary reason is that ITHs located in resort areas regained their advantage in year 2002, since year 2001 government provided subsidies to government employees. ITHs that are close to CKS international airport operate slightly worse on average than ones far from CKS international airport. Fifthly, congestion analysis denotes that inefficient ITHs lack the ability to integrate their resources, especially in the total area of the catering division and the number of guest rooms. Sixthly, among those efficient ITHs, international chain ITHs are able to more easily become benchmarks. The findings show that the international chain ITHs are more competitive and they should provide examples of operating practice.

In regard to cross-period efficiency study (using 1997-2002 operating data), the findings can briefly be concluded as follows. Firstly, the mean window analysis score is 0.73, indicating that the market for lodging services does not operate efficiently in Taiwan. However, the overall managerial performance has steadily improved and the variance among all the ITHs has converged over the period. Secondly, most ITHs are operating at decreasing returns to scale (DRS), indicating that ITHs are facing a highly competitive environment in Taiwan. Thirdly, the "count" method points out that the Sherwood Hotel Taipei and Hotel Landis China Yangmingshan are benchmarks for those in metropolitan and resort areas, respectively. Fourthly, international chain ITHs have more robust competitive power, because they have a better reputation, brand image, internet marketing, an efficient reservation system, and economics of scale. Fifthly, Taiwan's 921 earthquake in 1999 might crucially have affected the managerial efficiency of resort ITHs in the period 1999-2000. Sixthly, the compulsory government subsidies significantly have affected the managerial efficiency of resort ITHs in the year 2002 and the 911 incident in 2001 significantly affected the managerial performance of ITHs close to CKS international airport in the year 2001. Results also indicate that differences in management style do have a very significant influence upon ITHs' managerial performance.

Furthermore, we also find that the operating efficiency of the catering departments is better than the operating efficiency of the room server departments. This finding is consistent with the finding by Tsaur (2000). Therefore, we suggests that managers take some actions to improve the operational efficiency of the room service departments, such as the quality of room service, booking through internet, internet service in guest rooms, special smart deals packages. To help the Taiwan's hotel industry, the Tourism Bureau and Hotel Association can play an important role by organizing more international conferences and business exhibitions in Taiwan as well as providing better tourism environments and various tour packages. In doing so, it may attract more foreign guests to visit Taiwan and, hence, increase the occupancy rate of hotels.

A few notes of caution are in order here. Our study is in terms of highly aggregated measures of outputs and inputs. There are important qualitative dimensions of outputs that are not taken into account. For instance, these qualitative dimensions can be quality of services, consumer satisfaction, and quality of employees. It would be desirable to treat these outputs explicitly in the models used herein. Our basic methodology will still remain valid, however. A further investigation would be the examination of environment variables including the reputation of the hotel, scenic spot, easily accessible etc. Such an approach would allow a more complete viewpoint to explore of the multidimensional performance of ITHs.

Our findings can serve as a guideline in the tourism industry for coping with issues relating to ITHs. It is also hoped that the models and methods implemented in this study can bring about other related research to a variety of industries.

References

[1] Andersen, P. and Petersen, N.C. (1993), A procedure for ranking efficient units in data envelopment analysis, Management Science 39 (10), 1261-1264.

[2] Anderson, R.I., Fish, M., Xia, Y. and Michello, F. (1999), Measuring efficiency in the hotel industry: a stochastic frontier approach, International Journal of Hospitality Management 18 (1), 45-57.

[3] Anderson, R.I., Fok, R. and Scott, J. (2000), Hotel industry efficiency: an advanced linear programming examination, American Business Review 18 (1), 40-48.

[4] Angulo-Meza, L. and Lins, M.P.E. (2002), Review of methods for increasing discrimination in data envelopment analysis, Annals of Operations Research 116 (1), 225-242.

[5] Baker, M. and Riley, M. (1994), New perspectives on productivity in hotels: some advances and new directions, International Journal of Hospitality Management 13 (4), 297-311.

[6] Baker, R.C. and Talluri, S. (1997), A closer look at the use of data envelopment analysis for technology selection, Computers Industry and Engineering 32 (10), 101-108.

[7] Banker, R.D., Charnes, A. and Cooper, W.W. (1984), Some models for estimating technical and scale inefficiencies in data envelopment analysis, Management Science 30 (9), 1078-1092.

[8] Banker, R.D. and Thrall, R.M. (1992), Estimation of returns to scale using data envelopment analysis, European Journal of Operational Research 62 (1), 74-84.

[9] Banker, R.D., Bardhan, I. and Cooper, W.W. (1995), A note on returns to scale in DEA, European Journal of Operational Research 88 (3), 583-585.

[10] Banker, R.D., Chang, H. and Cooper, W.W. (1996), Equivalence and implementation of

alternative methods for determining returns to scale in data envelopment analysis, European Journal of Operational Research 89 (3), 473-481.

[11] Barros, C.P. and Alves, F.P. (2004), Productivity in the tourism industry, International Advances in Economic Research 10 (3), 215-225.

[12] Bell, R.A. and Morey, R.C. (1995), Increasing the efficiency of corporate travel management though macro benchmarking, Journal of Travel Research 33 (3), 11-21.

[13] Brockett, P.L. and Golany, B. (1996), Using rank statistics for determining programmatic efficiency differences in data envelopment analysis, Management Science 42 (3), 466-472.

[14] Byrnes, P., Färe, R. and Grosskopf, S. (1984), Measuring productive efficiency: An application to Illinois strip mines, Management Science 30 (6), 671-681.

[15] Charnes, A., Cooper, W.W. and Rhodes, E. (1978), Measuring the efficiency of decision making units, European Journal of Operational Research 2 (6), 429-444.

[16] Charnes, A., Clark, C.T., Cooper, W.W. and Golany B. (1985), A development study of data envelopment analysis in measuring the efficiency of maintenance units in the U.S. Air Forces, Annals of Operations Research 2, 95-112.

[17] Charnes, A., Cooper, W.W. and Li, S. (1989), Using DEA to evaluate relative efficiencies in the economic performance of Chinese key cities, Socio-Economic Planning Sciences 23 (6), 325-344.

[18] Charnes, A., Lewin, A., Cooper, W.W. and Seiford, L.M. (1994), Data envelopment analysis: theory, methodology and application, Boston: Kluwer Academic Publishers.

[19] Chiang, W.E., Tsai, M.H. and Wang, L.S.M. (2004), A DEA evaluation of Taipei hotels, Annals of Tourism Research 31 (3), 712-715.

[20] Coltman, M.M. (1978), Hospitality Management Accounting, Boston: CBI Publishing Co., Inc.

[21] Cooper, W.W., Seiford, L.M. and Tone, K. (2000), Data envelopment analysis: a comprehensive text with models, applications, references and DEA-solver software, Boston: Kluwer Academic Publishers.

[22] Cooper, W.W., Li, S., Seiford, L.M., Tone, K., Thrall, R.M. and Zhu, J. (2001), Sensitivity and stability analysis in DEA: some recent developments, Journal of Productivity Analysis 15 (3), 217-246.

[23] Cooper, W.W., Deng, H., Gu, B., Li, S. and Thrall, R.M. (2001), Using DEA to improve the management of congestion in Chinese industries (1981–1997), Socio-Economic Planning Science 35 (4), 227-242.

[24] Doyle, J. and Green, R. (1994), Efficiency and cross-efficiency in DEA: Derivation, meanings and uses, Journal of Operational Research Society 45 (5), 567-578.

[25] Enz, C. and Canina, L. (2002), Best of times, the worst of times: difference in hotel performance following 9/11, Cornell Hotel & Restaurant Administration Quarterly 43 (5), 22-32.

[26] Färe, R., Grosskopf, S. and Lovell, C.A.K. (1985), The Measurement of Efficiency of Production, Kluwer Nijhoff, Boston.

[27] Färe, R., Grosskopf, S., Lindgren, B. and Roos, P. (1992), Productivity Changes in Swedish Pharmacies 1980-1989: a non-parametric malmquist approach, Journal of Productivity Analysis 3 (1), 85-101.

[28] Färe, R. and Grosskopf, S. (1994), Estimation of returns to scale using data envelopment analysis: A comment, European Journal of Operational Research 79 (2), 379-382.

[29] Fay, C.T., Rhoads, R.C. and Rosenblatt, R.L. (1971), Managerial Accounting for Hospitality Service Industries, Bubuque, Iowa, William C. Brown Publishers.

[30] Gattoufi, S., Oral, M. and Reisman, A. (2004), Data envelopment analysis literature: bibliography update (1951-2001), Socio-Economic Planning Sciences 38 (2-3),159-229.

[31] Hwang, S.N. and Chang, T.Y. (2003), Using data envelopment analysis to measure hotel managerial efficiency change in Taiwan, Tourism Management 24 (4), 357-369.

[32] Ismail, J., Dalor, M. and Mills, J. (2002), Using RevPar to analyze lodging-segment variability, Cornell Hotel & Restaurant Administration Quarterly 43 (6), 73-80.

[33] Jaedicke, R.K. and Robichek, A.A. (1975), Cost-volume-profit analysis under conditions of uncertainty. In A. Rappaport (ed.), Information for Decision-Making-Quantative and Behavioural Dimensions (2nd Edition), Prentice-Hall, Englewood, Cliffs, NJ.

[34] Kimes, S.E. (1989), The basics of yield management, Cornell Hotel & Restaurant Administration Quarterly 30 (3), 14-19.

[35] Lewin, A.Y., Morey, R.C. and Cook, T.J. (1982), Evaluating the administrative efficiency of courts, Omega, International Journal of Management Science 10 (4), 401-411.

[36] Li, X.B. and Reeves, G.R. (1999), A multiple criteria approach to data envelopment analysis, European Journal of Operational Research 115 (3), 507-517.

[37] Morey, R.C. and Dittman, D.A. (1995), Evaluating a hotel gm's performance: a case in benchmarking, Cornell Hotel & Restaurant Administration Quarterly 36 (5), 30-35.

[38] Seiford, L.M. (1997), A bibliography for data envelopment analysis (1978-1996), Annals of Operations Research 73, 393-438.

[39] Seiford, L.M. and Zhu, J. (1999), Infeasibility of super-efficiency data envelopment analysis, *INFOR* 37 (2), 174-187.

[40] Sexton, T., Silkman, R. and Hogan, A. (1986), Data Envelopment Analysis: Critique and Extensions, Measuring Efficiency: An Assessment of Data Envelopment Analysis, New Directions for Program Evaluation, San Francisco: Jossey-Bass.

[41] Sherman, H.D. (1986), Managing productivity of health care organizations in R.H. Silkman (eds.), San Francisco, Jossey-Bass Inc., Publishers.

[42] Smith, P. and Mayston, D. (1987), Measuring efficiency in the public sector, Omega,

International Journal of Management Science 20 (3), 181-189.

[43] Sueyoshi, T. (1999), Data envelopment analysis non-parametric ranking test and index measurement: Slack-adjust DEA and an application to Japanese agriculture cooperatives, Omega, International Journal of Management Science 27 (3), 315-326.

[44] Taiwan Tourism Bureau, Ministry of Transportation and Communications (2004), Annual Report on Tourism, Taipei, Taiwan Tourism Bureau (in Chinese).

[45] Taiwan Tourism Bureau (1998), The Operating Report of International Tourist Hotels in Taiwan 1997, Taipei, Taiwan Tourism Bureau (in Chinese).

[46] Taiwan Tourism Bureau (1999), The Operating Report of International Tourist Hotels in Taiwan 1998, Taipei, Taiwan Tourism Bureau (in Chinese).

[47] Taiwan Tourism Bureau (2000), The Operating Report of International Tourist Hotels in Taiwan 1999, Taipei, Taiwan Tourism Bureau (in Chinese).

[48] Taiwan Tourism Bureau (2001), The Operating Report of International Tourist Hotels in Taiwan 2000, Taipei, Taiwan Tourism Bureau (in Chinese).

[49] Taiwan Tourism Bureau (2002), The Operating Report of International Tourist Hotels in Taiwan 2001, Taipei, Taiwan Tourism Bureau (in Chinese).

[50] Taiwan Tourism Bureau (2003), The Operating Report of International Tourist Hotels in Taiwan 2002, Taipei, Taiwan Tourism Bureau (in Chinese).

[51] Thrall, R.M. (1996), Duality, classification and slacks in DEA, Annals of Operations Research 66, 109-138.

[52] Tsaur, S.H. (2000), The operating efficiency of international tourist hotels in Taiwan, Asia Pacific Journal of Tourism Research 6(1), 29-37.

[53] Tone, K. (2001), A slacks-based measure of efficiency in data envelopment analysis, European Journal of Operational Research 130 (3), 498-509.

[54] Tone, K. (2002), A slacks-based measure of super-efficiency in data envelopment

analysis, European Journal of Operational Research 143 (1), 32-41.

[55] Torgersen, A.M., Førsund, F.R. and Kittelsen, S.A.C. (1996), Slack-adjusted efficiency measures and ranking of efficient units, Journal of Productivity Analysis 7 (4), 379-398.

[56] Van Doren, C.S. and Gustke, L.D. (1982), Spatial analysis of the U.S. lodging industry, Annals of Tourism Research 9 (4), 543-563.

[57] Wassenaar, K. and Stafford, E.R. (1991), The lodging index: an economic indicator for the hotel/motel industry, Journal of Travel Research 30(1), 81-21.

[58] Wijeysingle, B.S. (1993), Breakeven occupancy for a hotel operation, Management Accounting 71 (2), 32-33.

[59] World Tourism Organization (WTO) Website (2005), http://www.world-tourism.org/.

[60] World Travel & Tourism Council (WTTC) Website (2005), http://www.wttc.org/.

[61] Yang, C. and Lu, W.M. (2006), Assessing the Performance and Finding the Benchmarks of the Electricity Distribution Districts of Taiwan Power Company, IEEE Transactions on Power Systems (paper in press).

[62] Yang, C., Wang, T.C. and Lu, W.M. (2006), Performance Measurement in Military Provisions: The Case of Retail Stores of Taiwan's General Welfare Service Ministry, Asia-Pacific Journal of Operational Research (paper in press).

[63] Zhu, J. (1996a), DEA/AR analysis of the 1988-1989 performance of the Nanjing Textiles Corporation, Annals of Operations Research 66, 311-335.

[64] Zhu, J. (1996b), Robustness of the efficient DMUs in data envelopment analysis, European Journal of Operational Research 90 (3), 451-460.

[65] Zhu, J. (2000), Multi-factor performance measure model with an application to Fortune 500 companies, European Journal of Operational Research 123 (1), 105-124.

[66] Zhu, J. and Shen, Z. (1995), A discussion of testing DMUs' returns to scale, European Journal of Operational Research 81 (3), 590-596.

[67] Zhu, J. (2003), Quantitative Models for Performance Evaluation and Benchmarking: Data Envelopment Analysis with Spreadsheets, Kluwer Academic Publishers, Boston

Appendix A. The Detailed Information of ITHs in Taiwan

Code	Chinese/English Name	Tel and Fax	Websites
H01	圓山大飯店 Grand Hotel Taipei	（02）2886-8888 （02）2885-2885	http://www.grand-hotel.org/
H02	國賓大飯店 Ambassador Hotel	（02）2551-1111 （02）2561-7883	http://www.ambassadorhotel.com.tw/
H03	中泰賓館 Mandarina Crown Hotel	（02）2712-1201 （02）2712-2122	http://www.mcrown.com.tw/
H04	台北華國大飯店 Imperial Hotel Taipei	（02）2596-5111 （02）2592-7506	http://www.imperialhotel.com.tw/
H05	華泰王子大飯店 Gloria Prince Hotel	（02）2581-8111 （02）2581-5811	http://www.gloriahotel.com.tw/
H06	國王大飯店 Emperor Hotel	（02）2581-1111 （02）2531-2586	http://www.emperorhotel.com.tw/
H07	豪景大酒店 Riverview Hotel	（02）2311-3131 （02）2361-3737	http://www.riverview.com.tw/
H08	台北凱撒大飯店 Caesar Park Hotel	（02）2311-5151 （02）2331-9944	http://www.caesarpark.com.tw/
H09	康華大飯店 Golden China Hotel	（02）2521-5151 （02）2531-2914	http://www.golden-china.com.tw/
H10	兄弟大飯店 Brother Hotel	（02）2712-3456 （02）2717-3334	http://www.brotherhotel.com.tw/
H11	三德大飯店 Santos Hotel	（02）2596-3111 （02）2596-3120	http://www.santoshotel.com/
H12	亞都麗緻大飯店 Landis Ritz Hotel	（02）2597-1234 （02）2596-9223	http://www.landistpe.com.tw/
H13	國聯大飯店 United Hotel	（02）2773-1515 （02）2741-2789	http://www.united-hotel.com.tw/
H14	台北喜來登大飯店 Sheraton Taipei Hotel	（02）2321-5511 （02）2394-4240	http://www.lailai-sheraton.com/
H15	富都大飯店 Fortuna Hotel	（02）2563-1111 （02）2561-9777	http://www.taipei-fortuna.com.tw/
H16	假日大飯店環亞台北 Holiday Inn Asiaworld Taipei	（02）2715-0077 （02）2713-4148	http://www.ichotelsgroup.com/h/d/hi/1/en/hd/tpetn
H17	台北老爺大酒店 Royal Hotel Taipei	（02）2542-3266 （02）2543-4897	http://www.royal-taipei.com.tw/

Continued

Code	Chinese/English Name	Tel and Fax	Websites
H18	福華大飯店	(02)2700-2323	http://www.howard-hotels.com/
	Howard Plaza Hotel Taipei	(02)2700-0729	
H19	力霸皇冠大飯店	(02)2763-5656	http://www.crowneplaza-taipei.com/
	Rebar Crowne Plaza Hotel	(02)2767-9347	
H20	台北君悅大飯店	(02)2720-1200	http://taipei.hyatt.com/taigh_tw/
	Grand Hyatt Taipei	(02)2720-1111	
H21	晶華酒店	(02)2523-8000	http://www.grandformosa-taipei.com.tw/
	Grand Formosa Regent Taipei	(02)2523-2828	
H22	西華大飯店	(02)2718-1188	http://www.sherwood.com.tw/
	Sherwood Hotel Taipei	(02)2713-0707	
H23	遠東國際大飯店	(02)2378-8888	http://www.feph.com.tw/
	Far Eastern Plaza Hotel	(02)2377-7777	
H24	六福皇宮	(02)8770-6565	http://www.whatis.com.tw/westin2005/
	The Westin Taipei	(02)8770-6555	
H25	華王大飯店	(07) 551-8211	http://www.hotelkingdom.com.tw/
	Hotel Kingdom	(07) 521-0403	
H26	華園大飯店	(07) 241-0123	http://www.hotelhg.com.tw/
	Holiday Garden Kaohsiung	(07) 251-2000	
H27	高雄國賓大飯店	(07) 211-5211	http://www.ambhotel.com.tw
	Ambassador Hotel Kaohsiung	(07) 281-1115	
H28	高雄霖園大飯店	(07) 332-2000	http://www.25457890.com.tw/hotel/lindenroom.htm
	Linden Hotel Kaohsiung	(07) 384-4739	
H29	漢來大飯店	(07) 216-1766	http://www.grand-hilai.com.tw/
	Grand Hi-Lai Hotel	(07) 216-1966	
H30	高雄福華大飯店	(07) 236-2323	http://www.howard-hotels.com/
	Howard Plaza Hotel Kaohsiung	(07) 235-8383	
H31	高雄金典酒店	(07) 566-8000	http://www.gfk.com.tw/
	Splendor Kaohsiung	(07) 566-8080	
H32	敬華大飯店	(04)2220-5181	http://www.taiwaninfo.org/info/twtour/chi
	Park Hotel	(04)2222-5757	
H33	全國大飯店	(04)2321-3111	http://www.hotel-national.com.tw/
	Hotel National	(04)2321-3124	
H34	通豪大飯店	(04)2295-6789	http://www.taichung-plaza.com/
	Plaza International Hotel	(04)2293-0099	

Continued

Code	Chinese/English Name	Tel and Fax	Websites
H35	台中長榮桂冠酒店	(04) 2313-9988	http://www.hotels.evergreen.com.tw/
	Evergreen Laurel Hotel Taichung	(04) 2313-8642	
H36	台中福華大飯店	(04) 2463-2323	http://www.howard-hotels.com/
	Howard Prince Hotel Taichung	(04) 2463-1234	
H37	台中金典酒店	(04) 2328-8000	http://www.splendor-taichung.com.tw/
	Splendor Taichung	(04) 2323-8921	
H38	花蓮亞士都飯店	(03) 8326-111	http://astar-hotel.network.com.tw/
	Astar Hotel Hualine	(03) 8324-604	
H39	統帥大飯店	(03) 8326-123	http://www.marshal-hotel.com.tw/
	Marshal Hotel	(03) 8326-140	
H40	花蓮中信大飯店	(03) 8221-171	http://www.chinatrust-hotel.com/
	China Trust Hotel Hualien	(03) 8221-185	
H41	美侖大飯店	(03) 8222-111	http://www.parkview-hotel.com/
	Parkview Hotel	(03) 8226-999	
H42	陽明山中國麗緻大飯店	(02) 2861-6661	http://www.landisresort.com.tw/
	Hotel Landis China Yangmingshan	(02) 2861-3885	
H43	高雄圓山大飯店	(07) 370-5911	http://www.grand-hotel.org/
	Grand Hotel Kaohsiung	(07) 370-4889	
H44	凱撒大飯店	(08) 886-1888	http://www.caesarpark.com.tw/
	Caesar Park Hotel Kenting	(08) 886-1818	
H45	知本老爺大酒店	(089) 510-666	http://www.hotel-royal-chihpen.com.tw/
	Royal Chihpen Resort Hotel	(089) 510-678	
H46	天祥晶華度假酒店	(03) 8691-158	http://www.grandformosa-taroko.com.tw/
	Grand Formosa Taroko	(03) 8691-160	
H47	墾丁福華渡假飯店	(08) 886-2323	http://www.howard-hotels.com/
	Howard Beach Resort Kenting	(08) 886-2300	
H48	曾文.山芙蓉渡假大酒店	(06) 575-3333	http://www.hchibiscus.com/
	The Hibiscus Resort	(06) 575-3377	
H49	桃園大飯店	(03) 325-4021	http://www.holidayhotel.com.tw/
	Taoyuan Holiday Hotel	(03) 325-1222	
H50	南華大飯店	(03) 337-9222	
	Hotel Nanhwa	(03) 337-9250	
H51	台南大飯店	(06) 228-9101	http://www.hotel-tainan.com.tw/
	Hotel Tainan	(06) 226-8502	

Continued

Code	Chinese/English Name	Tel and Fax	Websites
H52	大溪別館	（03）387-6688	http://www.tasheeresort.com.tw/
	Ta Shee Resort Hotel	（03）387-5288	
H53	新竹老爺大酒店	（035）63-1122	http://www.royal-hsinchu.com.tw/
	Hotel Royal Hsinchu	（035）63-1899	
H54	新竹國賓大飯店	（035）15-1111	http://www.ambassador-hsinchu.com.tw/
	Ambassador Hsinchu	（035）15-1112	
H55	娜路彎大酒店	（089）239-666	http://www.naruwan-hotel.com.tw/
	Formosan Naruwan Hotel	（089）239-777	
H56	大億麗緻酒店	（06）213-5555	http://www.tayihlandis.com.tw/tayih_ok/
	Tayih Landis	（06）213-5599	

Data Source：Tourism Bureau, M.O.T.C. Republic of China

Appendix B. Ranking Extensions to DEA Model

B.1 Super Efficiency (Andersen and Petersen, 1993)

Andersen and Petersen (1993) developed a new procedure for ranking efficient units. The methodology enables an extreme efficient unit k to achieve an efficiency score greater than one by removing the kth constraint in the multiplier model, as shown in model (a.1).

$$
\begin{aligned}
h_k = Max \ & \sum_{r=1}^{s} u_r y_{rk} \\
s.t. \ & \\
& \sum_{i=1}^{m} v_i x_{ik} = 1, \\
& \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, \quad j = 1,\ldots,n, \ j \ne k \\
& u_r, v_i \ge 0; \ \ i = 1,\ldots,m; \ \ r = 1,\ldots s.
\end{aligned}
\tag{a1}
$$

The dual formulation of the super-efficient model, as seen in model (a.2), computes the distance between the Pareto frontier, evaluated without unit k, and the unit itself i.e. for $J = \{ j = 1,\ldots,n, \ j \ne k \}$.

$$
\begin{aligned}
Min \ & \theta_k \\
s.t. \ & \\
& \sum_{j=1, j\ne k}^{n} \lambda_j x_{ij} \le \theta_k x_{ik}, \quad i = 1,\ldots,m, \\
& \sum_{j=1, j\ne k}^{n} \lambda_j y_{rj} \ge y_{rk}, \quad r = 1,\ldots,s, \\
& \theta_k, \ \lambda_j \ge 0; \ \forall \ i \ and \ r; j = 1,\ldots,n.
\end{aligned}
\tag{a2}
$$

However, there are two problematic areas with this methodology. First, the super-efficient methodology can give "specialized" DMUs an excessively high ranking (Sueyoshi, 1999). The second problem lies with an infeasibility issue, which if it occurs, means that the super-efficient technique cannot provide a complete ranking of all DMUs (Seiford and Zhu, 1999).

B.2 Cross-Evaluation (Doyle and Green, 1994)

The cross-evaluation matrix was first development by Sexton et al. (1986), inaugurating the subject of ranking in DEA. Indeed, as Doyle and Green (1994) argued, decision-makers do not always have a reasonable mechanism from which to choose assurance regions, thus they recommend the cross-evaluation matrix for ranking units. The basic idea is to use DEA in a peer-appraisal instead of a self-appraisal, which is calculated by the CRS (constant returns to scale) model. A peer-appraisal means that the efficiency score of a DMU is achieved when evaluated with the optimal weights (input and output weights obtained by the output-oriented CRS model) of other $DMUs$. Thus, for each DMU there are $(n-1)$ cross-efficiency scores where n represents the total number of $DMUs$. Averaging the cross-efficiency scores of DMU_k by using the weighting scheme of other $DMUs$, we can compute the mean cross-efficiency score of DMU_k by the following formulation:

$$CEM_k^{Mean} = \sum_{j=1}^{n} \left(\sum_{r=1}^{s} u_{rj} y_{rk} \Big/ \sum_{i=1}^{m} v_{ij} x_{ik} \right) \Big/ (n-1), \quad j \neq k . \tag{a3}$$

Here, CEM_k^{Mean} becomes an index for effectively differentiating between good and poor performers. Thus, the performer of the $DMUs$ can be ranked based on mean cross-efficiency scores. Table A1 summaries a generalized CEM. The zth row and the kth column represent the efficiency measure of DMU k by the optimal weights for DMU z (E_{zk}).

As indicated by Baker and Talluri (1997), a limitation of the CEM evaluated from the classic DEA model is that input/output weights (optimal weights) obtained from this formulation may not be unique. This condition occurs if multiple optimum solutions exist, because one scheme can be favorable to one *DMU* and not favorable to another, or vice versa. Doyle and Green (1994) propose aggressive and benevolent formulations to solve this ambiguity. Doyle and Green not only maximize the efficiency of the target *DMU*, but also take a second goal into account. This second goal, in the case of aggressive formulation, minimizes the efficiency of the composite *DMU* constructed from $(n-1)$ *DMUs*. The outputs and inputs of a composite *DMU* are obtained by summing the corresponding outputs and inputs of all the other *DMUs* except the target *DMU*. The weights obtained from this formulation make the efficiency of the target *DMU* the best that it can be, and all other *DMUs* are the worst. Thus, the CEM in Eq. (a4), which is evaluated from these weights, is more meaningful.

The aggressive formulation is generally used when relative dominance among the *DMUs* is to be identified. The formulation is shown below:

$$
\begin{aligned}
& Min \quad \sum_{r=1}^{s} u_r \left(\sum_{j \neq k}^{n} y_{rj} \right) \\
& s.t. \\
& \quad \sum_{i=1}^{m} \left(v_i \sum_{j \neq k}^{n} x_{ij} \right) = 1, \\
& \quad \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, \quad \forall j \neq k, \\
& \quad \sum_{r=1}^{s} u_r y_{rk} - \theta_{kk} \sum_{i=1}^{m} v_i x_{ij} = 0, \\
& \quad v_i, u_r \geq 0, \quad \forall\ i \text{ and } r,
\end{aligned}
\tag{a4}
$$

where DMU_k is the target *DMU*, $\sum_{r=1}^{s} u_r \left(\sum_{j \neq k}^{n} y_{rj} \right)$ is the weighted output of composite *DMU*, $\sum_{i=1}^{m} \left(v_i \sum_{j \neq k}^{n} x_{ij} \right)$ is the weighted input of composite *DMU*, and θ_{kk} is the efficiency of DMU_k obtained from Eq. (1). The benevolent formulation uses the same set of constraints except that the efficiency of the composite DMU is maximized. As reported by Angulo-Meza and Lins (2002), these two formulations give very similar results, which is why only one of these formulation is used, generally the aggressive formulation.

A DMU potentially becomes as 'false positive' when it is exhibiting a high efficiency score by heavily weighting on a few favorable inputs and outputs. The self-appraisal and peer-appraisal are used in computing a false positive index (FPI) (Baker and Talluri, 1997). The FPI relates to the percentage increment in efficiency that a DMU achieves when moving from peer-appraisal to self-appraisal. This FPI is similar to the maverick index suggested by Doyle and Green (1994). It is calculated by using Eq. (a5). The higher the value of FPI_k is, the more 'false positive' the DMU_k will be. FPI is defined as:

$$FPI_k = \left(\theta_{kk} - CEM_k^{Mean}\right) / \left(CEM_k^{Mean}\right), \qquad \text{(a5)}$$

where θ_{kk} is the self-appraisal efficiency of DMU_k, and CEM_k^{Mean} is the mean cross-efficiency score of DMU_k.

Table B1 A Generalized Cross-Efficiency Matrix

Rating DMU	Rated DMU						
	1	2	3	$\cdots$	k	$\cdots$	n
1	E_{11}	E_{12}	E_{13}	$\cdots$	E_{1k}	$\cdots$	E_{1n}
2	E_{21}	E_{22}	E_{23}	$\cdots$	E_{2k}	$\cdots$	E_{2n}
3	E_{31}	E_{32}	E_{33}	$\cdots$	E_{3k}	$\cdots$	E_{3n}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\cdots$	$\vdots$	$\cdots$	$\vdots$
z	E_{z1}	E_{z2}	E_{z3}	$\cdots$	E_{zk}	$\cdots$	E_{zn}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\cdots$	$\vdots$	$\cdots$	$\vdots$
n	E_{n1}	E_{n2}	E_{n3}	$\cdots$	E_{nk}	$\cdots$	E_{nn}
CEM^{Mean}	$E_{\bullet 1}$	$E_{\bullet 2}$	$E_{\bullet 3}$	$\cdots$	$E_{\bullet k}$	$\cdots$	$E_{\bullet n}$

B.3 Infeasibility of Super-Efficiency Model (Seiford and Zhu, 1999)

Seiford and Zhu (1999) presents super efficiency VRS (SE-VRS) model. The SE-VRS model is based on based on a reference technology constructed from all other DMUs. The super efficiency of DMU k is evaluated by solving the LP problem below:

$$
\begin{aligned}
&\theta_k^* = Min \ \ \theta_k \\
&s.t. \\
&\quad \sum_{j=1, j \neq k}^{n} \lambda_j x_{ij} \leq \theta_k x_{ik}, \quad i = 1, \ldots, m, \\
&\quad \sum_{j=1, j \neq k}^{n} \lambda_j y_{rj} \geq y_{rk}, \quad r = 1, \ldots, s, \\
&\quad \sum_{j=1, j \neq k}^{n} \lambda_{\mathrm{j}} = 1 \\
&\quad \theta_k, \ \lambda_j \geq 0; \ \forall \ i \ and \ r; j = 1, \ldots, n,
\end{aligned}
\tag{a6}
$$

where θ_k^* is the optimal value for DMU k to the input-oriented SE-VRS model.

Thrall (1996) shows that the SE-CRS model can be infeasible. However, Thrall (1996) fails to recognize that the output-oriented SE-CRS model is always feasible for the trivial solution which has all variables set equal to zero. Moreover, Zhu (1996b) shows that the input-oriented SE-CRS model is infeasible if and only if a certain pattern of zero data occurs in the inputs and outputs. Figure A1 illustrates how the SE-VRS model works the infeasibility for the case of a single output and a single input case. We have three VRS frontier DMUs, *A, B, and C.* $\overline{AB}$ exhibits IRS and $\overline{BC}$ exhibits DRS. The SE-VRS model evaluates point *B* by reference to *B'* and *B"* on section $\overline{AC}$ through output-reduction and input-increment, respectively. In an input-oriented SE-VRS model, point *A* is evaluated against *A'*. However, there is no referent DMU for point *C* for input variations. Therefore, the input-oriented SE-VRS model is infeasible at point *C*. Similarly, in an output-oriented

SE-VRS model, point *C* is evaluated against *C'*. However, there is no referent DMU for point A for output variations. Therefore, the output-oriented SE-VRS model is infeasible at point *A*. Note that point A is the left most end point and point *B* is the right most end point on this frontier.

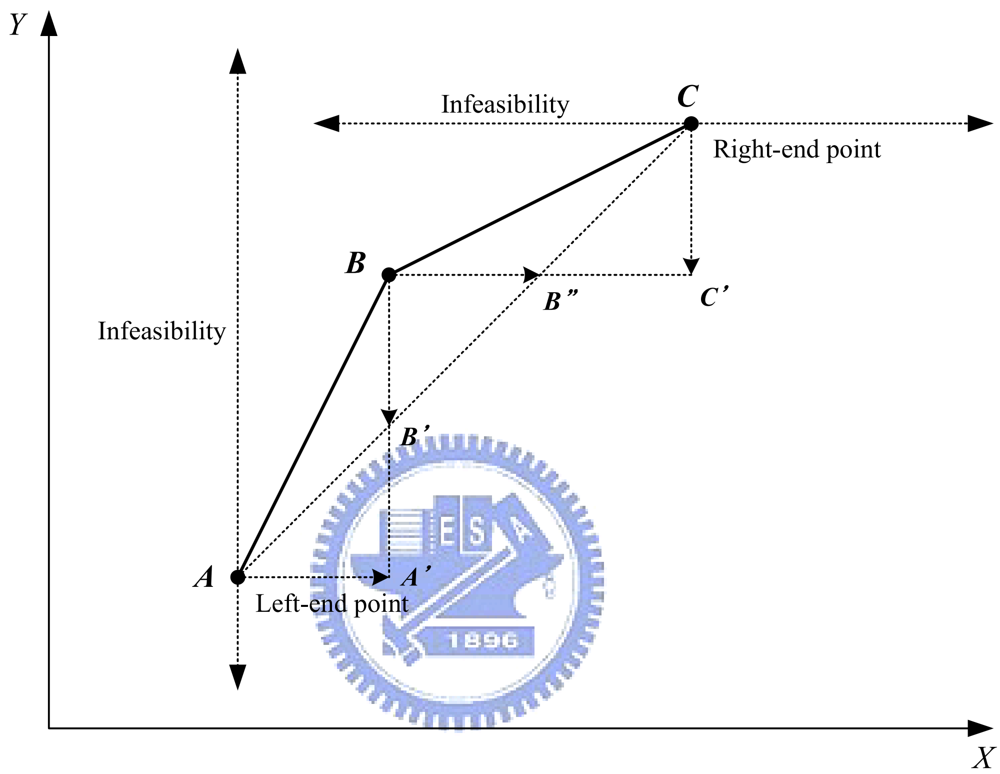

Figure B1 Infeasibility of Super-Efficiency Model

B.4 A Multiple Objective Approach (Li and Reeves, 1999)

Li and Reeves (1999) present a multiple objective approach that they called Multiple Criteria DEA – MCDEA, which focuses on solving two key problems: lack of discrimination and inappropriate weighting schemes. MCDEA introduces three objective functions into a LP problem. The first objective function seeks minimization of the inefficiency of a target DMU *k*, measured by d_k, such that the weighted sum of outputs is less than or equal to the weighted sum of inputs for each DMU. Thus, we can say that DMU *k* is not efficient its efficiency score would be $\theta_k = 1 - d_k$. The second objective function aims at the minimization of the maximum deviation, for which the restriction included in the new formulation, $M - d_i \geq k \;\; (i = 1, \ldots, n)$, makes *M* the maximum deviation. The third objective function seeks maximization of the deviation of all DMUs. All three objective functions are based on the deviation variable. The LP problem is as follows:

$$
\begin{aligned}
& Min\ d_k \ (\text{or } Max\ \theta_k = \sum_{r=1}^{s} u_r y_{rk}) \\
& Min\ M \\
& Min\ \sum_{j=1}^{n} d_i \\
& s.t. \\
& \sum_{i=1}^{m} v_i x_{io} = 1, \\
& \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + d_j = 0, \quad j = 1, \ldots, n, \\
& M - d_j \geq 0, \quad i = 1, \ldots, n, \\
& u_r,\ v_i \geq 0, \quad \forall\ r,\ i,\ and\ j.
\end{aligned}
\tag{a7}
$$

B.5 Non-Oriented Super-SBM model (Tone, 2002)

In most DEA models, the best performers share the full efficient status denoted by the score unity, and from experience we know that plural DMUs usually exist with this 'efficient' status. The Super-efficiency model discriminates these efficient DMUs. The basic concept is that we delete the efficient DMU concerned from the production possibility set (PPS) and measures the distance from the DMU to the remaining PPS. If the distance is small, then the super-efficiency of the DMU is judged to be lower as the DMU only marginally outperforms other DMUs. On the contrary, if the distance is large, then the super-efficiency of the DMU is high compared with the remaining DMUs. Hence, it makes sense to rank the efficient DMUs in the order of the distance thus obtained. The main problem is how to define the 'distance' between an efficient DMU and the PPS formed by excluding the DMU. The non-oriented super-SBM model (2002) is a well-known solution to evaluate the super-efficiency $DMU_o\left(x_{io}, y_{ro}\right)$ $(o = 1,\dots,n)$ by solving the following fractional program:

$$
\begin{aligned}
\text{Min} \quad & \eta_o = \left(\frac{1}{m}\sum_{i=1}^{m} \bar{x}_i / x_{io}\right) \Big/ \left(\frac{1}{s}\sum_{r=1}^{s} \bar{y}_r / y_{ro}\right) \\
s.t. \quad & \\
& \bar{x} \geq \sum_{j=1, j\neq o}^{n} x_{ij}\lambda_j, \quad i = 1,\dots,m, \\
& \bar{y} \leq \sum_{j=1, j\neq o}^{n} y_{ij}\lambda_j, \quad r = 1,\dots,s, \\
& \sum_{j=1}^{n} \lambda_j = 1, \\
& \bar{x} \geq x_{io}, \bar{y} \leq y_{ro}, \bar{y} \geq 0, \lambda_j \geq 0.
\end{aligned}
\tag{a8}
$$

The fractional program can be transformed into LPs. See Tone (2002) for detailed discussions.

B.6 Context-Dependent DEA (Seiford and Zhu, 2003)

DEA is a methodology for identifying the efficient frontier of DMUs. Context-dependent DEA refers to a DEA approach where a set of DMUs are evaluated against a particular evaluation context. Each evaluation context represents an efficient frontier composed by DMUs in a specific performance level. The context-dependent DEA measures (i) the attractiveness when DMUs exhibiting poorer performance are chosen as the evaluation context, and (ii) the progress when DMUs exhibiting better performance are chosen as the evaluation context. The Context-dependent DEA, by incorporating the stratification DEA method, attractiveness measure, and progress measure, can draw the DMUs' benchmark-learning roadmap to improve the inefficient DMUs progressively and to identify the best DMU.

B.6.1 Stratification DEA Method

The context-dependent DEA (Seiford and Zhu, 2003) is introduced as follows. Let $J^1 = \{DMU_j, j = 1,\ldots,n\}$ (the set of all n $DMUs$). Interactively define $J^{l+1} = J^l - E^l$, where $E^l = \{DMU_k \in J^l \,|\phi(l,k)\}$, and $\phi(l,k)$ is the optimal value to the following LP when DMU_k is under evaluation.

$$
\begin{aligned}
&\underset{\lambda_j,\phi(l,k)}{Min}\ \phi(l,k) \\
&s.t. \\
&\sum_{j\in F(J^l)} \lambda_j x_{ij} \le \phi(l,k)\, x_{ik}, \\
&\sum_{j\in F(J^l)} \lambda_j y_{rj} \ge y_{rk}, \\
&\phi(l,k),\ \lambda_j \ge 0;\ \forall\ i\ and\ r,\ j \in F(J^l),
\end{aligned}
\qquad \text{(a9)}
$$

where $j \in F(J^l)$ means $DMU_j \in J^l$, i.e., $F(.)$ represents the correspondence from a DMU set to the corresponding subscript index set. When $l=1$, Eq. (a9) becomes the original input-oriented CCR model, Eq. (4), and E^1 consists of all the frontier $DMUs$. These $DMUs$ in set E^1 define the first-level best-practice frontier. When $l=2$, Eq. (a9) gives the second-level best-practice frontier after the exclusion of the first-level frontier $DMUs$, and so on. In this manner we identify several levels of best-practice frontiers. We call E^l the lth-level best practice frontier. The following algorithm accomplishes the identification of these best-practice frontiers by Eq. (a9).

- Step 1: Set $l=1$. Evaluate the entire set of $DMUs$, J^1, by Eq. (a9) to obtain the first-level frontier $DMUs$, set E^1 (the first-level best-practice frontier).
- Step 2: Exclude the frontier $DMUs$ from future DEA runs. $J^{l+1}=J^l-E^l$. (If $J^{l+1}=\varnothing$, then stop).
- Step 3: Evaluate the new subset of 'inefficient' $DMUs$, J^{l+1}, by Eq. (a9) to obtain a new set of efficient $DMUs$, E^{l+1} (the new best-practice frontier).
- Step 4: Let $l=l+1$. Go to step 2.
- Stopping rule: $J^{l+1}=\varnothing$, the algorithm stops.

B.6.2 Attractiveness Measure

Based upon these evaluation contexts E^l ($l=1,\ldots,L-1$), we can obtain the relative attractiveness measure by the following LP:

$$H_q^*(d) = \underset{\lambda_j, H_q(d)}{Min} H_q(d), \quad d = 1,\ldots,L-l_o,$$

$$s.t.$$

$$\sum_{j \in F\left(E^{l_o+d}\right)} \lambda_j x_{ij} \le H_q(d) x_{iq}, \; i = 1,\ldots,m, \tag{a10}$$

$$\sum_{j \in F\left(E^{l_o+d}\right)} \lambda_j y_{rj} \ge y_{rq}, \qquad r = 1,\ldots,s,$$

$$H_q(d),\ \lambda_j \ge 0;\ \forall\ i\ and\ r,\ j \in F\left(E^{l_o+d}\right),$$

where $DMU_q = (x_{iq}, y_{rq})$ is from a specific level E^{l_o}, $l_o \in \{1,\ldots,L-1\}$. In Eq. (a10), each best-practice frontier of E^{l_o+d} represents an evaluation context for measuring the relative attractiveness of $DMUs$ in E^{l_o}. The larger the value of $H_q^*(d)$ is, the more attractive the DMU_q is. Because this DMU_q makes itself more distinctive from the evaluation context E^{l_o+d}, we are able to rank the $DMUs$ in E^{l_o} based upon their attractiveness scores and identify the best one.

B.6.3 Progress Measure

To obtain the progress measure for specific $DMU_q = (x_{iq}, y_{rq}) \in E^{lo}$, $l_o \in \{2,...,L\}$, we use the following LP:

$$G_q^*(g) = \underset{\lambda_j, G_q(g)}{Min} G_q(g), \quad g = 1,\ldots,l_o-1,$$

$$s.t.$$

$$\sum_{j \in F\left(E^{l_o-g}\right)} \lambda_j x_{ij} \le G_q(g) x_{iq}, \; i = 1,\ldots,m, \tag{a11}$$

$$\sum_{j \in F\left(E^{l_o-g}\right)} \lambda_j y_{rj} \ge y_{rq}, \qquad r = 1,\ldots,s,$$

$$G_q(g),\ \lambda_j \ge 0;\ \forall\ i\ and\ r,\ j \in F\left(E^{l_o-g}\right).$$

Each efficient frontier, E^{l_o-g}, contains a possible target for a specific DMU in E^{l_o} to improve its performance. The progress measure here is a level-by level improvement. For a larger $1/G_q^*(g)$, more progress is expected for DMU_q. Thus, a smaller value of $1/G_q^*(g)$ is preferred.

B.6.4 Attractiveness/Progress Cross-tabulation

In fact, for DMUs that are not located on the first or last level of efficient frontier, we can characterize their performance by their attractiveness and progress as shown in Figure A2 where the solid circle represents the DMU being evaluated. The most desirable category is the low progress − high attractiveness (LH) and the least desirable category is the high progress − low attractiveness (HL). A high progress indicates that the DMU needs to improve its outputs substantially, and a high attractiveness indicates that the DMU does not have any close competitors.

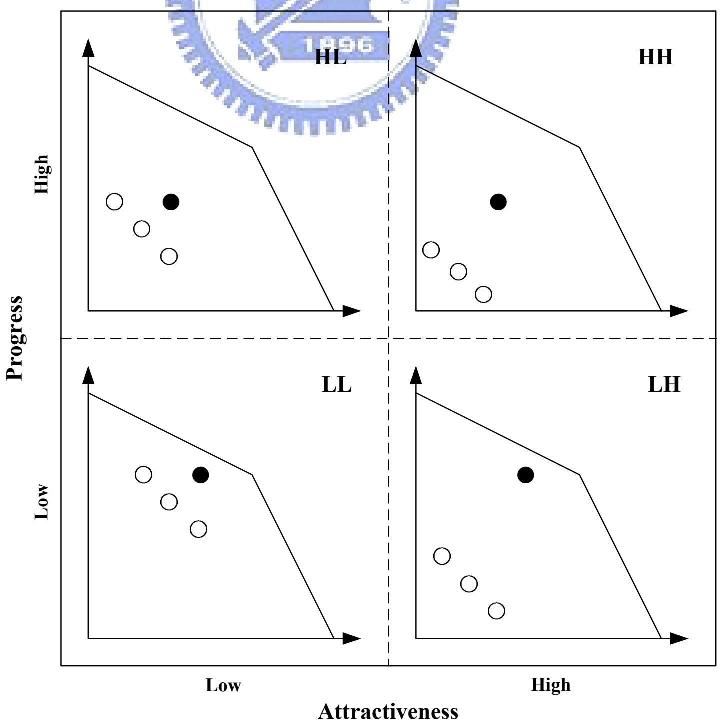

Figure B2 Attractiveness/Progress Cross-tabulation

簡　　歷

姓名：盧文民（Wen-Min Lu）

學歷：

Ph.D., Institute of Business and Management, National Chiao Tung University, 06/2006.

M.B.A., Graduate School of Defense Decision Sciences, National Defense Management College, National Defense University, 06/2000.

B.A., Department of Statistics, National Defense Management College, National Defense University, 11/1995.

著作：

1. Chyan Yang and Wen-Min Lu (2006), A Macro Analysis of Taiwan's International Tourist Hotel Industry by Using the Sliding Window Method, *Journal of the Operations Research Society of Japan*. (SCI, paper accepted).
2. Chyan Yang and Wen-Min Lu (2006), Assessing the Performance and Finding the Benchmarks of the Electricity Distribution Districts of Taiwan Power Company, *IEEE Transactions on Power Systems*. (SCI, paper accepted).
3. Chyan Yang, Tsung-Cheng Wang, and Wen-Min Lu (2006), Performance Measurement in Military Provisions: The Case of Retail Stores of Taiwan's General Welfare Service Ministry, *Asia-Pacific Journal of Operational Research*. (SCI, paper accepted).

Email: wenmin.lu@gmail.com