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Evaluating the Performances of Taiwan's International Tourist Hotels: Applying the Directional Distance Function and Meta-Frontier Approach

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Abstract: This study employs the directional distance function in the meta-frontier model by expanding outputs, contracting inputs, and fastening quasi-fixed inputs simultaneously on a dataset of 170 observations obtained from the annual reports of international tourist hotels. Empirical results show that the meta-efficiency and technology gap (TG) of foreign-owned hotels are better than those of domestic hotels. In addition, employees of foreign-owned hotels are more productive than those of domestic hotels. The findings imply that Taiwan's tourist hotels should structure a plan to augment their operating scales.

Keywords: International tourist hotel; DEA; directional distance function; meta-frontier; quasi-fixed inputs

1. Introduction

The tourism industry combines various related industries, including food and beverage, hotel, airline, and ground transportation. Therefore, a boost to the tourism industry can help promote all of these related industries, increase consumption, and lead to a rise in the economy. The positive benefits to a country include greater employment opportunities and the earning of more foreign exchange. In addition, hotel businesses can offer various services to visitors, such as accommodation, catering, entertainment, information, and shopping. Thus, utilizing an appropriate way to evaluate the performance of international tourist hotels can offer a good indicator of the development level of tourism in a country.

Data envelopment analysis (DEA) is widely used to measure the performance of the hotel industry [1–3]. These studies assume that all hotels share the same production frontier, i.e., they have the same technology set. However, different types of tourist hotels (for instance, domestic hotels and international chain hotels) may have distinct production frontiers because of different national cultures, operational philosophies, and managerial modes [4]. Our study adopts the meta-frontier approach to accommodate the sample hotels that have different production frontiers.

Conventional DEA models can only consider output expansion or input contraction but not both. Moreover, when the technology set is characterized by variable returns to scale (VRS), both output-oriented and input-oriented technical efficiencies are not generally equal. If we evaluate the efficiency of a tourist hotel by the output-oriented approach, then we may not fully characterize its operational management since it is unable to distinguish between quasi-fixed inputs (such as



the number of rooms and floor space) and variable inputs. On the other hand, the approach may overestimate the ability for adjustment by hotel management if the input-oriented model ignores the existence of quasi-fixed inputs [5]. Furthermore, the objective of tourist hotels is to expand outputs rather than to contract inputs. Hence, it is inappropriate to evaluate hotels' efficiency by ignoring output expansion. The directional distance function, proposed by Färe and Grosskopf [6] and capable of expanding outputs and contracting inputs simultaneously, can fulfill the demand of this study. Therefore, this study modifies the directional distance function in the meta-frontier model in order to consider expanding outputs, contracting inputs, and fixed quasi-fixed inputs in the short-run. In addition, quasi-fixed inputs can be adjusted in the long run, and thus we offer different strategies and analysis over different periods.

This paper is organized as follows. Following this introduction, Section 2 is the literature review. Section 3 describes the methodology. Section 4 consists of data sources, empirical results, and a discussion. Section 5 concludes this paper.

2. Literature Review

Unlike manufacturing products that could be inventoried for future use, the inseparability of services requires the presence and involvement of providers and customers [7,8]. Since there are no buffer inventories of service to smooth out any imbalances between capacity and demand, demand uncertainty affects the performance of the hotel industry severely. To avoid a suboptimum period of over- or under-capacity, the service industry has to pay considerable attention to harmonizing the timing of capacity and demand [8]. Holthausen [9] claimed that demand uncertainty is positively related to the capacity expansion decision of firms. Abel [10] also indicated that uncertain demand leads to greater capital investment. In other words, demand uncertainty may result in an overcapacity problem, which is empirically supported by Lee and Jang [11] and Chen and Lin [12] in the U.S. and Taiwan hotel industries, respectively. Chen and Yeh [13] argued that demand uncertainty may increase the chance of hotel failure.

Constrained by different resources and operating restrictions, various operating modes of tourist hotels likely have different capabilities for bearing the risk generated from demand uncertainty. By joining a hotel chain system, tourist hotels can immediately gain a better reputation and brand image. In addition, they gradually benefit from management knowledge transfer and learning from the parent chain organization through Internet marketing, a global reservation system, economies of scale, promotional assistance, marketing research, employee training, and so on [14–21]. Hence, chain hotels can carry more business capital and bear a higher risk of demand uncertainty. On the contrary, independent hotels, due to insufficient resources, have a lower level of capability to bear risks. In addition, demand uncertainty might lead to overcapacity for tourist hotels [11] and thus increase the possibility of operational failure [13]. Hence, effective strategies to decrease demand uncertainty should be different between independent and chain hotels, and thus, both types of hotels should have distinctive efficiency frontiers.

3. Methodology

Conventional DEA models can only consider output expansion or input contraction, but not both. For the hotel industry, the output-oriented approach cannot distinguish between quasi-fixed inputs and variable inputs, while the input-oriented model ignores the existence of quasi-fixed inputs [5]. Moreover, the primary goal of tourist hotels is to expand outputs rather than to contract inputs. The directional distance function, capable of expanding outputs and contracting inputs simultaneously, can fulfill the requirements of this study. In addition, because they may have different national cultures, operational philosophies, and managerial modes, different types of tourist hotels (for instance, domestic hotels and international chain hotels) should thus own different efficiency frontiers [4]. A meta-frontier approach is able to measure efficiencies of decision making units (DMUs) associated with distinctive technologies.

3.1. Directional Distance Function

Suppose that there are *H* DMUs. Each DMU employs *N* variable inputs $x = (x_1, ..., x_N) \in \mathfrak{R}^N_+$ and *I* quasi-fixed inputs $k = (k_1, ..., k_I) \in \mathfrak{R}^I_+$ to produce *P* outputs $y = (y_1, ..., y_P) \in \mathfrak{R}^P_+$. The modified directional distance production is defined as:

$$\vec{D}(\underbrace{x,k,y}_{\sim};-\underset{\sim}{g},\underset{\sim}{g}) = \sup\left\{\beta:(\underbrace{x-\beta g}_{\sim x},\underbrace{k,y+\beta g}_{\sim y}) \in T\right\},\tag{1}$$

where $T = \left\{ \begin{pmatrix} x, k, y \\ \ddots \end{pmatrix} : \begin{array}{c} x \\ \sim \end{array}$ and $\begin{array}{c} k \\ \sim \end{array}$ can produce $\begin{array}{c} y \\ \sim \end{array} \right\}$ is the technology set. Equation (1) searches for the largest feasible expansion of output vector y in the $g \\ \sim y$ direction and the largest feasible contraction of input vector x in the $-g \\ \sim y$ direction. Note that we treat quasi-fixed input vector $\begin{array}{c} k \\ \sim \end{array}$ as fixed. This specification not only can characterize the property of quasi-fixed inputs in the operational management of hotels, but also satisfy the request of output expansion. Let $\hat{\beta}$ be the optimal value of Equation (1). An efficient DMU corresponds to $\hat{\beta} = 0$. In other words, the technology frontier is constructed by those DMUs associated with $\hat{\beta} = 0$. Hence, the larger the value $\hat{\beta}$ is, the farther the DMU is from the frontier.

3.2. Meta-Frontier Approach

The production possibility set T in the DEA models is generally assumed to be convex, i.e., all DMUs belong to a single operating system. Due to different national cultures, operational philosophies, managerial modes, etc., domestic and foreign-owned hotels distinctly belong to different operating systems and thus the assumption of convexity may not be valid. The meta-frontier approach allows each group to have its own group-frontier. The meta-frontier is defined as a common boundary that envelops the group frontiers. The technology set associated with the meta-frontier could be convex or non-convex. We illustrate this by Figure 1.



Figure 1. Illustration of the technology set associated with the meta-frontier.

Assume that there are two groups, A and B. The frontier of group A is the line segment connecting A1, A2, G, and A3. Similarly, the frontier of group B consists of points B1, G, B2, and B3. If the technology set is non-convex, then the relevant meta-frontier is the line segment connecting A1, A2, G, B2, and B3. It is apparent that each part of the meta-frontier belongs to at least one of the group-frontiers. If the technology set is convex, then the relevant meta-frontier is the line segment connecting A1, A2, G, B2, and B3. Convexity allows for input–output combinations beyond the boundaries of group-frontiers, such as the dot line connecting A2 and B2. It may imply that existing technology can upgrade through spillover and/or mutually learning among the groups for a considerable period. In this sense, the non-convex meta-frontier is suitable for analyzing efficiency in the short run, while the convex meta-frontier may be appropriate for analysis in the long run. We also follow the basic assumption that the quasi-fixed inputs cannot be adjusted in the short run, but they are variable in the long run.

We now describe how to incorporate the directional distance function in the meta-frontier approach. Let T^m be the meta-technology set that envelopes the G group frontiers such that $T^m = T^1 \cup T^2 \cup ... \cup T^G$, where T^g is the technology set of group g, g = 1, 2, ..., G. The directional distance function relative to the meta-technology set can be expressed as:

$$\overrightarrow{D}^{m}(\underset{\sim}{x},\underset{\sim}{k},\underset{\sim}{y};-\underset{\sim}{g},\underset{\sim}{g}) = \sup\left\{\beta:(\underset{\sim}{x}-\beta\underset{\sim}{g},\underset{\sim}{k},\underset{\sim}{y}+\beta\underset{\sim}{g}) \in T^{m}\right\}.$$
(2)

The directional distance function relative to the technology set of group *g* can be defined as:

$$\overrightarrow{D}^{g}(\underset{\sim}{x},\underset{\sim}{k},\underset{\sim}{y};-\underset{\sim}{g},\underset{\sim}{g}) = \sup\left\{\beta:(\underset{\sim}{x}-\beta\underset{\sim}{g},\underset{\sim}{k},\underset{\sim}{y}+\beta\underset{\sim}{g})\in T^{g}\right\}.$$
(3)

This study applies the following approach to calculate the direction distance function for the non-convex meta-technology set: (1) calculate the direction distance function of each DMU based on the efficient frontier of group g, say $\hat{\beta}_g$, g = 1, 2, ..., G; (2) the relevant value of the direction distance function $\hat{\beta}^m$ for each DMU is the maximum of $\{\hat{\beta}_1, \hat{\beta}_2, ..., \hat{\beta}_G\}$, i.e., $\hat{\beta}^m = \{\hat{\beta}_1, \hat{\beta}_2, ..., \hat{\beta}_G\}$. For G = 2, we write the linear programming of DMU j under VRS as:

$$\vec{D}(\underbrace{x,k,y;-g}_{\sim},\underbrace{g}_{\sim},\underbrace{g}_{\gamma}) = \max_{\beta_j,\lambda_1,\dots,\lambda_H} \beta_j + \varepsilon \left(\sum_{n=1}^N S_n^- + \sum_{p=1}^P S_p^+\right)$$
(4a)

s.t.
$$\sum_{h \in A} \lambda_h x_{nh} + \sum_{h \in B} \lambda_h x_{nh} + S_n^- = x_{nj} - \beta_j g_{nx}, \quad n = 1, \dots, N$$
 (4b)

$$\sum_{h \in A} \lambda_h y_{ph} + \sum_{h \in B} \lambda_h y_{ph} - S_p^+ = y_{pj} + \beta_j g_{py}, \qquad p = 1, \dots, P$$
(4c)

$$\sum_{h \in A} \lambda_h k_{ih} + \sum_{h \in B} \lambda_h k_{ih} \le k_{ij}, \qquad i = 1, \dots, I$$
(4d)

$$\sum_{h \in A} \lambda_h = Z_A \tag{4e}$$

$$\sum_{h \in B} \lambda_h = Z_B \tag{4f}$$

$$Z_A + Z_B = 1 \tag{4g}$$

$$Z_A, Z_B = 0$$
 or 1; $\lambda_1, \ldots, \lambda_H \ge 0; \beta$ is free

Here, S_p^+ and S_n^- are the non-radial p^{th} output slack and the n^{th} input slack, respectively; ε is a small non-Archimedean quantity, usually 10^{-6} . The first constraint labeled (4b) seeks the largest contraction of the n^{th} variable input in the direction g_{nx} . The constraints in (4c) search for the largest expansion of the p^{th} output in the direction g_{py} . Expression (4d) holds the quasi-fixed inputs to be fixed in the short run. Constraints (4e) to (4g) ensure the technology is VRS.

The non-convex meta-technology set is only suitable for analysis of the short run. We thus employ the convex meta-technology set to analyze the efficiency in the long run. In addition, we assume that

the quasi-fixed inputs can be adjusted in the long run, so that all inputs are variable. The corresponding linear programming is:

$$\vec{D}(\underbrace{x,k,y;-g}_{\sim_{x},\sim_{y}}, \underbrace{g}_{\sim_{y},\sim_{y}}) = \underset{\beta_{j},\lambda_{1},\dots,\lambda_{H}}{\operatorname{Max}} \qquad \beta_{j} + \varepsilon \left(\sum_{n=1}^{N} S_{n}^{-} + \sum_{i=1}^{I} S_{i}^{-} + \sum_{p=1}^{P} S_{p}^{+} \right) \\
s.t. \qquad \sum_{h=1}^{H} \lambda_{h} x_{nh} + S_{n}^{-} = x_{nj} - \beta_{j} g_{nx}, n = 1,\dots,N \\
\sum_{h=1}^{H} \lambda_{h} y_{ph} - S_{p}^{+} = y_{pj} + \beta_{j} g_{py}, p = 1,\dots,P \\
\sum_{h=1}^{H} \lambda_{h} k_{ih} + S_{i}^{-} = k_{ij} - \beta_{j} g_{ik}, \qquad i = 1,\dots,I \\
\sum_{h=1}^{H} \lambda_{h} = 1 \\
\lambda_{1},\dots,\lambda_{H} \ge 0; \qquad \beta \text{ is free}$$
(5)

The meta-technology can be viewed as true technology, while the group-technologies are regarded as revealed technology. In other words, we measure the group-efficiency based on the revealed technology and evaluate the meta-efficiency based on the true technology. Hence, each DMU can generate two directional distance functions: one based on the meta-technology $\hat{\beta}^m$ and the other on the group-technology $\hat{\beta}$. The difference between these two values is the technology gap (TG), measuring the distance between the group-frontier and the meta-frontier, i.e., $\hat{\beta}^m = \hat{\beta} + TG$. Figure 2 explains this relation.



Figure 2. Illustration of meta-efficiency and the technology gap.

Consider point A inside the technology set. The directional distance function $\overrightarrow{D}^g(\cdot)$ moves the input–output vector (x, y) to the frontier of group g at point \hat{A} , $(x - \hat{\beta}g_x, y + \hat{\beta}g_y)$, along the direction $(-g_x, g_y)$. Similarly, the directional distance function $\overrightarrow{D}^m(\cdot)$ projects point A to the meta-frontier at point A^{*}, $(x - \hat{\beta}^m g_x, y + \hat{\beta}^m(\cdot)g_y)$, along the direction $(-g_x, g_y)$. We can imagine that TG is able to translate point \hat{A} on the group-frontier to the meta-frontier at point $((x - \hat{\beta}g_x) - TGg_x, (y + \hat{\beta}g_y) + TGg_y)$ along the direction $(-g_x, g_y)$. However, both points A^{*} and $((x - \hat{\beta}g_x) - TGg_x, (y + \hat{\beta}g_y) + TGg_y)$ are the same. Hence, we obtain $\hat{\beta}^m = \hat{\beta} + TG$.

4. Empirical Analysis

4.1. Data and Input–Output Variables

The dataset, obtained from the annual reports of international tourist hotels published by the Taiwan Tourism Bureau (TTB) for 2005–2007, consisted of 170 observations. Since we had three years of data, all nominal variables were transformed into real variables into 2001 prices by GDP deflators. Following previous studies, we chose four inputs and 3 outputs. The two variable inputs were catering expense and number of employees. Both the number of guest rooms and total floor space of the catering division were treated as quasi-fixed inputs. The variable inputs could be adjusted in both the short run and the long run, while the quasi-fixed inputs could only vary in the long run and were regarded as fixed in the short run. There were three output variables: room revenue, catering revenue, and other revenue. According to the annual reports of international tourist hotels in Taiwan, accommodation and catering incomes were their two primary sources of revenues. Other revenue, accounting for about 20% of total revenue, included laundry operations, beauty salons, nightclubs, service fees, and so on. The summary statistics of inputs and outputs used in the analysis are reported in Table 1.

Variable	Mean	Std. Dev.	Minimum	Maximum
Number of employees	318.041	206.137	53.000	982.000
Catering expense	110.265	104.368	3.722	754.364
Number of guest rooms	305.406	152.619	50.000	873.000
Floor space of catering division	1179.988	906.517	48.000	4777.000
Room revenue	270.720	240.019	35.643	1482.742
Catering revenue	281.599	273.427	8.730	1174.773
Other revenue	95.877	123.291	0.360	595.754

Table 1.	Statistics	of the	Variables	(NT\$ million)
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4.2. Empirical Results

We first investigated whether or not the efficient frontiers of both groups, domestic and foreign-owned tourist hotels in Taiwan, were significantly different from each other in order to select an appropriate empirical model. To compare the efficient frontier of two groups, it was natural to run the DEA model separately in each group and obtain the efficient DMUs of each group. Next, we mixed all efficient DMUs together to run the DEA model again and perform the non-parametric test, but this procedure excluded a lot of inefficient DMUs and resulted in the problem of degrees of freedom. Cooper et al. [22] suggested replacing each inefficient DMU by its corresponding projection point on its respective efficient frontier to avoid this problem.

Figure 3 is used to describe this procedure. The efficient frontier of domestic hotels consisted of points A, C, and E. We projected the inefficient point B, D, F, and G onto the efficient frontier of domestic hotels to obtain points B*, D*, F*, and G*, respectively. Hence, the efficient DMUs of domestic hotels were A, B*, C, D*, E, F*, and G*. Similarly, we could get the efficient DMUs of foreign-owned hotels. All efficient DMUs were pooled together to run the DEA model. The non-parametric Mann–Whitney U test, based on the ranking of DEA results, was employed to test the hypothesis that both groups, domestic and foreign-owned tourist hotels, had the same efficient frontiers. The test statistic indicated that the efficient frontiers of both types of hotels were significantly different with a *p*-value of 0.027. Hence, this study used the meta-frontier approach to evaluate efficiencies of domestic and foreign-owned tourist hotels.



Figure 3. Projection on the Efficient Frontier.

4.2.1. Short-Run Analysis

Table 2 summarizes the empirical results of the non-convex meta-frontier model. The average meta-efficiency scores $\hat{\beta}^m$ of domestic and foreign-owned hotels were 0.111 and 0.061, respectively, which suggests that foreign-owned hotels were more efficient than domestic hotels. Nevertheless, we needed to perform a test to investigate whether these two meta-efficiency scores were significantly different or not. The non-parametric Mann-Whitney U test statistic indicated that foreign-owned hotels outperformed domestic hotels significantly with a *p*-value of less than 0.001.

The average values of TG for domestic and foreign-owned hotels were 0.111 and 0.061, respectively. The non-parametric Mann–Whitney U test demonstrated that both average values were significantly different, with a *p*-value of 0.005. Hence, the technology of foreign-owned hotels was significantly superior to that of domestic hotels. Furthermore, group-efficiency scores $\hat{\beta}$ could not be compared directly since different groups faced different technology sets (or frontiers). However, the value could be viewed as a measure for the spread of group efficiency [23]. In other words, the group with a better value of $\hat{\beta}$ may have indicated that its DMUs operated under similar conditions. Empirical results suggested that the operating conditions of foreign-owned hotels were more homogenous than those of domestic hotels.

Indicator	Classification	Sample Size	Mean	Std. Dev.	Minimum	Maximum
ô	Domestic	113	0.091	0.113	0	0.467
Р	Foreign-owned	51	0.054	0.068	0	0.382
	Domestic	113	0.111	0.010	0	0.467
\hat{eta}^m	Foreign-owned	57	0.061	0.015	0	0.703
	Total	170	0.094	0.009	0	0.703
	Domestic	113	0.023	0.003	0	0.127
TG	Foreign-owned	57	0.019	0.008	0	0.321
	Total	170	0.022	0.003	0	0.321

Table 2. Empirical Results of the Non-Convex Meta-Frontier Model.

Note: The *p*-values of the Mann–Whitney U test for technology gap (TG) and $\hat{\beta}^m$ are 0.005 and less than 0.001, respectively.

4.2.2. Long-Run Analysis

Firms generally operate in the short run and plan strategy for the long run. A firm has enough time to adjust its operating scale and/or to adopt different technologies in the long run. Hence, we

used a convex meta-frontier approach with inputs to be all variables so as to find appropriate planning strategies. Table 3 shows the summary of the convex meta-frontier model. The empirical results were basically similar to the non-convex meta-frontier model.

Indicator	Classification	Sample Size	Mean	Std. Dev.	Minimum	Maximum
â	Domestic	113	0.088	0.109	0	0.419
Р	Foreign-Owned	57	0.042	0.065	0	0.382
	Domestic	113	0.121	0.010	0	0.448
\hat{eta}^m	Foreign-Owned	57	0.065	0.012	0	0.515
	Total	170	0.102	0.008	0	0.515
	Domestic	113	0.032	0.003	0	0.122
TG	Foreign-Owned	57	0.024	0.005	0	0.212
	Total	170	0.030	0.002	0	0.212

Table 3. Empirical results of the Convex Meta-Frontier Model.

Note: The *p*-values of the Mann–Whitney U test for TG and $\hat{\beta}^m$ are 0.016 and less than 0.001, respectively.

We summarized the characteristics of returns to scale, as seen in Table 4. The characteristics of returns to scale showed that about 70% of tourist hotels were operating in the stage of increasing returns to scale. Hence, Taiwan's tourist hotels structure their design to augment the operating scales in order to improve their productivity.

Table 4. Summary of Returns to Scale (RS).

Types of Hotels	Decreasing RS	Constant RS	Increasing RS
Domestic Hotels	0.133	0.124	0.713
Foreign-Owned Hotels	0.176	0.105	0.719

5. Discussion

In Table 5 the results show that the performance of urban hotels was better than that of leisure hotels. The *p*-values of the Mann–Whitney test for TG and $\hat{\beta}^m$ were 0.016 and <0.001, respectively. Therefore, we know that the development of the tourism industry in Taiwan is not mature enough. The urban hotels outperformed the leisure ones, suggesting that Taiwan should do more marketing and promotion of the leisure tourism, which would help enhance the leisure hotels' operating efficiencies.

Indicator	Classification	Sample Size	Mean	Std. Dev.	Minimum	Maximum
	Urban	124	0.100	0.008	0.000	0.463
$\hat{\beta}^m$	Leisure	46	0.101	0.022	0.000	0.702
,	Sum	170	0.100	0.008	0.000	0.702
	Urban	124	0.000	0.000	0.000	0.000
TG	Leisure	46	0.055	0.016	0.000	0.660
	Sum	170	0.015	0.004	0.000	0.660

Table 5. Efficiency Indicator of Urban and Rural Hotels.

With the issue of environmental protection being taken more seriously by the world, tourism, as a so-called non-chimney industry, is highly respected. The production process of the tourism industry brings much less environmental pollution versus manufacturing industries. International tourist hotels are one of the key factors to successfully boost the tourism industry. An appropriate way to evaluate the performance of international tourist hotels can offer a good indicator of the development level of a country's tourism.

Slack analysis can be used to measure output expansion and variable inputs' contraction. Table 6 gives the proportions of output expansion and input contraction. The proportions are the sum of radio and non-radio slack divided by the current amount of variables. Both groups have to reduce similar proportions of catering expense. However, the proportion of excess employees at domestic hotels is double that at foreign-owned hotels. This suggests that domestic hotels have too many unnecessary employees and/or lower labor productivity. Theses might result from those constrained by different resources and operating restrictions; various operating modes of tourist hotels likely have different capabilities for bearing the risk generated from demand uncertainty. By joining a hotel chain system, tourist hotels can immediately gain a better reputation and brand image. In addition, they gradually benefit from management knowledge transfer and learning from the parent chain organization through Internet marketing, a global reservation system, economies of scale, promotional assistance, marketing research, employee training, and so on [15,19,21]. Hence, chain hotels can carry more business capital and bear a higher risk of demand uncertainty, and thus be able to absorb more employees.

For the part of output slack, domestic hotels also have to expand the large proportion of room and food revenues, compared with foreign-owned hotels. In general, foreign-owned hotels have a better brand awareness and can offer a wide variety of catering service, and so they have less output slack. Empirical results provide guidelines to managers of domestic hotels to set their operational strategies. In the short run, domestic hotels can hire employees who have job experiences at foreign-owned hotels, which should help upgrade labor productivity. Domestic hotels can also focus on marketing and promotion of the catering sector to provide differentiated service.

Types of Hotels	Number of Employees	Catering Expense	Room Revenue	Catering Revenues	Other Revenues
Domestic	0.159	0.120	0.239	0.099	0.484
Foreign-Owned	0.078	0.121	0.092	0.047	0.272

Table 6. Summary of Output and Variable Input Slack.

Note: The values are the sum of radio and non-radio slack divided by the current amount of variables.

5.2. Long-Run Strategy

A long-term strategy can be developed by the scale analysis of hotels. We summarize the characteristic of returns to scale in Table 7, which shows that about 70% of tourist hotels are operating at the stage of increasing returns to scale. Hence, Taiwan's tourist hotels should set up a design to augment the operating scales in order to improve their productivity.

Fable 7. Summary of Returns to Scale (R
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Types of Hotels	Decreasing RS	Constant RS	Increasing RS
Domestic Hotels	0.133	0.124	0.713
Foreign-Owned Hotels	0.176	0.105	0.719

Foreign-owned hotels have the best performance on average whether in the long or short run. A possible reason for this result is that foreign-owned hotels adopt international management systems, train human resources, promote managerial capacities, share knowledge assets, and benefit from economies of scale. From an international network they can cumulate the learning experiences of operating under different countries. They also have a better brand image and reputation, share reservation systems and information so that they can provide better quality of customer service, and have more foreign visitors [14,24].

The managers of domestic hotels can thus participate in international exhibitions, such as the International Travel Expo Hong Kong (ITE), to promote their own hotels and link to the international network. They also can join an international hotel association (i.e., the Leading Hotels of the World). Their service quality will be monitored, and their information will be shared, so that the operating efficiency may become better than others. Moreover, according to the result of environment analysis, Taiwan's government should continue to improve the development of tourist attractions and promote the country's tourism aspects to the world.

6. Conclusions

DEA is widely used to measure the performance of the hotel industry. Previous studies assume that all hotels share the same production frontier, i.e., they have the same technology set. However, different types of tourist hotels may have distinct production frontiers because of different national cultures, operational philosophies, managerial modes, etc. In addition, previous studies of hotel performance neglected the quasi-fixed inputs that may overstate firms' capabilities for adjustment. Hence, this study modifies the directional distance function in the meta-frontier model in order to consider expanding outputs, contracting inputs, and fixed quasi-fixed inputs in the short-run. Moreover, we consider that all inputs can be adjusted in the long run, and thus offer different strategies and analysis over different periods.

The dataset, obtained from the annual reports of international tourist hotels, consists of 170 observations. Empirical results show that the efficient frontiers of both domestic and foreign-owned tourist hotels are significantly different with a *p*-value of 0.027, and thus we should use the meta-frontier approach to analyze the operational efficiency of tourist hotels. Other empirical findings include: (1) the meta-efficiency and technology gap (TG) of foreign-owned hotels are better than those of domestic hotels; (2) employees of foreign-owned hotels are more productive than those of domestic hotels; and (3) Taiwan's tourist hotels should set up plans to augment their operating scales.

This study assumed the production to be variable returns to scale. If the production exhibits constant returns to scale globally, the method we used is inefficient [25]. Future studies can use the bootstrap estimation procedures, proposed by Simar and Wilson [25], to test returns to scale of the tourist hotels. Furthermore, the meta-frontier approach cannot only analyze the operational efficiency of the hotel industry, but also examine the performance of different operational types of commercial banks, different developing levels of regions, and so on. In addition, the directional distance function is useful to evaluate DMUs associated with undesirable outputs such as air pollution and non-performing loans.

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