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Regional hotel performance and benchmarking in the Pearl River Delta: An input and output efficiency analysis

Abstract

Purpose – This study models cost efficiency against revenue for hotels in the Pearl River Delta (PRD)—in Guangzhou, Hong Kong, and Macau—by considering regional differences and weight restrictions on revenue output.

Methodology – We modified and applied a context-dependent assurance region data envelopment analysis (CAR-DEA) model in assessing the performance of 41 hotels in the PRD. The model considers the relationships among output variables and sets the revenue composition of the hotels as weight restrictions in accounting for the relative importance of different revenue sources.

Findings – (1) When assessing the 41 hotels all together, those in Guangzhou outperformed the other two cities by showing better pure technical efficiency, while those in Macau had the best scale efficiency. (2) When the assurance region restriction was imposed, the hotels in Macau outperformed those of the other two cities by showing better scale efficiency. (3) When considering regional differences, the Macau hotels ranked first in terms of both the average efficiency score and the overall ranking. (4) All the sample hotels in Guangzhou and half of the sample hotels in Hong Kong and Macau exhibited increasing, constant, and decreasing returns to scale, respectively.

Research limitations – The research results are limited by data quality and the variables included in the models.

Practical implications – The study helps hotel practitioners in the PRD better assess their cost efficiency performance by considering regional differences and operational parameters so as to strategically improve their performance.

Originality/value – Our study improves upon previous hotel efficiency studies by considering the influence of different operational parameters across different localities. It can be extended to examine the performance of different calibers of hotels, restaurants, or tourism entities located in various localities and possessing different operational characteristics.

Keywords – data envelopment analysis (DEA); efficiency; performance; benchmarking; Pearl River Delta (PRD)

Introduction

Tourism in the Pearl River Delta (PRD) in southern China, particularly in Guangzhou, Hong Kong, and Macau, has seen tremendous growth. In 2014, visitor arrivals to Hong Kong reached 60.84 million, with 45.6% staying overnight (Hong Kong Tourism Board; HKTB, 2015a). Macau also attracted a record high of 31.53 million visitors with 46% staying overnight (Statistics and Census Service of Macau, 2015). Growth in tourism directly benefits hotels because they provide accommodation to visitors. Hong Kong hotels' recent performance has been impressive, with operating income doubling to HKD 40.8 billion from 2009 to 2013. Hotels in Guangzhou and Macau earned HKD 64.6 billion and HKD 24.6 billion, respectively, in operating income in 2013 (Guangzhou Bureau of Statistics, 2015; Statistics and Census Service of Macau, 2015). Competition in the PRD's tourism and hotel industries—and their development—is becoming fiercer, due in part to supportive, tourism-friendly policies and the expected benefits resulting from the Hong Kong–Zhuhai–Macau Bridge to be completed in 2017. An assessment of regional hotel performance is of critical importance for the sustainable industrial development of the hotel industry in the PRD (Long *et al.*, 2016).

From the supply perspective, in 2013 there were 227 star-rated hotels in Guangzhou, 225 in Hong Kong, and 65 in Macau. Between 2009 and 2013, the average growth rates of hotel guestroom inventory in Guangzhou, Hong Kong, and Macau were 5.34%, 4.18%, and 10.49%, respectively (Guangzhou Bureau of Statistics, 2015; HKTD, 2015b; Statistics and Census Service of Macau, 2015). While ongoing hotel investments in these cities provide a greater number and variety of accommodation options to leisure and business tourists alike, the large supply of guestroom inventory could pose a threat to hotels, due to intense competition in the market (Hsu and Gu, 2010). If these fixed asset investments are not utilized well in terms of producing expected returns, they could become redundant resources (Madanoglu and Ozdemir, 2016).

From the demand perspective, between 2009 and 2013, the average occupancy percentages of hotels in Guangzhou, Hong Kong, and Macau were 63.20%, 86.40%, and 85.48%, respectively, and the average daily rates (ADRs) were HKD 477, HKD 1,274, and HKD 1,229, respectively (Guangzhou Bureau of Statistics, 2015; HKTB, 2015b; Statistics and Census Service of Macau, 2015). While occupancy percentage and ADR (and revenue per available room, or RevPAR) are the most commonly used singular key performance indicators (KPIs) in measuring operation outcomes (Wayne *et al.*, 2008), they cannot fully reflect hotel performance (Enz *et al.*, 2001) due to their deficiency in revealing hidden information regarding the efficiency of hotels' resource utilization (Tsai *et al.*, 2011). For example, while the ADRs in Hong Kong and Macau were higher than those in Guangzhou, the higher ADRs came at the expense of higher operational costs (Hanson *et al.*, 2009). In optimizing profitability, a more comprehensive examination of hotel performance in the PRD is needed to better inform industry stakeholders' strategic decision making.

As constituents within the PRD, Guangzhou, Hong Kong, and Macau play major roles in demonstrating how regional economic growth can be achieved in southern China's development (Yeung, 2014). However, hotels in these three cities are characterized by somewhat different operating environments, which should be taken into consideration when their performance is assessed. In this study, we aim to assess the performances of hotels in the three cities, and identify common benchmarks by considering regional differences. We first investigate the performance, in terms of efficiency, of hotels in Guangzhou, Hong Kong, and Macau all together by employing data envelopment analysis (DEA). Second, we modify the DEA model by imposing context-dependent assurance region (CAR) restrictions on output weights to account for regional differences. Third, we compare the results of the performance assessment between the DEA models with assurance region (AR) and CAR restrictions. Common benchmark hotels can then be identified for hotels in the PRD.

Literature review

Assessment of hotel performance

Previous studies assess hotel performance using various metrics such as customer satisfaction, customer loyalty, and service quality. For example, Kandampully and Suhartanto (2000) found that customer satisfaction and operating performance (e.g., housekeeping, reception, etc.) are positively correlated to customer loyalty. Choi and Chu (2001) found that staff service quality, room quality, and value were three determinants leading to travelers' overall satisfaction with Hong Kong hotels. Qu and Sit (2007) showed that promptness of service, accuracy of billing, and reservation-system reliability were important antecedents of customer satisfaction. In addition to customer satisfaction, Assaf *et al.* (2015) considered the influence of customer complaints on hotel service quality performance, and suggested that managers of larger hotels should pay attention to managing customer satisfaction while those of smaller hotels should minimize complaints rather than increase satisfaction.

Additionally, some scholars used financial indicators such as ADR in measuring hotel performance. Pine and Phillips (2005) compared the performance of hotels in terms of ADR, occupancy percentage, and total revenues in China and found that Hong Kong- and Macau-funded hotels outperformed others in their sample. O'Neill and Mattila (2006)—looking at a sample of 1,900 hotels—found that ADR is significantly related to hotels' net income. Lam *et al.* (2009) found that star rating and availability of casino facilities had a significant impact on Macau hotel performance in terms of occupancy percentage and ADR. Ching and Si (2010) found that ADR, tourist arrival, and casino facilities significantly influenced the occupancy performance of Macau hotels.

While the above studies have contributed to hotel performance research, they focus mainly on output attributes alone and ignore resource input factors. Although there are several ways of appraising outputs with given inputs, such as ratio analysis (Sigala, 2003), the studies' limitations lie in their inability to simultaneously consider multiple inputs and outputs. The DEA method can be applied to complement traditional performance assessment indices for the hotel industry (Sigala, 2004).

Benchmarking in the hotel industry

Benchmarking is used to identify best practice(s) by comparing performance indices across organizations/industries. The best practices are then adopted as performance goals (Camp, 1989). For example, Breiter and Kline (1995) considered the role of benchmarking in hotel quality management. Boger *et al.* (1999) compared different levels of discounting among various hotels and benchmarked the best practices. Phillips and Moutinho (2000) measured the effectiveness of marketing activities and facilitated a hotel benchmarking process.

While the previous studies contributed to the development of benchmarking research in the hotel industry, their selection of the best practice unity is rather judgmental. It is also questionable whether using a single criterion (e.g., ADR) to select the best practice unit is sufficient and justified (Wober, 2000). As a feasible benchmarking tool, the method of DEA allows practitioners to develop their own performance models, ones that reflect their own business aspirations, using empirical data (Avkiran, 2002). Benchmarking studies were also conducted by Barros (2005), Chiang (2006), and Hsieh and Lin (2010) through the provision of benchmarks for under-performing hotels. However, these studies treated all hotels homogeneously and ignored possible influences caused by operational and environmental differences (Wu *et al.*, 2011), leading to potentially biased evaluation and inappropriate benchmarks (Dyson *et al.*, 2001).

DEA applications in the hotel industry

The first hotel DEA study was conducted by Morey and Dittman (1995) in the US., followed by research applied to the hotel industry in Angola (Barros and Dieke, 2008), Taiwan (Chiu and Huang, 2012), Portugal (Oliveira *et al.*, 2013), and Italy (Detotto *et* *al.*, 2014), among others. As for hotels in the PRD, Peng and Chen (2004) first used DEA to measure the efficiency of star-rated hotels in Guangdong Province and found that, although the hotels' ADRs were favorable, inputs such as human resources were needlessly high. Lu and Lian (2010) employed DEA to examine the efficiency of hotels in Macau between 1991 and 2008 and showed that hotel efficiency was at decreasing returns of scale in most years, despite ADR performance being favorable. Long *et al.* (2016) also examined the efficiency of hotels in different cities in Guangdong Province. While these studies have contributed to hotel efficiency evaluation in the PRD, an in-depth analysis of efficiency and benchmarking, particularly for hotels belonging to localities possessing heterogeneous operation parameters, has not been conducted.

In addressing the heterogeneity issue, we argue that non-homogenous environments would allow DMUs to internally prioritize their operations, thus leading to different revenue composition (e.g., the percentage of food and beverage revenue in some hotels is high, while in other hotels, it is low). Thus, in our study we propose a modified context-dependent assurance region data envelopment analysis (CAR-DEA) model to consider regional differences in the revenue composition of hotels from an internal perspective to reflect the external influence of non-homogenous operational environments on performance evaluation.

Methodology

Traditional and assurance region DEA models

DEA is an approach for evaluating the performance of a set of peer entities called decision-making units (DMUs), which are projected to a frontier depicted by best-practice DMUs (Cooper *et al.*, 2011a). The DEA model was first introduced by Charnes, Cooper, and Rhodes (termed CCR; 1978) and is widely applied in many industries as an efficiency evaluation and benchmarking tool (Banker *et al.*, 1984). In the CCR model, there is a set of J DMUs to be evaluated; each DMU consumes varying amounts of I different inputs to produce R different outputs. Specifically, DMU_j consumes x_{ij} amount of input i and produces y_{rj} amount of output r. Taking DMU_0 as an example, the CCR model can be expressed as follows:

$$\begin{aligned} &\max \sum_{r\in R} \mu_r y_{r0} \\ &s.t. \sum_{i\in I} v_i x_{i0} = 1 \\ &\quad \sum_{r\in R} \mu_r y_{rj} - \sum_{i\in I} v_i x_{ij} \le 0, \quad \forall j \in J, \\ &\quad \mu_r, v_i \ge 0, \qquad \forall r, i \end{aligned} \tag{1}$$

The optimal result of Model (1), $\max \sum_{r\in R} \mu_r y_{r0}$, is the technical efficiency (TE) of any given DMU (i.e., DMU_0), representing its comprehensive managerial efficiency (Yang and Lu, 2006). If DMU_0 is efficient, its TE is one and DMU_0 is on the best-practice technology frontier; otherwise, DMU_0 is inefficient with its TE less than one, representing an estimated percentage of efficiency relative to the best-practice technology frontier (Barros and Dieke, 2008). A subsequent model was developed by Banker, Charnes, and Cooper (termed BCC; 1984) to partition TE into pure technical efficiency (PTE) and scale efficiency (SE) for operations where variable returns to scale are present, expressed as follows:

$$\begin{aligned} &\max (\sum_{r\in R} \mu_r y_{r0} - \mu_0) \\ &s.t. \sum_{i\in I} v_i x_{i0} = 1 \\ &\quad \sum_{r\in R} \mu_r y_{rj} - \sum_{i\in I} v_i x_{ij} - \mu_0 \le 0, \quad \forall j \in J, \\ &\quad \mu_r, v_i \ge 0, \quad \mu_0 \ \textit{free in sign}, \quad \forall r, i \end{aligned} \tag{2}$$

The optimal result of Model (2), $\max (\sum_{r\in R} \mu_r y_{r0} - \mu_0)$, is PTE; SE can be obtained by dividing TE by PTE, which is used to examine a DMU's economies of scale (Giokas, 1991). Returns to scale are constant if $\mu_0 = 0$, increasing if $\mu_0 < 0$, and decreasing if

$\mu_0 > 0$. Based on the efficiency results obtained from Models (1) and (2), the efficiency ranking of all DMUs can then be derived by comparing the efficiency score of each DMU against that of the others. In particular, PTE reflects the efficiency level achieved as a result of management effort and denotes a DMU's deviation from the best practice DMU due to management's inability to efficiently use available inputs. SE, on the other hand, shows the efficiency level of a DMU against one that is operating on an optimal scale in the long run (Joo *et al.*, 2009).

In Models (1) and (2), (μ_r^*, v_i^*) is the optimal value of the weight of each output and input variable, which is notably arbitrary and obtained by maximizing the efficiency score of DMU*0*. A distorted set of weights (μ_r^*, v_i^*) (e.g., lots of zeros) for input and output variables derived from the models is possible and may lead to unreasonable evaluation results (Cooper *et al.*, 2011b). To address the problem of weight distortion, an assurance region DEA model with weight restrictions was developed (Thompson *et al.*, 1997) and is assumed to be applicable across all DMUs within the analytical set (Cook and Zhu, 2011). From the output perspective, a typical form of the ratio constraint between the two weights μ_t and μ_r is expressed as follows:

$$c_{rtL} \leq \frac{\mu_r}{\mu_t} \leq c_{rtU}, r = 2, \ldots, s, t = 1, 2, \ldots, s-1, r > t, \quad (3)$$

where c_{rtL} and c_{rtU} are the lower and upper limits of the relationships between the weights μ_t and μ_{r}. Then, a general assurance region model can be derived by incorporating the ratio constraint formula—Formula (3)—into Models (1) and (2). Thus, the weights (μ_r, v_i) for input and output variables could be controlled within a certain range to reasonably assess efficiency.

Context-dependent assurance region DEA model

While the assurance region DEA model can yield efficiency scores based on reasonable weight sets for hotels belonging to the same region, it is incapable of measuring the performance of hotels from different regions possessing varying characteristics. The lack of homogeneity among hotels means that the range of bounds for weights (μ_r, v_i) could be different for hotels in different localities (Cook and Zhu, 2008), thus resulting in a need for context-dependent assurance regions (CAR). Most often, source markets or customer segments for hotels in different localities are associated with different quality structures reflecting operational environment, such as room and food and beverage (F&B) services (Lee and Back, 2010; Luo and Yang, 2016), which could be depicted by applying CAR. To assess the efficiency of hotels in different localities, a CAR-DEA is proposed to incorporate multiple sets of assurance region restrictions with each set reflecting individual context differences in terms of quality structure. The main idea behind the CAR-DEA model is described below, and its algorithm is provided in the appendix.

First, the weight restrictions of each output variable, in terms of ratio constraint for each city, are calculated (see Equations (4) and (5) in the appendix) to depict the characteristic and quality structure of hotels in the different cities. Second, the weight restrictions for the different cities are adjusted as common weight restrictions for all the cities (see Equations (6), (7), and (8) in the appendix). Finally, the CAR-DEA models are derived when Equation (8) is combined with Equations (1) and (2) (see Equations (9) and (10) in the appendix). The selection of weight restrictions is also depicted in the appendix.

Assessment procedure

In carrying out performance assessment, Models (1) and (2) are employed to evaluate the performance of the sample hotels in Guangzhou, Hong Kong, and Macau all together. Then, assurance region CCR and BCC models are employed to evaluate the sample hotels' performance under assurance region restriction. Last, all the sample hotels are divided into three different groups (Guangzhou, Hong Kong, and Macau) and the CAR-DEA models—Models (9) and (10)—are employed to evaluate their performance. In the above assessment, the TE, PTE, and SE scores are obtained.

Input and output selection

Several input and output variables were considered. For example, Morey and Dittman (1995) used *non-salary expenses for property*, *salaries and related expenses for advertising*, *non-salary expenses for advertising*, and *fixed marked expenses for administrative work* as input variables to assess hotel performance in the US. Anderson *et al*. (2000) used *total gaming-related expenses*, *total F&B expenses*, and *other expenses* as input variables to assess the performance of 48 hotels. Chen and Yeh (2012) used *cost of F&B*, *cost of room*, and *other cost* as input variables to evaluate hotels in Taiwan, and *F&B revenue*, *room revenue*, and *other revenue* are treated as output variables. The same output variables were employed by Hwang and Chang (2003), Hu *et al.* (2009), and Yu and Lee (2009). Having considered both the above and our proposed model, we collected data from *STR Global* on room expenses (X_1), F&B expenses (X_2), administrative and general expenses (A&G, (X_3)), marketing expenses (X_4), and other expenses (X_5) as candidates for input variables, while room revenues (Y_1), F&B revenues (Y_2), and other revenues (Y_3) were candidates for output variables from 41 hotels in the three cities in 2013.

In particular, the 41 hotels (13 from Guangzhou, 24 from Hong Kong, and four from Macau) were selected on the basis that hotels from different cities should be representative in terms of hotel class, location, years of establishment, and room count. All input and output figures are in Hong Kong dollars (HKD 7.8 ≈ USD 1). Descriptive statistics for the input and output variables, and the attributes of these 41 hotels are presented in Table I and Table II, respectively.

[Insert Table I here]

[Insert Table II here]

Empirical results

In 2013, 13.96% of the overnight visitors in the Guangzhou hotels in our sample were international tourists and the occupancy percentage was 64.40% (Guangzhou Bureau of Statistics, 2015). The average room revenue to total revenue (RevRoom), F&B revenue to total revenue (RevFB), and other revenue to total revenue (RevOther) ratios were 49.66%, 43.84%, and 6.51%, respectively.

For the hotels in Hong Kong, 63.20% of the overnight visitors were international tourists, and the occupancy percentage was 89.00% (HKTB, 2015c). The average RevRoom, RevFB, and RevOther were 60.53%, 34.59%, and 4.88%, respectively.

For the Macau hotels, 37.45% of the overnight visitors were international tourists, and the occupancy percentage was 83.10% (Statistics and Census Service of Macau, 2015). The average RevRoom, RevFB, and RevOther were 76.59%, 21.70%, and 1.71%, respectively.

The assurance region restrictions set for the hotels in the three cities are displayed in Table III. The maximum upper limits of RevRoom (μ_1), RevFB (μ_2), and RevOther (μ_3) for all the hotels were 0.9196, 0.7530, and 0.3254, respectively. The minimum lower limits were 0.1587, 0.0742, and 0.0030, respectively. Accordingly, the assurance region restrictions were $0.0807 \leq \mu_2/\mu_1 \leq 4.7457$ and $0.0040 \leq \mu_3/\mu_2 \leq 4.3845$ for all the hotels regardless of their localities.

[Insert Table III here]

Based on the values in Table III, common weight bounds [a_r^{car}, b_r^{car}] and CAR $c_{rtL}^{car} \leq \frac{\mu_r}{\mu_t} \leq c_{rtU}^{car}$ for all the hotels in every city were calculated (see Table IV).

[Insert Table IV here]

The CAR $c_{rtL}^{car} \leq \frac{\mu_r}{\mu_t} \leq c_{rtU}^{car}$ was developed based on common weight bounds [a_r^{car}, b_r^{car}], as shown in the appendix. Here, the assurance region restriction was imposed to limit the relationships of output proportion (RevRoom, RevFB, and RevOther) for all hotels, while the CAR restriction was to limit those for hotels in the three cities. The efficiency scores of the hotels are displayed in Table V.

[Insert Table V here]

Analyses assuming hotels under homogeneous environment

When hotel characteristics—such as geographical locations and hotel grades—were ignored and the 41 sample hotels were compared with each other in one homogeneous group, 13 hotels were rated as efficient with TE without assurance restriction equaling one (see Table V). Specifically, seven were located in Guangzhou, four in Hong Kong, and two in Macau. The ratio of efficient hotels in Hong Kong was the lowest (16.67%). PTE scores, representing the efficiency level achieved due to management effort, show that 19 hotels were efficient (PTE = 1), among which six (GZ10, HK01, HK14, HK22, HK23, and MC04) were scale inefficient, leading to their overall TE being less than one. Additionally, one hotel in Macau (MC03) had efficiency indices of TE = 0.5340, PTE = 0.5347, and SE = 0.9987, signaling a good level of SE, but low management efficiency; thus it should be examined further. Overall, judging from the average efficiency scores in the last four rows of Table V, we can see that, with an average TE score of 0.9433 the hotels in Guangzhou outperformed those in Hong Kong and Macau, mainly due to their outstanding PTE scores. Macau outperformed the other two cities in terms of SE.

When the assurance region restrictions were imposed, there were only three hotels (GZ07, HK05, and MC02) considered as efficient (TE = 1). The lowest TE score was 0.2775 (MC03), due to poor hotel management performance (PTE = 0.2815). Of the 41 hotels, 11 had a PTE equaling one, indicating good management efficiency. However, the majority of these hotels had mediocre SE, decreasing their TE. Nevertheless, we observed that the SE levels of some hotels (GZ02, HK24, and MC03) were better than their PTE levels. It should be noted that the assurance region restriction imposed affected the average efficiency scores of the hotels in different regions. The Macau hotels outperformed those of the other two cities with an average TE score of 0.7718, most likely due to much higher SE (0.9862). The Guangzhou hotels outperformed those of the other two cities in terms of average PTE score (0.8226).

Analyses with CAR restrictions

In applying the CAR restrictions, the weights represent the contribution ratio of a type of production output to total revenue (RevRoom (μ_1), RevFB (μ_2), and RevOther (μ_3)). We chose the hotels in Hong Kong as the criterion ($a_r^{car} = a_r^{\mathrm{HK}}$) for adjustment and the CAR can then be obtained (see Table IV).

The CAR imposes stricter restrictions than the assurance region restriction by considering various operational emphases (i.e., revenue composition) of the hotels in Guangzhou, Hong Kong, and Macau. The results of the efficiency assessment—including TE, PTE, and SE scores with CAR restriction—are listed in Table V. There was only one efficient hotel, MC02 (in Macau), with a TE of one, while the most inefficient hotel was MC03. Furthermore, five hotels (GZ10, HK05, HK14, MC02, and MC04) were considered efficient in terms of their PTE. However, the SE scores of four hotels (GZ10, HK05, HK14, and MC04) were 0.2754, 0.5893, 0.6267, and 0.9539, respectively, indicating SE scores fluctuate (such as with GZ10, HK05, and HK14) when different operational emphases are considered. The average efficiency scores of the hotels in Guangzhou, Hong Kong, and Macau show that the performance of the Macau hotels was the best in all efficiency measures (TE = 0.6615, PTE = 0.7318, and SE = 0.8166). When all the hotels in the three cities were evaluated, the hotels in Macau (but not in Hong Kong) performed best even though the CAR restriction reflected the operational emphasis of the hotels in Hong Kong.

Ranking and benchmarking analysis

The average scores of various efficiency indices, including TE, PTE, and SE, with different restrictions for the hotels in each city are listed in the last four rows of Table V. When output weight restrictions were not imposed, the performance of the Guangzhou hotels was deemed the best (TE = 0.9433). Nevertheless, when the assurance region and CAR restrictions were considered, the performances of the Macau hotels were the best (TEs = 0.7718 and 0.6615), due to both good SE (0.9862) and PTE (0.8166).

Comparing the results of the models with assurance region and CAR restrictions, the performances of the Guangzhou hotels were overestimated the most in terms of TE (Average-GZ was reduced by 59.74% from 0.6645 to 0.2675; Average-HK 46.38% from 0.6442 to 0.3454; Average-MC 14.29% from 0.7718 to 0.6615, as shown in Table V). Once the homogenous operating environment assumption is removed from the analysis and non-homogenous CAR is imposed, more realistic performances regarding regional differences are revealed. The performances of each city's hotels were affected differently because of their specific operating emphases.

The average rankings of TE, PTE, and SE, based on DEA models without restriction, with assurance region, and with CAR restrictions are shown in Figure 1.

[Insert Figure 1 here]

Figure 1 shows that the TE ranking of the hotels in Macau and Hong Kong rose along with the increase of restrictions on weights, while in Guangzhou it decreased. The general management performance (in terms of TE) of the Guangzhou hotels at first appeared to be the best under traditional DEA evaluation; however, its management performance deteriorated when the operational emphases were factored in the evaluation through the addition of weight restrictions. Combined with the analysis of average efficiency scores and judging from PTE and SE rankings, the pure management and scale performance of the Macau hotels were deemed the best. That is, the hotels in Hong Kong and Guangzhou can benchmark against their counterparts in Macau to improve their SE and PTE performances when CAR restrictions are imposed.

As shown in Table V, from the perspective of improving a hotel's general management level (TE) or scale efficiency (SE), 13 hotels can serve as benchmarks for the other hotels when evaluated with no weight restriction; three hotels can do this with assurance region restrictions; and one hotel can do this with CAR restrictions. From the perspective of improving hotels' pure management levels (PTE), 19, 11, and five hotels can be benchmarks for other hotels when evaluated with no restriction, with assurance region, and with CAR restrictions, respectively. Both these perspectives are popular practices (Yang and Lu, 2006; Lu and Huang, 2009; Wu *et al.*, 2011) for benchmarking exercises, from which common benchmark hotels can be identified when different operational emphases are considered. The hotels that are efficient under CAR restriction should serve as the common benchmark for all the hotels in the different localities.

As such, with its TE score of one, hotel MC02 shall be treated as a common benchmark of technical efficiency for the other 40 hotels when evaluated with CAR restrictions. With PTE scores equaling one, hotels GZ10, HK05, HK14, MC02, and MC04 can serve as common benchmarks of pure technical efficiency when evaluated with CAR restrictions. Finally, with a SE score of one, hotel MC02 with CAR restrictions can be a common benchmark of scale efficiency. Ultimately, hotel MC02, a luxury chain hotel located in Macau with more than 500 rooms open in 2009, ought to be the super benchmark for all hotels due to its efficiency, regardless of whether restrictions were imposed or what the restriction was. Hotel MC02 had only been open for seven years and, compared to the other hotels, had a below-average amount of ADR (HKD 1,028), with an above-average occupancy percentage (87.5%), but still managed to outperform the others in all its efficiency measures. Blindly pursuing high ADR or occupancy percentage does not necessarily translate into good performance in terms of efficiency.

Conclusions and implications

Conclusions

In this study we modified a CAR-DEA model by setting weight restrictions for output variables and examined the performance of a sample of hotels in Guangzhou, Hong Kong, and Macau using four progressive DEA models. This study found that, when evaluated without weight restrictions on revenue outputs, due to outstanding PTE the hotels in Guangzhou outperformed those in the other two cities, while the scale efficiency of the Macau hotels was the best. The scale efficiency of the Macau hotels was also the best when assurance region restrictions were factored into the evaluation. The performance assessment results of the Guangzhou hotels were less favorable under the weight restriction placed on output variables.

The performance of the Macau hotels was deemed the best in terms of both average efficiency score and ranking once the homogenous operating assumption was removed and non-homogenous assurance region (and CAR) was imposed on the evaluation. The Macau hotels could therefore serve as benchmarks for their scale efficiency and management performance.

Theoretical implications

Our study has made several theoretical contributions. First, the results supported Dyson *et al.*'s (2001) argument that efficiency scores calculated from a model with output restrictions imposed would be lower than those without. Second, by considering the reality of the relative importance of various operating departments in a hotel and information regarding revenue and expenses, our study introduced a new method in setting revenue output weight restrictions and assurance regions, extending the works of Kong and Fu (2012), Cook and Zhu (2008), and Schaffnit *et al.* (1997). Third, we addressed another gap in the literature to evaluate DMUs belonging to localities possessing heterogeneous operating characteristics by proposing a modified CAR-DEA model to examine scale and management efficiencies in distinct, developing economic environments.

Practical implications

This study also offers several practical implications. First, the finding that the performances of the hotels in Guangzhou were overestimated most in terms of technical efficiency when regional differences were considered suggests that hotel managers in Guangzhou should better recognize and capitalize on the differences of their operational characteristics against their competitors in the PRD and work on devising measures to enhance their managerial efficiency. Second, the findings that the Guangzhou hotels' average SEs (0.5346) were the lowest and their returns to scale were increasing further suggest that their performance improvement efforts may be better focused on increasing their resource inputs. Third, for the hotel practitioners in Hong Kong, while their occupancy percentages and ADR outperformed those in Macau and Guangzhou, the efficiency assessment outcome indicated otherwise. They should carefully re-evaluate their resource inputs and revenue outputs, given the comparisons provided in this study that suggest inefficiencies, as opposed to what their ADR and occupancy might have suggested. Furthermore, the returns to scale for half of the hotels in Hong Kong appeared constant; further attention to management performance may be more fruitful than continued market development through expansion.

When considering regional differences, all the average efficiency measures of the hotels in Macau topped those of their counterparts in Guangzhou and Hong Kong. Hotels in Hong Kong and Guangzhou should benchmark their performance against those in Macau to improve their SE through monitoring their asset scales, and to improve their PTE through bettering their internal management. The finding that half of the Macau hotels were experiencing decreasing returns to scale, which echoed Lu and Lian (2010), should be paid close attention. That is, hotel developers in Macau should be cautious of further expanding their scales, as returns from further development show signs of decrease.

Finally, our proposed model can be further extended to examine the performance of different calibers of hotels, restaurants, or tourism entities in varying localities possessing distinct operational characteristics. For example, it is not unusual that an international hotel chain operates or manages an array of luxury, upscale, and mid-scale hotels. Assessing the performance of such a group of hotels within a mother corporation could be a challenging task. How does an assessment evaluate such an array fairly? Our model could be adjusted and applied to supplement the use of common KPIs, such as ADR and occupancy percentage, in helping assess the performance of individual units.

Limitations and further research

There are limitations associated with our study. First, all our findings were based on the sample and on data collected from *STR Global* in 2013 and therefore, the results should be interpreted with caution. The masking of hotel identity with codes somewhat limits our study's practical implications in terms of naming best-performing and benchmark hotels. However, our methodological contribution could outweigh such a limitation. Second, the performance rankings in our study could change if, instead of using a revenue mix of the Hong Kong hotels as an adjustment criterion for the other cities' hotels, another hotel locality is used in the process of CAR calculation.

Future studies are encouraged to include more years of data and include other operational parameters for weight restriction calculations (e.g., restaurant operation hours, guestroom size, and meeting space unit rental), to further validate the results of this study and to advance methodological contributions regarding the DEA technique as a preferred performance assessment tool.

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Appendix. Modeling the CAR-DEA and weight restriction selection

Modeling the CAR-DEA

All the hotels under assessment are assumed to be divisible into K regions $\{J_k\}_{k=1}^{K}$, and each region J_k has a set of weight restrictions in the following form:

$$a_r^k \le \mu_r^k \le b_r^k, \quad r = 1, 2, \ldots, s, k = 1, 2, \ldots, K, \quad (4)$$

where a_r^k and b_r^k are the minimum and maximum weights of output r, respectively, observed for region k. Furthermore, we can get the assessment region (AR) restriction for region k in the following form:

$$c_{rtL}^k \le \frac{\mu_r^k}{\mu_t^k} \le c_{rtU}^k, \quad r = t+1, t = 1, 2, \ldots, s-1, k = 1, 2\ldots, K, \quad (5)$$

where c_{rtL}^k and c_{rtU}^k are the minimum and maximum values of $\frac{\mu_r^k}{\mu_t^k}$, respectively, observed for region k.

A DEA model that can address multiple sets of weight constraints is required when there are multiple areas in which hotels are located. Cook and Zhu (2008) proposed that the same lower AR bound can be assigned to all AR restrictions and the aggregated output for hotels belonging to different localities can be adjusted. That is, let $a_r^k = \min_k\{a_r^k\}$, and replace the lower bound a_r^k by $a_r^{\bar{k}}$. At the same time, the upper bounds b_r^k are replaced by $b_r^{k'} = b_r^k(\frac{a_r^{\bar{k}}}{a_r^k})$ (Equation 6), using a method of equal proportion for K ($\bar{k} \in K$), then $b_r^{car} = \min_{k'}\{b_r^{k'}\}$. Finally, let $a_r^{car} = a_r^{\bar{k}}$ and the transformed weight restrictions can be listed as follows: $a_r^{car} \le \mu_r \le b_r^{car}$ (Equation 7). Here, [a_r^{car}, b_r^{car}] is the weight range of output r, which is common to all K groups. Per Equations (6) and (7), the AR restriction (5) can be replaced by the CAR restriction, as shown in Formula (8) below.

$$c_{rtL}^{car} \leq \frac{\mu_r}{\mu_t} \leq c_{rtU}^{car}, \qquad r = t+1, t = 1, 2, \ldots, s-1, k = 1, 2 \ldots, K. \quad (8)$$

where c_{rtL}^{car} and c_{rtU}^{car} can be obtained through Equation (7). The CAR-CCR DEA model for DMU $j_{k0} \in J_k$ could thus be constructed as:

$$\begin{aligned}
&\max \sum_{r \in R} \mu_r \left(\frac{\dot{a}_r^k}{a_r^k}\right) y_{rj_{k0}} \\
&s.t. \sum_{i \in I} v_i x_{i0} = 1 \\
&\sum_{r \in R} \mu_r \left(\frac{\dot{a}_r^k}{a_r^k}\right) y_{rj_k} - \sum_{i \in I} v_i x_{ij} \leq 0, \qquad \forall j \in J_k, \forall k, \\
&c_{rtL}^{car} \leq \frac{\mu_r}{\mu_t} \leq c_{rtU}^{car}, \qquad r = t+1, t = 1, 2, \ldots, s-1, \\
&\mu_r, v_i > 0, \qquad \forall r, i
\end{aligned} \quad (9)$$

Similar to Model (9), the CAR-BCC DEA model for DMU $j_{k0} \in J_k$ could be constructed as:

$$\begin{aligned}
&\max \sum_{r \in R} \mu_r \left(\frac{\dot{a}_r^k}{a_r^k}\right) y_{rj_{k0}} - \mu_0 \\
&s.t. \sum_{i \in I} v_i x_{i0} = 1 \\
&\sum_{r \in R} \mu_r \left(\frac{\dot{a}_r^k}{a_r^k}\right) y_{rj_k} - \sum_{i \in I} v_i x_{ij} - \mu_0 \leq 0, \qquad \forall j \in J_k, \forall k, \\
&c_{rtL}^{car} \leq \frac{\mu_r}{\mu_t} \leq c_{rtU}^{car}, \qquad r = t+1, t = 1, 2, \ldots, s-1, \\
&\mu_r, v_i > 0, \quad \mu_0 \textit{ free in sign}, \qquad \forall r, i
\end{aligned} \quad (10)$$

Models (9) and (10) should be applied to calculate the TE, PTE, and SE scores of the DMUs by considering multiple AR constraints. While the CAR-DEA model developed by Cook and Zhu (2008) can calculate the TE score of DMUs with multiple ARs, the models we modified—Models (9) and (10)—could not only produce TE, PTE, and SE scores, but also directly restrict the relationships of any two output variables next to each other.

Weight restriction selection

Three different approaches have been documented in the literature to set bounds in weight restrictions for DEA models. First, weight bounds can be obtained by referring to experts' opinions, as seen in Beasley (1990) and Takamura and Tone (2003). In the latter paper, the information obtained from experts was processed using an analytic hierarchy process (AHP). Kong and Fu (2012), and Lee *et al.* (2014) also set weight bounds by using AHP to assess industrial productivity, business colleges, container terminals, and the photovoltaics industry. In the hotel literature, only Cheng *et al.* (2010) obtained the AR bounds of the DEA model using AHP and experts' opinions—when assessing hotel performance in Taiwan. While this way of thinking could reflect characteristics of different resource inputs and production outputs, the evaluation outcome could be biased, subject to experts' subjectivity.

Second, the optimal weights of some DMUs can be used as weight restrictions (see Brockett *et al.*, 1997). Once the unbounded DEA model is solved, a weight matrix is compiled for all the variables. On the basis of this, Roll *et al.* (1991) set the bounds by first eliminating outliers and extreme weights and then imposing a certain percentage (e.g., 75%) of weights falling within the bounds or at an acceptable ratio of variation for each weight within the range of the unbounded weights. Alternatively, one can start from a known and feasible set of common weights and allow changes in weights for individual DMUs to vary by a pre-determined percentage. While this method is objective, it may not reflect the characteristics of different inputs/outputs of the hotels belonging to different cities.

Third, the information regarding prices and/or costs could be used to set weight restrictions, as seen in Schaffnit *et al.* (1997), or experts' opinions and price information can be combined, as seen in Thompson *et al.* (1992). While this appears objective and could reflect the operating characteristics of different hotel locations, its application is limited due to difficulties in obtaining empirical data.

From the data provided by *STR Global*, we can see that RevRoom, RevFB, and RevOther of hotels in different cities vary. In 2013, the average RevRoom of hotels in Guangzhou, Hong Kong, and Macau was 49.66%, 60.53%, and 76.59%, respectively. The RevFB of hotels in Guangzhou, Hong Kong, and Macau was 43.84%, 34.59%, and 21.70%, respectively. From this, we can infer that the operational foci of particular hotels in different cities are different.

Combining the reality of the relative importance of various departments in a hotel and the third way of thinking mentioned above, this paper proposes a new method of setting weight restrictions and ARs by considering RevRoom, RevFB, and RevOther of each hotel in the data sample as the choice of output weight (μ_1, μ_2, and μ_3) restriction and calculates the CAR restrictions according to Equations (4)-(8).