Journal of Infrastructure, Policy and Development 2024, 8(5), 5805.
https://doi.org/10.24294/jipd.v8i5.5805

Article

Measuring the efficiency of four star hotels in Makarska-Croatia using data envelopment analysis

Marijana Jurišić Mustapić

Hospitality and Gastronomy Studies, University of Split, City Makarska 21300, Croatia; marijana1308@gmail.com

CITATION

Jurišić Mustapić M. (2024). Measuring the efficiency of four star hotels in Makarska-Croatia using data envelopment analysis. Journal of Infrastructure, Policy and Development. 8(5): 5805. https://doi.org/10.24294/jipd.v8i5.5805

ARTICLE INFO

Received: 15 April 2024
Accepted: 1 May 2024
Available online: 9 May 2024

Abstract: This study explores the scale efficiency of four star hotels in a small tourist destination in Croatia. The number of overnight stays and the increase in hotel beds are two indicators of the development of a tourist destination. Among the accommodation facilities, hotels play a significant role in the development of a tourist destination, but they are increasingly facing a labor force crisis. Data envelopment analysis is used to rank hotels by efficiency coefficient. The aim of the paper is to investigate the efficiency of the hotel by taking certain inputs and outputs, which are explained in detail in the paper. The paper uses the CCR (Charnes, Cooper, and Rhodes) and BCC (Banker, Charnes, and Cooper) models to calculate hotel scale efficiency and also presents an overview of previous research around the world.

Keywords: CCR-BCC method; data envelopment analysis; hotel scale efficiency; productivity; staff turnover

1. Introduction

The tourist industry in Croatia emerged as an important source of economic expansion. Hotels play a crucial role in enhancing and optimizing the efficiency of the tourism business by increasing accommodation capacity. This encourages the growth and development of the travel and tourism sector. The rising tourism sector faces challenges related to workforce shortages and employee motivation at the same time. Destinations that see a rise in visitor numbers are also experiencing an expansion in lodging capacity, particularly during periods of increased seasonality, as observed in Crete and Spain (De Jorge and Suárez, 2014; Manasakis et al., 2013). In the last few years, the importance of employment within the tourist business has been recognized as one of the crucial things in the industry. The bustling tourism industry is currently experiencing a significant workforce shortage. The delivery of services is dependent on the availability of human resources (Barros, 2005). Hoteliers encounter a multitude of issues, including seasonality, inadequate compensation, paid overtime, employee turnover, and fluctuating and dynamic demand. The hotel development direction includes the establishment of work guidelines and the improvement of business processes to achieve competitiveness (De Jorge and Suárez, 2014). This study incorporates the labor productivity coefficient. Some of the research questions are: how are the scale efficiency results of different hotels within one tourist destination and a certain geographical area ranked? What are the effects of different input parameters (such as the number of hotel rooms, maximum bed capacity and total number of employees) and output parameters (number of overnight stays and labor productivity coefficient) on the scale efficiency results of the hotels in Makarska? How do the different models (CCR and BCC) used in the data envelopment analysis affect the evaluation of scale efficiency results? What strategies can be recommended to the hotels to improve human resource management and headcount based on DEA efficiency analysis? This study aims to assess the scale efficiencies of hotels that are listed in the Makarska tourist area. Multiple studies have demonstrated that data envelopment analysis (DEA) is well-suited for implementation in the hotel industry (Barros, 2005; Manasakis et al., 2013; Sigala, 2004).

The introduction emphasizes the importance of researching hotel efficiency in light of the dynamic tourist market and changing workforce. The introduction also provides an insight into the different spectrums of application of the DEA method by presenting general information about data envelopment analysis. The literature review discusses previous studies related to efficiency analysis using DEA method, especially in hotels in different geographical areas. This part also shows a table of applications of different DEA models (CCR, BCC), the number of hotels included in the research and their area together with the input and output variables shown. The methodology explains the rationale behind selecting Makarska as the tourist destination and outlines the data collection process. In the results and discussion section, the specificity of the DEA method is presented, and the results of the DEA ranking of hotels, including hotel scale efficiency, are also presented. Conclusions summarize key findings, discuss practical implications, and suggest strategies for improvement based on scale efficiency results.

The DEA created by Charnes et al. (1978) in 1978, is a commonly used benchmarking technique for evaluating the efficiency of management performance. Efficiency means that the inputs and outputs consistently outperform other options. This is found by looking at all the options and their features in detail (Barros, 2005). The application of DEA in the hotel industry research was initially conducted by Morey and Dittman (1995) to measure the performance of the 54 hotels in the USA. Since then, the CCR and BCC models have been commonly utilized in the literature on hotel efficiency. The DEA began with Charnes et al. (1978) per Farrell's (1957) work, which sought to clarify the mathematical programming methods employed in generating production borders and evaluating the effectiveness of these frontiers. A decision-making unit (DMU) or the efficiency of a single unit, which converts inputs (resources) into outputs (products and/or services), was first suggested by Farell in 1957. Efficiency refers to the optimization of resource allocations across various potential applications within the DEA's structure (Manasakis et al., 2013). The model CCR supported by Charnes et al. (1978) exhibited an input orientation and assumed continuous returns-to-scale (CRS). Other frameworks have been studied further. The framework of variable returns-to-scale (VRS) was initially introduced by Banker et al. (1984) in 1984. The literature refers to this paradigm as the BCC model.

DEA uses empirical nonparametric techniques to evaluate the productive efficiency of decision-making units (DMUs). This article uses the DEA method to evaluate homogenous units, like hotels, commonly known as DMUs. The measurement of a DMU efficiency is determined by calculating the ratio of outputs to inputs. The effectiveness of each DMU can be determined by comparing the connection between the spots on the frontier and the points below it, once the frontier has been created. Three crucial model features need to be defined by the researcher to solve the linear programming issue: the input-output orientation system, the returns to scale, and the weights of the evaluation system (Barros, 2005a; Kularatne et al., 2019).

The market conditions of the DMU are the basis for the decision between input-oriented or output-oriented DEA, as opposed to the previous option. Decision-making units (DMUs) typically focus on output in competitive markets. This is due to the assumption that the decision-making unit, which is not part of the DMU, has control over the inputs and aims to maximize its performance based on market demand (Kumbhakar, 1987). There are multiple methods available for calculating the DEA index (Cooper et al., 2007). This study (Kumbhakar, 1987) estimates a DEA index that is output-oriented and technically efficient. Outputs present a tangible indicator that signify the achievement of an organization’s objectives (Bire, 2020). Revenue is the primary factor influencing outputs, whereas inputs typically include people, expenditures, and capital investments.

Furthermore, in the literature, there exist several DEA models: assurance region method (Sellers-Rubio and Casado-Díaz, 2018), super-efficiency model (Sharma and Mogha, 2023), multi-stage use of parametric and non-parametric models—the most used is stochastic frontier analysis (Liu and Tsai, 2021), efficiency change over time—the most famous is Malmquist Index (Assaf and Agbola, 2011; Cracolici et al., 2007), allocation models include cost efficiency (Panfilova et al., 2020) revenue efficiency (Oliveira et al., 2013) and profit efficiency (Arbelo et al., 2017) and the multiplicative model (Charnes et al., 1982). DEA is a management technique that is being used in many different business disciplines and is growing in popularity, for example, branding (Brown and Ragsdale, 2002), advertising (Cheong and Leckenby, 2006; Hamelin et al., 2022), insurance companies (Kaffash et al., 2020), sports sponsorship (Walraven et al., 2016) and non profit organizations (Coupet et al., 2021a) and also for restaurants (Reynolds and Thompson, 2007).

The motivation of this study is to calculate the efficiency of hotels to identify ways to optimize the use of human resources in the context of the number of the employees, reduce costs, and improve productivity, which is crucial in a competitive tourism market because understanding the efficiency of hotels helps to assess their economic contribution to business, including employment, and how hotel efficiency can provide insight into how hotels in Makarska can improve their competitive advantage over other tourist destinations. The study’s contribution to the efficiency coefficient calculation provides hotel management with a foundation for improved performance and strategic decision-making. The efficiency coefficient helps hotels swiftly identify the needs and respond to shifting labor requirements, market conditions, and demand in the ever-changing tourist industry.

2. Literature review

The literature review will primarily focus on the inputs and outputs that have been used as part of this study, and their context, which is significant, will be reviewed.

According to Sigala (2004), defining and identifying the quantification of supplied inputs and outputs poses a significant challenge to the DEA model. The exact measurement of inputs and outputs within the service sector is challenging due to the fragile nature and diverse features of the company (Johnston and Jones, 2004). Fernández and Becerra (2015) conducted a study that demonstrates a significant correlation between the level of quality and efficiency. The research indicates that larger hotels usually achieve higher levels of efficiency than smaller ones due to their investment in intangible assets, such as information systems. On the other hand, mid-range hotels tend to prioritize quality as a motivating factor, in contrast to “higher class” hotels. Small hotels encounter challenges in effectively managing their operations and are often subject to misinterpretation within the realm of business organization (Lee-Ross and Ingold, 1994). Technological innovation is not a priority for the small hotels due to their small size. However, the lack of technology often results in enhanced time management, operations management, and self-service, and this is all connected to automation. This, in turn, leads to growth in labor productivity (Witt and Witt, 1989). Based on the research conducted by Kilic and Okumus (2005), staffing, staff training, meeting customer standards, and service quality are the main factors that affect productivity in small hotels, and on the other hand, crises, technology, marketing, and projections are considered to have a relatively lower impact. The negative influence of the size variable of the hotel coefficient on the technical efficiency (TE) in Sri Lanka has been observed. The hotel efficiency literature presents conflicting conclusions regarding the correlation between size and efficiency. Hwang and Chang (2003) contend that there is no difference in efficiency across hotels of different sizes, whether they are huge or small. In their study conducted in Luanda (Ben Aissa and Goaied, 2016) they reached the conclusion that large hotels exhibit greater efficiency compared to small hotels. This finding is consistent with previous research conducted on Portuguese hotels (Barros, 2005, 2006). The observed inverse relationship between hotel efficiency and size in this setting can be attributed to the potential for medium-sized hotels to enhance their efficiency through increased size, while large hotels may encounter diseconomies of scale as a result of their growth trajectory (Romano and Guerrini, 2011).

In their studies, Brown and Dev (1999) observed a considerable boost in productivity irrespective of the hotel’s size, particularly when the number of staff was higher. Furthermore, research has indicated that an increase in the number of rooms offered for purchase has a positive impact on the efficiency of larger hotels. Furthermore, it has been observed that large hotels have been shown to perform more productively when managed by branded management businesses. The productivity of each employee has a greater impact on the success of hotel business operations than the number of employees. (Simpao, 2018). Additionally, it can be observed that there exists an inverse relationship between labor productivity efficiency ratios and the number of employees in a hotel. This implies that as the hotel increases its workforce, the labor cost rises while the labor output per employee decreases (Simpao, 2018). The following indicators allow for the measurement and evaluation of labor productivity at the hotel level—global indicators of labor productivity at the hotel industry, The study conducted by Avelini Holjevac and Vrtoduşić Hrgović (2012) in 2012 examines the productivity indicators at the hotel department level and the labor productivity indicators for various professions in the hospitality industry. According to Črnjar (2005), there are several indicators of labor productivity, but for this research, importance is given to the productivity coefficient that is measured the ratio of overnight stays the total number of hotel staff, both during different months of the season. For example, some others are: the ratio of income from food service (when adjusted for inflation) to the average number of employees in the kitchen, or the ratio of the quantity of meals issued to the average number of employees in the kitchen. Hu and Cai (2004) measured the labor productivity of a selection of hotels in the State of California using the DEA method. Sigala et al. (2005) expanded upon existing DEA methodologies by proposing a systematic methodology for assessing the efficiency of the hotel room division. Reynolds (2003) conducted a study that demonstrated the application of DEA in assessing the effectiveness of hotel resource allocation and identifying external factors that managers cannot control.

The number of employees at a hotel may be used to measure its human resources (Barros and Mascrenhas, 2005; Chiang, 2006; Manasakis et al., 2013; Oliveira et al., 2013; Tarim et al., 2000; Yand and Lu, 2006). The number of employees can be viewed as the total number of employees, or they can be divided into full time employees and part time employees (Avkiran, 2002; Sigala, 2004). In the works, employment indicators can appear separately by department: number of full-time employees in the room service department; number of full-time employees in the food and beverage service department (Yu and Lee, 2009); or number of full-time employees in the room department; number of full-time employees in the food and beverage department (Wang et al., 2006) or the number of full-time employees for each service can simply be taken into account (Sigala, 2004).

The number of overnight stays is a very important indicator for hotels because resources such as staff, food and beverages are planned based on this prediction (Oukil et al., 2016). Research that is oriented to output, in addition to sales revenue, will certainly consider the indicator of nights spent or the total number of nights (Barros, 2004; Oukil et al., 2016). In the research, authors often focused on the number of guests (Barros et al., 2011; Barros, 2005) and some authors also focused on the number of arrivals (Hodžić and Alibegović, 2019; Rabar and Blažević, 2011).

Authors who used CCR and BCC models are shown in the **Table 1** of the overview of previous researches.

Table 1. Overview of previous research using DEA for hotels (Source: author).

Authors	Methods	Units & destination	Input	Output
(Morey and Dittman, 1995)	DEA model Benchmarking Managerial efficiency	54 hotels over continental United States	(1) room division expenditure; (2) energy costs; (3) salaries; (4) nonsalary expenditure for property; (5) salaries and related expenditure for advertising; (6) nonsalary expenses for advertising; (7) fixed marked expenditure for administrative work.	(1) total revenue; (2) level of service delivered; (3) market share; (4) rate of growth.
(Johns et al., 1997)	DEA model VRS output-oriented DMU Productive efficiency Benchmarking Hotel productivity	15 hotels in United Kingdom over a 12-month period	(1) number of room nights available; (2) total labor hours; (3) total food and beverage costs; (4) total utilities cost.	(1) number of rooms nights sold; (2) total covers served; (3) total beverage revenue.
(Tarim et al., 2000)	DEA model Input and output oriented DEA CCR and CRS Modified restrictions	21 4/5-star hotels in Antalya	(1) investment costs; (2) number of employees; (3) administrative expenses.	(1) customer loyalty index; (2) occupancy rate; (3) net profit.

Table 1. (*Continued*).

Authors	Methods	Units & destination	Input	Output
(Wober, 2000)	DEA model Input-oriented DEA CRS model	61 hotels in Austria	(1) total payroll and related costs; (2) material-types expenses and energy; (3) cleaning; (4) maintenance; (5) communication; (6) marketing; (7) administration costs; (8) number of beds, seats, and opening days.	(1) total accommodation revenue; (2) food and beverage revenue; (3) average bed occupancy.
(Anderson et al., 2000)	DEA model Technical and allocative	48 hotels in United States	(1) fulltime equivalent employees; (2) number of rooms; (3) total gaming related expenses; (4) total food and beverage; expenses; (5) other expenses.	(1) total revenues; (2) other revenues.
(Tsaur, 2001)	DEA model CCR model Index efficiency	53 hotels in Taiwan	(1) total operating expenses; (2) number of rooms occupied; (3) total floor space; (4) number of employees in the catering division; (5) catering costs.	(1) total operating revenues; (2) number of rooms; (3) average daily rate; (3) total operating revenue of the catering division.
(Brown and Ragsdale, 2002)	DEA model CCR model and cluster analysis Competitive brand efficiency	46 hotels rated in consumer report in United States	(1) median price; (2) problems (defined in a 4- point scale); (3) service; (4) upkeep; (5) hotels and (6) rooms.	(1) satisfaction value (defined on a 100-point scale); (2) value (defined in a 5- point scale).
(Avkiran, 2002)	DEA model Productivity Benchmarking Technical efficiency	23 hotels in Queensland	(1) number of full-time employees; (2) number of part-time employees; (3) number of beds.	(1) total revenue; (2) room rates.
(Hwang and Chang, 2003)	DEA model CCR model Efficiency change	45 hotels in Taiwan	(1) number of full-time employees; (2) guest rooms;(3) total area of meal department; (4) operating expenses.	(1) room revenue; (2) food and beverages revenue; (3) other revenues.
(Barros, 2004)	DEA model Productivity efficiency	43 hotels in Pousada	(1) full-time workers; (2) cost of labor; (3) rooms; (4) surface area of the hotel; (5) book value of property; (6) operational costs; (7) external costs.	(1) sales; (2) number of guests; (3) nights spent.
(Chiang et al., 2004)	DEA model CCR and BCC model	25 hotels in Taipei	(1) rooms; (2) food; (3) beverages; (4) number of employees; (5) total cost.	(1) yielding index; (2) food; (3) beverage revenue; (4) miscellaneous revenue.
(Sigala, 2004)	DEA model Stepwise DEA Benchmarking Productivity	93 hotels in United Kingdom	(1) number of full-time employees for each service; (2) number of part-time employees; (3) total expenses for each service sector; (4) management fees.	(1) number of full-time employees for each service; (2) number of part-time employees; (3) total expenses for each service sector; (4) management fees.
(Barros, 2005)	DEA model Output-oriented DEA CRS and VRS model	43 hotels in Pousada	(1) full-time workers; (2) cost of labor; (3) area of the hotel; (4) book value of the property; (5) rooms; (6) operational; (7) external costs.	(1) sales; (2) number of guests; (3) nights spent.

Table 1. (*Continued*).

Authors	**Methods**	**Units & destination**	**Input**	**Output**
(Barros and Mascarenhas, 2005)	DEA model technical and allocative output-oriented DEA CRS and VRS model	43 public chain hotels in portugal	(1) employees; (2) physical capital; (3) rooms.	(1) sales; (2) number of guests; (3) nights spent.
(Barros, 2005a)	DEA model CCR and BCC model	42 hotels in portugal	(1) capital; (2) labor.	(1) sales; (2) number of guests; (3) nights spent.
(Barros, 2005b)	DEA model CCR and BCC model	42 hotels in Portugal	(1) fulltime employees; (2) cost of labor; (3) rooms; (4) surface area of the hotel; (5) book value of property; (6) operational costs; (7) external costs.	(1) sales; (2) number of guests; (3) nights spent.
(Barros and Santos, 2006)	DEA model Allocative CCR and CRS model Product efficiency	15 hotels in Portugal	(1) employees; (2) physical capital.	(1) sales; (2) added value; (3) earnings.
(Chiang, 2006)	DEA model CCR, BCC	24 hotels in Taipei	(1) hotel rooom (2) F&B capacity (3) number of employees (4) total operating cost.	(1) yielding index (2) F&B revenue (3) Miscellaneous revenue.
(Keh et al., 2006)	DEA model VRS output-oriented model Efficiency Allocative Rts Productivity	49 hotels in Asia Pacific	(1) total expenses; (2) number of rooms; (3) marketing expenses.	(1) marketing expenses; (2) room revenues; (3) f&b revenue.
(Yang and Lu, 2006)	DEA model BCC model Benchmarking	56 hotels in Taiwan	(1) total operating expenses; (2) number of employees; (3) number of guest rooms; (4) total area of catering division.	(1) total operating revenues; (2) average occupancy rate; (3) average room rate; (4) average production; (5) value per employee in the catering division; (6) average production value of catering division.
(Wang et al., 2006)	DEA model SFA model Cost efficiency	49 hotels in Taiwan	(1) number of rooms; (2) number of full-time employees in room department; (3) area of food and beverage department; (4) number of full-time employees in food and beverage department.	(1) room revenue; (2) food and beverage revenue; (3) other revenue.
(Botti et al., 2009)	DEA model CRS I VRS model	15 hotels in France	(1) costs; (2) territory coverage; (3) chain duration.	(1) sales.
(Yu and Lee, 2009)	Hiperbolic network DEA model Productivity efficiency	57 Hotels in Taiwan	(1) number of full-time employees in the room service department; (2) number of full-time employees in the food and beverage service department; (3) number of rooms; (4) total floor area in the food and beverage service department; (5) total expenses for each service sector.	(1) total revenue generated from rooms; (2) total revenue generated from food and beverages; (3) other revenue.

Table 1. (*Continued*).

Authors	Methods	Units & destination	Input	Output
(Barros et al., 2011)	DEA model CCR, BCR, CRS and VRS model Farrell Debreu—type output-oriented technical efficiency measure	15 Hotels in Portugal	(1) number of full-time workers; (2) book value of property; (3) operational costs.	(1) sales; (2) number of guests.
(Rabar and Blažević, 2011)	DEA model CCR and BCC output-oriented model Window analysis	Hotels in 21 Croatian countries	(1) number of beds; (2) number of seats; (3) number of employees.	(1) number of arrivals; (2) number of stays; (3) number of nights.
(Oliveira et al., 2013)	DEA model CRS and VRS model	84 hotels in Algarve	(1) number of rooms; (2) number of employees; (3) food & beverage capacity; (4) other costs.	(1) total revenue.
(Manasakis et al., 2013)	DEA model CCR and BCC model	50 hotels in Crete	(1) number of employees; (2) number of beds; (3) total operative expenses.	(1) total revenue; (2) number of nights.
(Hathroubi et al., 2014)	DEA model CCR model Technical efficiency	42 hotels in Tunisia	(1) number of hotel stars; (2) cleaning personnel; (3) service personnel; (4) management personnel; (5) number of rooms; (6) number of beds.	(1) arrivals; (2) nights slept.
(De jorge and Suárez, 2014)	DEA model CCR and BCC model Productivity change	303 hotels in the Spanish market	(1)employment (2) labor costs (3) number of rooms (4) operational costs.	(1) sales (2) market share.
(Antonic and Skender, 2015)	DEA model CCR and BCC model	Hotels in Croatia	(1) coast length and number of employees; (2) revenues and number of employees.	(1) passenger turnover.
(Oukil et al., 2016)	DEA model CCR, CRS and VRS model	58 hotels in Oman	(1) number of beds; (2) salary of employees.	(1) annual revenue; (2) number of guests; (3) number of nights; (4) occupancy rate.
(Poldrugovac et al., 2016)	DEA model BCC output-oriented model CCR output-oriented model	105 hotels in Croatia	(1) energy expenses; (2) room expenses; (3) f&b expenses; (4) expenses associated with other services; (5) labor expenses.	(1) total revenue; (2) occupancy rate.
(Hodzic and Alibegović, 2019)	DEA model CCR and BCC input-oriented models	Hotels in 20 Croatian countries	(1) average expenditures for tourism; (2) average expenditures for recreation, culture, and religion.	(1) total tourist arrivals; (2) total tourist nights.
(Higuerey et al., 2020)	DEA model CRS input-oriented Total factor productivity	147 hotels in Ecuador	(1) total personnel; (2) non-current assets; (3) consumption.	(1) revenue.

The specifics of the paper, the chosen methods and the like are highlighted under the methods. The table shows that no one used the same method, the same inputs and outputs. The chosen method often involves a combination of models. Only hotels with an emphasis on the use of the CCR and/or BCC methods were considered in this review.

3. Materials and methods

The sample of this study consists only of hotels with accommodation capacities. Only four-star hotels were included in the sample because there were no five-star hotels in Makarska in 2022, and three-star hotels were not available because they had already closed the facility for business. The research took place in September 2023. Due to the ongoing nature of the season, the available data for that particular season was incomplete, requiring the acquisition of data from the previous season. The list of existing hotels was obtained from a public document from the Ministry of Tourism. Every hotel address in Makarska received an e-mail survey, containing the needed data required for calculating the labor productivity coefficient. There was only one hotel that responded. The performance coefficient for hotels in the city of Makarska was calculated using average ratings, taking into account the specificity of the data. Makarska boasts a total of 18 hotels, comprising five three-star businesses, twelve four-star businesses, and one five-star hotel. Of the twelve four-star hotels that are constantly open for the season, as many as there were last year, one was completely newly built and opened. Due to the extended duration of data collection, it was excluded from the research. Furthermore, the data collected two years earlier was inadequate to be taken into consideration because of insufficient data. So, data was acquired from seven hotels in the destination after a direct request with the help of personal contact to the general manager of hotel, out of a total of ten hotels and 58.33 percent represents the share of hotels that submitted the requested data in relation to the total number of four-star hotels in the tourist market. This percentage highlights the response rate within the stated accommodation category, indicating a significant level of participation by the targeted four-star hotels. Other four-star hotels were unavailable and unwilling to provide information.

Table 2. The variety of accommodation possibilities offered in Makarska (Source: Tourist Board).

Year	**2022**					
Accommodation/month	**5**	**6**	**7**	**8**	**9**	**10**
Apartments*	501	1558	2054	2055	1591	324
Hotels	17	18	18	19	19	18
Camps	3	3	3	3	3	1
Total arrivals	10.292	13.616	18.172	18.307	12.863	10.360
Total overnight stays	36.893	69.222	98.663	106.198	73.327	39.999

* Rooms, apartments, studio apartments, and vacation houses are examples of apartments.

Table 2 presents consistent average percentage of campsites in accommodation capacities, indicating the city's as a tourist destination, while the expansion of hotels, rooms, apartments, and other types of accommodations increases accordingly. This phenomenon can be attributed to the rise in the development of vacation residences, apartments and villas. However, it is essential for the destination to acknowledge the importance of increasing the number of hotels, as they play an important role in driving the overall economy. The most recent census in 2021 estimates Makarska's population at around 14,000 individuals. Nevertheless, in the summer season, the town experiences a substantial surge in population as a result of the significant increase in the number of visitors. In research conducted by Marušić et al. (2018), it was found that tourists showed an elevated level of satisfaction with the offerings and resources provided by the destination. According to Prpić and Barićević (2017), the satisfaction of tourists with the destination was significantly influenced by the quality of the lodging. The selection of Makarska as a tourism destination is based on its significant popularity in Croatia. The growth of tourism in Makarska has caused numerous development projects and the uncontrolled construction of accommodation facilities and residential buildings (Kranjcevic and Hajdinjak, 2019). The study of Makarska can help in understanding the socioeconomic changes that tourism brings to small coastal towns, and for this reason, it has been considered.

The time frame under consideration was 2022, as the hotels agreed to provide this data. The data is provided individually for the months ranging from May to October, which corresponds to the typical six-month season in Makarska. The total number of overnight stays in hotels was calculated by summing the monthly overnight stays. The average number of employees for the six months was used to determine the number of employees, along with the productivity coefficient. The paper examines the mean monthly employment count, which includes both permanent employees and those employed only during the season, excluding students. Productivity of staff refers to the proportion of overnight stays among the total number of employees. Staff productivity refers to the proportion of overnight stays among the overall number of employees. A hotel with a higher coefficient indicates a correspondingly higher level of employee productivity.

The DEA approach was employed for data analysis, utilizing Excel tables and Solver software. The "DEA-solver" software program was utilized to calculate the scale efficiency. It was used in this paper output-oriented technical efficiency.

4. Results and discussion

According to Ball et al. (1986), the measurement units utilized in DEA can encompass financial, non-financial, or a hybrid combination of both. The inputs utilized in this study encompass the aggregate count of rooms, the aggregate count of beds, and the mean count of staff during the season. This study (**Table 3**) employs two criteria as the output variables in the DEA framework: the total count of overnight stays during the season and the labor productivity coefficient.

Table 3. Descriptive statistics of output and input variables (Source: author).

Input	**Unit**	**Range**	**Mean**	**SD**
Rooms	Total number of rooms	21–286	89.86	90.78
Capacitary	Total number of beds	42–600	199.71	189.88
Employees	Average number of employees in the season	12.66–167.83	54.59	52.64
Output				
Overnight stays	Total number of overnight stays in season	5806–79,181	24,945	25,360.61
Staff productivity	Labor productivity coefficient	35.08–163.89	82.60	41.45

To deal with multiple inputs and outputs, a ratio like Equation (1) the following is used (Cooper et al., 2007):

$$\frac{\sum_{r=1}^{s} u_r y_r}{\sum_{i=1}^{m} v_i x_i} = \frac{u_1 y_1 + u_2 y_2 + \cdots + u_s y_s}{v_1 x_1 + v_2 x_2 + \cdots + v_m x_m} \quad (1)$$

which is an explanation for y_r = amount of output r, u_r = weight assigned to output r,

x_i—amount of input i and v_i = weight assigned to input i.

The **Table 4** displays the input and output values of hotels in Makarska participating in this research. The number of overnight stays (x_1) is not shown as the hotels insisted that this data not be publicly disclosed. The destination mostly consists of smaller hotels, with around fifty rooms each. All hotels belong to the four-star category.

Table 4. Values of DMUs (Source: author).

DMU	y_1	y_2	y_3	x_1	x_2
Milenij	21	42	17	x_{11}	54.89
Miramare	57	200	33	x_{12}	94.11
Mirjam	48	96	19	x_{13}	163.89
Osejava	52	105	30	x_{14}	60.48
Biokovo	52	105	42.17	x_{15}	35.08
Park	113	250	60	x_{16}	89.59
Meteor	286	600	132	x_{17}	80.18

A crucial part of the DEA framework is the differentiation between technical and allocative efficacy (Anderson et al., 2000). Barros and Mascarenhas (2005) employed the data envelopment analysis (DEA) method to examine the technical efficiency and allocative efficiency of a state-owned hotel chain in Portugal. Technical efficiency refers to the hotel's ability to effectively utilize inputs in order to achieve its outputs, relative to its maximum potential. On the other hand, allocative efficiency refers to the hotel's ability to set prices based on its marginal productivity. According to Sathye (2001), the initial DEA efficiency index assesses technical efficiency (Equations (2) and (3)), which refers to the productivity of a company as a result from its input/output configuration and operational scale.

$$\max\varphi: \sum_{j=1}^{N} \lambda_j y^j \geq \varphi y^0, \sum_{j=1}^{N} \lambda_j x^j \leq x^0, \sum_{j=1}^{N} \lambda_j = 1$$
$$\lambda_{j\geq 0}\ (j = 1,2,3,\ldots,N) \tag{2}$$

$$\min\theta: \sum_{j=1}^{N} \lambda_j y^j \geq y^0, \sum_{j=1}^{N} \lambda_j x^j \leq \theta \times x^0, \sum_{j=1}^{N} \lambda_j = 1$$
$$\lambda_{j\geq 0}\ (j = 1,2,3,\ldots,N) \tag{3}$$

The model determines for each DMU the optimal set of input weights and output weights that maximize its technical efficiency. Other approach treats one DMU at a time, but in this paper the Multiplier model is used where the DMUs are numerous and it is not clear which ones require attention (Cooper et al., 2007, p. 287).

The multiplier model x_{ij} and y_{rj} are variables that represent the inputs and outputs of the Decision-Making Units (DMUs). x_{ij} represents the amount of the i-th input used by the j-th DMU. y_{rj} represents the amount of the r-th output produced by the j-th DMU. Other indicators: j—serial number of the hotel, s—number of input, m—number of output, r—input sequence number, i—output sequence number, y—value of input and x—value output. According to Thompson et al. (1996) multiplier model Equation (4) is:

$$\mathrm{SE}_j = \frac{\sum_{r=1}^{s} u_r \times y_{rj}}{\sum_{i=1}^{m} v_i \times x_{ij}} \tag{4}$$

CCR index was created by Charnes et al. (1978) and assumes constant returns-to-scale (CRS) production technology, i.e., an increase in the inputs is followed by the same proportional increase in the outputs for all DMUs. It means that the CCR index is calculated by maximizing the ratio of the weighted sum of outputs over the weighted sum of inputs for all units, according to Cooper et al. (2011).

The scale efficiency Equation (5) is defined by (Cooper et al., 2007, p. 153):

$$\mathrm{SE} = \frac{\theta_{\mathrm{CCR}}}{\theta_{\mathrm{BCC}}} \tag{5}$$

SE is not greater than one (Cooper et al., 2011). The scale efficiency of a BCC efficient DMU with CRS features, or in the highest productive scale size, is one. The CCR score is called the (global) technical efficiency (TE), since it takes no account of scale effect as distinguished from PTE and BCC expresses the (local) pure technical efficiency under variable returns-to-scale circumstances (Cooper et al., 2007, p. 153).

The scale efficiency index is obtained by dividing the CCR index by the BCC index, which measures the managerial ability in choosing the optimal resource size, i.e., to decide on hotels' size or in other words, to choose the scale of production that will attain the expected output levels" (Kumar and Gulati, 2008). The fundamental difference between the CCR and BCC models in DEA analysis lies in the assumptions regarding returns to scale. The CCR model assumes constant returns to scale, which implies a proportional relationship between inputs and outputs, making it ideal for analyzing organizations operating at optimal levels. Conversely, the BCC model allows for variable returns to scale, rendering it suitable for analyzing organizations that may not be operating optimally, where increases in inputs do not necessarily reflect a proportional increase in outputs. Using both models can provide complementary insights, with CCR indicating efficiency under the assumption of scale optimality and BCC offering insights into how efficiently DMUs manage their resources irrespective of their scale. The Decision-Making Units (DMUs) analyzed in this article are hotels that belong to the tourism services sector. The analysis of the DMUs is confined to a single, smaller coastal tourist destination.

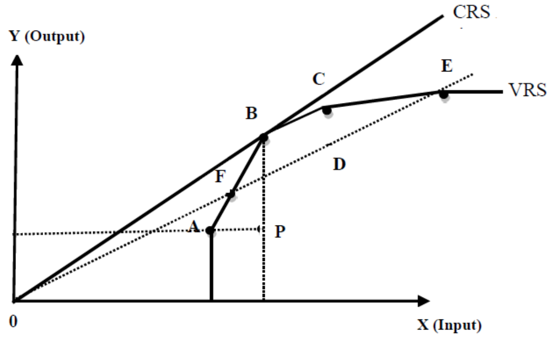

Figure 1. Measuring the efficiency (Cooper et al., 2011, p. 137).

According to Cooper et al. (2011) in **Figure 1**, the graph plots output (*Y*) against input (*X*) for a number of units (A, B, C, D, E, F). Two frontiers can be seen: the CRS (Constant Returns to Scale) frontier and the VRS (Variable Returns to Scale) frontier. Units on the CRS and VRS frontiers, like C and E, are considered efficient as they are on the boundary of the maximum feasible output. The scale efficiency is concerned with whether a unit is operating at an optimal size. Units on the VRS frontier but not on the CRS frontier (like D) are experiencing scale inefficiencies. They have optimal efficiency given their size (technically efficient on the VRS frontier), but they could achieve a better scale of operation (they're not on the CRS frontier). The point P represents the potential output for A if it were operating efficiently. Units like A, B, and F are below the frontier, indicating inefficiency so they could produce more output with the same input if they were operating like their peers on the frontier. The distance between the CRS and VRS frontiers indicates the degree of returns to scale. For scale efficiency specifically, one could calculate the ratio of the distance of a DMU on the VRS frontier to its distance on the CRS frontier. DMUs like D would have a scale efficiency score of less than 1, indicating they are not operating at an optimal scale. Units on both frontiers (like C and E) would have a scale efficiency of 1, indicating they are scale efficient.

The CCR model in DEA methodology is applicable to hotels when the objective is to evaluate their efficiency, where a proportional increase in inputs (such as labor in this case) is expected to result in a proportional increase in outputs (such as the number of guests or overnight stays). Thus, the CCR model can provide a clear picture of how well hotels are utilizing their resources. In conclusion, the CCR model provides valuable insights into how hotels manage their resources in terms of producing desired outcomes such as the number of overnight stays, enabling management to make informed decisions about staffing levels and potential improvements.

The CCR, BCC and scale efficiency scores for each hotel in the sample are presented in **Table 5**. The results of the technical efficiency (CCR) index are displayed in the sixth column, and the pure technical efficiency (BCC) index findings are shown in the seventh column. The scale efficiency is the main index is one of the efficiency indicators. If the scale efficiency is equal to 1, it means that the DMU has reached the optimal size of operations and there is no need to change. If the scale efficiency is less than 1, it suggests that a certain hotel should work on efficiency. Hotel Biokovo is the most efficient, which means that it achieves the best outputs with the resources it has, in other words, with the existing capacity of rooms and beds and the number of employees it has, it achieves the best results so that it achieves its maximum and has the optimal number of overnight stays. Mirjam has the highest scale efficiency (0.980249) among the hotels not operating at optimal scale. This suggests that while its overall efficiency might not be the highest, it is operating very close to its most productive scale size. The Milenij, Osejava, Park, and Meteor have lower CCR and BCC scores but their scale efficiencies are all very close to 1, suggesting they might be operating at an efficient scale but there are other inefficiencies in their operations. Given that the other hotels have very small differences in the coefficient of scale efficiency, it indicates that their business strategies are very similar. The differences between CCR and BCC scores indicate how much each hotel could potentially improve by operating at an optimal scale.

Table 5. Scale efficiency results of Hotels in Makarska for 2022 year (Source: author).

2022	Lamda	Lamda	$\sum_{r=1}^{s} u_r \times y_{rj}$	$\sum_{i=1}^{m} v_i \times x_{ij}$	CCR	BCC	Scale
Hotel	*u*	*v*					Efficiency
Milenij	0.003929	0.033525	0.816847	201.2922	0.661456	0.688915	0.960149
Miramare	0.014244	0.121127	3.336886	671.2294	0.810323	0.843506	0.960656
Mirjam	0.008006	0.065253	1.708104	439.9761	0.632809	0.645562	0.980249
Osejava	0.009185	0.082636	1.940079	500.1031	0.632335	0.658535	0.960222
Biokovo	0.009782	0.085397	2.03751	345.8978	1	1	1
Park	0.020776	0.175487	4.485265	1092.052	0.669472	0.69714	0.960312
Meteor	0.05	0.436577	10.72672	2664.219	0.656273	0.683415	0.960292

What cannot be recognized from the results is the fact that the owner of the Biokovo and Miramare hotels is the same, but the results show that they achieve the greatest efficiency in the Biokovo hotel, which is surprising considering that some employees work double-time, so, if necessary, they work extra hours for the Miramare Hotel. Mirjam's management is very effective at utilizing its scale, and marginal adjustments in scale may lead to optimal efficiency. Hotels Milenij, Osejava, Park, Meteor these hotels show a gap between CCR and BCC scores which implies that there are inefficiencies in operations that are not related to scale. For instance, it may suggest areas such as employee productivity where it is necessary to consider whether they have a sufficient number of employees in order to achieve as many overnight stays as possible. However, the difference is small enough to suggest that they are introducing major changes in their strategies. All hotels are privately owned except for Hotel Meteor, which belongs to the Valamar Group.

5. Conclusion

This paper provides an overview of previous research into the efficiency of hotels and presents research in the tourist destination of Makarska in Croatia. The review of previous research included works that used DEA, namely a certain base method CCR and BCC. In this paper, unlike before, unchanging variables such as the number of rooms and possible capacity were used for input and the average number of employees in the season, while the output was measured by the number of overnight stays and the labor productivity coefficient. Scale efficiency in the DEA method shows the extent to which the DMU utilizes its resources in accordance with the size of its operations. The ranking is useful for comparison with competitors on the tourism market in the hotel industry segment. The main contribution is the measurement of scale efficiency to be competitive in the market in terms of the considered inputs and outputs. The results can be useful to hotel managers for managing resources, making decisions about the number of employees, length of business and planning improvements in operations and strategies.

The main limitation of this research is the small sample size and not all hotels responded to the invitation, so it was difficult and slow to get the data. The data is from 2022, which may be outdated, but more recent data was not available for analysis. Only hotels with a four-star rating were considered, other categories of hotels should have been included as well. The geographic area is too small for the sample. Most hotels work seasonally, so the average number of employees was taken for six months when it is the highest season, and the number of overnight stays is the sum of overnight stays for all six months. There is a possibility that some of the hotels were closed in October, which affected the calculation of the average. Also, the data used to calculate scale efficiency are not homogeneous because different dimensions, numbers and coefficients were compared, but they are from the same hotel, so they are comparable because they follow the same strategy. There are other small coastal tourist destinations in Croatia, so it is necessary to explore other destinations or expand the geographical area of research. For future research, it is recommended to take at least one monetary income or expense that will represent inputs and outputs and to research a wider area. It is recommended for future research to calculate super efficiency because it allows for efficiency ratings greater than one and especially the approach helps distinguish units that are efficient.

Acknowledgments: I am thankful to the hotels that participated in this research and to student Petra Lausic for organizing the data. Special thanks go to my uncle Zvonimir Pezer for teaching me the DEA method, because without him this paper wouldn't be possible. Thank you ujkino!

Conflict of interest: The author declares no conflict of interest.

References

Anderson, R. I., Fok, R., Scott, J. (2000). Hotel industry efficiency: An advanced linear programming examination. American Business Review, 18(1), 40.

Antonic, J. J., Skender, H. P. (2015). Efficiency of Passenger Seaports as a Factor in Tourism Development. In: Proceedings of the International Multidisciplinary Scientific Conference on Social Sciences and Arts SGEM 2015. pp. 235–244.

Arbelo, A., Perez-Gomez, P., & Arbelo-Perez, M. (2017). Cost efficiency and its determinants in the hotel industry. Tourism Economics, 23 (5), 1056–1068. https://doi.org/10.1177/1354816616656419

Arbelo, A., Pérez-Gómez, P., González-Dávila, E., et al. (2017). Cost and profit efficiencies in the Spanish hotel industry. Journal of Hospitality & Tourism Research, 41(8), 985–1006. https://doi.org/10.1177/1096348015587999

Assaf, A. G., Agbola, F. W. (2011). Total productivity in the Australian hotel industry: Estimating and bootstrapping Malmquist indices. Tourism Analysis, 16(3), 295–304. h Long-term analysis of labour productivity in the Croatian hotel industryttps://doi.org/10.3727/108354211x13110944387121

Avelini Holjevac, I., Vrtodušić Hrgović, A. (2012). Long-term analysis of labour productivity in the Croatian hotel industry (Croatian). Acta Turistica, 24(1), 39–59.

Avkiran, N. K. (2002). Monitoring hotel performance. Journal of Asia-Pacific Business, 4(1), 51–66.

Ball, S. D., Johnson, K., Slattery, P. (1986). Labour productivity in hotels: an empirical analysis. International Journal of Hospitality Management, 5(3), 141–147.

Banker, R. D., Charnes, A., Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management science, 30(9), 1078–1092. https://doi.org/10.1287/mnsc.30.9.1078

Barros, C. A. P., Santos, C. A. (2006). The measurement of efficiency in Portuguese hotels using data envelopment analysis. Journal of Hospitality & Tourism Research, 30(3), 378–400. https://doi.org/10.1177/1096348006286798

Barros, C. P. (2004). A stochastic cost frontier in the Portuguese hotel industry. Tourism Economics, 10(2), 177–192. https://doi.org/10.5367/000000004323142416

Barros, C. P. (2006). Analysing the rate of technical change in the Portuguese hotel industry. Tourism Economics, 12(3), 325–

346. https://doi.org/10.5367/000000006778493673

Barros, C. P., Mascarenhas, M. J. (2005). Technical and allocative efficiency in a chain of small hotels. International journal of hospitality management, 24(3), 415–436. https://doi.org/10.1016/j.ijhm.2004.08.007

Barros, C. P., Botti, L., Peypoch, N., & Solonandrasana, B. (2011). Managerial efficiency and hospitality industry: the Portuguese case. Applied Economics, 43(22), 2895–2905. https://doi.org/10.1080/00036840802600145

Barros, C.P., (2005a). Measuring efficiency in the hotels: an illustrative example. Annals of Tourism Research 32, 456–477. https://doi.org/10.1016/j.annals.2004.07.011

Barros, C.P., (2005b). Evaluating the efficiency of small hotel chain with a malmquist productivity index. International Journal of Tourism Research 7, 173–184. https://doi.org/10.1002/jtr.529

Ben Aissa, S., Goaied, M. (2016). Determinants of tourism hotel market efficiency. International Journal of Culture, Tourism and Hospitality Research, 10(2), 173–190. https://doi.org/10.1108/ijcthr-11-2013-0080

Bire, R. B. (2020). Efficiency Analysis of Hotels Listed in the Indonesian Stock Exchange Market. TOURISM: Jurnal Travel, Hospitality, Culture, Destination, and MICE, 3(1), 1–6.

Botti, L., Briec, W., Cliquet, G. (2009). Plural forms versus franchise and company-owned systems: A DEA approach of hotel chain performance. Omega, 37(3), 566–578. https://doi.org/10.1016/j.omega.2007.12.002

Brown, J., Dev, C. (1999). Looking beyond RevPar: productivity consequences of hotel strategies. Cornell Hotel and Restaurant Administration Quarterly, 40(2), 23–33. https://doi.org/10.1177/001088049904000213

Brown, J. R., Ragsdale, C. T. (2002). The competitive market efficiency of hotel brands: An application of data envelopment analysis. Journal of Hospitality & Tourism Research, 26(4), 332–360. https://doi.org/10.1177/109634802237483

Charnes, A., Cooper, W. W., Rhodes, E. (1978). Measuring the efficiency of decision making units. European journal of operational research, 2(6), 429–444.

Charnes, A., Cooper, W. W., Seiford, L., et al. (1982). A multiplicative model for efficiency analysis. Socio-Economic Planning Sciences, 16(5), 223–224.

Cheong, Y., & Leckenby, J. D. (2006). An evaluation of advertising media spending efficiency using data envelopment analysis. In: Proceedings of the American Academy of Advertising. American Academy of Advertising. p. 263.

Chiang, W. E. (2006). A hotel performance evaluation of Taipei international tourist hotels–using data envelopment analysis. Asia Pacific Journal of Tourism Research, 11(1), 29–42. https://doi.org/10.1080/10941660500500667

Chiang, W. E., Tsai, M. H., Wang, L. S. M. (2004). A DEA evaluation of Taipei hotels. Annals of tourism Research, 31(3), 712–715. https://doi.org/10.1016/j.annals.2003.11.001

Cooper, W. W., Seiford, L. M., Tone, K. (2007). Data envelopment analysis: a comprehensive text with models, applications, references and DEA-solver software. New York: springer.

Cooper, W. W., Seiford, L. M., Zhu, J. (2011). Data envelopment analysis: History, models, and interpretations. Handbook on Data Envelopment Analysis. pp. 1–39.

Coupet, J., Berrett, J., Broussard, P., et al. (2021). Nonprofit benchmarking with data envelopment analysis. Nonprofit and Voluntary Sector Quarterly, 50(3), 647–661. https://doi.org/10.1177/0899764020977670

Cracolici, M. F., Nijkamp, P., Cuffaro, M. (2007). Efficiency and productivity of Italian tourist destinations: a quantitative estimation based on data envelopment analysis and the Malmquist method. In Advances in modern tourism research: Economic perspectives. Heidelberg: Physica-Verlag HD. pp. 325-343.

Črnjar, K. (2005). Factors of productivity in the hotel industry in Croatia (Slovenian). Tourism and hospitality management, 11(1), 251–262. https://doi.org/10.20867/thm.11.1.16

De Jorge, J., Suárez, C. (2014). Productivity, efficiency and its determinant factors in hotels. The Service Industries Journal, 34(4), 354–372. https://doi.org/10.1080/02642069.2013.778977

Farell, P. (1957). DEA in production center: An input-output mode. Journal of Econometrics, 3, 23–49.

Fernández, M. A., Becerra, R. (2015). An analysis of Spanish hotel efficiency. Cornell hospitality Quarterly, 56(3), 248–257. https://doi.org/10.1177/1938965513509877

Hamelin, N., Al-Shihabi, S., Quach, S., et al. (2022). Forecasting advertisement effectiveness: Neuroscience and data envelopment analysis. Australasian Marketing Journal, 30(4), 313–330. https://doi.org/10.1177/18393349211005061

Hathroubi, S., Peypoch, N., Robinot, E. (2014). Technical efficiency and environmental management: The Tunisian case. Journal of Hospitality and Tourism Management, 21, 27–33. https://doi.org/10.1016/j.jhtm.2014.03.002

Higuerey, A., Viñan-Merecí, C., Malo-Montoya, Z., et al. (2020). Data Envelopment Analysis (DEA) for Measuring the efficiency of the hotel industry in Ecuador. Sustainability, 12(4), 1590. https://doi.org/10.3390/su12041590

Hodžić, S., Alibegović, D. J. (2019). The efficiency of regional government expenditure in smart tourist destination: The case of Croatia. Tourism in Southern and Eastern Europe, 5, 307–318.

Hu, B. A., Cai, L. A. (2004). Hotel labor productivity assessment: A data envelopment analysis. Journal of Travel & Tourism Marketing, 16(2/3), 27–38.

Hwang, S. N., Chang, T. Y. (2003). Using data envelopment analysis to measure hotel managerial efficiency change in Taiwan. Tourism management, 24(4), 357–369.

Johns, N., Howcroft, B., Drake, L. (1997). The use of data envelopment analysis to monitor hotel productivity. Progress in Tourism and Hospitality Research, 3(2), 119–127.

Johnston, R., Jones, P. (2004). Service productivity: Towards understanding the relationship between operational and customer productivity. International Journal of Productivity and performance management, 53(3), 201–213. https://doi.org/10.1108/17410400410523756

Kaffash, S., Azizi, R., Huang, Y., et al. (2020). A survey of data envelopment analysis applications in the insurance industry 1993–2018. European journal of operational research, 284(3), 801–813. https://doi.org/10.1016/j.ejor.2019.07.034

Keh, H. T., Chu, S., Xu, J. (2006). Efficiency, effectiveness and productivity of marketing in services. European Journal of Operational Research, 170(1), 265–276. https://doi.org/10.1016/j.ejor.2004.04.050

Kilic, H., Okumus, F. (2005). Factors influencing productivity in small island hotels: evidence from Northern Cyprus. International Journal of Contemporary Hospitality Management, 17(4), 315–331. https://doi.org/10.1108/09596110510597589

Kularatne, T., Wilson, C., Månsson, J., et al. (2019). Do environmentally sustainable practices make hotels more efficient? A study of major hotels in Sri Lanka. Tourism Management, 71, 213–225. https://doi.org/10.1016/j.tourman.2018.09.009

Kumar, S., Gulati, R. (2008). The impact of size and group affiliation on technical efficiency of Indian public sector banks: An empirical investigation. The IUP Journal of Bank Management, 7(4), 18–40.

Kumbhakar, S. C. (1987). The specification of technical and allocative inefficiency in stochastic production and profit frontiers. Journal of econometrics, 34(3), 335–348.

Lee-Ross, D., Ingold, T. (1994). Increasing productivity in small hotels: are academic proposals realistic? International Journal of Hospitality Management, 13(3), 201–207.

Liu, H., Tsai, H. (2021). A stochastic frontier approach to assessing total factor productivity change in China's star-rated hotel industry. Journal of Hospitality & Tourism Research, 45(1), 109–132. https://doi.org/10.1177/1096348020946363

Manasakis, C., Apostolakis, A., Datseris, G. (2013). Using data envelopment analysis to measure hotel efficiency in Crete. International Journal of Contemporary Hospitality Management, 25(4), 510–535. https://doi.org/10.1108/09596111311322907

Marušić, M., Prebežac, D., Antunović, M. (2018). Tourist satisfaction in small-scale tourist destinations: The case of Makarska Riviera. Tourism and Hospitality Management, 24(2), 24(2), 287–306. https://doi.org/10.20867/thm.24.2.3

Morey, R. C., Dittman, D. A. (1995). Evalatn a hotel GM's performance: A case study in benchmarking. Cornell Hotel and Restaurant Administration Quarterly, 36(5), 30–35. https://doi.org/10.1177/001088049503600521

Oliveira, R., Pedro, M. I., Marques, R. C. (2013). Efficiency and its determinants in Portuguese hotels in the Algarve. Tourism Management, 36, 641–649. https://doi.org/10.1016/j.tourman.2012.06.009

Oukil, A., Channouf, N., Al-Zaidi, A. (2016). Performance evaluation of the hotel industry in an emerging tourism destination: The case of Oman. Journal of Hospitality and Tourism Management, 29, 60–68. https://doi.org/10.1016/j.jhtm.2016.05.003

Panfilova, E., Dzenzeliuk, N., Domnina, O., et al. (2020). The impact of cost allocation on key decisions of supply chain participants. International Journal of Supply Chain Management, 9(1), 552–558.

Poldrugovac, K., Tekavcic, M., Jankovic, S. (2016). Efficiency in the hotel industry: an empirical examination of the most influential factors. Economic research-Ekonomska istraživanja, 29(1), 583–597. https://doi.org/10.1080/1331677x.2016.1177464

Prpić, K., Baričević, A. (2017). Tourist satisfaction in the city of Makarska. Journal of Business and Management, 23(1), 107–122. https://doi.org/10.24818/jbman.2017.011

Rabar, D., Blažević, S. (2011). Efficiency Assessment of Croatian Counties in Tourism Using Data Envelopment Analysis (Croatian). Economic Trends and Economic Policy, 21(127), 25–56.

Reynolds, D. (2003). Hospitality-productivity assessment-using data envelopment analysis. Cornell Hotel and Restaurant

Administration Quarterly, 44(2), 130–137. https://doi.org/10.1177/0010880403442012

Reynolds, D., Thompson, G. M. (2007). Multiunit restaurant productivity assessment using three-phase data envelopment analysis. International Journal of Hospitality Management, 26(1), 20–32. https://doi.org/10.1016/j.ijhm.2005.08.004

Romano, G., Guerrini, A. (2011). Measuring and comparing the efficiency of water utility companies: A data envelopment analysis approach. Utilities Policy, 19(3), 202–209. https://doi.org/10.1016/j.jup.2011.05.005

Sathye, M. (2001). X-efficiency in Australian banking: An empirical investigation. Journal of Banking & Finance, 25(3), 613–630.

Sellers-Rubio, R., Casado-Díaz, A. B. (2018). Analyzing hotel efficiency from a regional perspective: The role of environmental determinants. International Journal of Hospitality Management, 75, 75–85. https://doi.org/10.1016/j.ijhm.2018.03.015

Sharma, N., Mogha, S. K. (2023). Super Efficiency and Sensitivity Analysis of the Indian Hotels and Restaurants. https://doi.org/10.21203/rs.3.rs-2732233/v1

Sigala, M. (2004). Using data envelopment analysis for measuring and benchmarking productivity in the hotel sector. Journal of Travel & Tourism Marketing, 16(2–3), 39–60.

Simpao, K. (2018). Labour productivity measurement and control standards for hotel. Journal of Service Science Research, 10, 25–76. https://doi.org/10.1007/s12927-018-0002-1

Tarim, Ş., Dener, H. I., Tarim, Ş. A. (2000). Efficiency measurement in the hotel industry: output factor constrained DEA application. Anatolia, 11(2), 111–123. https://doi.org/10.1080/13032917.2000.9686989

Thompson, R. G., Dharmapala, P. S., Diaz, J., et al. (1996). Chapter 7 DEA multiplier analytic center sensitivity with an illustrative application to independent oil companies. Annals of Operations Research, 66, 163–177. https://doi.org/10.1007/bf02187299

Tsaur, S. (2001). The operating efficiency of international tourist hotels in Taiwan. Asia Pacific Journal of Tourism Research, 6(1), 73–81. https://doi.org/10.1080/10941660108722090

Tumer, N. (2010). Measuring hotel performance using data envelopment analysis. Anatolia, 21(2), 271–287. https://doi.org/10.1080/13032917.2010.9687103

Walraven, M., Koning, R. H., Bijmolt, T. H., et al. (2016). Benchmarking sports sponsorship performance: Efficiency assessment with data envelopment analysis. Journal of Sport Management, 30(4), 411–426. https://doi.org/10.1123/jsm.2015-0117

Wang, F. C., Hung, W. T., Shang, J. K. (2006). Measuring the cost efficiency of international tourist hotels in Taiwan. Tourism Economics, 12(1), 65–85. https://doi.org/10.5367/000000006776387150

Witt, C. A., Witt, S. F. (1989). Why productivity in the hotel sector is low. International Journal of Contemporary Hospitality Management, 1(2). https://doi.org/10.1108/eum0000000001669

Wober, K. W. (2000). Benchmarking hotel operations on the internet: a data envelopment analysis approach. Information Technology & Tourism, 3(3), 195–211.

Yang, C., Lu, W. M. (2006). Performance benchmarking for Taiwan's international tourist hotels. INFOR: Information Systems and Operational Research, 44(3), 229–245. https://doi.org/10.1080/03155986.2006.11732750

Yu, M. M., Lee, B. C. (2009). Efficiency and effectiveness of service business: Evidence from international tourist hotels in Taiwan. Tourism Management, 30(4), 571–580. https://doi.org/10.1016/j.tourman.2008.09.005

Zhu, J. (2015). DEA based benchmarking models. Data Envelopment Analysis: A Handbook of Models and Methods, 291–308.