Two-Stage Double Bootstrap Data Envelopment Analysis for Evaluating Efficiencies of Indonesia's Hotel Sector

Rio Benecto Bire
Politeknik Negeri Kupang, Indonesia
Kupang, Indonesia
rio.bire@pnk.ac.id

Asbi Nasar
Politeknik Negeri Kupang, Indonesia
Kupang, Indonesia
nasarazbii@gmail.com

Yohana Mau
Politeknik Negeri Kupang, Indonesia
Kupang, Indonesia
yohana.mau@gmail.com

***Abstract*—Surprisingly, empirical research that endeavor on efficiency of hotels and its determinants are less studied, given the rapid growth and sudden turmoil surrounding the tourism industry of late. Such study is critical in terms of providing insights into mapping future plans for development. Accordingly, this research aims to analyze efficiencies of hotels concerning 34 provinces in Indonesia and the factors that influence the efficiency levels. From a time-frame of 2016 to 2020 data, we employed the innovative two-stage double bootstrap data envelopment analysis (DEA) to provide a blueprint of the accommodation sector's competitiveness. Results show that the average hotel efficiency of Indonesian provinces is low, with the most efficient provinces are DKI Jakarta, Bali, Sulawesi Utara, Gorontalo, Papua Barat, and Papua. Moreover, testing the influence of 8 external variables towards hotel efficiency revealed negative relationships from population size, human development index (HDI), climate, formal workforce, crime rate, and micro and small enterprises. Positive influences were pointed towards unemployment rate and transportation. This research offers practical benefits as it provides general insights concerning hotel competitiveness which can be used as a basis for allocating adequate resources to enhance hotel performances.**

Keywords— Hotel efficiency, tourism competitiveness, data envelopment analysis, two-stage double bootstrap

I. Introduction

The accommodation sector plays a pivotal role in Indonesia's tourism outlook [1]. As tourism is one of the prioritized industries for development by the national government [2], strengthening the capacity of the hotel sector becomes imperative in order to support medium and long-term plans concerning travel and tourism. Therefore, optimal strategies for the accommodation sector are critical, which accordingly derives from proper performance measurement as the starting point for future development initiatives and policies [3]. Moreover, performance measurement in the accommodation industry will help assist policy makers in identifying and classifying better, average, or worse performing hotels, which are judged based on their ability to capitalize on production inputs, i.e., monetary, material, and human resources, in order to gain as much as possible guest stays or revenue. Such typical performance measurement sees two classes of production factors, which are inputs and outputs. Nonetheless, the analysis should lie upon solid theoretical applications in order to identify the critical success factors. [4].

One of the contemporary methods widely applied in literature concerning performance measurement in the hotel industry is that of data envelopment analysis (DEA) [5], which is a non-parametric linear programming technique that evaluates relative performances of decision-making units (DMUs) [6]. DEA is set on the efficiency paradigm that compares a set of inputs to a set of outputs without requiring any specific production function, which is one of the advantages of the method. Past works that have employed DEA in measuring performances of hotels include [7], [8], [9], [10], [11],. [12], and [13]. Among these studies, only [13] and [9] have initiated on extending the use of DEA into a two-stage analysis which simultaneously corrects the statistical shortcomings of the traditional DEA, and evaluates the effect of external variables on efficiency levels.

Considering the rapid growth of Indonesian tourism in recent years, and its sudden halt due to the COVID-19 pandemic that utterly has altered the landscape of accommodation demand and offering, it is therefore imperative to conduct empirical research concerning performance measurement of hotels in Indonesia. This study will provide important insights in regards to the success of hotel management, as well as the factors that might influence their performances. In turn, it will help supply policy-makers with information to craft future strategies and policies towards the development of the accommodation sector and tourism in general. Accordingly, this research aims to evaluate relative efficiencies of the accommodation sector in Indonesia which is classified into that of 34 provinces, and to identify the effect of external variables towards the performances. In doing so, we employ the innovative two-stage, double bootstrapping DEA technique based on the iteration developed by Simar & Wilson [14]. This method provides the correction towards the biases in efficiency scores produced by the traditional DEA, and further

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extends to an analysis of externalities through a truncated regression, which is contended to be more robust than the tobit-censored model [14]. To the best of our knowledge, this study is the first of its kind in the context of Indonesia.

II. LITERATURE REVIEW

Data Envelopment Analysis (DEA) is a renowned non-parametric linear programming technique that is used to measure relative efficiencies of decision-making units (DMUs). The application of DEA has been prevalent in various contextual studies across industries, including travel and tourism. The prime advantages DEA include is its adaptability to specific problem settings [15], and its ability to accommodate various types of inputs and outputs to its production function [16]–[18].

The applications of DEA in measuring efficiency in the hotel sector has been initiated and popularized throughout the last two decades. [17] analyzed the efficiency of 45 hotels for the year 1998 in Taiwan along with the changes in efficiency from 1994 to 1998. The research utilized 4 inputs as number of personnel, number of rooms, food department area, and operational expenses; and 2 outputs which comprise room revenue and food and beverages revenue. Conducted upon government-owned hotels in Portugal, [3] evaluated the efficiency levels in year 2001 using number of full-time employees, employee expenses, hotel area, property book value, operational expenses, and external expenses as inputs; and sales, number of guests, and nights spent, as outputs. Furthermore, current studies of the related topic include the study conducted by Huang et al. [19], who analyzed performances of international hotels in Taiwan by employing operational costs, number of rooms, catering capacity, and number of employees, as the input variables; and rooms revenue and number of guests as the output variables. [7] conducted the efficiency analysis by using a uniform input as 1; and room occupancy rate and room revenue as outputs, which was performed upon categories of mid-price, economy, and budget hotels in France. Another categorical analysis was found in the work of [10] who categorized hotels in Croatia based on size and quality. This study used a total of 6 variables, which include 4 inputs as energy costs, room operational costs, other services costs, and employee costs; and 2 outputs as total revenue and room occupancy rate. Moreover, [12] utilized number of employees, capital, operational expenses, and external costs as inputs to be compared towards 3 outputs of sales, number of guests, and average number of nights spent.

Beyond the traditional application of DEA are studies that employ a second-stage iteration to determine the influence of externalities on the hotels' performances. Such can be found in the work of [8] who investigated the influencing factors of quality, size, affiliation, intangible investments, star rating, and segmentation. This study that was conducted upon hotels in Spain utilized 2 inputs and 1 output, which are physical capital and working capital, and sales, respectively. [9] evaluated the efficiency of hotels in Oman by seeing the use of number of beds and employee salary as inputs; and number of guests, yearly sales, number of nights spent, and room occupancy rate as the output variables. A second-stage analysis saw regression of type of ownership, hotel size, star rating, and tourist attractions, towards the hotels' performances. In the context of Italian hotels, the monetary value of tangible and intangible assets, and employee expenses were employed as inputs by [11] to be assessed upon a sole output of hotel sales. In the analysis of externalities influence, it was found a positive effect from short-term debt index and long-term debt index towards efficiency levels. Additionally, the research by [13] explored the duration of tourist stay, number of international tourists, quality of destination, and the sun and sand tourism model on efficiency of hotels which were categorized based on regions in Spain. The study employed 3 inputs as number of hotels, number of beds available, and number of full-time hotel employees; and 3 outputs as average room rate, revenue per available room, and average room occupancy rate, as the first stage DEA variables.

From the review above, it can be inferred that DEA applications in the hotel sector varies in terms of the selection of inputs and outputs as forming the production function, nonetheless it is clear that it does not require an explicit formula to relate the variables. In general, it is observed that inputs generally constitute that of costs, monetary value, number of resources, and capacity. On the other hand, sales/revenue, number of guests, and number of nights spent are commonly referred to as the outputs. Moreover, concerning studies that evaluate the influence of externalities, it can be concluded that the chosen attributes to be regressed upon the efficiencies generally are those that are not directly controllable by the hotel managers, for example number of tourist attractions, quality of destination, number of international tourists to the destination, etc.

The references reviewed creates a gap for this study to explore the application of the two-stage double bootstrap DEA into other contextual settings, and to test the influences of other external variables which have never been explored before. To the best of our knowledge, the innovative method of the two-stage double bootstrap has only been explored twice before in the hotel sector, i.e., [13] and [9]. Nevertheless, the specific method is regarded more robust in correcting efficiency biases produced in the traditional DEA, and in regressing the external variables [14]. To put into context, this research evaluates the efficiencies of hotels of 34 provinces in Indonesia and its determinants.

III. RESEARCH METHOD

This study employs the two-stage double bootstrap method developed by [14], that simultaneously evaluates levels of efficiency and the influence of external variables on the efficiency. The procedure has only seen a few applications in the hotel sector literature, including [9] and [13], rendering space for more exploration in different contexts. The basic operation is based on data envelopment analysis (DEA), a non-parametric linear programming technique which is generally used to analyze performances of decision-making units (DMUs). DEA forms a frontier envelopment sample from a sample of observations. DEA assumes the existence of n decision-making units (DMUs) that utilizes a vector of inputs (X_{in}) to produce a vector of s outputs (Y_{im}). The so-called efficient frontier further defines distances towards other observed samples, projecting a radial reduction of inputs for a given measure of output, or the increment of outputs for a given number of inputs.

The DEA assumption used in this study is that of the input oriented model under the variable return to scale (VRS) [20]. The formula used to calculate the model can be derived from the constant returns to scale (CRS) model [21] as:

$$max\ \theta_h$$

Subject to:

$$\sum_{k=1}^{K} \lambda_k x_{ik} \leq x_{ih} \quad i = 1, \ldots, N$$

$$\sum_{k=1}^{K} \lambda_k y_{ik} \geq \theta_h y_{jh} \quad j = 1, \ldots, M$$

$$\lambda_k \geq 0 \quad k = 1, \ldots, K$$

The VRS model can be calculated by modifying the CRS version by adding a convexity constraint, i.e., $\sum_{k=1}^{K} \lambda_k = 1$.

In the first stage of analysis, which is the evaluation of efficiencies, we utilize 4 inputs and 2 output variables. In this case, number of accommodations, number of rooms, number of beds, and average number of hotel employees, are selected as inputs. Meanwhile, room occupancy rate and average nights spent are determined as outputs. All data were classified based on each province in Indonesia, and were collected from the official publications of Indonesia's Central Bureau of Statistics along a 5-year period (2016 – 2020).

Subsequently, the second stage analysis is concerned with employing a truncated regression that assesses the influence of externalities towards the hotel efficiency levels that were produced in the previous analysis. The efficiency values θ_h, are used as the dependent variables, whilst the environmental variables Z_i, are employed as the independent constructs. The formula for the regression analysis is as follows:

$$\theta_h = f(Z_i, \beta_i) + \epsilon_i$$

where β_i is the estimator that identifies the influence of Z_i towards the efficiencies, and ϵ_i represents the random distributed variable $N(0, \sigma_i)$. In this analysis, the externalities that were tested are population, human development index, formal workforce, climate, crime rate, micro and small enterprises, and transportation. To the best of our knowledge, these variables have never before been evaluated their effects on hotel efficiency. In fact, in the tourism literature, only climate and crime rate have been included in such assessment. Data analysis was conducted by the aid of RStudio software.

IV. RESULTS AND DISCUSSION

Table I presents the descriptive statistics of all variables used in this study. From a time period of 2016 to 2020, it can be observed that the average Indonesian province offers a total of 374 accommodations, and nearly 10,000 rooms with 15,000 beds. The average room occupancy rate was 41.6% with the number of nights spent just above 1.5 nights. Moreover, standard deviation and maximum and minimum values point to wide spread of range concerning the inputs. Similarly, the second stage variables also show a large value disparity.

Table I. Variable Descriptives

First Stage Variables				
Variables	Mean	St.dev.	Minimum	Max
Input				
Num.of.acc.	374.0294	437.108	1899.667	53.66667
Num.of.rooms	9879.426	11830.98	48825.83	1076
Num.of.beds	14720.84	17126.28	68853.33	1670.5
Output				
ROR	41.71669	6.387303	65.38125	31.06125
Av. Nights	1.660074	0.271129	2.75875	1.26625
Second Stage Variables				
Population	7768.911	10911.7	48473.83	682.8
HDI	70.06598	4.894895	80.43	53.51333
Climate	35.56029	1.274165	39.6	33.4
Workforce	42.65632	10.87848	69.325	21.3
Unemployment	4.872549	1.660569	8.62	1.483333
Transportation	4106	5207.597	20791.29	195.4273
Crime rate	7950.412	7761.833	31934	718
MSE	119781.3	190792.5	853279	6691.333

First Stage Analysis: Efficiency Estimates

Results concerning hotel efficiencies of 34 Indonesian provinces are shown in Table II. As presented, the average hotel performance is rated at 3.616 under the traditional DEA, and at 4.519 for the bias-corrected model. These figures indicate a relatively high inefficiency level, as the scores reflect modes of inefficiency instead of efficiency. Accordingly, on average, the hotels could have managed a 36% and 45% reduction in input for producing the same amounts of outputs under both assumptions, respectively. As the efficiency show a 9% difference, a Pearson correlation test was conducted, and revealed a very high correlation between the scores (Pearson = 0.990; p = .000). However, the higher estimates under the bias-corrected model also indicate that the traditional model generate underestimated values.

Table II. Efficiency Estimates

Province	Eff.	Cor.Eff.	Bias	UB	LB
Aceh	3.657	4.9625	-1.305	6.0986	4.4016
Sumatera Utara	5.054	6.3161	-1.262	7.1879	5.2945
Sumatera Barat	2.987	3.6989	-0.712	4.2478	3.1132
Riau	2.532	2.9164	-0.384	3.1915	2.4762
Jambi	1.860	2.3742	-0.514	2.8602	2.0627
Sumatera Selatan	1.915	2.3932	-0.478	2.7716	1.9997
Bengkulu	1.018	1.2236	-0.206	1.3594	1.0530
Lampung	1.268	1.7298	-0.462	2.0238	1.4653
Kep. BaBel	1.475	1.8577	-0.383	2.1911	1.5888
Kep. Riau	1.967	2.4418	-0.474	2.8084	2.1018
DKI Jakarta	1.000	1.2605	-0.260	1.5124	0.9207
Jawa Barat	13.723	16.3748	-2.651	18.2759	13.8293
Jawa Tengah	14.204	16.6941	-2.490	18.6835	14.3191
DI Yogyakarta	7.622	10.1482	-2.526	11.6663	8.7291
Jawa Timur	16.441	21.3055	-4.864	24.2993	18.4207
Banten	2.572	2.8964	-0.325	3.1646	2.4302
Bali	1.000	1.5570	-0.557	1.9958	1.2948
NTB	5.634	7.4435	-1.809	8.9243	6.4414
NTT	3.313	4.4084	-1.095	5.0279	3.8828
Kalimantan Barat	2.890	3.3088	-0.418	3.6700	2.8419
Kalimantan Tengah	2.581	3.1549	-0.574	3.5943	2.6621
Kalimantan Selatan	2.577	2.9259	-0.349	3.2543	2.4393
Kalimantan Timur	4.086	4.9259	-0.840	5.4467	4.2608
Kalimantan Utara	1.335	1.6898	-0.354	2.0108	1.4613
Sulawesi Utara	1.000	1.5487	-0.549	1.8870	1.3104
Sulawesi Tengah	2.955	3.7314	-0.776	4.3579	3.2105
Sulawesi Selatan	6.610	8.0937	-1.484	9.0908	7.2030
Sulawesi Tenggara	2.690	3.2536	-0.564	3.7480	2.6357
Gorontalo	1.000	1.4722	-0.472	1.8282	1.3314
Sulawesi Barat	1.090	1.3525	-0.262	1.5926	1.1235
Maluku	1.645	2.0599	-0.415	2.4171	1.7383
Maluku Utara	1.230	1.5305	-0.301	1.8153	1.2734
Papua Barat	1.000	1.2977	-0.298	1.5477	0.9916
Papua	1.000	1.3014	-0.301	1.5683	1.0401
Average	3.616	4.519	-0.903	5.180	3.863
St.Dev.	3.852	4.7637	0.957	5.3686	4.1055
Minimum	1.000	1.224	-4.864	1.359	0.921
Maximum	16.441	21.306	-0.206	24.299	18.421

In terms of efficient regions, DKI Jakarta, Bali, Sulawesi Utara, Gorontalo, Papua Barat, and Papua are regarded as the efficient performers, i.e., the most efficient in managing their hotel resources to generate desired outputs which are occupancy rate and number of nights spent. On the other hand, Jawa Barat, Jawa Tengah, and Jawa Timur recorded the largest inefficiencies.

Further results as a projection of the bias-corrected model show the bias scores, and upper and lower bounds of efficiency confidence intervals as a product of 2000 bootstrap iterations (B=2000). It can be inferred that the original estimates are more advanced than the real values as all biases are less than 0. Moreover, high statistical variability concerning the estimates are reflected by the relatively wide interval levels. As the efficiency values are in between the intervals, this indicates a serious bias produced by the traditional DEA model.

Second Stage Analysis: Testing Influence of Environmental Variables

Subsequent analysis presents results concerning the effects of externalities on the bias-corrected scores produced in the previous analysis. This can be observed in Table III. Once again, it should be underlined that the estimates from the first stage represents modes of inefficiency, hence a positive intercept from the second stage analysis implies a negative effect towards hotel efficiency.

Table III. Truncated Regression Results

Z	Intercept	2.5%	97.5%
Population	0.000391569	0.000084109	0.000712295
HDI	0.5090397	0.08549677	0.9702916
Climate	0.6636985	-0.127941	1.654921
Workforce	0.008654836	-0.1941131	0.2366291
Unemployment	-0.7453299	-1.70945	0.3296119
Transportation	-0.001324144	-0.002271578	-0.000025381
Crime rate	0.000303762	0.000077686	0.000563233
MSE	0.00002845	0.000006752	0.000047743

The intercept value for population reads as positive, therefore as the size of a province's population increases, hotel efficiency tends to decrease. Previous literature has pointed to population as a particular control variable concerning tourism competitiveness [22]; respectively, our study provides further insights on how population actually may influence the hotel sector's efficiency. Somewhat surprising, the intercept value for human development index (HDI) implies an opposite relationship with efficiencies. Although it has been widely regarded that HDI is a critical enabler for tourism competitiveness [23]–[26] higher levels of education and living standards just might bring upon decreasing worker production capacity, which is in line with the arguments of [15]and [27].

Temperature was found to have a positive influence, which means that higher temperature renders lower efficiency. This also may indicate that the climate of the average Indonesian provinces might not be favourable for most tourists. Our particular finding contests that of [15] who indicated that temperature has a positive relationship with tourism competitiveness in China. Nonetheless, literature has pointed that climate is a particular attribute for supporting tourism competitiveness [28], [29], therefore our study has provided more insights related to the subject. Furthermore, the formal workforce variable shows an unexpected relationship with hotel efficiency, where as the number of workforces increase, hotel efficiency declines. Such suggests that the regional formal workforce in Indonesia may not deliver proportional qualified labor into the hotel industry. This may also explain for the result concerning unemployment, which render a positive relationship with hotel efficiency.

Table III also reports for the influence of transportation on hotel efficiency. The negative sign for the intercept value signals that efficiency increases as numbers of transportation also goes up, which is considerably straightforward in reasoning that transportation growth propels for the improvement of tourism related services. Results concerning crime rate are largely as expected, in which hotel competitiveness increases as crime rate declines. This in particular agrees with the findings of [30], who concluded for negative effect of petty crime on destination competitiveness. Lastly, results related to the influence of micro and small enterprises reveal a negative relationship with hotel efficiency. As smaller scale businesses are the backbone for the economy of developing countries [31], including Indonesia, its development should actually encourage the growth of related tourism and travel enterprises such as accommodation. The deviating results therefore should signal for efforts to refocus and enhance related resources concerning the hotel sector.

V. CONCLUSION

This research contributed to literature by applying the innovative two-stage double bootstrap DEA method into examining hotel efficiency levels and factors that influence the performances. Such theme has seen very limited applications in the accommodation sector, considering its pivotal role within the tourism industry, and the importance of tourism towards regional and national growth. In doing so, we took the case of Indonesian provinces, and utilized a panel of data from 2016 – 2020, which also encapsulates the effect of the COVID-19 pandemic, bringing the contemporary horizon into the line of study. Furthermore, in testing the influence of externalities, we employed 8 externalities which have never been studied before in relation to hotel efficiency.

Results from the first stage analysis point to relatively high levels of hotel inefficiencies for the average Indonesian province, where according to the traditional DEA, a possible 36% of input reduction is projected. Moreover, the bias-corrected model revealed the inefficiency to be 45%. This further suggests that the traditional DEA actually overestimates performances. The second stage analysis of externalities effects on hotel efficiency showed negative influences from population size, human development index (HDI), climate, the formal workforce, crime rate, and micro and small enterprises, and positive effects from unemployment rate and transportation. The somewhat unexpected outcomes concerning population, HDI, formal workforce, unemployment, and micro and small enterprises, should encourage governments to revisit prioritization programs concerning human resources that could be refocused towards the tourism industry, especially accommodation.

This study offers useful insights for tourism policy-makers in terms of recognizing the competitiveness map of hotels and allocating adequate resources to enhance hotel competitiveness. Further research can extend what is presented here by experimenting on other variables in the first and second stage analysis.

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