COMPARISONS OF EFFICIENCY RANKINGS USING FINANCIAL RATIOS ANALYSIS AND DATA ENVELOPMENT ANALYSIS: A CASE STUDY OF HOTEL BUSINESSES IN THAILAND

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Abstract - This study compares the performance rankings based on cross-efficiency of data envelopment analysis (DEA) and financial ratios analysis consisting of return on assets (ROA) and return on equity (ROE). Ten businesses running hotel operations listed in the Stock Exchange of Thailand were selected for comparison. Spearman's rank correlation tests were used to investigate the association of rankings. The tests revealed that the rankings of cross-efficiency had an insignificant correlation with the rankings of ROA and ROE, while the rankings of ROA significantly correlated with ROE. The study found that DEA can be used to complement the financial ratios as the evaluation tools of performance.

Keywords - Data Envelopment Analysis, Cross-efficiency, ROA, ROE

I. INTRODUCTION

Performance measurement is an important management dimension for business firms. Firms need to benchmark themselves with other organizations to identifytheir strengths and weaknesses in order to set strategic improvements in gaining more sustainable operations and competitive advantage. Financial ratios have long been used by firms as performance measures [1]. A financial ratio uses two numbers, one for the numerator and another for the denominatorwhich are normally extracted from financial statements. Typically, assets, equity, and expenses are selected as inputs and revenue and profit are selected as outputs[2]-[3].

However, a financial ratio may not reflect overall efficiencysince it involves only one input and oneoutput[4]-[5]. Thus, data envelopment analysis (DEA) was introduced as a tool to evaluate aggregated efficiency using multiple inputs and multiple outputs simultaneously. DEA gives the relative efficiency of a firm compared to other firms with similar operational characteristics. There are studies demonstrating how DEA was used in benchmarking for firms in various categories such as banks [6]-[7]hospitality businesses [8]-[11]andmanufacturing [12].

Although each financial ratio does not give overall efficiency due to their use of only a single input and a single output, it is simple to compute and interpret [13]. DEA can provide more integrative performance measurement but its computation is more complex. Moreover,the efficiency rankings provided by financial ratios analysis and by DEA may be different. Some studies [14]-[16]compared DEA efficiency and financial ratios in which DEA was recommended to be the performance measurement tool in addition to financial ratios analysis. This study aims to expand the comparison of efficiency ranking between DEA and financial ratios for firms in Thailand by using ten Thai public hotel firms listed in the Stock Exchange of Thailand (SET) [17] as acase study. The Thai hotel industry is expected to have increased occupancy rates and revenues as a result of expected growth in domestic and international tourism [18]. Hotel businessesare included as a part of tourism and recreation under the service industry according to SET. The rankings of DMUs on previous studies were arranged according to basic DEA models and it is possible to have more than one DMU with efficiency scores equal to 1 which are considered as efficient units. There has been some adjustment to DEA models to better discriminate the rankings of units including an approach called cross-efficiency proposed by Sexton, Silkman, and Hogan [19]. Therefore, this study intends to use the cross-efficiency of data envelopment analysis in ranking the performance of Thai hotels and to investigate if there isa correlation between the DEA cross-efficiency rankings and financial ratios analysis rankings.

The rest of this paper is organized as follows. Section 2 presents a brief review of financial ratios analyses, data envelopment analysis and DEA cross-efficiency. Section 3 explains the research methods. Section 4 presents the results and discussionand section 5 is the conclusion.

II. LITERATURE REVIEW

2.1. Financial Ratios Analysis

Financial ratios use one accounting number as the numerator and the other as the denominator. Usually, accounting numbers are extracted from financial statements, especially balance sheets and income statements. Numbers used in the same quotient may be from different types of statements. The financial ratios of each period should be compared with those of other firms, the industry average and prior periods

as a part of firms' benchmarking. Firms commonly need to disclose their financial statements and financial ratios to investors and creditors. Financial ratios can be classified into five major categories: current liquidity ratios, long-term solvency ratios, profitability ratios, activity ratios, and operating ratios. Current liquidity ratiosreflect the performance of firms in paying short-term obligations. Long-term solvency ratios express the abilities of firmsto pay their long-term obligations by comparing the total debts with total assets and with total equity. Profitability ratios demonstrate the efficiency of firms in using their sales, assets and equity to generate income. The common profitability ratios are return on assets (ROA) which measures how well firms can utilize their assets to generate income, return of equity (ROE) which demonstrate the ability to deploy owner's equity into profit, and profit margin which is the net income per sales. Activity ratios measure how fast the firms can use their assets to generate cash and sales. Examples of activity ratios are inventory turnovers, account receivable turnovers and total asset turnovers. Operating ratios measure the efficiency of firms' operations. For more details, see [20]-[21].

Firms in the hospitality industry including hotel or lodging businesses also use financial ratios to measure their performance. For example, Kim and Ayoun[22] compared the financial ratios of hotels and motels, restaurants, amusement and recreation services, and airline companies. The study found that hotels and motels sector had better activity ratios than the amusement and recreational services sector. Also, hotel and motels hada better ratio on return on assets and net profit margins indicating greater ability in utilizing assets and generating profits from their revenue. Singh and Schmidgal[1] and Schmidgall[23] found that general managers, owners, executives, and bankers of hotel businesses had different perceptions toward the importance of financial ratios.

2.2 Data Envelopment Analysis

DEA is a linear-programming based tool which is used to identify the relative efficiency of comparable entities, namely decision-making units (DMUs). The idea was firstly proposed by Charnes, Coopers and Rhodes [24, p.430] who gave a definition of efficiency as "the maximum of a ratio of weighted outputs to weighted inputs subject to the condition that the similar ratios for every DMU be less or equal to unity". DEA is a technique that can be used to evaluate the performance of several DMUs with the same set of inputs and outputs. Comparisons using DEA should involve DMUs with similar operations or characteristics. The efficiency values are between 0 and 1 inclusively. DEA classifies each DMU as efficient or inefficient units. Efficient DMUs have an efficiency value of 1 and are located on the efficiency frontier. The inefficient DMUs have an efficiency value of less than 1 and are located beneath the efficiency frontier.

The DEA model originally proposed by Charnes, Coopers and Rhodes [24] assumes that all the firms under study have operations at an optimal scale implying the same proportion of increases ininputs and outputs.In other words, firms are assumed to operate under constant return to scale (CRS) conditions. These DEA models are named CRS (constant return to scale). A CRS model to find the efficiency value of k^{th} DMU (E_k) can be presented as follows.

$$E_k = \text{maximize } \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \qquad (1)$$

Subject to :

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \qquad j = 1, \dots, n \qquad (2)$$

$$u_r, v_i > 0 \qquad \forall r = 1, \dots, s; i = 1, \dots m \qquad (3)$$

Where:
u_r = the weight of output r
y_{rk} = the output r of the k^{th} DMU
v_i = the weight of input i
x_{ik} = the input i of the k^{th} DMU
s = the number of outputs
m = the number of inputs
n = the number of DMUs

Linear programming is used to find the weights given to each input and output that optimize the efficiency value for each DMU separately. Besides defining the relative efficiency of each DMU, the DEA model also gives additional useful information such as efficient peers for the inefficient units,the slacks of inputs and outputs, and the type of return-to-scale (increasing return-to-scale, decreasing return-to-scale or constant-return-to-scale) [8],[25].

After introducing the CRS model, Banker, Charnes, and Cooper [26] extended the DEA model to the variable return to scale (VRS) models[25]. VRS DEA models allowthe inclusion of some possible constraints from operating at an optimal value. Moreover, DEA models can be further classified as input orientation or output orientation. Input-oriented models aim to minimize input to achieve the given level of outputs. Whereas the output-oriented models focus on maximizing outputs with a given level of input. However, DEA efficiency values are relative among the DMUs in the selected sample. The efficiency value of a DMU may vary according to the changesin members of the sample.

There have been some studies demonstrating the application of the DEA models in evaluating the performance of hotels [27]. Neves &Lourenço[8] computed the efficiency value of 83 hotels using revenue and EBITDA (earnings before interest, tax,

depreciation and amortization) as outputs and current assets, net fixed assets, shareholders' equity and cost of goods and services as the inputs. The performance comparison using DEA showed that the hotels with a focused strategy performed better than those with a diversified strategy.Manasakis, ApostolakisandDatseris[28] compared the efficiency values of hotels with different operational styles (independent, international brand, national brand and local brand) on the island of Crete in Greece using the number of beds, the number of employees and the total operational costs as inputs and total revenues along with the total number of nights as outputs. The national-brand hotels were found to be the most efficient while the international-brand hotels were the least efficient. The results of the DEA analysis were used to guide how to increase hotel efficiency. Min, et al.[29] performed four DEA-based analyses. Each of the first two models used costs of land property, building capacity, other assets, and operating expenses as inputs. The first model assigned the revenue from food/beverages, revenues from rooms and other revenue as the outputs; whereas, the second model used operating income and non-operating income as the outputs. The third and fourth models investigated the impact of location on revenue and income. Sanjeev [10] investigated the influence of business size on the DEA efficiency scores of hotel and restaurant companies. Capital, gross fixed assets, current assets and the operating costs were used as inputs and operating income and profit before depreciation, interest and tax (PBDIT) were used as the outputs.

2.3 DEA Cross-Efficiency

In typical DEA models, it is common to have more than one efficient DMU or DMUs with efficiency value of 1 [30]. Thus, methods have been developed to better discriminate DMUs including cross-efficiency evaluationas proposed by [19], [31]-[32]. Traditionally, each DMU is only self-evaluated in CRS and VRS models. But cross-efficiency also evaluates each DMU with the optimum weights of others in addition to self-evaluation.Theequation for finding the efficiency scores of DMU_k using the optimal weights of DMU_o is given as follows[32]-[33]:

$$CE_{ok} = \frac{\sum_{r=1}^{s} u_{ro}^{*} y_{rk}}{\sum_{i=1}^{m} v_{io}^{*} x_{ik}}$$

Where

CE_{ok} is the cross-efficiency score of DMU_k using the optimal self-evaluated weights of DMU_o

$u_{ro}^{*}$is the optimal self-evaluated weight of output r for DMU_o

$v_{io}^{*}$is the optimal self-evaluated weight of input i for DMU_o

y_{rk} is the amount of output r for DMU_k

x_{ik} is the amount of input i for DMU_k

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There will be n cross-efficiency scores for each DMU, where n is the total number of DMUs.The cross-efficiency of the k-th DMU is the average of n cross-efficiency scores. It is possible to have multiple sets of optimal self-evaluated weights. The weight set may be chosen arbitrarily or selected according to specific criteria such as the aggressive or the benevolent approaches proposed by Doyle and Green [31].

III. RESEARCH METHODS

This research compared the rankings obtained from the cross-efficiency of DEA with the rankings according to return on assets (ROA) and return on equity (ROE) of hotel companies listed in the Stock Exchange of Thailand. Financial statements were obtained from the Stock Exchange of Thailand (SET) database from the years 2016 to 2018. ROA and ROE are considered as important financial ratios in evaluating the efficiency of firms in using assets and equity to generate profit [35]. For the DEA analysis, the sales and service revenue is selected as the output and total assets, total equity, and service costs as the inputs. Hotel industry revenues may depend on external uncontrollable factors[8] such as economic conditions, degree of competition, and weather; thus, the input-oriented DEA model is used in this study. Drake and Howcroft[36] suggested using the number of DMUs which is greater than twice the total number of inputs and outputs for the DEA analysis. Since 10 DMUs is greater than twice the sum of 3 inputs and 1output, the numbers are deemedto beappropriate. DeaR package [37] which is an R package [38]was used to perform a DEA computation including input-oriented CRS models and the cross-efficiency with arbitrary weights selection.

IV. RESULTS AND DISCUSSION

The descriptive statistics of variables used in this studywhich are total assets, total equity, service cost, sales and service revenue, and income are shown in Table 1.

	Financial Items				
	Total Assets	Total Equity	Service Costs	Sales and Service Revenue	Income
Year 2016					
Average	6,176,672.20	3,574,834.62	655,252.66	1,331,795.02	295,073.39
SD	4,879,687.31	2,565,578.37	475,081.15	931,233.98	297,118.63
CV	0.79	0.72	0.73	0.70	1.01
Year 2017					
Average	6,449,129.79	3,573,465.79	737,447.11	1,441,464.16	165,840.23
SD	4,980,314.17	2,477,935.74	495,582.87	979,731.08	437,851.70
CV	0.77	0.69	0.67	0.68	2.64
Year 2018					
Average	6,935,429.92	3,744,594.49	704,709.30	1,397,954.84	303,353.51
SD	5,330,667.49	2,578,868.80	539,894.38	1,064,253.06	371,596.36
CV	0.77	0.69	0.77	0.76	1.22

Table 1: Descriptive statistics of accounting items used in this study (unit: thousand baht)

None of the percentages of the changes in average values between the consecutive years (2017 VS. 2016 and 2018 VS. 2017) for total assets, total equity, service cost, and sales/service revenue were greater than 12%. But there were large percentage changes in average income during the period of three years. The average income decreased in 2017 from 2016 by about 44% and then the average income increased in 2018 from 2017 by about 83%.

Table 2-Table 4 show the value of self-efficiency scores according to the basic input-oriented CRS model along with the values and rankings of the DEA cross-efficiency with the arbitrary weight selection, ROA and ROE for 2016, 2017 and 2018 consecutively. In the CRS models, multiple DMUs have self-efficiency scores of 1. DEA cross-efficiency discriminated DMUs better as all DMUs had different cross-efficiency scores and they were assigned different ranks.

DMUs	Self-Efficiency Scores	Cross-efficiency Scores		ROA		ROE	
		Value	Rank	Value	Rank	Value	Rank
DMU1	0.4859	0.4284	9	0.0490	5	0.0829	5
DMU2	0.5248	0.4932	8	0.0655	4	0.1440	2
DMU3	0.7157	0.6071	6	0.0174	8	0.0210	9
DMU4	0.7928	0.7351	4	0.0418	6	0.0760	6
DMU5	0.9734	0.7977	3	0.0148	9	0.0360	8
DMU6	0.5692	0.3053	10	0.0388	7	0.0471	7
DMU7	0.6242	0.5253	7	0.0039	10	0.0083	10
DMU8	1	0.7340	5	0.0889	1	0.2743	1
DMU9	1	0.9771	1	0.0689	3	0.1134	3
DMU10	1	0.9436	2	0.0813	2	0.0990	4

Table 2:Self-efficiency, Cross-efficiency, ROA, and ROE for 2016

DMUs	Self-Efficiency	Cross-efficiency Scores		ROA		ROE	
		Value	Rank	Value	Rank	Value	Rank
DMU1	0.5579	0.4993	9	0.0173	8	0.0290	8
DMU2	0.5493	0.5202	7	0.0622	3	0.1373	2
DMU3	0.5364	0.5009	8	0.0231	5	0.0386	7
DMU4	0.8482	0.7945	3	-0.0553	10	- 0.1120	10
DMU5	0.7179	0.6908	5	0.0221	6	0.0570	5
DMU6	0.5810	0.3112	10	0.0145	9	0.0167	9
DMU7	0.6261	0.5448	6	0.0203	7	0.0395	6
DMU8	1	0.7485	4	0.1372	1	0.3483	1
DMU9	1	0.9944	1	0.0585	4	0.0986	4
DMU10	1	0.9322	2	0.0977	2	0.1184	3

Table 3:Self-efficiency, Cross-efficiency, ROA, and ROE for 2017

DMUs	Self-Efficiency Scores	Cross-efficiency Scores		ROA		ROE	
		Value	Rank	Value	Rank	Value	Rank
DMU1	0.5315	0.4943	9	0.0209	8	0.0348	8
DMU2	0.5247	0.4961	8	0.0785	3	0.1623	2
DMU3	0.5459	0.5203	6	0.0326	5	0.0621	5
DMU4	0.7876	0.7430	3	0.0248	6	0.0516	6
DMU5	0.6126	0.5177	7	0.0079	9	0.0230	9
DMU6	0.5293	0.2595	10	-0.0034	10	-0.0040	10
DMU7	0.6270	0.5290	5	0.0240	7	0.0405	7
DMU8	1	0.7258	4	0.1814	1	0.4322	1
DMU9	1	0.9595	2	0.0655	4	0.1110	4
DMU10	1	0.9718	1	0.1012	2	0.1212	3

Table 4:Self-efficiency, Cross-efficiency, ROA, and ROE for 2018

According to Table 2-Table 4, the rankings given by three performance measures: DEA cross-efficiency, ROA, and ROE were not the same for every DMU. It seems that ranking of ROA issomewhat similar to that of ROEbut DEA cross-efficiency gives quite different ranking compared to either ROA or ROE.

To investigate if there is a significant correlation between the performance rankings evaluated by these three methods, Spearman's rank correlation tests were run for three comparisons which were DEA cross-efficiency with ROA, DEA cross-efficiency with ROE and ROA with ROE. The null hypothesis of Spearman's rank correlation testfor each

comparisonisthat there is no association between the rankings provided by each evaluation method. The Spearman's rank correlations are presented in Table 5.

Comparisons	Spearman's Rank Correlation		
	2016	2017	2018
Cross-efficiency and ROA	0.309	0.418	0.648
Cross-efficiency and ROE	0.248	0.333	0.564
ROA and ROE	0.939*	0.952*	0.988*

Table 5: Spearman's rank correlation

*Correlation is significant at the 0.01 level (2-tailed)

The critical value of Spearman's rank correlation 2-tailed test at 0.01 alpha level and sample size of 10 units is 0.794 [39]. Correlation coefficients being higher than the critical value indicates significant correlation between ranks. The years 2016 to 2018 showed insignificant correlations between DEA cross-efficiency and ROA and between DEA cross-efficiency and ROE since all correlation coefficients were less than the critical value of 0.794. While there wasa significant correlation between ROA and ROE in all three years as the correlations were larger than the critical value. These results show that the rankings given by DEA cross-efficiency has no significant association with the rankingsof ROA or ROE. For example, in 2018, ROA and ROEof the second DMU were in the third rank and the second rank, respectively, but its DEA cross-efficiency score was ranked as the eighth. This means DMU2 may be able to utilize assets and equity in generating income better than most of the other firms. However, the DEA analysis impliesthe possibility of DMU2 in decreasingtotal assets, total equity, and service costs while still obtaining the same level of sales and service revenue.

V. CONCLUSIONS

These studies used DEA cross-efficiency, ROA, and ROE to evaluate the efficiency rankings of hotel firms listed inthe Stock Exchange of Thailand. Sales and service revenue, total assets, total equity, service costs, and incomewere extracted from the financial statements of years 2016 to 2018 forthe analyzation. It was found that the rankings of cross-efficiency had insignificant association with rankings of ROA and ROE. Whereas, ROA rankings correlated significantly with ROE rankings.This study indicates that DEAcan give different evaluation results from the well-known financial ratios like ROA and ROE. Hence, firms should consider DEA efficiency in addition to financial ratios in evaluating performance.However, the results of comparisons may vary depending on the selected inputs and outputs for DEA, types of financial ratios, and business characteristics. Moreover, a sensitivity analysis may be performed by changing inputs and outputs for DEA in order to set managerial implications.

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