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Evaluation and Improvement of the Efficiency of Logistics Companies with Data Envelopment Analysis Model

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Abstract. The performance of global trade depends on the logistics industry to move products, information, finances, technology and human resources along the supply chain. The current situation during the pandemic relies on the logistics industry particularly in the courier, parcel and express service providers to deliver daily essentials. Product customization, customer demand, technological sophistication, threat of new entrants, border closure, compliance to Covid-19 regulations and global economic crisis have taken the logistics industry by storm. For the sustainment and growth of these companies, strategic decision making shall take place. A huge determinant of these decisions is the financial efficiency of the companies. Therefore, this paper aims to determine the efficiency of the logistics companies in Malaysia by analyzing their financial performances using current ratio, debt to assets ratio, debt to equity ratio, earnings per share, return on assets and return on equity with data envelopment analysis model. The results of this study found that five companies, COMPLETE, GDEX, MISC, SURIA and WPRTS are efficient. This study fills the research gap by determining the efficiency scores of these companies and suggesting potential improvements for inefficient companies to enhance and optimize their financial positions.

Keywords: Data envelopment analysis, efficiency, linear programming model, potential improvement.

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1. Introduction

The ASEAN Economic Community Blueprint 2025 has provided great opportunities for Malaysia to collaborate and integrate with countries in the region to develop the economy to compete in the global market [1-3]. This blueprint aims to allow easier access of products, services, human capital and investments among member countries [4-5]. The logistics industry then serves as a facilitator in delivering the supplies of goods by linking consumers to suppliers and manufacturers in the supply chain in this region [6-7]. Malaysia's economic growth has also been large supported by the logistics industry since the beginning of the pandemic [8]. However, higher consumer expectation for quicker delivery of goods at lower cost, increased product variety, technological modernization and the COVID-19 contingency plan have led to greater financial burden for the logistics companies [9-10].

Therefore, logistics companies need to monitor their financial performance to ensure that they can cope and survive through this period of great uncertainty. Financial performance serves as a key performance indicator which conveys information about a company's financial health. This financial assessment could be used to study a company before any collaboration or partnership takes place. Financial institutions and investors may also use the financial assessment for credit analysis. A financial analysis could also serve as a guide for a company in terms of strategy formulation to leverage business potentials and mitigate risks [11].

Financial analysis can be based on a logistics company's annual report including the profit and loss statement and balance sheet which are historical in nature. They can include analysis on the liquidity, solvency and profitability ratios to measure the ability of a company to satisfy short term and long-term obligations and for-profit generation. Nevertheless, profitability is the main concern of a logistics company to create values, hiring employees, enhance research and development and for the sustainment and expansion of the company [12].

Logistics companies could measure and perform achievement evaluations based on financial analysis such as profitability ratios, debt ratios and current ratio. The analyses of all these financial ratios could provide an insight for logistics companies for decision making in their investments for annual strategic planning, especially in their plans for the procurement, insurance and maintenance of transport units [13].

As logistics companies become increasingly sensitive over capital structures, profit and cost reduction, managerial focus on financial analysis is particularly imperative. Lee et al. [14] performed a financial analysis on shipping companies in Korea and Taiwan with financial ratios such as current ratio, return on asset (ROA), return on equity (ROE), debt to asset ratio and debt to equity ratio.

Woo et al. [15] studied the financial ratios such as debt ratio, current ratio, ROA, ROE and earnings per share

(EPS), which affect the credit risks in listed logistics and shipping companies listed. The logistics and shipping companies were chosen because this industry is very prone to the global economic crisis. This study found that current ratio and ROA had the most positive relationships with credit risk in the logistics and shipping companies. Therefore, financial ratio analysis is particularly important to mitigate losses in this sector.

Korneta [16] studied the relationship between financial performance and the growth of road transportation companies in Poland from 2013 to 2017. The road transportation industry was selected as it was the biggest service sector to contribute to the economy of the country. The result of this study showed that profitability affected the growth of sales in road transportation companies while optimum liquidity value also supported sales growth.

Efficiency is an important measurement in the evaluation of financial performance of the companies. The efficiency of the companies can be measured using data envelopment analysis (DEA) model. DEA model aims to create an efficient production frontier using multiple inputs and multiple outputs. DEA is a linear programming model which evaluates the relative efficiency of the decision-making units (DMUs). The entities under evaluation will be the DMU [17]. In DEA model, efficiency score is a measure of how well an organizational unit utilizes the resources to generate outcomes. The efficiency of DEA model is defined as the ratio of the total weighted output to total weighted input. In short, the efficiency of a DMU to produce output by taking in certain input will be determined in comparison with other DMUs under study [18].

Ma et al. [19] studied the efficiency and risk of financial institutions in Taiwan from 2012 to 2017 using super efficiency DEA method. This study extracted data such as fixed assets, employee number and operating expenses as inputs while using financial data such as operating income, earnings per share (EPS), net profit, return on assets and return on equity as outputs. DEA was also used to forecast the future efficiency of these financial institutions.

The efficiency of 17 shipbuilders in the world was also analyzed using financial ratio-based DEA. This study was output-based with variables including return on equity (ROE), return on assets (ROA), inventory turnover, current ratio, quick ratio, debt ratio and solvency ratio. The highest number of efficient companies was recorded in 2008, with 4 shipbuilders scoring 1, which meant that they were financially efficient in that year [20].

Past studies have included a variety of business activities for the logistics companies using DEA model. Chen [21] stated that the logistics industry involved the transportation, storage and postal companies and proceeded to include these three types of companies to evaluate the performances of the logistics industry in China. Zheng et al. [22] analyzed the efficiency of logistics companies in China with DEA model. The logistics companies studied included transportation, warehousing

and postal companies in all the regions in China. Wohlgemuth et al. [23] assessed the Brazilian logistics companies which included the logistics service providers with a variety of business activities along the supply chain. Meanwhile, a study by Thi [24] in Vietnam also evaluated railway, airline, ocean shipping, trucking and freight forwarding companies with DEA model.

DEA has a very wide application in forecasting [25-26], routing problem [27-29], energy [30-32], healthcare [33-35] and construction [36-37]. Based on past studies, there is no comprehensive research done on the efficiency evaluation of logistics companies with financial ratios using DEA model. Therefore, this paper aims to determine the efficiency of logistics companies in Malaysia using DEA model. This paper shall propose a DEA model with financial ratios including current ratio, debt to assets ratio and debt to equity ratio as the inputs while earnings per share (EPS), ROA and ROE shall serve as the outputs. Moreover, the target potential improvements will also be identified for each inefficient company to achieve optimal efficiency.

This study fills the research gap by being the pioneer study in Malaysia to examine the logistics industry by analyzing and evaluating the efficiency scores of the logistics companies and enhancing their performances through benchmarking with DEA model. The efficient and inefficient logistics companies can be identified through DEA model in this study. Moreover, once the reference set is determined, the new target improvements can be identified to allow inefficient logistics companies to be at par with the efficient logistics companies. Benchmarking provided by DEA model in this paper helps the logistics companies to draft for improvement plans to manage their finances well for future business operations and expansions. The next section of this paper shall consist of data and methodology, the third section will be about results and discussions, followed by conclusion to end this paper.

2. Data and Methodology

The data of this study consists of the logistics companies listed in the Malaysian stock market from the year 2015 to 2019 [38]. Table 1 presents the proposed research framework to evaluate the efficiency of logistics companies in Malaysia.

Table 1. Proposed Research Framework with DEA Model.

Items	
Objective	Evaluation of efficiency of logistics companies
Inputs	Current ratio (CR), Debt to assets ratio (DAR), Debt to equity ratio (DER)
Outputs	Earnings per share (EPS), Return on asset (ROA),

Return on equity (ROE)

Decision-making units (DMUs)	
	AIRPORT
	BIPORT
	CJCEN
	COMPLET
	EATECH
	FREIGHT
	GDEX
	HARBOUR
	LITRAK
	MISC
	MMCCORP
	POS
	PRKCORP
	SEEHUP
	SURIA
	TASCO
	TNLOGIS
	WPRTS

As presented in Table 1, the financial ratios used as inputs are current ratio, debt to assets ratio and debt to equity ratio. Earnings per share (EPS), return on asset (ROA) and return on equity (ROE) are applied as the outputs.

The DEA model ranks the DMUs according to their respective efficiency scores which range from 0 to 1. The efficiency score is obtained based on the weighted sum of outputs over the weighed sum of inputs [39-40]. A DMU is classified as an efficient unit if it achieves an efficiency score of 1. On the other hand, the DMU is classified as an inefficient unit if the efficiency score is less than 1 [41-42]. The DEA model is formulated as follows [40,43]:

$$\text{Maximize } h_k = \frac{\sum_{r=1}^s t_r y_{rk}}{\sum_{i=1}^m w_i x_{ik}} \quad (1)$$

Subject to

$$\frac{\sum_{r=1}^s t_r y_{rj}}{\sum_{i=1}^m w_i x_{ij}} \leq 1, j = 1, 2, 3, \dots, n \quad (2)$$

$$w_i \geq \varepsilon, i = 1, 2, 3, \dots, m \quad (3)$$

$$t_r \geq \varepsilon, r = 1, 2, 3, \dots, s \quad (4)$$

where

h_k = relative efficiency of company k

x_{ij} = observed value of i type input for company j

w_i = weight for input i

m = number of inputs

y_{rj} = observed value of r type output for company j

t_r = weight for output r

s = number of outputs

n = number of companies

ε = small positive value

Equation (1) shows the maximization function of the relative efficiency of company k . Equation (2) states the constraints to limit the efficiency of every company to be between 0 and 1. t_r and w_i are the weights of the outputs and inputs to maximize the efficiency as in the model. Then, all the equations from Eq. (1) to Eq. (4) are rearranged to transform into linear form in Eq. (5) to Eq. (9) [42-43].

$$\text{Maximize } h_k = \sum_{r=1}^s t_r y_{rk} \quad (5)$$

Subject to

$$-\sum_{r=1}^s t_r y_{rj} + \sum_{i=1}^m w_i x_{ij} \geq 0, j = 1, 2, 3, \dots, n \quad (6)$$

$$\sum_{r=1}^m w_i x_{ik} = 1 \quad (7)$$

$$w_i \geq \varepsilon, i = 1, 2, 3, \dots, m \quad (8)$$

$$t_r \geq \varepsilon, r = 1, 2, 3, \dots, s \quad (9)$$

This DEA formulation will then be solved using the LINGO optimization software. This software has been used to solve linear programming, non-linear programming, goal programming and integer programming models [44-50].

3. Result and Discussion

The efficiency score and ranking of the logistics companies are shown in Table 2.

Table 2. Efficiency Score and Ranking of Transportation and Logistics Companies.

Companies	Efficiency Score	Rank	Classification
AIRPORT	0.2781	16	Inefficient
BIPORT	0.5660	13	Inefficient
CJCEN	0.4073	14	Inefficient
COMPLET	1.0000	1	Efficient
EATECH	0.2184	18	Inefficient
FREIGHT	0.5723	12	Inefficient
GDEX	1.0000	1	Efficient
HARBOUR	0.8459	8	Inefficient
LITRAK	0.9486	6	Inefficient
MISC	1.0000	1	Efficient
MMCCORP	0.7992	9	Inefficient
POS	0.2973	15	Inefficient
PRKCORP	0.8700	7	Inefficient
SEEHUP	0.2576	17	Inefficient
SURIA	1.0000	1	Efficient
TASCO	0.5984	11	Inefficient
TNLOGIS	0.5998	10	Inefficient
WPRTS	1.0000	1	Efficient

From Table 2, logistics companies with efficiency scores of 1.0000 are classified as efficient companies with first ranking. There are five companies which have obtained efficiency score of 1.0000, namely COMPLET, GDEX, MISC, SURIA and WPRTS, based on the optimal solution of DEA model. These companies have maximized the use of their inputs or resources to generate maximum outputs. Therefore, COMPLET, GDEX, MISC, SURIA and WPRTS are classified as efficient companies. These companies are able to serve as benchmarks to other inefficient logistics companies to improve their efficiency.

However, AIRPORT (0.2781), BIPORT (0.5660), CJCEN (0.4073), EATECH (0.2184), FREIGHT (0.5723), HARBOUR (0.8459), LITRAK (0.9486), MMCCORP (0.7992), POS (0.2973), PRKCORP (0.8700), SEEHUP (0.2576), TASCO (0.5984) and TNLOGIS (0.5998) are classified as inefficient companies since their efficiency scores are below 1.0000 based on the optimal solution of DEA model.

LITRAK has an efficiency score of 0.9486 which implies that the company is close to being an efficient company. POS, AIRPORT, SEEHUP and EATECH have efficiency scores of 0.2973, 0.2781, 0.2576 and 0.2184 respectively, which indicate that these companies are very far away from being efficient as their efficiency scores are less than 0.3000. These companies could not fully utilize their resources to generate maximum outputs.

Table 3 shows the summary of efficiency scores based on the optimal solution of DEA model.

Table 3. Summary of Efficiency Scores.

Items	Efficiency Score
Average efficiency	0.6810
Minimum efficiency	0.2184
Maximum efficiency	1.0000
Percentage of efficient companies	27.78%
Percentage of inefficient companies	72.22%

As shown in Table 3, 27.78% of the companies are efficient in using their inputs to obtain maximum outputs with efficiency score 1.000. This is in line with the percentage of efficiency in past studies which were between 10.00% and 40.00%. A study by Wang et al. [51] showed that 16.67% of Chinese provinces were efficient from 2008 to 2016. Another study on the efficiency of campuses of a university in Iran using DEA model also yielded a percentage of efficiency of 22.22% [52]. The efficiency of elementary schools in Indonesia found that 35.29% provinces were efficient [53].

Based on the optimal solution of DEA model in this study, Table 4 shows the reference set for inefficient companies. The efficient companies serve as the benchmark to the inefficient companies in determining the potential improvements according to the optimal coefficient as shown in Table 4.

Table 4. Reference Set for Inefficient Companies.

Inefficient companies	Efficient companies (Optimal coefficient)				
	COMPLET	GDEX	MISC	SURIA	WPRTS
AIRPORT			0.3501		0.0389
BIPORT		0.0544	0.5843		0.3062
CJCEN	0.2558				0.1443
EATECH			0.0106		0.0564
FREIGHT	0.2058			0.1873	0.1992
HARBOUR	0.2209			0.2479	0.3259
LITRAK		0.0972	0.5100		0.9152
MMCCORP			0.3813		0.1435
POS			0.1177	0.0061	0.1425
PRKCORP		0.1688			0.1752
SEEHUP	0.0587			0.0776	0.0759
TASCO			0.1832	0.1544	0.2885
TNLOGIS			0.1412		0.3035

AIRPORT, BIPORT, CJCEN, EATECH, FREIGHT, HARBOUR, LITRAK, MMCCORP, POS, PRKCORP, SEEHUP, TASCO and TNLOGIS are grouped under inefficient companies because their efficiency scores are less than 1.000. The efficient companies, namely COMPLETE, GDEX, MISC, SURIA and WPRTS serve as benchmarks for the inefficient companies in achieving optimal efficiency [54].

As an example, AIRPORT is relatively less efficient as compared to MISC and WPRTS based on the optimal solution of DEA model. Therefore, MISC and WPRTS are identified as the benchmarks to AIRPORT for further improvements. In DEA model, the optimal coefficients of MISC (0.3501) and WPRTS (0.0389) are used to set new target values for the inputs and outputs of AIRPORT. The feasible improvement aim for AIRPORT will then be the sum of the products of weights of MISC (0.3501) and WPRTS (0.0389) of AIRPORT multiplied by the financial ratios of MISC and WPRTS respectively.

When compared to GDEX, MISC and WPRTS, BIPORT is considered inefficient. Therefore, GDEX, MISC and WPRTS serve as the reference set for BIPORT to achieve optimal efficiency. The new target values for EPS, ROA, ROE, current ratio, debt to assets ratio and debt to equity ratios shall be based on the optimal coefficient of GDEX (0.054), MISC (0.5843) and WPRTS (0.3062) of BIPORT.

Table 5 describes the potential improvements for all inefficient logistics companies according to reference set in Table 4.

Table 5. Potential Improvements for Inefficient Logistics.

Inefficient companies	Inputs/ Outputs	Current values	Target values	Potential Improvements (Target- Actual)
AIRPORT	CR	2.0266	0.5637	-1.4629
	DAR	0.5506	0.1209	-0.4298
	DER	1.2815	0.1848	-1.0967
	EPS	0.1599	0.1599	0.0000
	ROA	0.0117	0.0181	0.0064
	ROE	0.0287	0.0287	0.0000
BIPORT	CR	3.3792	1.9127	-1.4665
	DAR	0.5950	0.3368	-0.2582
	DER	1.4785	0.5870	-0.8915
	EPS	0.3087	0.3087	0.0000
	ROA	0.0470	0.0646	0.0176
	ROE	0.1167	0.1167	0.0000
CJCEN	CR	2.1956	0.8943	-1.3014
	DAR	0.3574	0.1347	-0.2228
	DER	0.5820	0.2371	-0.3450
	EPS	0.0368	0.0442	0.0075
	ROA	0.0321	0.0321	0.0000
	ROE	0.0462	0.0561	0.0100
EATECH	CR	0.5003	0.1093	-0.3910
	DAR	0.7415	0.0327	-0.7087
	DER	3.0128	0.0672	-2.9457
	EPS	0.0143	0.0143	0.0000
	ROA	0.0074	0.0074	0.0000
	ROE	0.0000	0.0154	0.0154
FREIGHT	CR	2.3538	1.3472	-1.0066
	DAR	0.3726	0.1958	-0.1768
	DER	0.5952	0.3406	-0.2545
	EPS	0.0929	0.0929	0.0000
	ROA	0.0457	0.0457	0.0000
	ROE	0.0730	0.0797	0.0066
HARBOUR	CR	2.0751	1.7554	-0.3198
	DAR	0.3656	0.2801	-0.0856
	DER	0.5967	0.5048	-0.0920
	EPS	0.1297	0.1297	0.0000
	ROA	0.0653	0.0653	0.0000
	ROE	0.1075	0.1181	0.0105
LITRAK	CR	3.4492	3.2718	-0.1774
	DAR	0.6773	0.6425	-0.0348
	DER	2.2174	1.2432	-0.9742
	EPS	0.3808	0.3808	0.0000
	ROA	0.0890	0.1408	0.0518
	ROE	0.2768	0.2768	0.0000
MMCCORP	CR	0.9792	0.7827	-0.1965
	DAR	0.5708	0.1849	-0.3859
	DER	1.3414	0.3139	-1.0275
	EPS	0.1914	0.1914	0.0000
	ROA	0.0258	0.0323	0.0065
	ROE	0.0578	0.0578	0.0000
POS	CR	1.4177	0.4215	-0.9962
	DAR	0.4083	0.1102	-0.2981
	DER	0.7004	0.2082	-0.4921
	EPS	0.0773	0.0773	0.0000
	ROA	0.0224	0.0224	0.0000
	ROE	0.0329	0.0440	0.0112
PRKCORP	CR	2.3665	2.0589	-0.3076
	DAR	0.6485	0.1172	-0.5313

	DER	0.2591	0.2254	-0.0337
	EPS	0.0000	0.0316	0.0316
	ROA	0.0000	0.0356	0.0356
	ROE	0.0627	0.0627	0.0000
SEEHUP	CR	1.8598	0.4790	-1.3807
	DAR	0.3248	0.0715	-0.2533
	DER	0.4883	0.1258	-0.3625
	EPS	0.0353	0.0353	0.0000
	ROA	0.0166	0.0166	0.0000
	ROE	0.0228	0.0294	0.0066
TASCO	CR	1.9144	1.1457	-0.7688
	DAR	0.4017	0.2404	-0.1613
	DER	0.7421	0.4427	-0.2994
	EPS	0.1651	0.1651	0.0000
	ROA	0.0506	0.0506	0.0000
	ROE	0.0807	0.0958	0.0152
TNLOGIS	CR	1.1800	0.7078	-0.4722
	DAR	0.6008	0.2003	-0.4006
	DER	1.5084	0.3952	-1.1132
	EPS	0.1138	0.1137	0.0000
	ROA	0.0353	0.0430	0.0076
	ROE	0.0871	0.0871	0.0000

Based on the optimal solution of DEA model, there are rooms of improvement for inefficient companies with regards to the optimal coefficients of efficient companies as computed in Table 5. The inefficient logistics companies are AIRPORT, BIPORT, CJCEN, EATECH, FREIGHT, HARBOUR, LITRAK, MMCCORP, POS, PRKCORP, SEEHUP, TASCO and TNLOGIS. Inefficient companies need to perform reduction to their inputs and increment to their outputs to become efficient.

From the potential improvement in DEA model generation, AIRPORT shall reduce its current ratio by 1.4629 from 2.0266 to 0.5637, bring down the debt to assets ratio from 0.5506 to 0.1209 and lower the debt-to-equity ratio from 1.2815 to 0.1848. On the other hand, ROA of AIRPORT should be increased from 0.0117 to 0.0181 in order to be efficient. The target values of EPS and ROE remain the same respectively. The potential improvements for current ratio, debt to assets ratio, debt to equity ratio, EPS, ROA and ROE for AIRPORT are therefore -1.4629, -0.4298, -1.0967, 0.0000, 0.0064 and 0.0000 respectively.

AIRPORT should reduce its current ratio by focusing more on short term liabilities. AIRPORT may also use its current assets such as cash to pay off some long-term obligations and manage the company's working capital. To increase its ROA, AIRPORT may choose to reduce the cost of assets such as better management of inventory to reduce inventory carrying cost [55].

The second inefficient company is BIPORT. BIPORT should reduce its current ratio from 3.3792 to 1.9127, bring down its debt to assets ratio from 0.5950 to 0.3368 and lower its debt-to-equity ratio from 1.4785 to 0.5870. At the same time, BIPORT's ROA has to rise from 0.0470 to 0.0646 while the EPS and ROE remain constant. The potential improvements for current ratio, debt to assets ratio, debt to equity ratio, EPS, ROA and ROE are -1.4665, -0.2582, -0.8915, 0.0000, 0.0176 and 0.0000 respectively.

BIPORT's debt to equity ratio is rather high which means that the company has high leverage as the company may finance its operations by debt and loans which is risky to investors. Restructuring debt, improving sales and lowering costs are some actions which may be taken by BIPORT to reduce its debt-to-equity ratio.

For CJCEN, the potential improvement for current ratio is -1.3014, which means that CJCEN shall reduce its current ratio from 2.1956 to 0.8943. CJCEN's debt to assets ratio shall reduce from 0.3574 to 0.1347, with a potential improvement of -0.2228. Debt to equity ratio of CJCEN shall be lowered from 0.5820 to 0.2371 as the potential improvement is -0.3450. CJCEN's EPS shall rise from 0.0368 to 0.0442, by a potential improvement of 0.0075. ROE of CJCEN shall increase by 0.0100 from 0.0462 to 0.0561.

EPS of CJCEN may rise by increasing revenue from higher volume of sales, reduction in cost such as materials, production, marketing and administrative costs. CJCEN may also consider reducing share count by share repurchase. CJCEN may also manage the company's capital well to maximize profit from the shareholders' equity to increase the ROE [56]. Companies with high efficiency especially with high EPS, ROA and ROE shall contribute to shareholders' value creation which is an important attribute in the capital market of the logistics industry, therefore, companies should work on increasing their outputs with similar or even fewer inputs [57].

4. Conclusion

The efficiency and potential improvements of logistics companies in Malaysia have been determined in this study using DEA model. The efficient companies with score of 1.000 are COMPLET, GDEX, MISC, SURIA and WPRTS. This implies that 27.88% of logistics companies are efficient. These efficient companies have successfully utilized their resources to maximize the outcomes. On the contrary, AIRPORT, BIPORT, CJCEN, EATECH, FREIGHT, HARBOUR, LITRAK, MMCCORP, POS, PRKCORP, SEEHUP, TASCO and TNLOGIS are classified as inefficient companies in this study. The potential improvements for these inefficient companies have also been found with references to the efficient companies. This study is significant because the analysis of the financial performances of the logistics companies with DEA model provides meaningful information and insights for their decision making. Future studies may be done with the application of this proposed research framework with DEA model in other countries. Moreover, this proposed framework may also be applied in other fields such as the information and technology industry, healthcare sector and the oil and gas industry.

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