

Improvement on the Efficiency of Technology Companies in Malaysia with Data Envelopment Analysis Model

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Abstract. Efficiency evaluation is vital as it is able to determine the financial performance of the companies. Efficiency describes how well the companies in utilizing their inputs to generate outputs. The objective of this study is to propose a financial ratio based Data Envelopment Analysis (DEA) model to evaluate and compare the efficiency of listed technology companies in Malaysia for the period of 2011–2015. In DEA model, the efficiency is defined as the ratio of sum-weighted outputs to sum-weighted inputs. In this study, LINGO software is used to solve the DEA model. The results of this study indicate that ELSOFT, GTRONIC, KESM, MPI and VITROX are ranked as efficient technology companies in Malaysia. Besides that, the potential improvement for each inefficient company can be identified based on the benchmark efficient companies. This study is significant because it helps to identify the efficient technology companies which can serve as benchmarks to other inefficient companies for further improvement. Moreover, it is a pioneer study of proposing DEA model with financial ratio to evaluate and compare the efficiency of technology companies in Malaysia.

Keywords: Data Envelopment Analysis · Technology company · Linear programming model · LINGO software

1 Introduction

Technology sector is one of the dominating sectors in Malaysia as this sector has made a significant contribution in the economic growth of Malaysia. Technology company is a type of business entity that focuses primarily on the development and manufacturing of technology. Nowadays, technology has become an important dimension of national growth and development [1]. Furthermore, continuous improvement in technology is

essential for the economic growth in this competitive world. Therefore, efficiency evaluation is used to measure and assess the financial performance of the technology companies [2].

Data Envelopment Analysis (DEA) is a mathematical linear programming model which measures the relative efficiency of a set of companies [2]. In DEA model, the efficiency of the company is measured as the ratio of as sum-weighted outputs to sum-weighted inputs [3]. Charnes et al. [4] introduced the DEA model to measure the efficiency of the companies with multiple inputs and outputs. Mohamad and Said [5] mentioned that continuous improvement in performance is the first priority in today's world of business. Based on the past studies, DEA model has been applied to evaluate the financial performance of the companies by using financial ratio such as bank [3, 6, 7] and healthcare company [8] in different countries. However, the influence of financial performance on the survival of the technology companies is usually ignored. In fact, the financial performance of the technology companies is important because it gives impact on the economic growth of the country. Therefore, this paper aims to fill the research gap by studying the financial performance of the technology companies in Malaysia. The objective of this paper is to propose a financial ratio based DEA model to evaluate and compare the financial performance of listed technology companies in Malaysia stock market. The rest of the paper is organized as follows. The next section discusses about the data and methodology of the study. Section 3 presents the empirical results of this study. Section 4 concludes the paper.

2 Data and Methodology

2.1 Data

The data of this study consists of all listed companies from technology sector in Malaysia Main Market. These listed companies represent the overall performance of technology sector in Malaysia stock market. The data of this study are collected from the companies' financial annual reports from the year 2011 until 2015 [9].

Based on the past studies [10–15], the financial ratio such as current ratio, debt to assets ratio, debt to equity ratio, return on asset, return on equity and earnings per share are considered in this study. Current ratio is defined as the capability of the company to satisfy its current liabilities with current assets [16, 17]. Debt to asset ratio indicates the proportion of all assets that are financed with debt [18, 19]. Debt to equity ratio is defined as the measurement of the riskiness of the company's capital structure in terms of the relationship between the funds supplied by investors and creditors [18, 19]. Earnings per share (EPS) is the amount of earning gained during a period per share of common stock [18]. Return on assets (ROA) is the amount of net profit earned relative to the level of investment in total assets [19, 20]. Return on equity (ROE) measures the overall efficiency of the company in yielding the return in comparison to the total amount of shareholders' equity [17, 19, 21]. In this study, current ratio, debt to assets ratio and debt to equity ratio are treated as inputs that needed to be minimized. On the other hand, return on asset, return on equity and earnings per share are adopted as outputs that needed to be maximized.

2.2 Data Envelopment Analysis

DEA is a linear programming model which evaluates the relative efficiency of a set of companies by considering multiple inputs and outputs [7, 22, 23]. In DEA model, the efficiency is defined as the ratio of sum-weighted outputs to sum-weighted inputs. The formulation of the DEA model is presented as follows:

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

Subject to

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

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

$$w_i \geq \varepsilon, \quad i = 1, 2, 3, \dots, m \quad (4)$$

where

h_k is the relative efficiency of decision making unit- k (DMU $_k$)

s is the number of outputs

t_r is the weights to be determined for output r

y_{rj} is the observed value of r -type output for entity j

m is the number of inputs

w_i is the weights to be determined for input i

x_{ij} is the observed value of i -type input for entity j

ε is the positive value

n is the number of entities

The objective function (1) aims to maximize the efficiency of k -decision-making unit (DMU). Constraint (2) ensures that the efficiency of each company is within the range, $0 < h_k \leq 1$. The fractional objective function can be converted into a linear programming form by maximizing the sum-weighted outputs and setting the sum-weighted inputs equal to unity as shown in constraint (5) and (7) [7, 24]. The weights t_r and w_i represent the importance of each output and input variable to maximize the efficiency of each company.

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

Subject to

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

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

$$t_r \geq \varepsilon, r = 1, 2, 3, \dots, s \quad (8)$$

$$w_i \geq \varepsilon, i = 1, 2, 3, \dots, m \quad (9)$$

In this study, LINGO software is used to solve the DEA model. LINGO is an optimization software for solving linear programming model, non-linear programming model, goal programming model and integer programming model [25–30].

3 Empirical Results

Table 1 presents the empirical results of the efficiency and ranking of technology companies in Malaysia.

Table 1. Efficiency and ranking of technology companies

Companies	Efficiency (%)	Rank
AMTEL	42.93	13
CENSOF	16.76	17
CUSCAPI	27.35	14
DIGISTA	4.77	18
ECS	43.16	12
EFORCE	66.13	10
ELSOFT	100.00	1
GRANFLO	78.74	7
GTRONIC	100.00	1
INARI	82.82	6
JCY	50.30	11
KESM	100.00	1
MPI	100.00	1
NOTION	24.29	15
PANPAGE	21.90	16
UNISEM	67.92	9
VITROX	100.00	1
WILLOW	73.32	8

As shown in Table 1, the major findings of this study show that five technology companies are ranked efficient since they manage to achieve 100.00% efficiency score. These efficient companies are ELSOFT, GTRONIC, KESM, MPI and VITROX. This implies that these efficient companies have fully utilized their inputs optimally in maximizing the outputs. Therefore, these efficient companies obtain the first ranking based on the DEA model. On the other hand, AMTEL, CENSOF, CUSCAPI, DIGISTA, ECS, EFORCE, GRANFLO, INARI, JCY, NOTION, PANPAGE, UNISEM and WILLOW are classified as inefficient companies since their efficiency score are less than 100.00%. The efficiency score for GRANFLO, INARI and WILLOW are in the range of 73.32% to 82.82%. In summary, ELSOFT, GTRONIC, KESM, MPI and VITROX are ranked as efficient companies among the technology companies in Malaysia over the study period.

Table 2 presents the contribution of input and output weights in maximizing the efficiency for each technology company.

Table 2. Contribution of input and output weights in maximizing efficiency.

Companies	Current ratio (Input 1)	Debt to assets ratio (Input 2)	Debt to equity ratio (Input 3)	EPS (Output 1)	ROA (Output 2)	ROE (Output 3)	Efficiency (%)
AMTEL	0.40	0.00	99.60	99.57	0.43	0.00	42.93
CENSOF	1.54	98.46	0.00	0.30	99.40	0.30	16.76
CUSCAPI	2.07	0.00	97.92	0.21	99.57	0.21	27.35
DIGISTA	0.23	99.77	0.00	0.87	98.26	0.87	4.77
ECS	0.16	0.00	99.84	100.00	0.00	0.00	43.16
EFORCE	2.94	0.00	97.06	99.12	0.88	0.00	66.13
ELSOFT	0.40	0.00	99.60	99.57	0.43	0.00	100.00
GRANFLO	2.07	0.00	97.93	0.14	99.73	0.14	78.74
GTRONIC	0.40	0.00	99.60	99.57	0.43	0.00	100.00
INARI	0.24	0.00	99.76	0.23	0.23	99.53	82.82
JCY	0.21	99.78	0.00	0.33	0.33	99.33	50.30
KESM	0.54	99.46	0.00	99.69	0.00	0.31	100.00
MPI	0.81	0.00	99.19	99.77	0.00	0.23	100.00
NOTION	0.81	0.00	99.19	99.77	0.00	0.23	24.29
PANPAGE	0.98	99.01	0.01	0.69	0.69	98.63	21.90
UNISEM	99.98	0.01	0.01	97.89	2.11	0.00	67.92
VITROX	1.36	0.00	98.64	0.27	0.27	99.47	100.00
WILLOW	0.24	0.00	99.76	0.24	0.24	99.52	73.32
Overall (average)	6.41	27.58	66.01	49.90	22.39	27.71	61.13

As shown in Table 2, DEA model provides the contribution of input and output weights in maximizing the efficiency for the technology companies in Malaysia. In this study, the overall output weights in the maximization of efficiency of the technology

companies is mostly contributed by EPS (49.90%), followed by ROE (27.71%) and lastly ROA (22.39%). On the other hand, the overall input weights in the maximization of efficiency of the technology companies is mostly contributed by debt to equity ratio (66.01%), followed by debt to assets ratio (27.58%), and finally current ratio (6.41%).

Table 3 displays the reference set of efficient companies which serve as benchmark to inefficient companies for further improvement.

Table 3. Reference set for inefficient companies

Inefficient companies	Efficiency (%)	Efficient companies (optimal coefficients)				
		ELSOFT	GTRONIC	KESM	MPI	VITROX
AMTEL	42.93	0.126	0.084		0.029	
CENSOF	16.76	0.005				0.225
CUSCAPI	27.35	0.103				0.178
DIGISTA	4.77	0.082	0.099			
ECS	43.16		0.463		0.005	
EFORCE	66.13	0.121		0.007		0.542
GRANFLO	78.74	0.529				0.041
INARI	82.82	0.784	0.151			
JCY	50.30	0.504	0.257			
NOTION	24.29	0.179		0.039	0.017	
PANPAGE	21.90	0.738				0.025
UNISEM	67.92			0.093		0.041
WILLOW	73.32	0.084	0.593			

As shown in Table 3, the efficient companies such as ELSOFT, GTRONIC, KESM, MPI and VITROX serve as reference sets or benchmark to the inefficient companies for further improvement. AMTEL has an efficiency score of 42.93% and it is inefficient when compared with ELSOFT, GTRONIC and MPI according to the optimal coefficients. Based on the optimal solution of DEA model, AMTEL needs to benchmark the efficient companies such as ELSOFT, GTRONIC and MPI as reference sets with their optimal coefficients of 0.126, 0.084, and 0.029 respectively in order to achieve 100% efficiency score. The target improvement value for the inefficient company is determined as sum of the products of respective optimal coefficients for the reference sets multiplied by the matrix column ratios of reference sets. Based on Table 3, the target improvement values for inputs and outputs of AMTEL are determined as follows:

$$\begin{aligned}
 &\begin{bmatrix} \text{Target Value} \\ \text{EPS} \\ \text{ROA} \\ \text{ROE} \\ \text{Current ratio} \\ \text{Debt to asset ratio} \\ \text{Debt to equity ratio} \end{bmatrix} = 0.126 \begin{bmatrix} 0.060730 \\ 18.542089 \\ 19.656255 \\ 9.440078 \\ 0.069970 \\ 0.077571 \end{bmatrix} + 0.084 \begin{bmatrix} 0.163180 \\ 26.940999 \\ 27.064339 \\ 55.651241 \\ 0.004975 \\ 0.005007 \end{bmatrix} + 0.029 \begin{bmatrix} 0.300132 \\ 11.115824 \\ 11.728142 \\ 45.697625 \\ 0.087334 \\ 0.101352 \end{bmatrix} \\
 &= \begin{bmatrix} 0.030221 \\ 4.936188 \\ 5.104988 \\ 7.224925 \\ 0.011800 \\ 0.013172 \end{bmatrix}
 \end{aligned}$$

In summary, the target improvement values of inputs and outputs for other inefficient technology companies are determined and presented in Table 4.

Table 4. Potential improvement for inefficient technology companies

Companies			Current actual value	Target value	Potential improvement (%)
AMTEL	Outputs	EPS	0.030221	0.030221	0.00
		ROA	4.936188	4.936188	0.00
		ROE	5.031504	5.104988	1.46
	Inputs	Current ratio	16.827984	7.224925	-57.07
		Debt to asset ratio	0.029428	0.011800	-59.90
		Debt to equity ratio	0.030679	0.013172	-57.07
CENSOF	Outputs	EPS	0.005701	0.010433	83.01
		ROA	5.062774	5.062774	0.00
		ROE	5.151173	6.127274	18.95
	Inputs	Current ratio	8.879676	1.489521	-83.23
		Debt to asset ratio	0.215517	0.036152	-83.23
		Debt to equity ratio	0.356991	0.044227	-87.61
CUSCAPI	Outputs	EPS	0.012019	0.014238	18.47
		ROA	5.835332	5.835332	0.00
		ROE	6.599691	6.788561	2.86
	Inputs	Current ratio	7.709120	2.108511	-72.65
		Debt to asset ratio	0.130954	0.035531	-72.87
		Debt to equity ratio	0.156042	0.042679	-72.65

(continued)

Table 4. (continued)

Companies			Current actual value	Target value	Potential improvement (%)
DIGISTA	Outputs	EPS	0.007584	0.021090	178.07
		ROA	4.177063	4.177063	0.00
		ROE	4.088619	4.280195	4.69
	Inputs	Current ratio	131.529626	6.272770	-95.23
		Debt to asset ratio	0.130060	0.006203	-95.23
		Debt to equity ratio	0.203774	0.006826	-96.65
ECS	Outputs	EPS	0.076939	0.076939	0.00
		ROA	10.559108	12.518402	18.56
		ROE	10.628793	12.578403	18.34
	Inputs	Current ratio	60.109887	25.967853	-56.80
		Debt to asset ratio	0.006443	0.002720	-57.78
		Debt to equity ratio	0.006487	0.002802	-56.80
EFORCE	Outputs	EPS	0.033255	0.033255	0.00
		ROA	14.228041	14.228041	0.00
		ROE	16.744300	16.918789	1.04
	Inputs	Current ratio	7.006728	4.633442	-33.87
		Debt to asset ratio	0.148933	0.096169	-35.43
		Debt to equity ratio	0.177050	0.117080	-33.87
GRANFLO	Outputs	EPS	0.023372	0.033934	45.19
		ROA	10.701505	10.701505	0.00
		ROE	10.983147	11.482543	4.55
	Inputs	Current ratio	6.667781	5.250821	-21.25
		Debt to asset ratio	0.057235	0.043477	-24.04
		Debt to equity ratio	0.062164	0.048953	-21.25
INARI	Outputs	EPS	0.060246	0.072243	19.91
		ROA	18.177910	18.602827	2.34
		ROE	19.494864	19.494864	0.00
	Inputs	Current ratio	19.079734	15.801995	-17.18
		Debt to asset ratio	0.067297	0.055602	-17.38
		Debt to equity ratio	0.074336	0.061566	-17.18

(continued)

Table 4. (continued)

Companies			Current actual value	Target value	Potential improvement (%)
JCY	Outputs	EPS	0.050977	0.072472	42.17
		ROA	15.654375	16.255608	3.84
		ROE	16.848608	16.848608	0.00
	Inputs	Current ratio	37.846108	19.037314	-49.70
		Debt to asset ratio	0.072620	0.036529	-49.70
		Debt to equity ratio	0.080767	0.040368	-50.02
NOTION	Outputs	EPS	0.024927	0.024927	0.00
		ROA	3.358685	3.716970	10.67
		ROE	3.965568	3.965568	0.00
	Inputs	Current ratio	10.841365	2.633715	-75.71
		Debt to asset ratio	0.102424	0.022801	-77.74
		Debt to equity ratio	0.115372	0.028028	-75.71
PANPAGE	Outputs	EPS	0.020611	0.045947	122.93
		ROA	12.220372	14.233494	16.47
		ROE	15.171770	15.171770	0.00
	Inputs	Current ratio	32.521280	7.127714	-78.08
		Debt to asset ratio	0.253556	0.055572	-78.08
		Debt to equity ratio	0.374153	0.062062	-83.41
UNISEM	Outputs	EPS	0.023502	0.023502	0.00
		ROA	1.431203	1.431203	0.00
		ROE	1.584330	1.720194	8.58
	Inputs	Current ratio	0.983460	0.668051	-32.07
		Debt to asset ratio	0.217768	0.027873	-87.20
		Debt to equity ratio	0.284897	0.038122	-86.62
WILLOW	Outputs	EPS	0.032264	0.101918	215.89
		ROA	17.482116	17.543850	0.35
		ROE	17.710862	17.710862	0.00
	Inputs	Current ratio	46.111377	33.808849	-26.68
		Debt to asset ratio	0.012786	0.008844	-30.83
		Debt to equity ratio	0.012962	0.009504	-26.68

Based on the optimal solution of DEA model, each inefficient company is recommended for the target improvement values of inputs and outputs as shown in Table 4. For AMTEL, it is recommended to reduce the inputs and increase the output in order to become efficient company. Therefore, the input potential improvements of current ratio, debt to asset ratio and debt to equity ratio for AMTEL are -57.07% , -59.90% and -57.07% respectively. As for the output potential improvement, AMTEL is recommended to increase the ROE from 5.031504 to 5.104988 which contributes 1.46% improvement. As shown in Table 4, all inefficient technology companies are recommended to reduce further on the inputs such as current ratio, debt to asset ratio and debt to equity ratio in order to become efficient companies.

4 Conclusion

This paper aims to propose a financial ratio based DEA model to evaluate and compare the financial performance of the listed technology companies in Malaysia stock market. The results of this study show that ELSOFT, GTRONIC, KESM, MPI and VITROX are ranked as efficient technology companies since they manage to achieve 100% efficiency score. In this study, the overall output weights in the maximization of efficiency of the technology companies is mostly contributed by EPS, followed by ROE and ROA. On the other hand, the overall input weights in the maximization of efficiency of the technology companies is mostly contributed by debt to equity ratio, followed by debt to assets ratio and finally current ratio. Besides that, the potential improvement for each inefficient company can be determined based on the benchmark efficient companies identified by the DEA model. This study is significant because it helps to identify the efficient technology companies which can serve as benchmarks to other inefficient companies for further improvement.

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