An Optimal Control on the Efficiency of Technology Companies in Malaysia with Data Envelopment Analysis Model

Lam Weng Siew[1,2,3], Liew Kah Fai[1,2], Lam Weng Hoe[1,2,3]
[1] *Department of Physical and Mathematical Science, Faculty of Science, Universiti Tunku Abdul Rahman, Kampar Campus, Jalan Universiti, Bandar Barat, 31900 Kampar, Perak, Malaysia*
[2] *Centre for Mathematical Sciences, Universiti Tunku Abdul Rahman, Kampar Campus, Jalan Universiti, Bandar Barat, 31900 Kampar, Perak, Malaysia*
[3] *Centre for Business and Management, Universiti Tunku Abdul Rahman, Kampar Campus, Jalan Universiti, Bandar Barat, 31900 Kampar, Perak, Malaysia*
lamws@utar.edu.my

***Abstract*—Technology company is a type of business entity that focuses primarily on the development and manufacturing of technology. Technology sector plays an imperative role in the country as technological advancement can lead the country to move forward for continuous improvement. Therefore, efficiency is important in the evaluation on the performance of companies. The efficiency of the companies can be measured by using Data Envelopment Analysis (DEA) model. DEA is a linear programming model which measures the relative efficiency of the companies as the ratio of the sum-weighted outputs to sum-weighted inputs. Efficiency is used to describe how well an organizational unit is performing in utilizing resources to generate outputs or outcomes. The objective of this study is to propose a DEA model by using financial ratio to evaluate and compare the efficiency of the companies from the technology sector in Malaysia. Besides that, this study aims to determine the optimal control of inputs and output weights in maximizing the efficiency for each company. The data consists of the listed companies from the technology sector in Malaysia stock market from year 2011 until 2015. In this study, LINGO software is used to solve the DEA model. The major findings of this study indicate that AMTEL, ELSOFT, GRANFLO, GTRONIC, KESM, MPI, UNISEM and VITROX are ranked as efficient companies. This implies that 44% of the listed companies from technology sector in Malaysia stock market are efficient. This study is significant because it is a pioneer study of proposing a DEA model by using financial ratio to evaluate and compare the efficiency of the listed companies from technology sector in Malaysia stock market.**

***Index Terms*— Data Envelopment Analysis; Efficiency; Linear Programming Model; LINGO Software; Technology Company;**

I. INTRODUCTION

Technology company is a type of business entity that focuses primarily on the development and manufacturing of technology. The services that provided by technology companies in Malaysia include electronic systems maintenance and support services, provision of semiconductor burn-in and testing services, electronic manufacturing services, provision of management services to the subsidiaries, information and communication technology, telecommunications, infrastructure and services as well as property development. Malaysia is an emerging Asian economy aspiring to move towards as a technology-driven and high-tech production-based pattern of development [1]. In 1982, Malaysia implemented the Look East Policy programme which sent Malaysian students to universities and institutes of technology as well as training institutes in Japan. This programme aims to encourage the Malaysian to innovate and develop important skills after the training in foreign countries such as in Japan and South Korea. Furthermore, Look East Policy programme includes the innovation of new technology in the field of higher education in Malaysia and the application and development of Japanese-style technology in accordance with the needs and local practices in Malaysia. Moreover, Look East Policy programme also enhance Malaysia's position in the international arena and help to maintain social stability and economic prosperity of the country simultaneously. In addition, technology sector plays an imperative role in the country as technological advancement can lead the country to move forward for continuous improvement. The relevant units in Malaysia such as government or non-government organization should take the responsibility and strive to achieve the goals in order to move forward and attain the Vision 2020. Therefore, technology sector is important and need to be studied in terms of the performance efficiency. Efficiency is used to describe how well an organizational unit is performing in utilizing resources to generate outputs or outcomes. The efficiency of the companies can be measured by using Data Envelopment Analysis (DEA) model.

DEA model was originally introduced by Charnes et al. [2] and further improved by Banker et al. [3]. DEA is a non-parametric approach based on the mathematical linear programming model. DEA model is an important measure of organizational unit's efficiency [4, 5]. DEA model aims to evaluate the relative efficiency of homogenous organizational units that convert multiple inputs into multiple outputs. DEA model defines the efficiency as the ratio of sum-weighted outputs to sum-weighted inputs. DEA model is able to rank the units according to their respective efficiency score. The efficiency score is varied between 0 and 1 (0% and 100%). A unit is efficient if it achieves an efficiency score of 100%. On the other hand, the unit that fails to reach 100% efficiency level will be classified as inefficient unit. DEA model has been applied in various fields such as banks [6, 7] healthcare systems [8-10], hospitals [11, 12] and educations [13, 14].

The financial ratio is important and essential to determine the financial performance of the companies [15]. The financial ratio analysis has been adopted by the past researchers in banking sector [16-20]. Based on the past studies, DEA model has been studied in different fields to evaluate the performance efficiency of the companies from various countries. Most previous studies focus on the operational performance efficiency of manufacturing companies. However, the influence of financial performance on the survival of the companies is usually ignored. In fact, the financial performance of the company is important because it gives impact on the economic growth of the country. Besides that, there is no comprehensive study done on the efficiency evaluation of the listed companies from technology sector in Malaysia stock market. Investigation on the efficiency of listed technology companies is important because the companies represent the overall performance of technology sector in Malaysia stock market. Therefore, this paper aims to fill this research gap. The objective of this paper is to propose a DEA model by using financial ratio to evaluate and compare the efficiency of the listed companies from technology sector in Malaysia stock market. In addition, this study aims to determine the optimal control of inputs and output weights in maximizing the efficiency for each company. The main contribution of this study is to evaluate the efficiency of the listed companies from technology sector in Malaysia with financial ratio based DEA model. This pioneer study helps to examine the current financial strengths of the listed technology companies in Malaysia based on the efficiency score. The structure 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 and section 4 concludes the paper.

II. DATA AND METHODOLOGY

In this study, the data consists of all companies from the technology sector listed in Malaysia stock market as shown in Table 1. These listed companies represent the overall performance of technology sector in Malaysia stock market [21].

Table 1
Companies from the Technology Sector in Malaysia Stock Market

Company Name	Abbreviations	Code
AMTEL HOLDINGS BERHAD	AMTEL	7031
CENSOF HOLDINGS BERHAD [S]	CENSOF	5195
CUSCAPI BERHAD [S]	CUSCAPI	0051
DIGISTAR CORPORATION BERHAD	DIGISTA	0029
ECS ICT BERHAD [S]	ECS	5162
EXCEL FORCE MSC BERHAD	EFORCE	0065
ELSOFT RESEARCH BERHAD [S]	ELSOFT	0090
GRAND-FLO BERHAD [S]	GRANFLO	0056
GLOBETRONICS TECHNOLOGY BERHAD [S]	GTRONIC	7022
INARI AMERTRON BERHAD [S]	INARI	0166
JCY INTERNATIONAL BERHAD [S]	JCY	5161
KESM INDUSTRIES BERHAD [S]	KESM	9334
MALAYSIAN PACIFIC INDUSTRIES BERHAD [S]	MPI	3867
NOTION VTEC BERHAD [S]	NOTION	0083
PANPAGES BERHAD [S]	PANPAGE	0041
UNISEM (M) BERHAD [S]	UNISEM	5005
VITROX CORPORATION BERHAD [S]	VITROX	0097
WILLOWGLEN MSC BERHAD [S]	WILLOW	0008

Source: (Bursa Malaysia [21])

Financial ratios such as current ratio, debt to assets ratio, debt to equity ratio, earnings per share (EPS), return on asset (ROA) and return on equity (ROE) are utilized in this study. The input variables are current ratio, debt to assets ratio and debt to equity ratio whereas earnings per share (EPS), return on asset (ROA) and return on equity (ROE) are the output variables used in this study. The data is collected from their respective companies' financial annual report on Bursa Malaysia from year 2011 until 2015.

The current ratio is the measures a company's ability to counter balance current assets with the current liabilities [22]. Debt to assets ratio is a measure of financial leverage defined as debt divided by total assets. Debt to equity ratio is the relative proportion of shareholders' equity and debt used to finance a company's assets [23]. Earnings per share (EPS) is the monetary value of earnings per outstanding share of common stock for a company [23]. Return on asset (ROA) indicates how efficiently a company utilizes its assets to generate profits [24]. Return on equity (ROE) describes how much profit a company earned relative to the total amount of shareholder equity invested [25, 26].

Equation (1) to (6) present the formula of the financial ratios used in the efficiency evaluation of the technology companies [27].

$$\text{Current ratio} = \frac{\text{Current assets}}{\text{Current liability}} \tag{1}$$

$$\text{Debt to assets ratio} = \frac{\text{Total liability}}{\text{Total assets}} \tag{2}$$

$$\text{Debt to equity ratio} = \frac{\text{Total liability}}{\text{Total shareholde rs' equity}} \tag{3}$$

$$\text{Earnings per share} = \frac{\text{Net profit}}{\text{Number of shares}} \tag{4}$$

$$\text{Return on asset} = \frac{\text{Net profit}}{\text{Total assets}} \times 100\% \tag{5}$$

$$\text{Return on equity} = \frac{\text{Net profit}}{\text{Total shareholde rs' equity}} \times 100\% \tag{6}$$

The formulation of the DEA model is presented as follows:

$$\text{Maximize } h_k = \frac{\sum_{r=1}^{s} t_r y_{rk} + \alpha}{\sum_{i=1}^{m} w_i x_{ik}} \tag{7}$$

Subject to

$$\frac{\sum_{r=1}^{s} t_r y_{rj} + \alpha}{\sum_{i=1}^{m} w_i x_{ij}} \le 1, \; j = 1,2,3,...,n \tag{8}$$

$$t_r \ge \varepsilon, \qquad r = 1,2,3,...,s \tag{9}$$

$$w_i \ge \varepsilon, \qquad i = 1,2,3,...,m \tag{10}$$

where
h_k is the relative efficiency of DMU_k
s is the number of outputs
t_r is the weights to be determined for output r
y_{rj} is the observed magnitude 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 magnitude of i-type input for entity j
ε is the positive value
n is the number of entities
α is the free variable

The objective function in equation (7) maximizes the efficiency for k-decision-making unit (DMU). In this study, DMUs refer to the companies from the technology sector in Malaysia. Constraint (8) ensures that the efficiency is $0 < h_k \leq 1$ for each DMU. The weights w_i and t_r show the importance of each input and output in maximizing the efficiency which is determined by the model. The DEA model (7) – (10) consists of fractional objective function as well as fractional constraints. The linear programming model of DEA was developed and introduced by Charnes and Cooper [28] where the denominator is set equal to 1 and the numerator is being maximized. According to Charnes and Copper [28], the model above is converted into a linear programming model as shown in (11) – (15) [2, 29].

$$\text{Maximize} \quad h_k = \sum_{r=1}^{s} t_r y_{rk} + \alpha \tag{11}$$

Subject to

$$\sum_{i=1}^{m} w_i x_{ij} - \sum_{r=1}^{s} t_r y_{rj} - \alpha \geq 0, \; j = 1,2,3,...,n \tag{12}$$

$$\sum_{r=1}^{m} w_i x_{ik} = 1 \tag{13}$$

$$t_r \geq \varepsilon, \qquad r = 1,2,3,...,s \tag{14}$$

$$w_i \geq \varepsilon, \qquad i = 1,2,3,...,m \tag{15}$$

In this study, the DEA model is solved by using LINGO software.

III. Empirical Results

Table 2 presents the efficiency and ranking of the companies from the technology sector in Malaysia. As shown in Table 2, eight technology companies manage to achieve 100% efficiency score. Therefore, the companies such as AMTEL, ELSOFT, GRANFLO, GTRONIC, KESM, MPI, UNISEM and VITROX are classified as efficient companies over the five-year period. This implies that these efficient technology companies manage to fully utilize their resources or inputs to produce the maximum level of outputs. In this study, the number of efficient companies is 8 which accounts for 44% of the total number of companies. This indicates that 44% of the companies from technology sector in Malaysia stock market are efficient. This result is also in line with the past studies of Percin and Ayan [30], Zamani et al. [31], Kyritsis et al. [32] as well as Stavarek and Repkova [33] which showed that the percentage of efficient companies is ranging from 35% to 65% in financial sector by using financial ratio based DEA model.

Table 2
Performance Efficiency and Ranking of the Companies from Technology Sector in Malaysia

DMU	Efficiency Score (%)	Rank	Performance
AMTEL	100.00	1	Efficient
CENSOF	52.61	16	Inefficient
CUSCAPI	70.55	13	Inefficient
DIGISTA	18.69	18	Inefficient
ECS	90.11	10	Inefficient
EFORCE	83.50	12	Inefficient
ELSOFT	100.00	1	Efficient
GRANFLO	100.00	1	Efficient
GTRONIC	100.00	1	Efficient
INARI	85.70	11	Inefficient
JCY	58.37	15	Inefficient
KESM	100.00	1	Efficient
MPI	100.00	1	Efficient
NOTION	60.15	14	Inefficient
PANPAGE	24.91	17	Inefficient
UNISEM	100.00	1	Efficient
VITROX	100.00	1	Efficient
WILLOW	96.15	9	Inefficient

On the other hand, other companies such as CENSOF, CUSCAPI, DIGISTA, ECS, EFORCE, INARI, JCY, NOTION, PANPAGE and WILLOW are identified as inefficient companies since these companies are not able to reach 100% efficiency score. In this study, WILLOW achieves 96.15% efficiency. This shows that WILLOW is close to become an efficient technology company. On the other hand, PANPAGE and DIGISTA obtain the efficiency scores of 24.91% and 18.69% respectively which are below 30.00%. This indicates that PANPAGE and DIGISTA do not perform well in terms of efficiency as compared to other technology companies. In summary, AMTEL, ELSOFT, GRANFLO, GTRONIC, KESM, MPI, UNISEM and VITROX are ranked as efficient companies from the technology sector in Malaysia stock market.

Table 3 presents the optimal control of input and output weights (%) in maximizing the efficiency for each technology company in Malaysia stock market.

As shown in Table 3, DEA model provides the optimal control of input and output weights in maximizing the efficiency for each technology company in Malaysia stock market. The efficient technology companies with 100% efficiency score consist of AMTEL, ELSOFT, GRANFLO, GTRONIC, KESM, MPI, UNISEM and VITROX. In this study, the overall output weights in the maximization of efficiency is mostly contributed by EPS (53.73%) followed by ROE (25.79%) and finally ROA (20.48%). On the other hand, the overall input weights in the maximization of efficiency is mostly contributed by debt to equity ratio (60.25%), followed by debt to assets ratio (33.02%), and lastly current ratio (6.73%).

Table 3
Optimal Control of Input and Output Weights (%) in Maximizing the Efficiency

DMU	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	0.35	0.00	99.65	100.00	0.00	0.00	100.00
CENSOF	2.76	97.23	0.00	33.33	33.33	33.33	52.61
CUSCAPI	3.78	0.00	96.21	33.33	33.33	33.33	70.55
DIGISTA	0.07	99.93	0.00	33.33	33.33	33.33	18.69
ECS	0.07	0.00	99.93	33.33	33.33	33.33	90.11
EFORCE	4.74	0.01	95.25	99.23	0.01	0.77	83.50
ELSOFT	0.73	0.00	99.27	100.00	0.00	0.00	100.00
GRANFLO	0.21	0.00	99.79	0.28	99.44	0.28	100.00
GTRONIC	0.87	0.00	99.13	99.14	0.00	0.85	100.00
INARI	0.17	99.83	0.00	0.49	0.49	99.01	85.70
JCY	0.17	99.83	0.00	0.68	0.68	98.64	58.37
KESM	0.73	0.00	99.27	99.99	0.00	0.00	100.00
MPI	99.09	0.45	0.45	99.05	0.00	0.94	100.00
NOTION	2.76	97.24	0.00	99.98	0.01	0.01	60.15
PANPAGE	0.17	99.82	0.00	1.51	1.51	96.99	24.91
UNISEM	3.78	0.00	96.22	99.99	0.00	0.00	100.00
VITROX	0.65	0.00	99.34	0.09	99.83	0.09	100.00
WILLOW	0.07	0.00	99.93	33.33	33.33	33.33	96.15
Average	6.73	33.02	60.25	53.73	20.48	25.79	80.04

IV. Conclusion

In this study, a DEA model with financial ratio is proposed to evaluate and compare the efficiency of the listed companies from the technology sector in Malaysia stock market. The results of this study indicate that AMTEL, ELSOFT, GRANFLO, GTRONIC, KESM, MPI, UNISEM and VITROX are ranked as efficient technology companies since they manage to achieve 100% efficiency score. This implies that these efficient companies have fully utilized the inputs in maximizing the outputs. In this study, 44% of the companies from technology sector in Malaysia stock market are efficient. The main contribution of this study is to evaluate the efficiency of the listed companies from technology sector in Malaysia stock market with financial ratio based DEA model. This pioneer study helps to examine the current financial strengths of the listed technology companies in Malaysia stock market. The future research of this study should be extended to other sectors that listed in Malaysia stock market so that the efficiency of other sectors can also be evaluated and investigated with financial ratio based DEA model.

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