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An Evaluation of Company Operation Performance Using Data Envelopment Analysis (DEA) Approach: A Study on Malaysian Public Listed Companies

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Abstract: The purpose of this study is to measure and evaluate the relative efficiency of 14 public listed companies in Malaysia using a non-parametric approach-data envelopment analysis. Data were obtained from the financial statements gathered by OSIRIS for the period 2004-2008. The relative efficiency of each company, across the 5 years period was examined. The DEA results show under the CRS technology assumption, only one company is considered technically efficient while the average overall technical efficiency varies from 0.13 -0.50. When the aggregate efficiency is decomposed into pure technical efficiency and scale efficiency using VRS production function, it is found that the source of inefficiency is scale inefficiency rather than pure technical inefficiency. Most of the companies are found operating under increasing returns to scale. ThisJune 10, 2010 indicates that managers' capabilities to utilize a company given resources still need to be enhanced. They must reduce non essential expenses so as to produce efficiently. In addition, the results indicate that on average, 2 out of 14 companies are in quadrant I (super star), characterised by high efficiency and high profitability while 7 companies are in quadrant IV (problem child), characterised by low efficiency and low profitability.

Key words: Efficiency, data envelopment analysis, public listed companies, Malaysia, CRS, VRS

INTRODUCTION

Research on the performance and efficiency of companies has been given enormous attention over the past decades (Thore *et al.*, 1994; Lin and Liu, 2004; Hsu and Liu, 2008; Swai, 2009). Previous research basically uses conventional ratios such as return on assets. Later many studies use various measures of performance which include financial index, a non-parametric approach-Data Envelopment Analysis (DEA) and parametric approach-Stochastic Production Approach (SPA). DEA is frequently used to measure the efficiency of a company. DEA is a non-parametric multiple input-output efficiency technique that measures the relative efficiency of decision making units or DMUs using a linear programming model. It is non-parametric because it requires no assumption on the shape or parameters of the underlying production function.

This technique has been applied for measuring the relative efficiency of DMUs in various sectors such as hospitals, financial institutions, the textile industry, IT companies and transportation companies. Despite its drawbacks, DEA is popularly used because of its advantages. The main advantage is that it can readily incorporate multiple inputs and outputs to calculate technical efficiency. The purpose of this study is to examine the relative efficiency of 14 Malaysian companies from 2004-2008 using DEA approach. Then, we draw the performance matrix based on the DEA efficiency and profitability index (return on assets).

Literature review: Efficiency measurement is one aspect of a company's performance. Efficiency can be measured with respect to maximization of output, minimization of cost or maximization of profits. A company is regarded as technically efficient if it is able to obtain maximum outputs from given inputs or minimise inputs used in the production of given outputs. The objective of producers is to avoid waste. Various studies have been carried out to examine the performance of companies.

Many studies have used financial ratios such as sales (Wang, 2003). Return on assets (Lin and Liu, 2004; Naser and Mokhtar, 2004), return on equity (Ponnu and Ramthandin, 2008) and return on invested

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capital (Hsu and Liu, 2008). Some studies have used more advance methods to measure the performance of companies. Thore *et al.* (1994) examined the productive efficiency of U.S. computer manufacturers using DEA. Their results show that few corporations were able to stay at the productivity efficiency throughout the time period under study. Batra and Tan (2003) examined technical efficiency of SME using data from six countries Malaysia, Indonesia, Mexico, Colombia, Taiwan (China) and Guatemala. Their study shows that technical efficiency rises with company size and that there is a substantial overlap in the distribution of efficiency across company sizes with some small companies operating at the same or higher levels of efficiency than some large companies. Education and training of workers, investments in new technology, automation and quality control were factors that distinguish more efficient companies from less efficient companies in all 6 countries under investigation.

Wu (2005) examined the performance of Taiwan's Steel Industries for the period 1970-1996 and the results show that technical efficiency along with industrial evolution is generally influenced by policy measures engaging in market liberalization and adaptation to advanced technology. On the other hand, Wu (2005) examined the performance of the retailing industry in Taiwan using DEA and found that on average almost half of the retailing companies were inefficient.

Using DEA-Based approach, Hong and Park (2007) report that through the application of SVM model (Support Vector Machine), they were able to evaluate an individual company and provide the efficiency of an IT venture business without comparing it with other companies. Variables such as total capital turnover, sales/employees and the productivity of employees were important financial information in evaluating the efficiency of an IT business venture. Eslami *et al.* (2009) in a study on 18 Iranian companies producing automobiles and automobile parts reported that 8 companies were efficient in 2005, out of which only 4 companies remained efficient in 2006.

MATERIALS AND METHODS

We gathered data from the OSIRIS database, 2009. About 14 companies with data available from 2004-2008 were randomly chosen from the database. The analysis was conducted using DEAP.

In this study we employed the non-parametric measure, the DEA. It is non-parametric because it requires no assumption on the shape or parameters of the underlying production function. DEA is a linear programming technique based on the pioneering work of Farrell's efficiency measure (1957) to measure the different efficiency of Decision-Making Units (DMUs). Assuming the number of DMUs is s and each DMU uses m inputs and produces n outputs. Let DMU_k be one of s decision units, $1 \le k \le s$. There are m inputs which are marked with X_i^k (i = 1, ..., m) and n outputs marked with Y_j^k (j = 1,...., n). The efficiency equals to total outputs divided by total inputs. The efficiency of DMU_k can be defined as follows:

$$\text{The efficiency of } DMU_k = \frac{\sum_{j=1}^{n} u_j Y_j^k}{\sum_{i=1}^{m} v_i X_i^k} \tag{1}$$

$$X_i^k, Y_j^k \ge 0, i=1,...,m, j=1,....,n, k=1,$$
$$....,s\, u_j, v_i \ge 0, i=1,....,m, j=1,....,n$$

The DEA program enables one to find the proper weights which maximise the efficiency of DMU and calculates the efficiency score and frontier. The CCR model originated by Charnes has led to several extensions, most notably the BCC model by Banker. The CCR and BCC models can be divided into two terms; one is the input oriented model; the other is the output oriented model.

The input orientation seeks to minimize the usage of inputs given a fixed level of output while the output orientation maximizes the level of output for a given level of inputs. In CCR model, Constant Returns to Scale (CRS) is assumed which means one unit of input can get a fixed value of output. The BCC model assumes Variable Returns to Scale (VRS).

In this study, the input oriented model was chosen and used the dual problem model to solve the problems. The CCR dual model is as follows:

$$\text{Min}\, \theta - \varepsilon \left[\sum_{i=1}^{m} S_i^- + \sum_{k=1}^{n} S_j^+ \right] \tag{2}$$

$$\text{s.t} \sum_{i=1}^{s} \lambda_r X_i^r - \theta X_i^k + S_i^- = 0 \quad i=1,....,m$$

$$\sum_{i=1}^{s} \lambda_r Y_j^r - S_i^+ = Y_j^r \quad j=1,....,n$$

$$\lambda_r \ge 0 \quad r=1,.....,s$$
$$S_i^- \ge 0 \quad i=1,.....,m$$
$$S_j^+ \ge 0 \quad j=1,.....,n$$

Where:

θ = The efficiency of DMU

s_i^- = The slack variable which represents the input excess value

Table 1: Descriptive statistics for outputs and inputs used, 2004-2008 (in RM Million)

Years	Mean	SD	Minimum	Maximum
2004				
Y	3,704.584	3,255.772	220.800	12,451.079
X_1	526.934	369.129	17.685	1,285.926
X_2	3,243.763	2,231.956	1,004.771	8,802.014
2005				
Y	4,399.381	4,105.718	680.082	16,567.916
X_1	613.805	449.366	167.810	1,576.789
X_2	3,453.196	2,195.142	1,008.170	8,312.775
2006				
Y	4,769.897	4,693.425	1177.813	19,496.360
X_1	681.863	469.079	216.258	1,793.634
X_2	3,486.552	2,141.430	1,109.849	6,946.767
2007				
Y	5,397.168	5,327.742	1,319.208	22,301.580
X_1	676.825	396.557	243.276	1,605.757
X_2	4,020.415	2,981.338	1,228.353	8,609.608
2008				
Y	6,202.322	5,838.716	1,339.266	24,367.622
X_1	779.644	476.664	289.404	1,756.305
X_2	3,990.058	2,546.964	1,116.950	8,679.091

Y = Sales, X_1 = Total expenses, X_2 = Assets

s_j^+ = The surplus variable which represents the output shortfall value

ε = A non-Archimedean number represents a very small constant

λ_r = The proportion of referencing DMU_r when measuring the efficiency of DMU_k

If the constraint below is adjoined, the CCR dual model is known as the BCC model.

$$\sum_{r=1}^{s} \lambda_r = 1 \quad (3)$$

Equation 3 frees CRS and modifies BCC model to be VRS. For the measurement of efficiency, the CCR model measures Overall Efficiency (OE) of a DMU and the BCC model can measure both the Pure Technical Efficiency (PTE) and Scale Efficiency (SE) of DMU. The relationship of OE, PTE and SE is as Eq. 4:

$$OE = PTE \quad (4)$$

DEA technique has been applied successfully as a performance measurement tool in many fields including the manufacturing sector, hospitals, pharmaceutical companies, banks, education and transportation.

In this study, an input orientation as opposed to output orientation has been adopted. Based on past studies, input was measured by both total expenses (operating and financial expenses) and total assets. Output was measured in terms of sales. Table 1 shows the descriptive statistics of the outputs and inputs used in the study.

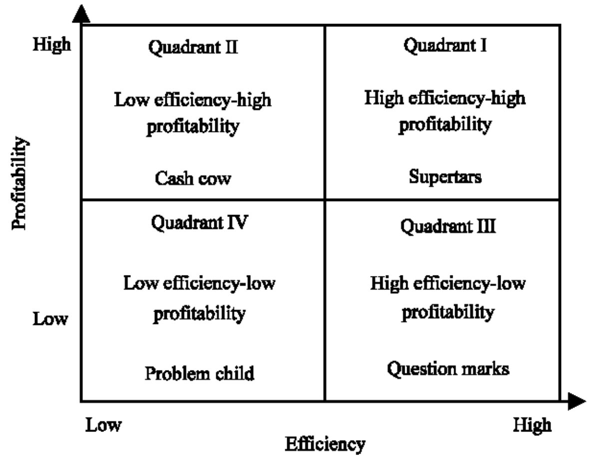

Fig. 1: Performance matrix

Performance matrix: As mentioned earlier, the efficiency derived from DEA could represent the management efficiency in allocating resources of the company. On the other hand, the ROA is a good indicator of the company's profitability. Following Lin *et al.* (2005) and Fang *et al.* (2008) we apply the performance matrix based on the characteristics of DEA and ROA to evaluate the performance of the Malaysian companies as shown in Fig. 1. The vertical axis represents the company's profitability, while the horizontal axis represents the efficiency score derived from the DEA model. From the matrix, a company can observe its performance from year to year and benchmark itself with the competitors. Based on this, the company can understand its operating status and develop a plan for improvement. In this study, ROA is obtained by taking EBIT divided by total assets.

RESULTS AND DISCUSSION

DEA relative efficiency: To take account of the year effects, we chose to calculate a different technology per year which implicitly incorporates the time effects of the analysis instead of computing a common benchmark for the whole accumulated sample (14 companies over 5 years). Figure 2 shows the various scores of efficiency. Over the period, the average score of overall efficiency was around 0.50, which indicated that these companies were wasting about 50% of their inputs.

These companies would have gained around 50% if they were aligned with the observable best practices. Over the years, the companies productive performance underwent a substantial down turn, especially when approaching the year 2008. Table 2 shows the DEA efficiency scores for the 14 companies for the 5 years period. Note that companies with a score of <1 are regarded as inefficient. It was found that only 1 company was consistently efficient in 5 years. This implied that majority of the sample of Malaysian companies did not show good efficiency during this 5 years period. The scores of inefficient companies show a discrepancy on the year-by-year basis and the trend seemed to be downward as shown in Fig. 2. For example, the efficiency score of company 7 was 0.88 in 2004 and then decreased to 0.22, 0.17, 0.21, 0.13 and 0.32 in year 2005-2008, respectively. This implies that in the year 2004, the company wasted 12% of the level of inputs of efficient companies with the same level of outputs. The original data for this company indicate that the company increased its expenses from 2004-2006 but reduced its expenses in 2007 and 2008 and this has affected its efficiency. Looking at the overall average performance, the Malaysian companies efficiency decreased in 2005 and 2006 but increased slightly in 2007 and then decreased again in 2008.

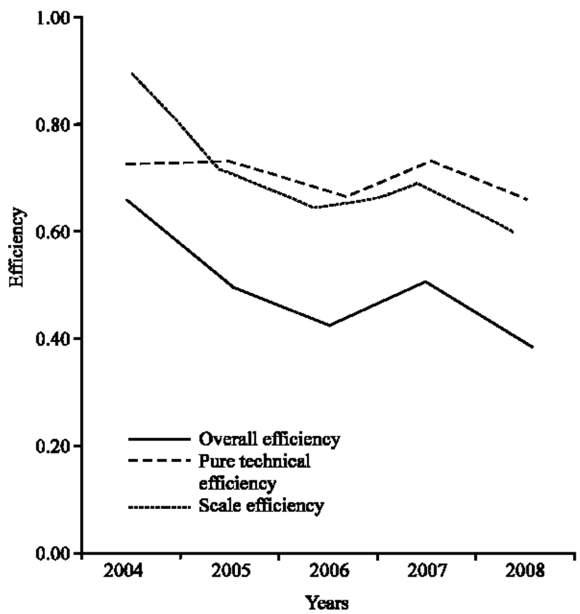

Fig. 2: Average efficiency score, 2004-2008

When the aggregate production efficiency is decomposed into pure technical efficiency and scale efficiency using VRS production function, it is found that the source of inefficiency is due to scale inefficiency rather than pure technical inefficiency for all years except 2005.

We further investigate the situation and utilize the returns to scale analysis to illustrate the change of the company's production scale. The returns to scale analysis are shown in Table 3. The constant returns to scale indicate that the company has reached the best scale. The increasing returns to scale indicate that an increase in inputs leads to a more than proportionate increase in output. Decreasing returns to scale indicate that an increase in inputs leads to a less proportionate increase in outputs. In 2008, all companies except company 2 and 8 show increasing returns to scale. This indicates that manager's capabilities to utilize a company's given resources still need to be enhanced. They must reduce non essential expenses so as to produce efficiently.

Performance matirx: To enable us to draw the performance matrix, we use ROA as the profitability measure. Table 4 shows the profitability ratio (ROA) for each company and for each year. Company 10, 12 and 6 show the highest average ROA among the 14 companies. Based on the profitability and DEA efficiency matrix, we can see clearly the trend of profitability and managerial efficiency among the 14 companies. The matrix is shown in Fig. 3-8 while Fig. 8 shows the performance matrix for 2004-2008.

Table 2: Efficiency scores from DEA model, 2004-2008

Co.	2004			2005			2006			2007			2008		
No.	OE	PTE	SE	OE	PTE	SE	OE	PTE	SE	OE	PTE	SE	OE	PTE	SE
1	0.55	0.55	1.00	0.29	0.30	0.99	0.16	0.20	0.81	0.24	0.31	0.79	0.15	0.20	0.74
2	1.00	1.00	1.00	0.92	1.00	0.92	0.88	1.00	0.88	0.88	1.00	0.88	0.76	1.00	0.76
3	1.00	1.00	1.00	0.58	1.00	0.58	0.32	0.43	0.75	0.53	0.66	0.80	0.42	0.54	0.78
4	0.47	0.48	0.97	0.49	0.59	0.83	0.47	0.56	0.84	0.47	0.58	0.82	0.38	0.49	0.78
5	0.32	0.34	0.95	0.23	0.42	0.56	0.23	0.41	0.57	0.26	0.50	0.52	0.27	0.62	0.44
6	0.20	0.28	0.71	0.18	0.24	0.74	0.19	0.30	0.65	0.31	0.38	0.83	0.16	0.26	0.59
7	0.88	1.00	0.88	0.22	1.00	0.22	0.17	0.62	0.27	0.21	0.78	0.26	0.13	0.69	0.19
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	0.65	0.69	0.94	0.48	0.70	0.68	0.32	0.68	0.47	0.29	0.79	0.37	0.28	0.61	0.45
10	0.60	0.66	0.91	0.53	0.65	0.82	0.48	0.74	0.65	0.73	0.92	0.80	0.42	0.78	0.53
11	0.33	0.61	0.55	0.30	0.60	0.49	0.24	0.64	0.38	0.32	0.52	0.62	0.21	0.44	0.48
12	0.73	0.82	0.89	0.59	0.76	0.78	0.48	0.79	0.61	0.59	0.77	0.77	0.35	0.69	0.51
13	0.50	0.80	0.62	0.47	1.00	0.47	0.49	1.00	0.49	0.45	1.00	0.45	0.35	1.00	0.35
14	0.97	1.00	0.97	0.77	1.00	0.77	0.64	1.00	0.64	0.76	1.00	0.76	0.51	1.00	0.51
Av	0.60	0.73	0.89	0.50	0.73	0.70	0.43	0.67	0.64	0.50	0.73	0.69	0.38	0.67	0.58
Mx	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mn	0.20	0.28	0.55	0.18	0.30	0.22	0.16	0.20	0.38	0.40	0.31	0.26	0.13	0.20	0.19

OE = Overall Efficiency, SE = Scale Efficiency, PTE = Pure Technical Efficiency

Table 3: Returns to scale analysis for each company, 2004-2008

	RTS			
Years	IRS	CRS	DRS	Total
2004				
No. of companies	11.0	3.0	-	14
Percentage share	78.6	21.4	0.0	100
2005				
No. of companies	12.0	1.0	1.0	14
Percentage share	85.7	7.1	7.1	100
2006				
No. of companies	12.0	1.0	1.0	14
Percentage share	85.7	7.1	7.1	100
2007				
No. of companies	12.0	1.0	1.0	14
Percentage share	85.7	7.1	7.1	100
2008				
No. of companies	12.0	1.0	1.0	14
Percentage share	85.7	7.1	7.1	100

RTS = Returns To Scale, IRS = Increasing Returns to Scale, CRS = Constant Returns to Scale, DRS = Decreasing Returns to Scale

Table 4: The ROA values for each company, 2004-2008

Co. No.	2004	2005	2006	2007	2008	Average
1	0.09	0.01	-0.10	0.02	-0.06	-0.01
2	0.05	0.12	0.14	0.10	0.12	0.11
3	0.07	0.08	0.09	0.11	0.09	0.09
4	0.16	0.13	0.18	0.09	-0.05	0.10
5	0.09	0.05	0.07	0.11	0.11	0.09
6	0.14	0.16	0.26	0.37	0.34	0.26
7	0.04	0.04	0.05	0.07	0.05	0.05
8	-0.05	0.03	0.01	0.03	-0.17	-0.03
9	0.10	0.09	0.05	0.07	0.14	0.09
10	0.64	0.51	0.64	0.72	0.74	0.65
11	0.10	0.11	0.11	0.10	0.10	0.10
12	0.25	0.25	0.26	0.27	0.28	0.26
13	0.14	0.13	0.14	0.11	-0.04	0.10
14	0.04	0.04	0.03	0.03	0.04	0.04
Average score	0.13	0.13	0.14	0.16	0.12	0.14
Maximum score	0.64	0.51	0.64	0.72	0.74	0.65
Minimum score	-0.05	0.01	-0.10	0.02	-0.06	-0.01

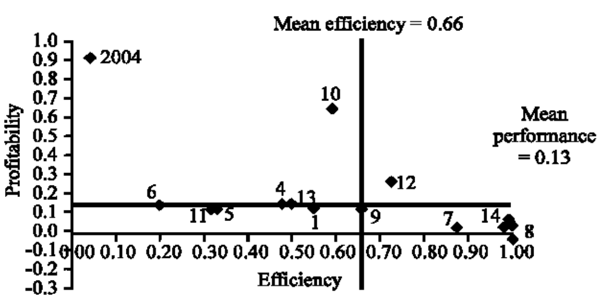

Fig. 3: The performance matrix for 2004

Figure 3 for example, shows that company 12 is in quadrant I (super star), which is characterised by high efficiency and high profitability.

Conversely, 3 out of the 14 companies are categorised by low efficiency and low profitability and are placed in quadrant IV (problem child). We can argue that these companies should rearrange input to improve their performance. In 2008 for example, we can observe that the number of companies in quadrant I and quadrant IV has increased, 2 companies are in the super star group, while 5 companies are in the problem child group. This study examined the relative efficiency of selected Malaysian public listed companies using the non-parametric

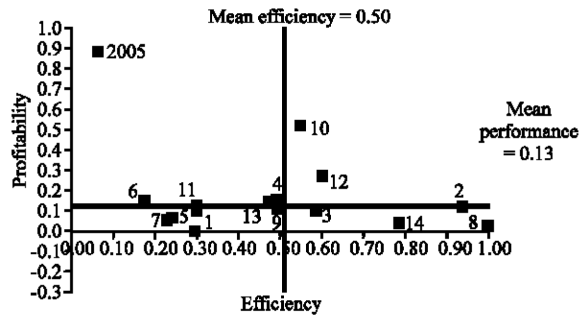

Fig. 4: The performance matrix for 2005

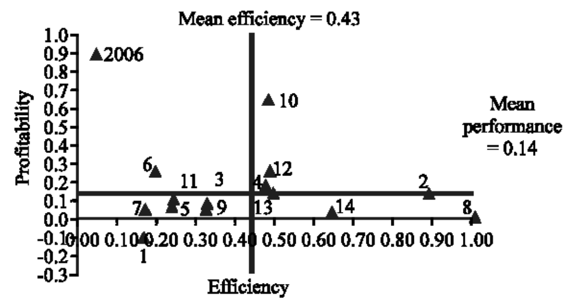

Fig. 5: The performance matrix for 2006

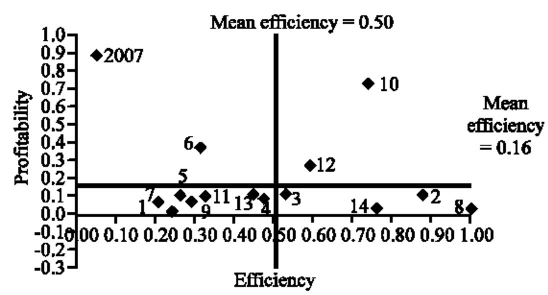

Fig. 6: The performance matrix for 2007

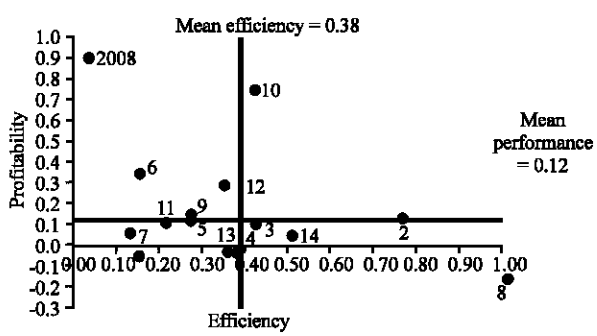

Fig. 7: The performance matrix for 2008

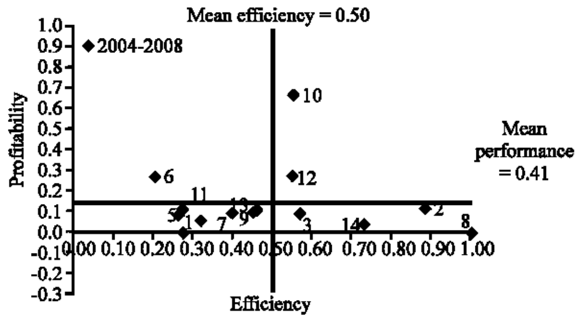

Fig. 8: The performance matrix for 2004-2008

approach of Data Envelopment Analysis (DEA) from 2004-2008. The DEA methodology is employed using both the Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) assumption to provide measures of technical and scale efficiency.

The results reveal a substantial level of dispersion of technical efficiency between companies within the sample for the year to year basis. The estimated results show that only 1 company was relatively efficient throughout the period under investigation, while the average overall technical efficiency varied from 0.13-0.50.

CONCLUSION

In this study, the source of inefficiency is mainly due to scale inefficiency rather than pure technical inefficiency. The inefficient companies can effectively promote resource utilization efficiency by better handling their inputs. Based on the DEA efficiency score and profitability index (ROA), the performance matrix is drawn to enable us to locate the position of the company in the matrix so as to take appropriate steps in improving performance. On average, 2 companies are in quadrant 1 (super star) which is characterised by high efficiency and high profitability. Conversely, 6 out of the 14 companies were characterised by low efficiency and low profitability and are placed in quadrant IV (problem child). Thus we cannot conclude which company has high performance based on financial ratios only. This study is not without its limitations. More companies should be included in the study and other input and output variables could be used. However, the findings could help the management of the companies to review their resources to increase performance and efficiency.

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