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Full Length Research Paper

Measuring the performance of 100 largest listed companies in Malaysia

Nordin Hj. Mohamad[1]* and Fatimah Said[2]

[1]Institute of Mathematical Sciences, University of Malaya, 50603 Kuala Lumpur, Malaysia.
[2]Faculty of Economics and Administration, University of Malaya, Malaysia.

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The purpose of this study is to measure and assess the performance of 100 largest listed companies in Malaysia. A modified strictly output- oriented Data Envelopment Analysis (DEA) model is used to measure the relative performance of each company by utilizing a list of normalized performance indicators based on data published in the Malaysian Business (16th October, 2009). The DEA scores indicate that only 6 and 19% of the companies are operating on the best-practice frontier under the assumptions of constant return to scale (CRS) and variable return to scale (VRS) respectively. No company exhibits increasing return to scale (IRS). Most of the relatively large (revenue-top-ranked) companies show serious scale inefficiency and exhibit decreasing return to scale (DRS). Ranking based on the performance index reveals that top-ranked companies by revenue are not necessarily top-ranked performers. Although ten of the seventeen governments linked companies, GLCs are top-20 by revenue, only one remains in the top-20 ranking by DEA. Three GLCs from bottom-20 by revenue join the top performers exhibiting full scale efficiency. Non-GLCs dominate 75% of the top-20 DEA ranking.

Key words: Performance, data envelopment analysis, relative technical efficiency.

INTRODUCTION

The advancement of knowledge, science and technology transforms the globe into a borderless world. This dynamicity changes not only physical environments but also business environments. Business organizations such as companies, firms, enterprises, big or small, public or private must be ready to meet and adapt to challenges emerging from these changes if they are to survive and remain in business as major players and prosper. One of the strategies of the game, among others, is improvement in performance and increase productivity. Thus company's performance measurement and assessment is one of the most important agendas in today's business world. Failure to perform and/or sustain some satisfactory performance target level may damage the company's reputation leading to customer defections and breakdowns in relations with other key stakeholders such as deterioration or lost of investor confidence in management.

Performance is not easy to define, but is closely related to productivity and efficiency. Efficiency is a dynamic concept that involves a firm being able to operate with the minimum level of resources or inputs such as capital, labour and materials to produce outputs and yet remains highly competitive over an extended period of time (Mayes et al., 1994). Measuring efficiency levels has thus become an important issue for managers of businesses and industries alike. Several methodologies have been employed for measuring and assessing business performance. These include score cards, economic production function, econometric stochastic frontier analysis, multi-attribute decision making techniques and Data Envelopment Analysis (DEA). However, a company's performance is multi-dimensional (Zhu, 2000), involving more than a single criteria to characterize its diverse business targets. A multi-factor performance model is able to identify to policy maker or management how far a company can be expected to increase its multiple outputs by simply improving its efficiency without the need to

*Corresponding author. E-mail: nordinhm@um.edu.my.

absorb further input.

DEA has been widely employed in a variety of disciplines as an efficiency or performance measurement tool for comparing a set of entities such as firms, banks, hospitals, nations and organizations which are generally termed as decision making units (DMUs). These DMUs utilize a set of multiple homogenous inputs to produce a set of multiple homogenous outputs. The concept of frontier analysis introduced by Farrell (1957) forms the basis for DEA, but the linear programming formulation and extensions was triggered by the article by Charnes et al., (1978). In DEA, neither specific functional relationship between production outputs and inputs nor any specific statistical distribution of the error terms is assumed. Thus DEA provides no statistical information on the goodness and reliability of the results. However, its ability to handle production processes involving multiple inputs and multiple outputs makes it an appealing choice and outweighs its statistical shortcomings. It provides detailed information on the comparative performance of each DMU in the form of an efficiency score (one for efficient DMUs and less than one for inefficient DMUs) which in this study is interpreted as a measure of business performance. For inefficient DMU, DEA identifies its peers from a set of efficient units that it is compared with, as well as improvements in output and/or input levels required by the unit to be on the efficient frontier. In other words, DEA provides the inefficient unit with guidance or path to the frontier.

The current study undertakes to estimate and evaluate the performance of 100 Malaysia's largest listed companies (MB100) using DEA methodology based on data published by the Malaysian Business magazine (2009) . The purpose of the research can be specifically stated as follows.

1. To measure and assess the performance of MB100 companies based on data for the year 2009 using a proposed strictly output-oriented DEA model under the assumptions of constant and variable returns to scale.
2. To estimate returns to scale and identify companies exhibiting most productive scale size.
3. To identify peer groups which act as benchmarks for nonperforming companies and to illustrate the possible increase in outputs by these companies (to guide them to the frontier).

The paper is organized as follows. The study reviews selected relevant literature, which is followed by a summary of the methodology and the proposed strictly output-oriented model used for conducting the analysis. Subsequently, the study discusses the data set and the empirical results of the DEA estimates. This includes identifying the sources of inefficiency, returns to scale and companies exhibiting the most productive scale size as well as the ranking of companies based on DEA performance efficiency score. Performance between GLCs and non-GLCs are also highlighted. Next, we illustrate the possible path to guide the nonperforming companies to the efficient frontier by utilising the efficiency score and the nonzero output slacks. Finally, the study concludes by outlining the research limitations and exploring avenues for future investigation.

LITERATURE REVIEW

Since its debut (Charnes et al., 1978), DEA has received tremendous acknowledgements. It has been revised, modified, extended and improved to suit various disciplines. Its simplicity and ability to handle multiple input and multiple output production processes without the need to specify a production function has made it one of the most extensively used performance assessment techniques in a variety of scenarios involving non-profit as well as profit-motivated organizations. Numerous studies on efficiency and performance using DEA have been conducted and reported. Apart from assessing industrial performance, DEA has also been used to evaluate the comparative performance of organizations such as academic institutions (Kao and Hung, 2008), banks and financial institutions (Mostafa, 2007), hospitals and health centres (Kirigia et al., 2002), manufacturing industries (Ali and Nakosteen, 2005) as well as economic and social performance of nations (Vannesland, 2005) . Tavares (2002) reported that until January of 2002, the DEA bibliography database includes 3202 publications written by 2152 distinct authors. Recently, Emrouznejad et al. (2008) provides more than 4000 comprehensive reference lists on methodological and application aspects of DEA.

Despite the long list of research papers on efficiency measurement using DEA, its appearance and impact in the business sector especially in developing countries is yet to be established. Al-Shammari (1999) applies the modified model of DEA to evaluate the operational efficiency of 55 Jordanian manufacturing shareholding companies listed in the Amman Financial Market (AFM) using financial data for the year 1995 extracted from the AFM (1996) Guide. Using three input indicators and three output indicators, 21.82% (12 companies) are found to be relatively efficient and 78.18% (43 companies) are found to be relatively inefficient with a relative efficiency score ranging from 0.1270 to 0.9114. The mean efficiency score is 0.5470 with a standard deviation of 0.2821. The inefficiency is attributed to the underutilization of some inputs. Most companies are getting less output per unit of input for these resources.

Zhu (2000) develops a multi-factor performance model to evaluate the performance of the Fortune 500 companies in 1995. Due to the presence of negative data, only 72.8% (364 companies) are short listed for evaluation using the input-oriented CRS DEA model for a three-stage analysis defined as profitability (Stage-1), marketability (stage-2) and overall (stage-3). Ten, eight and fourteen companies are found to be CRS-efficient in stage-1, stage-2 and stage-3 respectively. No company is CRS-efficient in all stages. Nineteen of the top-20 companies ranked by revenue are CRS-inefficient in all stages. An investigation on scale efficiency and returns to scale reveal that the top- 20 companies not only exhibit serious scale inefficiency, but also operate in a region of decreasing returns to scale (DRS). Most small industries, on the other hand, are operating in a region of increasing returns to scale (IRS). The paper also explores the issue of input congestion. The sensitivity analysis conducted suggests that the DEA results are in general insensitive to data errors in the sample.

Ramanathan (2004) applies DEA to study the business excellence of 19 industrial groups in the manufacturing sector of the Sultanate of Oman using data for the year 2001. Three of these groups are found to be operating at the highest level of business excellence. A dynamical study is also conducted over the time period 1997-2001 using the approach of Malmquist productivity index (MPI). The MPI for the group exhibits a decreasing trend, due mainly to a significant decline in technology changes. However, technical efficiency in the manufacturing sector shows slight improvement. A market efficiency study on top listed companies in Egypt is conducted by Mostafa (2007) using a two-stage approach. In the first stage, production frontier analysis, PFA (an alternative term used by the author for DEA) is used to establish the relative market efficiency of 62 listed companies using the output-oriented model. This is followed in the second stage by Tobit regression to econometrically explore some firm -specific factors such as age of the company and brand value of the company that are likely to interfere with the estimation of efficiency. Six and ten companies are found to be 100% efficient under the assumptions of CRS and VRS respectively. Thus six companies are 100% scale efficient. However the overall result does not suggest scale inefficiency as a serious source of technical inefficiency. The Tobit regression model predicts that company's efficiency falls with additional years of operation, and higher efficiency is expected from companies reporting positive brand value.

On the Malaysian scenario, studies are focused on companies with homogenous activity such as banking (Krishnasamy et al., 2003; Batchelor and Wadud, 2004; Sufian and Haron, 2009), life insurance industry (Mansor and Radam, 2000) and mobile telecommunications industry (Mohamad, 2000). Krishnasamy et al. (2003) studies the productivity change of ten commercial banks in Malaysia over the period 2000-2001 using DEA and MPI. The results indicate that total factor productivity increases in all eight banks except for EON which remains unchanged while PBB records a decrease in productivity. The growth in productivity is attributed to technological progress rather than technical efficiency change. Sufian and Haron (2009) examines the efficiency of banks which are listed on the Kuala Lumpur Stock Exchange (KLSE) using the individual bank's market data as the input and output variables. It is found that the most efficient bank is also highly ranked in terms of returns.

Mansor and Radam (2000) measure the productivity of life insurance industry by employing the non-parametric MPI approach. The mean technical efficiency index of the twelve Malaysian insurance companies is found to be 0.7265 for the period 1970-1997. The productivity growth is relatively low compared to the real economic growth of the nation. The study also suggests that the overall productivity growth is attributable to both technical efficiency and technological progress. A study of mobile telecommunications providers from 1996 to 2001 is undertaken by Mohamad (2004) . One output and four inputs are considered. The single output is the number of subscribers while the total number of labour and three subcomponents of capital, fixed capital stocks, total number of mobile switching centres and radio base stations constitute as inputs. Results show that productivity has increased significantly due to technological change rather than efficiency change. In this study we utilize a modified strictly output-oriented DEA model to evaluate the performance of MB100 companies using one input and six normalised output indicators to be defined later.

METHODOLOGY

DEA formulation is motivated by the classical engineering-science definition of productivity, extended to multiple inputs and outputs. Suppose there are S DMUs to be investigated, each utilizes m inputs to produce n outputs. Further, let DMU_k (1<k<S) uses a combination of m inputs, denoted by $X_k = \{X_{k1}, X_{k2}, ..., X_{km}\}$ to produce n outputs, denoted by $Y_k = \{Y_{k1}, Y_{k2}, ..., Y_{kn}\}$. The productivity or relative efficiency, E_0 for DMU_0 is defined by a linear programming problem

(LP1) maximize: $$E_0 = \sum_{j=1}^{n} h_j Y_{0j} \quad (1)$$

Subject to

$$\sum_{i=1}^{m} c_i X_{0i} = 1 \quad (2)$$

$$\sum_{i=1}^{m} c_i X_{ki} - \sum_{j=1}^{n} h_j Y_{kj} \geq 0, \quad k = 1, 2, \ldots, S. \quad (3)$$

$$c_i \geq \varepsilon > 0, \quad i = 1, 2, \ldots, m,$$

$$h_j \geq \varepsilon > 0, \quad j = 1, 2, \ldots, n.$$

The weights c_i represents the price (the value or shadow cost) of one unit of input X_{ki}, $1 \le i \le m$, $\forall$ k = 1, 2, …, S , and h_j represents the price (or the value of contribution) of one unit of output Y_{kj}, $1 \le j \le n$, $\forall$ k = 1, 2, …, S. This is termed as the multiplier form of the CCR model (after Charnes, Cooper and Rhodes, 1978) under CRS. If E_0 = 1, DMU_0 is said to be CCR-efficient. Otherwise, it is CCR-inefficient. Its dual

(DLP1) minimize $\theta_0 - \varepsilon\left(\sum_{i=1}^{n} s_i^- + \sum_{j=1}^{m} s_j^+\right)$ (4)

Subject to

$$\theta_0 X_{0i} - \sum_{k=1}^{S} X_{ki} Z_k - s_i^- = 0, \quad i = 1, 2, \ldots, n, \qquad (5)$$

$$-Y_{0j} + \sum_{k=1}^{S} Y_{kj} Z_k - s_j^+ = 0, \quad j = 1, 2, \ldots, m, \qquad (6)$$

$Z_k \ge 0, k = 1,2,..., S,$

$s_i^-, s_j^+ \ge 0, \forall i, j$,

θ_0 Unconstrained, is generally the most cited and preferred form to solve. The dual variable $Z_k, k = 1,2,..., S$, are the shadow prices related to the constraints limiting the efficiency of each DMU to be no greater than 1. The objective here is to find the minimum feasible θ_0 that reduces the inputs X_{0i} proportionally to $\theta_0 X_{0i}, \forall i$ while maintaining the output level of DMU_0 no lower than $Y_{0j}, \forall j$. Cooper, et al., (1999) defined the slacks $s_i^-, s_j^+, \forall i, j$ as input excesses and output shortfalls respectively, and are given by

$$s_i^- = \theta_0 X_{0i} - \sum_{k=1}^{S} X_{ki} Z_k, \quad i = 1, 2, \ldots, n, \qquad (7)$$

$$s_j^+ = \sum_{k=1}^{S} Y_{kj} Z_k - Y_{0j}, \quad j = 1, 2, \ldots, m, \qquad (8)$$

for any feasible solution ($\theta_0^*, Z_k^*, k = 1,2,..., S$) relating to DMU_0.

The focus of this study is to seek possible improvements in the levels of outputs, rather than reducing inputs. This calls for the formulation of an equivalent output-oriented DEA model. To do this we express the input-oriented (DLP1) model without the slack variables as

(DLP2) minimize θ_0 (9)

Subject to

$$\theta_0 X_{0i} - \sum_{k=1}^{S} X_{ki} Z_k \ge 0, \quad i = 1,2, \ldots, n, \qquad (10)$$

$$-Y_{0j} + \sum_{k=1}^{S} Y_{kj} Z_k \ge 0, \quad j = 1,2, \ldots, m, \qquad (11)$$

$Z_k \ge 0, k = 1,2,..., S,$

θ_0 Unconstrained.

Following Cooper, et al. (1999), we define $\theta_0 = 1/\Omega_0$ and $Z_k = \lambda_k / \Omega_k$, $\Omega_k \ne 0, \forall k.$ this transforms (DLP2) into

(DLP3) maximize Ω_0 (12)

Subject to

$$-X_{0i} + \sum_{k=1}^{S} X_{ki}\lambda_k \le 0, \quad i = 1,2, \ldots, n, \qquad (13)$$

$$-Y_{0j}\Omega_0 + \sum_{k=1}^{S} Y_{kj}\lambda_k \ge 0, \quad j = 1,2, \ldots, m, \qquad (14)$$

$\lambda_k \ge 0, k = 1,2,..., S,$

Ω_0 Unconstrained.

(DLP3) is the output-oriented DEA model under CRS. For evaluation under the assumption of VRS, an additional convexity constraint is imposed on λ_k (Banker et al., 1984) such that

$$\sum_{k=1}^{S} \lambda_k = 1. \qquad (15)$$

This results in the formation of a convex hull of intersecting planes which envelope the data points more tightly than the CRS conical hull and thus provides technical efficiency scores which are greater than or equal to those obtained under the assumption of CRS. (DLP3) with additional constraint (15) is normally referred to as BCC-DEA model. The difference in the technical efficiency scores under the two assumptions of returns to scale is mainly attributable to scale inefficiency. Thus, scale efficiency, SE, can be viewed as the extent to which a DMU can take advantage of returns to scale by altering its size towards the optimal size (defined as the region in which there are CRS in the relationship between outputs and inputs) and is computed as $SE = \theta_0^{CRS}/\theta_0^{VRS} \le 1$. The output-oriented model (DLP3) exhibits some special features:

The technical efficiency score, $\theta_0 = 1/\Omega_0$, such that $1 \le \Omega_0 < \infty$ since $0 \le \theta_0 \le 1$.

Proportional improvement in outputs for inefficient DMUs is given by $\Omega_0 - 1$.

The number of peers among efficient DMUs for an inefficient DMU under evaluation is not more than the number of constraints which corresponds to the total number of inputs and outputs. These peers can be identified from the nonzero λ_k values.

Each constraint is associated with an input (or output). This provides ease of selecting combinations of input-output mix by enabling/disabling the relevant constraint(s).

In evaluating the performance of DMUs, the focus is on how well are the businesses performing and how much could their performance be improved. Thus we seek to find the maximum Ω_0 that increases Y_{0j} proportionally to $\Omega_0 Y_{0j}, \forall j$ while retaining the input level of DMU0 unchanged at $X_{0i}, \forall i$. To achieve this we propose a strictly output-oriented model with zero input slacks as follows,

(DLP4) maximize Ω_0 (16)

Subject to

$$-X_{0i} + \sum_{k=1}^{S} X_{ki}\lambda_k = 0, \quad i = 1, 2 \ldots n, \tag{17}$$

$$-Y_{0j}\Omega_0 + \sum_{k=1}^{S} Y_{kj}\lambda_k \geq 0, \quad j = 1, 2 \ldots m, \tag{18}$$

$$\lambda_k \geq 0, \quad k = 1,2,\ldots, S,$$

Ω_0 Unconstrained.

Here, the input inequality constraint (13) is replaced by a strictly input equality constraint (17), $\forall i$. Improvement or movement towards efficient frontier by inefficient DMUs can be identified by inspecting the system of equations (18) with output slacks $t_j^+, \forall j$ such that

$$\sum_{k=1}^{S} Y_{kj}\lambda_k - t_j^+ = Y_{oj}\Omega_0, \quad j = 1, 2 \ldots, m. \tag{19}$$

For an inefficient DMU$_0$, say, the projected output on the efficient frontier is as dictated by its peers (identified from $\lambda_k \neq 0, \forall k$) and given by $\sum_{k=1}^{S} Y_{kj}\lambda_k, \quad j = 1,2,\ldots,m.$ This can be achieved by proportional improvements of $(\Omega_0 - 1)$ in all outputs plus additional amount (termed as slack movements) of t_j^+ in output Y_{0j} whenever $t_j^+ \neq 0$. Thus, $(\Omega_0 - 1)Y_{0j} + t_j^+$ is a measure of under-achievement of output Y_{0j}, $j = 1,2,\ldots,m$, experienced by DMU0. The projected position on (and the movement to) the efficient frontier can be expressed as

$$Y_{0j}^{\wedge} = \sum_{k=1}^{S} Y_{kj}\lambda_k^* = Y_{0j}\Omega_0^* + t_j^{+*}, \quad j = 1, 2 \ldots, m, \tag{20}$$

Where $(X_{0i}, Y_{oj}^{\wedge}, \forall i, j)$ is the position of the composite virtual efficient DMU on the frontier, and $(\Omega_0^*, t_j^{+*}, \lambda_k^*)$ is the optimal solution of (DLP4) for the decision making unit under evaluation, DMU$_0$.

DEA INPUT AND OUTPUTS

The sample addressed in the study relates to MB100 companies. The basic data are obtained from Malaysian Business magazine (2009) for financial year end that falls on or before July 31. Only companies which have been listed at Bursa Malaysia for at least two years are surveyed. Their financial performance are broken down into six sub-listings including turnover (or revenue), net profit, equity and assets. However, no information is furnished on input factors relating to labour, capital and expenditure.

Table 1 documented the main data on MB100 companies, ranked by revenue. The list includes seventeen GLCs. Fifty percent of the revenue top-20 are GLCs. Six of them, namely Sime Darby, Tenaga Nasional, Petronas Dagangan, Malaysia International Shipping Corporation (MISC), Malayan Banking and Malaysia Airlines (MAS) top the list. Also included in the MB100 are twelve financial related institutions. Among the bottom-20 are three GLCs - Malaysia Airport Holding Berhad (MAHB), Bank Islam Malaysia Berhad (BIMB) and Pharmaniaga. One input and six output indicators are chosen to characterize and reflect the diverge performance of the MB100 top listed companies. These indicators are defined as follows,

1. Input (X): Total operating expenditure (or cost), approximated as revenue less net profit.
2. Output 1 (Y_1): The rate of change of revenue, expressed in percentage.
3. Output 2 (Y_2): The rate of change of net profit, expressed in percentage.
4. Output 3 (Y_3): The rate of change of assets, expressed in percentage.
5. Output 4 (Y_4): The return on revenue, expressed in percentage.
6. Output 5 (Y_5): The return on equity, expressed in percentage.
7. Output 6 (Y_6): The return on assets, expressed in percentage.

The single input, total operating expenditure denotes the business operational costs of materials and labour to generate products or to provide the services. This may include salary and wages for the employees, office rentals, maintenance costs and others. However, no information is furnished on these items and we approximate it as revenue less net profit. The first three output measures capture the dynamicity of the performance while the next three measures capture the profitability ratios, normally equated with the company's ability to generate a return on its resources.

Table 2 summarizes the descriptive statistics. Despite a continuing loss in net profit from RM-425.70 million in 2008 to RM-495.6 million in 2009 (Malaysian Business, 2009), MB55 Air Asia records the highest growth in revenue from RM1159.00 million to RM2936.50 for the same period (an increase of 153.4%). The highest profit earner at RM3002.30 million is MB05 Malayan Banking but 7.7% lower than the previous year of RM3252.90 million. A relatively small company, MB79 Allianz Malaysia which was in the red in 2008 (at RM-2.6 million) springs 2809.9% to record a modest net profit of RM70.70 million. On the less fortunate side, we have MB51 Lion Corporation. Not only is it the biggest loser at RM-1215.50 million, it also records the worst change in earning at -4992.40% (from RM-24.80 million). It also bottoms two of the profitability ratios, return on revenue and return on asset.

All the six output measures take on negative values for some observations and DEA is not capable of handling negative data. Thus for consistency, all indicators (including input) are normalized on a scale of [1, 100] such that

$$X_{nor} = \frac{99(X_{act} - X_{min})}{X_{max} - X_{min}} + 1 \tag{21}$$

Where Xnor is the value of the normalized indicator,

Table 1. Malaysia's 100 largest listed companies, by revenue (Year ending 31 July, 2009).

MB Rank	Company's name	Revenue (RM million)	Net Profit (Loss) (RM million)	Equity (RM million)	Asset (RM million)
01	Sime Darby *	32.028.00	2,340.80	21,384.80	35,310.50
02	Tenaga Nasional Berhad *	26,545.40	2,600.40	25,657.20	69,841.90
03	Petronas Dagangan Berhad *	24,479.40	581.80	4,163.30	6,559.00
04	MISC *	16,107.00	1,527.20	20,953.20	35,733.50
05	Malayan Banking Berhad *	15,671.50	3,002.30	19,302.50	268,910.90
06	Malaysian Airlines (MAS) *	15,501.30	245.70	4,185.70	9,965.30
07	IOI Corporation	14,665.40	2,414.20	8,391.40	16,747.00
08	Shell Refining Company	13,119.90	-330.00	1,920.60	3,089.70
09	UMW Holdings	12,998.30	955.80	3,522.30	7,695.10
10	Bumiputra Commerce Holdings*	12,670.30	2,012.50	18,362.40	199,580.10
11	Esso Malaysia	11,758.90	-251.50	392.00	1,752.40
12	Axiata Group	11,526.70	471.10	11,216.70	29,026.10
13	Public Bank	10,500.30	2,622.70	9,536.70	194,091.10
14	Genting	9,500.90	983.40	12,442.00	26,927.60
15	Telekom Malaysia *	8,853.60	901.10	10,248.10	22,531.40
16	MMC Corporation	8,847.40	891.50	6,114.00	26,339.60
17	Kuala Lumpur Kepong	8,039.90	1,089.50	5,537.10	8,216.60
18	Titan Chemicals Corporation	7,079.40	-270.30	3,868.70	6,148.90
19	Boustead Holdings	7,029.80	667.70	2,910.80	7,610.60
20	YTL Corporation	7,001.80	1,465.80	8,033.40	37,444.90
21	DRB-Hicom	6,818.40	725.40	4,160.70	21,245.40
22	Proton *	6,765.10	-301.80	5,101.50	6,638.20
23	Berjaya Corporation	6,428.50	106.60	5,570.20	10,383.20
24	RHB Capital	6,000.80	1,049.80	7,814.40	100,746.60
25	AMMB Holdings	5,860.70	878.30	7,736.10	88,084.70
26	Oriental Holdings	5,158.30	362.00	3,581.40	5,011.20
27	Genting Malaysia	5,041.80	634.00	8,317.80	9,422.90
28	DIGI.com	4,826.90	1,140.70	1,897.20	3,661.80
29	IJM Corporation	4,758.50	402.00	4,770.20	11,827.00
30	Lion Industries Corporation	4,587.90	-238.70	2,728.40	5,302.40
31	YTL Power International	4,411.30	1,038.50	6,381.70	27,341.40
32	Berjaya Land	4,152.50	94.10	5,014.50	5,727.80
33	British American Tobacco (M)	4,148.10	811.70	406.80	1,060.70
34	Kulim (M)	4,104.70	526.60	3,249.30	6,299.10
35	Nestle (M)	3,882.50	340.90	515.80	1,599.40
36	Hong Leong Finance Group	3,862.20	85,869.00	962.30	4,570.00
37	WCT	3,862.00	145.80	1,188.20	4,480.20
38	Tanjong Plc	3,764.30	548.60	3,281.00	12,381.70
39	Hong Leong Bank	3,703.20	741.90	5,089.50	77,427.90
40	Berjaya Sports Toto	3,695.70	418.30	480.50	500.90
41	DKSH Holdings (M)	3,635.00	5.70	144.50	1,105.10
42	F & N Holdings	3,591.20	179.70	1,182.20	2,420.90
43	Petronas Gas Berhad *	3,537.90	928.00	8,039.00	9,876.10
44	Perlis Plantation Berhad Group	3,490.60	1,293.40	12,232.80	13,132.70
45	Sapura Crest Petroleum	3,464.90	249.80	922.40	3,381.80
46	Aeon Company (M)	3,435.80	120.60	882.30	2,092.10
47	Multi-Purpose Holdings	3,314.20	199.30	1,864.50	2,755.40
48	Southern Steel	3,238.10	102.60	758.60	1,877.30
49	Tan Chong Motor Holdings	3,221.20	245.70	1,421.50	2,251.40
50	Hap Seng Consolidated	3,199.80	377.20	2,456.90	5,545.20

Table 1. Contd.

51	Lion Corporation	3,155.70	-1,215.50	560.60	5,870.00
52	PLUS Expressways *	3,120.00	1,080.00	5,677.60	17,017.40
53	Hong Leong Industries	3,100.70	294.90	1,212.60	2,862.10
54	Astro All Asia Networks Plc	3,002.70	-530.50	799.50	3,433.40
55	AirAsia	2,936.50	-496.60	1,605.50	1,923.00
56	Parkson Holdings	2,841.40	774.10	1,748.40	5,314.20
57	Gamuda	2,765.00	204.20	3,161.00	5,812.70
58	KNM Group	2,614.70	336.20	1,813.90	2,675.10
59	Lafarge Malayan Cement	2,590.00	368.20	3,032.00	3,094.00
60	Leader Universal	2,552.20	86.50	500.00	1,291.10
61	Padiberas Nasional	2,524.00	-57.50	861.30	2,033.90
62	Kinsteel	2,495.40	50.50	796.50	3,993.30
63	Wah Seong Corporation	2,443.10	133.00	791.20	1,999.40
64	Edaran Otomobil Nasional, EON	2,431.50	25.70	617.40	818.10
65	EON Capital	2,410.70	133.80	3,204.60	43,336.10
66	Perwaja Holdings	2,310.50	90.10	1,050.10	2,464.60
67	Ranhill	2,282.10	472.40	675.50	11,685.20
68	Malayan Smelting	2,276.40	19.00	296.50	1,057.90
69	Ann Joo Resources	2,235.80	148.80	885.60	2,065.40
70	MAA Holdings	2,219.40	-70.00	211.70	7,676.70
71	KFC Holdings (M)	2,202.40	120.40	692.20	1,084.60
72	Scomi Group	2,194.20	136.30	918.20	2,394.80
73	Chemical Company of Malaysia *	2,172.20	85.50	747.50	1,889.00
74	Affin Holdings	2,115.40	292.80	4,411.30	35,798.70
75	The Store Group	2,092.00	26.90	397.30	976.00
76	Muhibbah Engineering (M)	2,039.10	34.90	441.40	2,587.80
77	Zelan	2,029.60	-129.80	475.20	1,382.60
78	Metrod (M)	2,008.50	64.90	285.90	945.10
79	Allianz Malaysia	1,898.90	70.70	388.10	3,655.60
80	Tradewinds (M)	1,787.20	222.20	1,373.50	3,358.50
81	Ancom	1,689.80	-16.20	329.80	807.60
82	Alliance Financial	1,636.40	228.90	2,761.90	31,485.90
83	Malaysia Airports Holdings *	1,604.10	305.80	3,178.60	3,804.50
84	Kwantas Corporation	1,592.60	-88.20	907.80	1,834.80
85	Sarawak Energy	1,581.80	276.80	2,865.40	6,531.00
86	Puncak Niaga Holdings	1,546.00	22.10	1,372.60	7,269.10
87	Malaysian Pacific Industries	1,541.60	147.30	765.60	1,612.50
88	Lingui Developments	1,497.20	83.30	1,686.10	3,180.10
89	YTL Cement	1,488.00	210.20	1,444.20	2,742.10
90	BIMB Holdings *	1,484.30	208.50	1,272.40	31,922.50
91	Sino Hua-An International	1,455.90	0.50	763.80	762.70
92	Texchem Resources	1,430.20	-1.80	168.40	614.50
93	Keck Seng (M)	1,409.30	68.90	1,117.70	1,394.70
94	Media Chinese International Ltd	1,407.70	60.70	979.30	1,063.60
95	QL Resources	1,397.90	96.70	417.90	947.90
96	Top Glove Corporation	1,386.90	108.10	667.00	1,089.40
97	CSC Steel Holdings	1,380.60	58.80	692.90	781.70
98	Nylex (M)	1,367.40	10.60	236.30	425.30
99	Pelikan International	1,335.00	37.80	543.60	1,339.00
100	Pharmaniaga *	1,308.80	61.40	388.00	767.00

* GLCs, Note: USD 1.00 RM 3.38, Source: Malaysian Business, 16th October 2009.

Table 2. Descriptive statistics.

Variables	Mean	Std. Dev.	Maximum	Minimum
Revenue (RM million)	5063.36	5402.34	32028.00	1308.80
Profit (RM million)	425.08	687.80	3002.30	-1215.50
Equity (RM million)	3720.94	4977.78	25657.20	144.50
Asset (RM million)	18238.25	41232.94	268910.90	425.30
Change in revenue (%)	16.71	27.10	153.40	-54.10
Change in profit (%)	-94.88	723.96	2809.90	-4992.40
Change in asset (%)	9.19	23.70	128.30	-38.71
Return on revenue	7.83	10.13	37.05	-38.52
Return on equity	10.23	35.86	199.53	-216.82
Return on asset	5.19	13.04	83.58	-25.82

Xact is the actual value of the indicator,
Xmax is the maximum value of the indicator,
Xmin is the minimum value of the indicator.
This transformation ensures that $\bar{X}_{[illegible]} \in [1,100]$, and is synonymous with United Nation Human Development Index.

DEA RESULTS AND INTERPRETATIONS

We used linear programming software LINDO to solve the strictly output-oriented DEA model (DLP4) under the assumptions of CRS and VRS. This amounts to solving 200 linear programming problems. The results for the top and bottom quartiles based on DEA rankings are presented in Table 3. The efficiency scores are interpreted as a measure of comparative performance of the units under investigation. It provides information on how each individual company performed in comparison with other companies for the year under consideration.

Technical efficiency

Six companies (three GLCs and three non-GLCs) are considered efficient under the assumption of CRS. These are QL Resources, YTL Cement, Pharmaniaga, Malaysia Airport Holdings, BIMB Holdings and Top Glove Corporation. Of these six top performers, only BIMB Holdings can be regarded as highly capital intensive (with a total asset of RM31.9 billion) while the others are relatively less capital intensive (with an asset of less than RM3.8 billion). Another interesting observation is that these top performers are from bottom-20 companies by revenue. These six companies are also efficient under VRS, thereby implying that they are also 100% scale efficient. Thirteen more companies (two GLCs and eleven non-GLCs), namely Sino Hua-An International, KNM Group, Allianz Malaysia, Ranhill, PLUS Expressway, Berjaya Sports Toto, British American Tobacco (M), PPB Group, Parkson Holdings, Air Asia, DRB Hicom, IOI Corporation and Sime Darby, are also considered efficient under the assumption of VRS. Two of the companies, DRB Hicom and Sime Darby can be regarded as capital intensive whose total assets are RM21.2 billion and RM35.3 billion, respectively.

Scale efficiency

The VRS efficiency scores measure pure technical efficiency (PTE) excluding the effects of scale operations and are greater than the corresponding CRS efficiency scores (TE). The ratio of CRS and VRS efficiency is the scale efficiency (SE = TE/PTE). This is reported in column 5. The thirteen VRS-efficient units are not able to register best business performance scores because of limitations of their scale and operation. Despite being efficient under VRS, MB01 Sime Darby recorded the lowest score of 1.036 % under CRS. This means, location wise, Sime Darby is on the VRS frontier but at a distance furthest from the CRS frontier. MB51 Lion Corporation achieved the lowest efficiency score of 14.2% under VRS. But its corresponding CRS-efficiency score of 3.53% suggests that it is located in the enveloped inefficient region closer to the CRS frontier than Sime Darby.

Table 4 provides a summary of the distributions of the MB100 companies according to the relative efficiency ranges. The technical efficiency score for inefficient units under CRS range from 0.0104 to 0.9846 with an average of 0.2671 and a standard deviation of 0.2398. Twenty-nine companies obtain a score of less than 0.1000. Only 24 percent of the companies studied achieve a score of more than 0. 4000. Results under VRS are more encouraging. The average score for inefficient units is higher at 0.8591 with a smaller standard deviation of 0.1082. The inefficient scores range from 0.1421 to 0.9914. Ninety-nine percent of the companies investigated achieve a pure technical efficiency score of more than 0.6000. MB51 Lion Corporation obtains the lowest score of 0.1421. None of the company's PTE scores falls in the range 0.2000 to 0.6000. The

Table 3. DEA results and ranking.

MB100 Rank	Company's name	TE (CRS)	PTE (VRS)	SE (TE/PTE)	List of peers (under VRS)	DEA Rank
95	QL Resources	1.0000	1.0000	1.0000	[95]	01
89	YTL Cement	1.0000	1.0000	1.0000	[89]	02
100	Pharmaniaga *	1.0000	1.0000	1.0000	[100]	03
83	Malaysia Airport Holdings *	1.0000	1.0000	1.0000	[83]	04
90	BIMB Holdings *	1.0000	1.0000	1.0000	[90]	04
96	Top Glove Corporation	1.0000	1.0000	1.0000	[96]	06
91	Sino Hua-An International	0.9846	1.0000	0.9846	[91]	07
58	KNM Group	0.6639	1.0000	0.6639	[58]	08
79	Allianz Malaysia	0.5210	1.0000	0.5210	[79]	09
67	Ranhill	0.4365	1.0000	0.4365	[67]	10
52	PLUS Expressway *	0.3971	1.0000	0.3971	[52]	11
40	Berjaya Sports Toto	0.3922	1.0000	0.3922	[40]	12
33	British American Tobacco (M)	0.3580	1.0000	0.3580	[33]	13
44	PPB Group	0.3576	1.0000	0.3576	[44]	14
56	Parkson Holdings	0.3532	1.0000	0.3532	[56]	15
55	AirAsia	0.3255	1.0000	0.3255	[55]	16
21	DRB Hicom	0.1849	1.0000	0.1849	[21]	17
07	IOI Corporation	0.0338	1.0000	0.0338	[07]	18
01	Sime Darby *	0.0104	1.0000	0.0104	[01]	19
85	Sarawak Energy	0.9596	0.9914	0.9679	[67, 79, 83, 89]	20
13	Public Bank	0.0538	0.9827	0.0548	[01, 21, 33, 44, 79]	21
02	Tenaga Nasional *	0.0132	0.9809	0.0134	[01, 07, 44, 79]	22
87	Malaysian Pacific Industries	0.7231	0.9712	0.7445	[33, 67, 79, 89, 95]	23
03	Petronas Dagangan *	0.0128	0.9709	0.0132	[01, 07, 33, 79]	24
05	Malayan Banking	0.0290	0.9622	0.0302	[01, 07, 21, 33, 44,79]	25
:	:	:				:
42	Fraser and Neave Holdings	0.1289	0.8299	0.1553	[07, 33, 52, 58, 78]	76
46	Aeon Company (M)	0.1636	0.8198	0.1874	[07, 21, 33, 44, 58,79]	77
81	Ancom	0.3755	0.8183	0.4589	[67, 79, 95]	78
57	Gamuda	0.1886	0.8156	0.2312	[07, 33, 52, 58,79]	79
23	Berjaya Corporation	0.0618	0.8152	0.0758	[07, 33, 55, 58, 79]	80
08	Shell Refining Company	0.0232	0.8125	0.0286	[01, 07, 33, 79]	81
84	Kwantas Corporation	0.3985	0.8091	0.4926	[67, 79, 95]	82
61	Padiberas Nasional	0.2890	0.8042	0.3594	[21, 33, 58, 79]	83
47	Multi-Purpose Holdings	0.1342	0.8024	0.1673	[01, 33, 44, 79]	84
65	EON Capital	0.2306	0.8024		[33, 44, 52, 58, 79]	85
48	Southern Steel	0.1418	0.7971	0.1779	[07, 33, 52, 58, 79]	86
75	The Store Corporation	0.2682	0.7917	0.3387	[33, 58, 67, 70, 95]	87
60	Leader Universal Holdings	0.1966	0.7913	0.2465	[01, 33, 44, 79]	88
62	Kinsteel	0.2233	0.7903	0.2826	[21, 33, 44, 58, 79]	89
77	Zetan	0.3166	0.7766	0.4077	[33, 55, 58, 79]	90
18	Titan Chemical Corporation	0.0458	0.7734	0.0593	[01, 07, 33, 79]	91
41	DKSH Holdings (M)	0.1079	0.7696	0.1402	[01, 07, 33, 44, 79]	92
22	Proton *	0.0466	0.7628	0.0611	[01, 07, 33, 79]	93
68	Malaysian Smelting Corp.	0.2809	0.7616	0	[21, 33, 44, 58, 79]	94
64	Edaran Otomobil Nasional	0.1950	0.7615	0.2561	[01, 33, 44, 79]	95
11	Esso Malaysia	0.0266	0.7519	0.0354	[01, 07, 55, 79]	96

Table 3. Contd.

30	Lion Industries Corporation	0.0740	0.7272	0.1017	[01, 33, 79]	97
70	MAA Holdings	0.2236	0.7215	0.	[01, 21, 33, 44, 79]	98
54	Astro All Asia Network Plc	0.1184	0.6175	0.1918	[07, 33, 52, 58]	99
51	Lion Corporation	0.0353	0.1421	0.2100	[21, 40, 58]	100

*GLC

distribution of SE score is quite similar to that of TE with an average score of 0.29455 and standard deviation of 0.2475. The scores for inefficient units vary in similar range of 0.0104 to 0.9846. Only twelve percent of the companies are more than 80.0% scale efficient.

More than 80.0% are scale inefficient at the 60.0% level. Thus, it seems that most companies appeared to be facing serious scale inefficiency.

Returns to scale

Apart from the inefficiencies that could arise in the conversion process, another reason for the inefficiencies of the inefficient units could be attributed to the scale of operations. DMUs that do not operate at the most efficient (or productive) scale size cannot be fully efficient. The inefficiency may arise because it is operating under DRS or IRS. A DMU is said to be operating under DRS if changing all inputs by the same proportion results in a smaller proportional change in outputs. IRS may also be defined similarly. Whether a DMU is operating under IRS or DRS can be determined by observing its TE and PTE efficiency scores, such that

• If TE = PTE, CRS prevails

• If TE PTE, then $\begin{cases} \sum_{k=1}^{S} \lambda_k < 1 & \text{IRS,} \\ \sum_{k=1}^{S} \lambda_k > 1 & \text{DRS.} \end{cases}$

In our analysis only the top six performers operate under CRS, and are 100% scale efficient, thereby implying the existence of multiple most productive scale size. The remainder DMUs all exhibit DRS. This suggests that most MB100 companies not only show serious scale inefficiency, but also operate in a region of DRS. No company is operating in an IRS region. Hence it may be concluded that one reason for the inefficiency of these companies comes from its scale size. It is operating under DRS leading to the fact that any increase in input results in less than proportionate increase in outputs or improvement in performance.

Analyzing non performing DMUs

Table 3 also provides information about peer(s) for non-performing companies. Peers are efficient units that could act as models for inefficient units to improve performance. A linear combination of these peers acts as a composite efficient DMU which identifies a corresponding efficient position on the frontier for the inefficient unit under evaluation. For example, MB81 Ancom is considered inefficient, and efficient units [MB67, MB79, and MB95] are its peers, meaning that MB81 can try to emulate a linear combination of these MB67, MB79 and MB95 companies in order to register the values of outputs to enable it to be on the performing frontier.

In addition to providing scores for the relative technical efficiency, DEA also identifies sources of inefficiency inherent in the inefficient DMUs and projects targets or levels to be adopted by these DMUs if they are to be on the efficient frontier. We will analyze the LINDO's output for MB81 Ancom to highlight the concept involved. Main outputs produced by LINDO are;

Objective value, $_{81}^{*} = 1.2221$.

$_k$ values: $_{67} = 0.4603$, $_{79} = 0.3238$, $_{95} = 0.2158$, $_k = 0$, others.

Slack values: $t^{-} = 0$, $t_1^{+} = 12.9659$, $t_2^{+} = 0$, $t_3^{+} = 21.8526$, $t_4^{+} = 6.1237$, $t_5^{+} = 0$, $t_6^{+} = 1.0480$.

The results are interpreted as follows.

1. The pure technical efficiency, PTE = 1/1.2221 = 0.8183.
2. Peers are [MB67, MB79, and MB95]. A linear combination of these DMUs forms a virtual composite DMU with output

$$\hat{Y_{81}}_j = 0.4603 Y_{67j} + 0.3238 Y_{79j} + 0.2158 Y_{95j}, \forall j. \quad (22)$$

This defines the corresponding projected efficient position of MB81 Ancom on the frontier.

Alternatively, slack variables which are related to sources of inefficiency can also be used to compute the corresponding projected efficient position on the frontier such that $\hat{Y}_{81j} = \Omega_{81}^{*} Y_{81j} + t_j^{+}, \forall j.$ computationally, this is equivalent to (in normalized units);

Table 4. Distribution of DMUs according to efficiency scores.

Score ranges	Number of companies		
	TE	PTE	SE
1.0000	6(6)	19 (19)	6(6)
0.9000 – 0.9999	2(8)	29 (48)	3(9)
0.8000 – 0.8999	3(11)	37 (85)	3(12)
0.7000 – 0.7999	4(15)	13 (98)	4(16)
0.6000 – 0.6999	3(18)	1(99)	3(19)
0.5000 – 0.5999	3(21)	0(99)	4(23)
0.4000 – 0.4999	3(24)	0(99)	5(28)
0.3000 – 0.3999	14 (38)	0(99)	16 (44)
0.2000 – 0.2999	12 (50)	0(99)	12 (56)
0.1000 – 0.1999	21 (71)	1 (100)	19 (75)
0.0000 – 0.0999	29 (100)	0 (100)	25 (100)
For inefficient units			
Average	0.2671	0.8591	0.2946
Maximum	0.9846	0.9914	0.9846
Minimum	0.0105	0.1421	0.0104
Std. Dev	0.2398	0.1082	0.2475

$$\hat{Y}_{81} = \begin{bmatrix} \hat{Y}_{811} \\ \hat{Y}_{812} \\ \hat{Y}_{813} \\ \hat{Y}_{814} \\ \hat{Y}_{815} \\ \hat{Y}_{816} \end{bmatrix} = 1.2221 \begin{bmatrix} Y_{811} \\ Y_{812} \\ Y_{813} \\ Y_{814} \\ Y_{815} \\ Y_{816} \end{bmatrix} + \begin{bmatrix} 12.9659 \\ 0.00 \\ 21.8526 \\ 6.1237 \\ 0.00 \\ 1.0488 \end{bmatrix} . \qquad (23)$$

This amounts to an equal increase of 22.2% in all outputs followed by a further 12.97, 21.85, 6.12 and 1.05 units for outputs 1, 3, 4 and 6 respectively. Thus, it can be deduced that outputs 1, 3 and 4 (relating to change in revenue, change in assets and return on revenue respectively) merit serious attention since they appeared to contribute to the low efficiency score.

Ranking by DEA

The last column in Table 3 provides ranking for the listed companies based on the DEA scores. This is determined as follows.

The eighty one nonperforming companies under VRS are ranked from 20 to 100 based on their PTE scores in descending order from 0.9914 (MB85 Sarawak Energy) to 0.1421 (MB51 Lion Corporation).

The thirteen nonperforming companies under CRS but achieved 100% PTE under VRS are ranked from 06 to 19 according to their TE scores in descending order from 0.9846 (MB91 Sino Hua-An International) to 0.0104 (MB01 Sime Darby).

The top six performers which scored 100% in all three measures (PTE, TE and SE) are ranked according to the number of peer counts, that is, the number of times it is a peer to the inefficient units since the peer count number can be consider as a measure of the extent to which the performance of an efficient company can be a useful benchmark for the inefficient ones (Mostafa, 2007).

Two non-GLCs from bottom-11 by revenue (MB95 QL Resources and MB89 YTL Cement) top the DEA list. Three of the GLCs from bottom-20 by revenue occupy the next three places. These are MB100 Pharmaniaga, MB83 Malaysia Airport Holdings and an Islamic financial institution, MB90 BIMB Holdings. Only two of the top-20 by revenue, MB07 IOI Corporation and MB01 Sime Darby made to the top-20 by DEA ranking at 18 and 19 respectively. Forty percent of the DEA top-20 comes from bottom-20 by revenue. GLCs account for 25% of the top-20 and 32% of top-25. Thus, bottom-rank by revenue does not imply bottom-performer by DEA. This is strongly highlighted by the lowest revenue earner, MB100 Pharmaniaga. One GLC, MB22 Proton is among the bottom-20 by DEA ranking.

A recent press release substantiates our findings in relation to the top performers as highlighted here.

"QL Resources Berhad: .... Net profit for the three months ended September 30," 2009 rose 3.4% to RM26.05 million while its revenue declined to RM337.17 million from RM391.62 million previously. (The Star Online, November 25, 2009)

"YTL Cement Berhad: .... For the six months ended

December 31, 2009, YTL Cement" recorded a 6.9% increase in net profit to RM125.7 million compared with RM117.6 million previously, while revenue slipped 2.1% to RM931.2 million from RM950.9 million. (The Star Online, February 26, 2010)

"BIMB Holdings: .... Bank Islam Malaysia Berhad (BIMB) net profit rose RM58.9" million to RM684.5 million for the six months ended Dec 31 compared with the same period a year ago ... The bank's return on equity was maintained at 16.4% while its return on assets improved from 0.9 to 1.2%. (The Star Online, March 9, 2010)

"Top Glove Corporation Berhad posted a net profit of RM70.53 million in its second" quarter ended Feb. 28, nearly double the RM36 million it recorded a year ago ... Revenue rose 47% to RM509.9 million for the period against RM346.5 million in the previous corresponding period. (The Star Online, March 18, 2010)

Conclusion

The study utilizes a strictly output oriented DEA methodology to assess the performance of Malaysian Business 100 largest listed companies based on multi-dimensional performance indicators under the assumptions of CRS and VRS. One input and six output indicators reflecting the business dynamicity and profitability achievements are used for the evaluation. A linear transformation is adopted to handle the negative data such that all indicators lie between 1.0 and 100.

Results obtain suggest that out of 100 companies, only 6 and 19% are found to be relatively efficient under CRS and VRS respectively. Thus, only 6% are 100% scale efficient with multiple most productive scale size. These top performers are from revenue-bottom-ranked companies. Three are GLCs. The remaining ninety-four companies exhibit serious scale inefficiencies. Non-GLCs, mainly from bottom-20 by revenue dominate 75% of the top-20 DEA ranking. Thus, revenue-top-ranked companies are not necessarily top-ranked performers. The VRS test suggests that the nonperformers are operating in the region of DRS. These findings are in agreement with findings by Zhu (2000). However, the study found no company is operating in the region of IRS.

The study also illustrates the use of slacks and peer units to identify not only the sources of inefficiency or non- performance but also the path to the efficient frontier. This can aid the managers to identify the shortcomings of their businesses and take the necessary remedial actions. However, it should be noted that some DEA targets might not be possible to achieve since not all inputs are under the full control of management and an inefficient company and its peers may not be inherently similar in their business practices. A performance-based clustering method capable of identifying a more appropriate peer group among similar cluster has been adopted by researchers in overcoming this problem.

Further, like any other performance or efficiency evaluation technique, DEA has several limitations. DEA efficiency scores are sensitive to sample size and input-output mix. Future studies should focus on larger sample size and experiment with different input-output mix to test the robustness of the results. Efficiency or performance gives more meaning when it is assessed over time. Given a set of panel data the Malmquist total factor productivity, TFP change index technique can be utilized to explore the dynamicity of MB100 companies. The Malmquist index not only provides estimates of TFP change but also decomposes it into technological change and technical efficiency change. The technological change component captures shift in the frontier technology and can be interpreted as providing a measure of innovation. Technical efficiency improvement or catching up effect, on the other hand is measured by the difference between the frontier output and the realized output. Thus, the decomposition of TFP into technological change and technical efficiency change is therefore useful in distinguishing innovation or adoption of new technology by best practice firms from the diffusion of technology. This provides avenue for future research.

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