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Productivity and efficiency analysis using DEA: Evidence from financial companies Listed in Bursa Malaysia

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A B S T R A C T

This study evaluates the technical efficiency, productivity change of financial companies listed in the Malaysian stock exchange (Bursa Malaysia) and examines the effects of productivity change on efficiency over the period 2007–2016. Moreover, this study also concentrates on the ranking of financial companies according to their efficiency scores. Data Envelopment Analysis (DEA) is utilized on a Malmquist Productivity Index in order to calculate the financial companies' efficiency scores. The results of this study show that some firms were fully efficient. The results implied that these companies were in optimal control of their inputs or resources to generate the maximum outputs. Also, the results indicate a tremendous productivity gain was mostly because of a positive shift in frontier technology and positive shift in technical efficiency. This study is significant because it helps to identify the efficient companies from the financial sector in Malaysia based on multiple inputs and outputs by using the DEA model. Common misspecification problems observed that instability of efficiency scores over productivity.

1. Introduction

Bursa Malaysia, Malaysian capital market, has been increased very significantly especially after several financial crises (Ong & Ng, 2018). Stable and developing financial market can attract investors (Ali et al., 2018a). It is well established in investors' mind that investing in the stock market will give them satisfactory return, and it will contribute a major improvement for economic development (Ali et al., 2018b; John, 2018). Many techniques have been applied by investors to optimize their return and minimize the risk of their investment (Rossi & Gunardi, 2018; Rashid & Mehmood, 2018; Azizan & Sorooshian, 2014). By using non-parametric or parametric frontier techniques, a great deal of efforts have been devoted on the financial system in attaining the overall economic performance with changes within the regulatory environment. Additionally, the globalization of financial markets to research the efficiency of financial firms has been created by using different techniques (Vardar, 2013). Moreover, the efficiency of the financial company is more important for financial growth. In current years, the

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academic research on the performance of financial institutions has increasingly focused on frontier efficiency. In case of corporate process progress performance evaluation and benchmarking are extensively practiced methods (Becsky-Nagy & Fazekas, 2014). If there is no standard available for the evaluation then benchmarking can be notably imperative for the evaluation (Orbán, 2013). For performance evaluation, ample change has occurred during the past two decades. Presently, performance evaluation is critical gain factors and the corporate performance evaluation is more difficult as a large number of variables (input and output) are involved in the measurement (Herczeg, 2014). Performance analysis gives opportunities to investors, particularly private equity shareholders to find the extra value for their non-financial performance (Becsky-Nagy & Fazekas, 2014).

There are many methods in the frontier analysis to evaluate performance such as parametric and non-parametric stochastic method (Fenyves et al., 2015).The present article introduces a non-parametric method, Data Envelopment Analysis (DEA), which is a non-parametric linear programming technique, and extends the idea of estimating efficiency by comparing each decision-making units with an efficient production frontier (Farrell, 1957). Fare et al. (1994) developed a DEA- based Malmquist productivity index (MPI). In non-parametric area, Malmquist index does not require the profit maximization or the cost minimization assumption. If the practitioner uses panel data, MPI allows the decomposition of changes in productivity (Noulas, 1997) into two components technical efficiency change and technological change. This is particularly interesting in cases of financial efficiency studies because the production frontier can shift upward or downward over time due to innovation, market structure, changes in regulatory policies, and shocks and severe financial disruptions. This explains the extensive application of total factor of productivity change in this strand of the literature (Portela & Thanassoulis, 2010; Duygun, et al., 2016; Casu et al., 2016, Fernandes et al., 2018; Soteriou & Zenios, 1999). This paper is structured as follows. The section 2 describes literature review. Section 3 describes methodology of DEA-MPI. The variables and data selection is presented in section 4. Result and discussion are explained in section 5. The final section offers some concluding remarks.

2. Literature review

Malmquist (1953) introduced the Malmquist productivity index that is a quantity index to apply in the analysis ratio of inputs and outputs. After this, Fare et al. (1994) jointed concept on the measurement of efficiency from Farrell (1957) to develop a MPI directly from input and output data by using DEA. The DEA method of measuring the technical efficiency does not allow a direct comparison of DMU's efficiency from one period to another. Therefore, this limitation does not allow the measurement of productivity growth over a period of time. The Malmquist productivity index can be defined as an index number that enables a productivity comparison of the same decision-making unit over two different periods (Zhu, 2003). Therefore, the MPI can be defined as an index number that enables a productivity comparison of the same firm over two different periods. Fare et al. (1994) considered any improvement in technical progress as evidence of innovation. Defining inputs, outputs and orientation is not a big issue in DEA (Cook et al., 2014) as many researchers preach "the input-oriented approach assuming that managers impose control over inputs variable rather than outputs variable" (Khodabakhshi et al., 2010; Tsolas & Charles, 2015). On the other hand, others believe it is more appropriate to answer how output quantities can be proportionally expanded without changing the underlying input quantities used over different time intervals (Fethi & Pasiouras, 2010). Although the literature was conflicting, many studies suggested that the choice of arrangement has less effect on the original finding scores. Accordingly, the orientation of DEA should not be a point of disagreement among the researchers' approaches (Fernandes et al., 2018).

Many researchers found efficiency, productivity, and benchmarking of state banking institutes, commercial banking institutes or both the banking institute. For instance, Canhoto and Dermine (2003), studied the magnitude of efficiency gains of Portugese banks using DEA –MPI, found productivity improved by 59% in the banks. This improvement was contributed by technological change rather than efficiency change. Stavárek and Řepková (2012) analyzed the Czech commercial banking sector and its efficiency over the period 2001-2010, Wozniewska (2008) examined the efficiency of the Polish banking sector from 2000 and 2007. Moreover, Fernandes et al. (2018) applied DEA-MPI to find efficiency in peripheral European domestic banks for the year 2007-2014. The majority of the studies, although, relied on both parametric and nonparametric methods to evaluate the bank performance in terms of efficiency but they did not rank the bank.

There are few studies on banking efficiency in Malaysia but they did not discuss productivity change and efficiency together. Siew et al. (2017) studied analyses efficiency of the financial sector of Bursa Malaysia using DEA and found the most efficient company in the financial sector of Bursa Malaysia. Some studies have based on DEA in banking sector: Sufian et al. (2016) found that banks from Asian countries to be relatively more efficient rather than foreign banks, and Davies (2017) postulated that technical efficiency of Malaysian commercial banks' technical efficiency was 71.33% and also found that domestic banks had been inefficient in controlling their costs due to their size. Doaei et al. (2013) found corporate diversification highly effective in financial performance in a study on manufacturing firms listed in Bursa Malaysia.

From the brief review we understand that there had been no study on the relationship between efficiency and productivity. The above background positions this work as an important topic in the respective literature and clarifies its motivation. First, DEA efficiency scores are calculated based on a Malmquist Productivity Index (MPI) on financial company listed in Bursa Malaysia. Then, the decomposition of the productivity changes into technological efficiency changes and technical efficiency changes. The third issue is productivity change over time and relationship between efficiency and productivity. Then the method of this paper ranks the companies according to their efficiency scores.

3. Methodology

DEA-MPI

The DEA method suggested by Charnes et al. (1978) and further developed to non-constant returns (NCR) by Banker et al. (1984) explained how to design the production possibility set without guessing a production function from given a set data of input, output variables. The first stage of this study utilises a DEA approach based on the Malmquist Productivity Index (MPI) to investigate how the productivity of each company changes through time. This is accomplished by following an output-oriented DEA approach described by Färe et al. (1994). If it is not possible to gain output without increasing or decreasing input usage then a firm is deemed to be technically efficient. Specifically, efficiency is measured as the distance between the point the firm lies in the input-output space and the production frontier (technology) that envelops the data. Let $u_n^t \in R^+$ and $v_n^t \in R^+$ the selected input and output variables (for $N \times 1$ input and $M \times 1$ output vectors) and n the total number of firms, then the production P_n^t in time t for the firm n can be expressed as:

$$P_n^t = \{(u_n^t, v_n^t) : v_n^t \text{ is produced by } u_n^t\}.$$

The output-oriented production function under the assumption of CRS (Constant Returns to Scale) can be defined as:

$$D_o^t(u_n^t, v_n^t) = Min\{\varphi \mid (u_n^t, v_n^t/\varphi) \in P^t\},\ n = 1, 2, \ldots i \tag{1}$$

In Eq. (1), the '0 ' subscript denotes the output orientation of the model. The distance aims to gain in outputs, given the set of inputs but also making the outputs achievable. Particularly, it defines the technology at time t of firm n relative to the output technical efficiency at time t (Fare et al.,1994). Here, the technical efficiency (TE) is estimated relative to the technology as $D_o^t(u_n^t, v_n^t) \le 1$. Only when the unit n is on the production frontier (i.e. technically efficient), can the equation be expressed in the form as $D_o^t(u_n^t, v_n^t) = 1$. Alternatively, as $D_o^t(u_n^t, v_n^t) < 1$ means that the unit below the frontier is technically inefficient. To define the MPI, a specification of distance functions with respect to two distinct time periods is needed. The efficiency of firm n relative to the technology at time $t+1$ is expressed by:

$$D_o^t(u_n^{t+1}, v_n^{t+1}) = Min\{\varphi \mid (u_n^{t+1}, v_n^{t+1}/\varphi) \in P^t\},\ n = 1, 2, \ldots i \tag{2}$$

In relation to technology at time t, this gap calculates the maximum comparative change in outputs required to make (u_n^{t+1}, v_n^{t+1}) worthwhile. By using DEA linear programming method distance functions are measured. The output oriented DEA (CRS) problem is defined as below:

$$D_o^t(u_n^t, v_n^t)^{-1} = Max\varphi_n \; s.t.\{-\varphi_n v_n^t + Y_t\lambda \geq 0, u_n^t - X_t\lambda \geq 0, \lambda \geq 0\}. \tag{3}$$

Here, X_t and Y_t express the vector of inputs and outputs respectively and λ represents the weight vector, which is compared with any distinct observation in order to find the distance to the efficient frontier. Caves et al. (1982) defined MPI at two consecutive time periods (t, s) as:

$$M^t(u_n^{t+1}, v_n^{t+1}, u_n^t, v_n^t) = D_o^t(u_n^{t+1}, v_n^{t+1}) / D_o^t(u_n^t, v_n^t), \tag{4}$$

$$M^{t+1}(u_n^{t+1}, v_n^{t+1}, u_n^t, v_n^t) = D_o^{t+1}(u_n^{t+1}, v_n^{t+1}) / D_o^{t+1}(u_n^t, v_n^t). \tag{5}$$

To avoid the use of an arbitrary benchmark, the two continuous MPIs are combined into one by estimating its geometric mean, which provides the calculation of the Total Factor Productivity Change (TFPCH):

$$M_o(u_n^{t+1}, v_n^{t+1}, u_n^t, v_n^t) = TFPCH = \{\frac{D_o^{t+1}(u_n^{t+1}, v_n^{t+1})}{D_o^t(u_n^t, v_n^t)}\} \times \{(\frac{D_o^t(u_n^{t+1}, v_n^{t+1})}{D_o^{t+1}(u_n^{t+1}, v_n^{t+1})} \times \frac{D_o^t(u_n^t, v_n^t)}{D_o^{t+1}(u_n^t, v_n^t)})^{\frac{1}{2}}\} \tag{6}$$

$$= \{\text{EFFCH}\} \times \{\text{TECHCH}\}.$$

When TFPCH <1 or >1, it is implied that there is a decrease or increase in productivity, while TFPCH =1 refers to cases where productivity is unchanged. From Eq. (6), it is also shown that TFPCH is decomposed into the Efficiency Change (EFFCH) and Technology Change (TECHCH) sub-indices as explained by Färe et al. (1994). The EFFCH ratio measures the change in technical efficiency of a DMU relative to the best practice frontier. This shows whether unit n moves away from the production frontier or comes towards the production frontier between the period t and $t + 1$.

A firm is assumed to be technically efficient if it is impossible to increase output without altering input usage. Specifically, efficiency is measured as the distance between the point the firm lies in the input–output space and the production frontier (technology) that envelops the data. The Technological Change (TECHCH) component is due to the variation of the production frontier between two periods and hence, exerts improvement or deterioration of the unit's technology between the period t and $t + 1$. The EFFCH is further decomposed into improvements in management practices or movements toward an optimal size. As suggested by Färe et al. (1994), the first refers to a measure of Pure Technical Efficiency Change (PECH), while the latter to a measure of Scale Efficiency Change (SECH):

$$PECH^{t,t+1} = \frac{D_{o,v}^{t+1}(u_n^{t+1}, v_n^{t+1})}{D_{o,v}^t(u_n^t, v_n^t)},$$

$$SECH^{t,t+1} = \frac{D_{o,c}^{t+1}(u_n^{t+1}, v_n^{t+1})}{D_{o,c}^t(u_n^t, v_n^t)} \times \frac{D_{o,v}^t(u_n^t, v_n^t)}{D_{o,v}^{t+1}(u_n^{t+1}, v_n^{t+1})}, \tag{7}$$

$$\text{EFFCH} = \text{PECH} \times \text{SECH}.$$

Here, Variable Returns to Scale (VRS) technology is used to calculate PECH, while the components of SECH are measured as the deviations between the CRS and VRS technologies. Therefore, the above subscripts "o,c " and "o,v " represents CRS and VRS technologies applied respectively for this 'enhanced decomposition' (Casu et al., 2004; Berg et al., 1991).

3.1 Data and Variables

The data for this study is obtained from Bloomberg terminal. After excluding some companies because of lack of data, the data cover 26 financial companies of Bursa Malaysia during the period 2007-2016. Data were converted to US dollar. To construct dataset, this study uses market data for different input, output variables. Table 1 and Table 2 below present listed companies name and the input, output variables, respectively. For some missing data, this study have used maximum likelihood estimation method by SPSS. When determining input and output variables of financial institutes, one should first select by the nature of financial approaches. There are three approaches frequently applied in financial institutes theory of literature such as intermediation, value added and production approaches (Sealey & Lindly, 1977). In this study, the production approach will be described because financial institutes are served as producers of services for the investor. The choice of inputs and outputs are guided by the choice made in previous studies. In this study, five outputs and three inputs are chosen. The selection of input and output variables are based on Ismail et al. (2012) and others major studies on the efficiency of financial sectors. The five input variables are market capital, total volume, dividend per share, financial leverage, price to book ratio. The three output variables are return on equity, return on assets and P/E ratio. The software package DEAP Version 2.1 is used to measure DEA estimations (Coelli, 1996, Coelli et al., 2005).

Table 1
Company Short Name

Company Name (DMUs)	Short term of companies
MALAYAN BANKING BHD	MAY
PUBLIC BANK BERHAD	PBK
CIMB GROUP HOLDINGS BHD	CIMB
HONG LEONG BANK BERHAD	HLBK
RHB BANK BHD	RHBBANK
HONG LEONG FINANCIAL GROUP	HLFG
AMMB HOLDINGS BHD	AMM
BIMB HOLDINGS BHD	BIMB
AFFIN HOLDINGS BERHAD	AHB
LPI CAPITAL BERHAD	LPI
SYARIKAT TAKAFUL MALAYSIA	STMB
ALLIANZ MALAYSIA BHD	ALLZ
MNRB HOLDINGS BHD	MNRB
MANULIFE HOLDINGS BHD	MHBS
PACIFIC & ORIENT BERHAD	PO
MALAYSIA BUILDING SOCIETY	MBS
BURSA MALAYSIA BHD	BURSA
AEON CREDIT SERVICE M BHD	ACSM
INSAS BHD	INS
RCE CAPITAL BHD	RCE
APEX EQUITY HOLDINGS BERHAD	APX
JOHAN HOLDINGS BHD	JOH
ECM LIBRA FINANCIAL GROUP BH	ECML
HONG LEONG CAPITAL BHD	HLG
TA ENTERPRISE BERHAD	TAE
MAA GROUP BHD	MAA

Table 2
Descriptive Statistics and Variable Short Name

Name of Variables	Kind of variable	Minimum	Maximum	Mean	Std. Deviation
Total Volume (TV)	Input	770400.0	3761712400	459870978.7	726230640.93
Dividends per share (DPS)	Input	0.00	1.34	.0481	0.09293
Market capitalization(MC)	Input	18.09	26844.15	2868.5974	5378.04424
Price to Book Ratio(PB)	Input	0.18	9.60	1.4813	1.23367
Financial Leverage(FL)	Input	1.01	32.19	8.4594	6.39369
Return on Assets(ROA)	Output	-5.24	26.13	2.6349	3.31450
Return on common Equity (ROE)	Output	-27.74	54.75	12.9440	10.27505
Price earnings ratio(PE)	Output	2.60	278.83	14.1755	19.37493

4. Result and Discussion

Before discussing the DEA results, the rule of thumb (DMUs should be three times of total inputs and output variables) was applied for the selection of sample variables (inputs and outputs) that is suggested by Cooper et al. (2002). Since in this study, the total number of financial companies is twenty six that is more than the number of input and output variables (e.g. (3×5 inputs + 3×3 outputs) = 23), so the number of variables selection is justified since it satisfies the rule of thumb and allows the efficiencies of companies to measured.

4.1 Technical efficiency and technical efficiency change

This study used the Malmquist index of Productivity (MIP) to measure the productivity change of financial company listed in Bursa Malaysia for the period 2007-2016. Table 3 and Table 4 present the technical efficiency and technical efficiency change for the 26 DMUs for each year. From the dataset of Table 3 it is obvious that the average technical efficiency was 0.935 which means companies were less than 7% inefficient to use their existing resources. On the other hand, Siew et al. (2017) found average efficiency score 0.5865 for the financial company of Malaysia. It is also seen that APX, JOH, ECML, MAA, BURSA, ACSM and LPI were fully efficient for all the time period. The results were approximately similar for most of the companies since Siew et al. (2017) also found similar results during the time period 2010-2015 where LPI, BURSA, ACSM, APX were reported to be fully efficient. The result also depict that AMM was the least efficient company as its efficiency was 79.45%. Moreover, the efficiency scores of STMB, ALLZ, MNRB, and MHBS were approximately the same as it was around 0.98.

The study would like to point out that TE change >1 only shows progress in technical efficiency (TE) changes. Average technical efficiency change shows that most of the companies made an increase in efficiency over the study period. From the average technical efficiency change it was seen that the highest technical efficiency change decreased for BIMB and increased for CIMB form 2007 to 2016. From the Table 4, it is seen that, all the financial companies' listed in Bursa Malaysia yearly technical efficiency declined 3 % from 2007 to 2008. Only the technical efficiency improved about 2.7% from 2008 to 2009. The average efficiency declined and improved vice versa from 2009 to 2013 for all the companies then continuously improved its efficiency from 2014 to 2015. After that efficiency was declined by 9.8% from 2015 to 2016. Overall, the average technical efficiency change was recorded 2.2 % decline in the financial companies. Fernandes et al. (2018) found technical efficiency increased more than 1% in peripheral European domestic banks.

Table 3
Technical Efficiency

Company Short Name	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
MAY	0.854	1	0.833	0.826	0.65	0.832	0.763	0.865	0.892	0.658	0.8173
PBK	0.949	0.995	1	0.973	0.83	0.912	0.816	0.879	0.908	0.758	0.902
CIMB	0.919	0.809	1	0.87	0.7	0.867	0.77	0.894	0.900	0.616	0.8345
HLBK	0.86	0.869	0.861	0.851	0.793	0.852	0.863	0.91	0.878	0.673	0.841
RHBBANK	0.836	0.833	0.836	0.826	0.697	0.801	0.776	0.903	1	0.613	0.8121
HLFG	0.866	0.894	0.866	1	0.791	0.891	0.949	0.932	0.92	0.620	0.8729
AMM	0.824	0.793	0.865	0.823	0.676	0.821	0.781	0.863	0.911	0.588	0.7945
BIMB	1	0.915	0.924	0.918	0.958	0.842	0.778	0.905	0.996	0.694	0.893
AHB	0.814	0.816	0.86	0.773	0.716	0.816	0.875	0.938	1	0.661	0.8269
LPI	1	1	1	1	1	1	1	1	1	1	1
STMB	1	0.858	1	1	1	1	1	1	1	0.957	0.9815
ALLZ	1	1	1	1	1	0.89	1	1	1	0.983	0.9873
MNRB	1	1	1	1	0.952	0.864	1	1	1	1	0.9816
MHBS	1	0.981	0.871	1	1	1	1	1	1	1	0.9852
PO	1	1	1	1	1	0.978	1	1	1	0.695	0.9673
MBS	0.978	0.969	0.876	1	1	1	1	1	0.998	0.802	0.9623
BURSA	1	1	1	1	1	1	1	1	1	1	1
ACSM	1	1	1	1	1	1	1	1	1	1	1
INS	1	1	1	1	1	1	1	0.989	1	1	0.9989
RCE	1	1	1	1	1	1	1	1	0.994	0.578	0.9572
APX	1	1	1	1	1	1	1	1	1	1	1
JOH	1	1	1	1	1	1	1	1	1	1	1
ECML	1	1	1	1	1	1	1	1	1	1	1
HLG	1	1	1	1	1	1	1	1	1	0.952	0.9952
TAE	0.966	1	1	0.803	1	0.833	0.822	0.974	1	0.575	0.8973
MAA	1	1	1	1	1	1	1	1	1	1	1
Average	0.9563	0.95121	0.9535	0.9485	0.9139	0.9307	0.9305	0.9635	0.9768	0.8239	0.9349

Table 4
Technical Efficiency Change

DMU	2008/2007	2009/2008	2010/2009	2011/2010	2012/2011	2013/2012	2014/2013	2015/2015	2016/2015	2016/2007
MAY	2.281	0.517	0.778	0.869	0.901	1.393	1.129	1.144	0.785	1.002
PBK	0.702	1.366	1.026	1.137	0.762	1.150	1.061	1.318	0.692	0.994
CIMB	0.742	1.532	0.626	1.095	0.818	1.428	1.472	1.145	0.764	1.018
HLBK	0.780	1.129	1.139	0.889	0.826	1.465	0.980	1.245	0.757	1.000
RHBBANK	0.947	1.090	0.836	1.084	0.858	1.545	0.947	1.325	0.639	0.999
HLFG	1.026	0.768	1.413	0.668	1.064	1.434	0.897	1.188	0.766	0.991
AMM	0.846	1.304	0.630	1.116	0.738	1.571	1.025	1.523	0.689	0.996
BIMB	0.705	0.835	0.978	0.935	0.583	1.097	0.886	1.514	0.612	0.869
AHB	0.938	1.141	0.913	0.988	0.903	1.283	0.949	1.725	0.619	1.014
LPI	1.000	1.000	1.000	1.000	1.000	1.000	0.824	1.213	1.000	1.000
STMB	0.626	1.598	1.000	1.000	0.335	1.025	0.023	1.168	0.889	0.894
ALLZ	1.000	1.000	1.000	1.000	0.864	1.157	1.000	1.000	0.981	0.998
MNRB	1.000	1.000	1.000	0.936	0.875	1.221	0.687	1.455	1.000	1.000
MHBS	0.795	0.815	1.257	1.258	1.000	1.000	1.000	1.000	1.000	1.003
PO	1.000	1.000	1.000	1.000	0.785	1.058	1.205	1.000	0.662	0.955
MBS	0.729	1.342	0.729	1.096	0.642	1.688	0.856	1.548	0.866	0.997
BURSA	1.000	1.000	1.000	0.986	0.897	0.831	1.361	0.812	0.721	0.942
ACSM	0.928	0.525	1.201	0.895	1.805	0.383	1.573	1.245	0.843	0.944
INS	1.000	1.000	1.000	1.000	1.000	1.000	0.839	1.192	1.000	1.000
RCE	1.132	0.755	1.258	1.186	1.000	1.000	1.000	0.959	0.522	0.951
APX	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
JOH	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ECML	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
HLG	1.000	1.000	1.000	1.000	1.000	0.406	2.463	1.000	0.525	0.931
TAE	1.048	1.000	0.616	1.386	0.714	0.991	1.076	1.537	0.538	0.938
MAA	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Average	0.970	1.028	0.977	1.020	0.899	1.120	1.048	1.202	0.803	0.978

4.2 Malmquist Index Decomposition

The DEA-MPI estimates are summarized in the Table 5. The TFPCH was decomposed into its components EFFCH, TECHCH, PECH and SECH (Fare et al., 1994). This decomposition is valuable for empirical setting, since it provides insight on the sources of overall productivity change in the financial firm. Overall, 3.13% productivity was gained by financial companies listed in Bursa Malaysia for the period 2007-2016. Among the financial companies, the highest productivity was gained by the MHBS (24.8%) and the lowest productivity was declined by PO (17%). INS showed passive mode in productivity. From the decomposition of the MPI, the average TFPCH (3.13%) was driven by +5.38% in technological efficiency and -2.7% in technical efficiency. This means the growth was driven mostly from the technological component rather than the technical efficiency. Fernandes et al. (2018) and Casu et al. (2004) found the same conclusion when they analyzed efficiency in peripheral European domestic banks and European banking respectively. More generally, the TFPCH of MHBS was driven by +24.5% in technological efficiency and +0.3% in technical efficiency. In the same way, the TFPCH of PO was declined by -13.1% in technological efficiency and -4.5% in technical efficiency. Now, the decomposition into PECH and SECH shows similar trends, that financial firms were decreasing their technical efficiency through the pure technical efficiency changes rather than scale ones. For example, average 2.17% declined in EFFCH is driven by the 0.3% decrease in SECH (as PECH is decreasing by 0.2%). A large amount of improvement in technological or efficiency change can improve the total productivity. Thus, a tremendous productivity gain is mostly because of a positive shift in frontier technology and positive shift in technical efficiency. The line graph in Fig. 1 depicts the TECHCH, EFFCH and TFPCH evaluation for year between 2007 and 2016. In 2008, TECHCH and TFPCH were high but TFPCH was low. Again in 2009 the scenery was opposite of 2008.Simillar results are also seen over the study period except 2015. From the line graph it can be inferred a tremendous productivity gain was mostly because of a positive shift in frontier technology and positive shift in technical efficiency.

Table 5

Malmquist Index Decomposition

DMU	EFFCH	TECHCH	PECH	SECH	TFPCH
MAY	1.002	1.001	0.972	1.031	1.002
PBK	0.994	1.035	0.975	1.019	1.029
CIMB	1.018	1.143	0.956	1.064	1.163
HLBK	1	1.055	0.973	1.027	1.054
RHBBANK	0.999	1.045	0.966	1.034	1.044
HLFG	0.991	1.057	0.964	1.029	1.048
AMM	0.996	1.113	0.963	1.034	1.109
BIMB	0.869	1.082	0.96	0.905	0.94
AHB	1.014	1.048	0.977	1.038	1.062
LPI	1	1.036	1	1	1.036
STMB	0.894	1.071	0.995	0.898	0.958
ALLZ	0.998	0.956	0.998	1	0.954
MNRB	1	1.064	1	1	1.064
MHBS	1.003	1.245	1	1.003	1.248
PO	0.955	0.869	0.96	0.995	0.83
MBS	0.997	1.029	0.978	1.019	1.026
BURSA	0.942	1.024	1	0.942	0.965
ACSM	0.944	1.026	1	0.944	0.969
INS	1	1	1	1	1
RCE	0.951	0.968	0.941	1.011	0.921
APX	1	1.133	1	1	1.133
JOH	1	1.086	1	1	1.086
ECML	1	0.968	1	1	0.968
HLG	0.931	1.089	0.994	0.936	1.014
TAE	0.938	1.052	0.944	0.994	0.987
MAA	1	1.204	1	1	1.204
Average	0.9783	1.0538	0.9814	0.997	1.0313

Notes: The table depicts the MPI decomposition (EFFCH = SECH * PECH and TFPCH = EFFCH *TECHCH. The values < 1 depicts decline in efficiency, while values >1 describes efficiency growth.

This study found that the average technical efficiency change was declined 2.17%, pure technical efficiency change was declined 1.86% and scale efficiency change was declined 0.3% but productivity was increased 3.13% due to increase of technological change 5.38%. These scores are in the range of what others have found (Ismail, 2005; Levine, 1998). The results indicate that the main source of inefficiency in financial sector of Bursa Malaysia was caused by technical inefficiency (failure to find the combination of inputs to produce optimal level of outputs). Based on pure technical efficiency change, the performance of the financial companies of Bursa Malaysia was relatively stable, with the score always remained close to 100% over the study period.

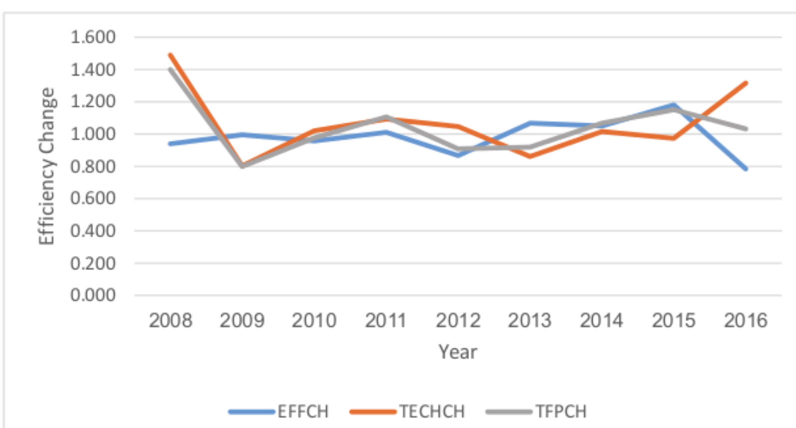

Fig. 1. Malmquist Index Summery of Annual Means

4.3 Efficiency scores stability over time and financial company type

Another very important, regulatory perspective, measure relates to the efficiency scores stability over time is shown in Fig. 2. The highest number of fully efficient (Score 1) company was 17 in the years 2009, 2010, 2015 and the least number of the fully efficient company was one in the year 2016. Doaei et al. (2013) found this kind of efficiency fluctuation in manufacturing firm of Bursa Malaysia. Even recognizing that some companies may go up or go down in their overall performance; except for fully efficient firm, it is unlikely that a very efficient firm in one year would become very inefficient in the following year. More generally it can be seen from Table 3 that TAE and RHBBANK were fully efficient in 2015 than in 2016 their efficiency decrease dramatically to 0.575 and 0.613, respectively. By Bauer et al. (1998) it was reported that there was more likely an efficient firm would maintain its efficiency in next year. However, this picture was different under the efficiency approach by DEA-MPI.

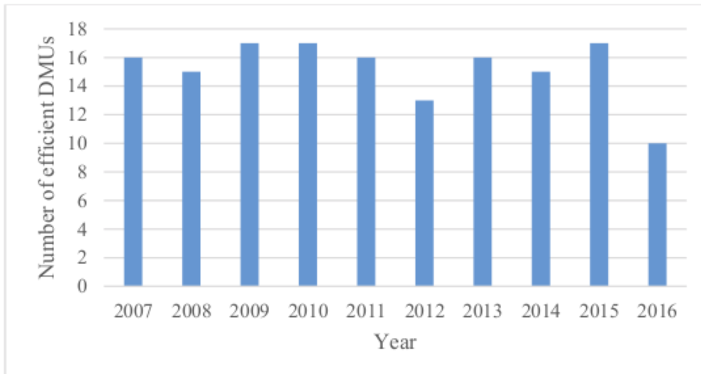

Fig. 2. Total Number of Efficient DMUs

4.4 Efficiency, productivity change and ranking

Fig. 3 shows the mean efficiency verses mean productivity. From the Fig. 3, it is seen that most of the companies' productivity were high, but their efficiency scores were low. Among the companies, productivity was highest in MHBS, CIMB, MAA. Almost all the companies' productivity greater than efficiency except PO, RCE, ALLZ. This kind of scenery also found by Fernandes et al. (2018) and Doaei et al. (2013) when they examined efficiency in peripheral European domestic banks and manufacturing firm of Bursa Malaysia respectively. Ranks, derived from DEA of the financial company listed in Bursa Malaysia, are shown in Table 6. Fully efficient company were LPI, BURSA, ACSM, APX, JOH, ECM, and MAA. The least efficient company was AMM but its productivity was relatively high.

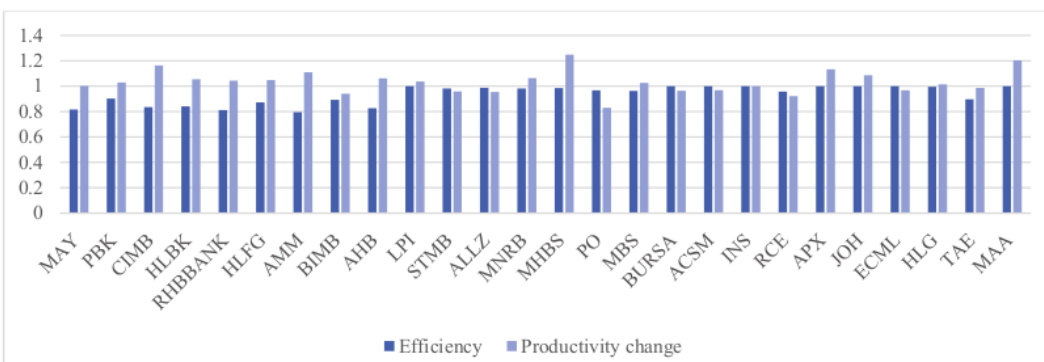

Fig. 3. Efficiency and Productivity Change

Table 6
Ranking of the Financial Company Listed in Bursa Malaysia

Rank* (DEA)	Company Short name
1	LPI
	BURSA
	ACSM
	APX
	JOH
	ECML
	MAA
2	INS
3	HLG
4	ALLZ
5	MHBS
6	MNRB
7	STMB
8	PO
9	MBS
10	RCE
11	PBK
12	TAE
13	BIMB
14	HLFG
15	HLBK
16	CIMB
17	AHB
18	MAY
19	RHBBANK
20	AMM

*Rank by result derived from DEA.

5. Conclusion

Bursa Malaysia has increased very significantly. The investors should have adequate knowledge strategy in case of stocks investment to boost their investments to at maximum level. One of the ways is to use profit optimization. The present study has provided the first attempt to identify whether or not there is a relationship between productivity and efficiency in financial companies. In the first stage of the analysis, this study used DEA-MPI to obtain efficiency and productivity of 26 listed financial companies over the period 2007-2016. The results depicted that the number of the fully efficient company was seven. Additionally, the results have indicated a tremendous productivity gain was mostly because of a positive shift in frontier technology and positive shift in technical efficiency. Based on pure technical efficiency change, the performance of the financial companies of Bursa Malaysia was relatively stable, with the score always remained close to 100% over the study period. These kinds of analysis could provide important and useful information for management decision making and regulatory investigations. Ultimately, this study observed no evidence to support our measurement most significant as the selection of variable may change the ranking.

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