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The efficiency of Islamic banks in Malaysia: Based on DEA and Malmquist productivity index

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ABSTRACT

This paper aims to investigate the impact of liberalisation move by Bank Negara Malaysia (BNM) towards the efficiency of domestic and foreign Islamic banks (IBs) in Malaysia. This is consequence of decision of BNM that awarded licenses to three international IBs, namely Kuwait Finance House (KFH), Al Rajhi Bank, and Asian Finance Bank in 2005. In addition, this study takes into consideration the existing foreign banks in the country that operate via Islamic banking subsidiaries as part of foreign IBs. The research evaluates the impact of foreign Islamic banks in Malaysia by measuring their contribution to the growth of the Malaysian Islamic banking industry. Using a sample of 16 IBs in Malaysia from 2008 to 2015, the study uses Data Envelopment Analysis (DEA) in measuring the efficiency level of each bank and comparative between the performance of domestic and foreign IBs in the country. The paper also employs the Malmquist Productivity Index to gauge the changes in its components between the same subjects and timeframe. The DEA results showed that the domestic Islamic banks are considered more efficient than most domestic Islamic banks outperforming the foreign Islamic banks. Banks like Hong Leong Islamic, Maybank Islamic, Public Islamic, and RHB Islamic are considered among the top performers for technical efficiency and scale efficiency. The study also found that based on the Malmquist Productivity Index, the least efficient banks based on DEA have improved in technical efficiency, technology, and total factor productivity (TFP).

1. Introduction

This paper examines the efficiency of domestic and foreign Islamic banks in Malaysia between 2008 and 2015 financial year by employing Data Envelopment Analysis (DEA). The researchers intend to evaluate the decision by the Malaysian government to liberalise its banking industry, specifically its impact on Islamic banks. BNM as the bank for the Malaysian government has granted multiple licenses to

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foreign Islamic banks throughout the nineties with the intention to stimulate competition for the local and international Islamic banks existing in the country. As mentioned, the method is a nonparametric approach to the estimation of the production frontier, which is used to measure the efficiency of the decision-making units (DMUs) for the Islamic banks in Malaysia.

According to Wezel (2010), data on each bank's input and output selection is to be collected and then constructed to view a complete efficient production frontier of the banking system. The next step involves the calculation of an individual bank's efficiency score and to analyse the distance between each bank's positions from the efficient frontier. The paper also examines the Malmquist Productivity Index and the changes in its components between the same subjects and timeframe.

DEA and the Malmquist Productivity Index are used in this paper due to their flexibility, applicable for multi-input and multi-output variables, and extensive use in various researches, especially in developing countries like Malaysia (Anouze, 2015; Johnes et al., 2014; Keskin and Degirmen, 2013; Srairi et al., 2015). Emrouznejad and Yang (2017) further elaborated that the works in DEA have shown strong growth with regards to journal articles publication with the number reaches 10,300 articles as of the end of 2016.

2. Literature Review

2.1 Measuring bank efficiency: Methods and techniques

It is becoming increasingly important for banks in Malaysia to compare their performance with others to remain competitive and relevant in the market. Recent developments in the Malaysian Islamic banking and finance sector have heightened the need to address this matter, especially after the process of liberalisation began in 2004 when the Malaysian government opened the door to three foreign Islamic banks to operate in Malaysia.

There are numerous econometric methods and models that can be used to measure performance. Mostafa (2007) narrowed it down further that the efficiency performance of the banks is mostly analysed based on the methods which are Stochastic Frontier Approach (SFA) (parametric) and Data Envelopment Analysis (DEA) (nonparametric).

SFA is the economic methodology that measures performance through benchmarking in various economic input-output systems. The method of analysis enables the researchers to explain the gap between the current performance and best performance of the banks. Berger and Humphrey (1997, p. 6) described SFA as, "a functional form for the cost, profit, or production relationship among inputs, outputs, and environmental factors and allows random errors". According to Kumbhakar and Lovell (2003), SFA added the random shocks element in the model which may impact production process such as weather changes or economic downturns.

Meanwhile, DEA is a technique based on the computation of comparative ratios of outputs and inputs for each unit related to efficiency score. It measures the efficiency of a decision making unit (DMU), and in the case of this research, this unit is considered to be a bank (Ray, 2004). DEA is a technique that has no fixed structure imposed on the data in determining the efficient units that lead to minimal specification error. It also uses a method that can handle multiple variables and relations (Cooper et al., 2007). The central feature of the DEA is related to the bank's efficiency that can be assessed based on other observed performance. Despite the advantages, one of the disadvantages of DEA is that the technique assumes data to be free from measurement error (Avkiran, 1999). If the data have been violated, the results from the findings could not be interpreted with confidence. Like other analyses that rely on reliable data, DEA is particularly sensitive to inaccurate data. The units deemed efficient in determining the efficient frontier and have an effect towards the efficient scores computed under the frontier. According to Ray (2004), results of DEA have no standard errors which make it difficult for hypotheses testing. Coelli et al. (2005)

suggested to use a distance functions similar (extension) to DEA that is the Malmquist Productivity Index in measuring technical efficiency change and technical change elements. This method is suitable in describing multi-input and multi-output functions, which are closely related to the banking sector. Coelli et al. (2005) further explained that the index measures the productivity change between two data points by calculating ratios of a value (increase/decrease rate) between two periods.

2.2 Empirical studies using the nonparametric approach

In theory, DEA uses data on costs, outputs, and input prices from a sample of banks and establishes which bank produced outputs at specified input prices at lowest costs. Denizer et al. (2000) employed DEA when measuring bank efficiency of commercial banks in Turkey for the 1970 to 1994 period. The study indicates that banks will go through a two-stage process. First is the production stage whereby banks collected deposits from customers via resources, labour, and physical capital. Second is the intermediation stage where banks use their managerial and marketing resources to convert the deposits into investment. The results show that the liberalisation took place in the Turkish banking industry had adverse impacts in terms of efficiency. A major reason identified was the rising macroeconomic instability in the Turkish economy during the study period.

As for the case of Malaysia, Matthews and Ismail (2006) investigated the efficiency and productivity of local and foreign commercial banks during 1994 to 2000. This was based on the earlier liberalisation exercise by BNM on the commercial banking in Malaysia, which is quite similar to this paper that focuses on Islamic banking industry. In applying DEA, the authors used number of employees, fixed assets, and total deposits as inputs, and total loan, other earning assets, and other operating income as outputs. Once they determined the efficiency of the banks, the authors constructed the Malmquist Productivity Index to determine the productivity growth for the banks. The outcome of the study shows that foreign banks are more efficient than the local banks, but the improvement in efficiency level was caused by technological change instead of improvement of efficiency.

Keskin and Degirmen (2013), on the other hand, employed DEA together with the Malmquist Productivity Index in analysing the Turkish banking sector between 2004 and 2009. They grouped the banks into public-owned deposit banks, private-owned deposit banks, and foreign-owned deposit banks with a total of 31 banks between them. The authors adopted the intermediation approach with deposits and interest expenses as inputs, and financing and interest incomes as outputs. They found that the foreign-owned deposit banks were the most efficient banks in Turkey during the period due to positive movement in their technology, technical resources, and TFP.

Anouze (2015) investigated the performance of banks in GCC by using slightly different approach that is DEA and classification and regression tree (CART). Ranging from 1997 to 2007, the author observed a total of 68 banks across all six GCC countries with fixed assets, non-earning assets and deposits as inputs. For outputs, they applied investments, loans, off-balance sheet items, and net profit in their DEA analysis. The outcome of the paper showed that all GCC commercial banks' technical efficiency were relatively constant prior, during, and after the crisis. Banks in Saudi Arabia are considered the most efficient in the region followed by the UAE. The least efficient banks were from Qatar.

3. DEA Model

DEA was originally introduced by Charnes, Cooper and Rhodes (CCR) in 1978. The authors proposed a model with input orientation and made an assumption on constant returns to scales (CRS) (Charnes, 1994). However, CRS is only applicable when all firms are running at an optimal level. A firm many not be at optimal scale due to imperfect competition or limitations in finance. Banker, Charnes and Cooper (BCC) improvised the CCR model that measures technical efficiency. Emrouznejad and Anouze (2010) explained that a bank's technical efficiency is measured by looking at the maximum amount of outputs that a bank can produce from the available inputs. A perfect score is one (or 100%) whereby banks that scored below than that are considered technically inefficient due to higher usage of assets and equity to produce the same amount of profits as the banks that scored 100%.

Banker et al. (1984) proposed the CCR model by diminishing the CRS assumption. As a result, the modified model of BBC aims to measure the firm's efficiency by looking at variable returns to scale (VRS). The newly formed model furnishes the measurement of pure technical efficiency (PTE), derived from the exclusion of scale efficiency effects from the technical efficiency. If there are any discrepancies between TE and PTE scores, it implies that there is an element of scale inefficiency.

Under the DEA model, the firm or organisation that is being studied is identified as DMU. The model assesses the performance of DMU with respect to the process of converting of multiple inputs into multiple outputs. In the estimation process, DEA allocates weights to the inputs and outputs of a DMU and determines the most probable efficiency. Simultaneously, DEA allocates the same weights to the other DMUs within the sample and compares the results against the focal DMU. If the focal DMU performs comparable with any other DMU, its efficiency score will be at a maximum. However, if there are other DMUs perform better, the focal DMU's efficiency score will be less than maximum. In general, it is of utmost importance to select the relevant input and output variables for a particular pool of DMUs to get the best result. According to Bader et al. (2008), the relative efficiency can be measured as follow:

$$\frac{weighted\ sum\ of\ outputs}{weighted\ sum\ of\ inputs} \quad (1)$$

This also can be written in following form:

$$\text{Efficiency of unit j} = \frac{uR_1R\ yR_{ij}R + uR_2R\ yR_{2j}R + \ldots}{vR_1R\ xR_{ij}R + vR_2R\ xR_{2j}R + \ldots} \quad (2)$$

where:

uR_1R= the weight given to output one.

$yR_{1j}R$ = the amount of output one from unit j.

vR_1R = the weight given to input one

$xR_{1j}R$ = the amount of input one to unit j

The DEA models calculate the input and output weights by enhancing the means of the population. This is followed by DMUs being grouped into efficient and inefficient units according to the computation. For inefficient units, the results indicate the target values of inputs and outputs that would direct them to efficiency. All of these are bound to the situation where the efficiency rate of any other units in the population must not be larger than one. The models must contain all the relevant characteristics considered including the weights of all inputs and outputs that should be greater than zero. Such type is defined as a linear divisive programming model, as follows:

$$maximise\ \frac{\Sigma_i u_i y_{iq}}{\Sigma_j v_j x_{jq}} \quad (3)$$

$$subject\ to\ \frac{\Sigma_i u_i y_{ik}}{\Sigma_j v_j x_{jk}} \leq 1\ k = 1, 2, \ldots, n$$

$$u_j \geq \in\ i = 1, 2, \ldots, s$$

$$v_j \leq \in\ j = 1, 2, \ldots, m$$

4. Empirical Process

4.1 Data envelopment analysis

In general, the choice of the number of inputs and outputs for DMUs ascertains how good a distinction exists between the efficient and inefficient units. There are two diverging considerations when estimating the size of the data set. One deliberation is to incorporate as many DMUs as possible. By including a high sample, there will be a greater chance that top performing firms will be included and form the efficient frontier that enhances the discriminatory power. Furthermore, a large data set may decrease the homogeneity of the population which means the external factors that unrelated to the models may give less impact to the results (Golany and Roll, 1989). Furthermore, the computational requirements will increase with larger data sets. Nevertheless, there are several rules of thumb for the number of inputs and outputs for selection and its connection to the number of DMUs.

Boussofiane et al. (1991) explained that in order to get decent discriminatory power out of the CCR and BCC models, the minimum number of DMUs should be derived from the multiplication of quantity of inputs against the quantity of outputs. In determining the efficiency of each DMU, the adaptability on the selection of weights for input and output values is very crucial. Therefore, a DMU may assign the entire weights to a particular input and output to be efficient based on a ratio of an output to an input. For instance, the minimum number of DMUs in a sample should be 6, if there are three inputs and two outputs (three multiply with two) to provide assured discriminatory power in the model.

As for Golany and Roll (1989), they proposed that the number of DMUs in the model should be a minimum of two times the quantity of inputs and outputs as a rule of thumb. For example, for a model that has three inputs and two outputs, there should be a minimum of 10 DMUs (based on the sum of three and two, and then multiply with two). Dyson et al. (2001) recommended the minimum number of DMUs should be at least twice of the multiplication of inputs and outputs. Using the same example, a model that has three inputs and two outputs should have a minimum of 12 DMUs (based on the multiplication of three and two, then multiply with two).

In conclusion, if there is a model with four inputs and three outputs, Boussofiane et al. (1991) proposed to use 12 DMUs, Golany and Roll (1989) suggested using 14 DMUs, and Dyson et al. (2001) recommend 24 DMUs. In general, the minimum number of DMUs based on these guidelines should be observed for any fundamental productivity model. These guidelines will ensure the discriminatory of the essential productivity models. Analysts may reduce the quantity of inputs or outputs if they find that the discriminatory power is non-existent because of the small number of DMUs.

In conducting an analysis of banking efficiency, either a production or intermediation approach can be opted for. In the 'production approach', the bank is considered as a firm that provides services, such as financing and remittances, using capital and labour inputs. The output is commonly represented by the size of deposit accounts or transactions, and inputs are expressed as number of employees (labour) and capital expenditures on fixed assets (capital). In the 'intermediation approach', banks operate an intermediary function between lenders and depositors and hence accept deposits and other funds to provide financing and alternative investments. The output is measured by income or profit from financing, total deposits and any other non-interest-bearing income while inputs are usually denoted by operating costs and costs of providing financing to customers. The latter is more acceptable approach in bank studies. It should be further noted that the 'production' approach is more suitable when analysing branch efficiency. Conversely, the intermediation approach is a more applicable reflection of banking activities when found at the bank level (Johnes et al., 2014; Pasiouras, 2008). It should be noted that most of the previous studies also have fallen into the latter classification.

The choice of outputs selected from previous literature (Keskin and Degirmen, 2013; Matthews and Ismail, 2006; Sufian, 2007), were by data availability and the available data should not have negative values. Accordingly, the outputs chosen for this study are total financing (loans) and other earning assets. As for the inputs, they are defined as total deposits (deposits and short-term funding), personnel expenses and total equity.

Most of literature on DEA used total deposits as one of the inputs that represent the intermediation role of a bank that collecting deposits from its customers. Among studies that used total deposits as inputs were Mokhtar et al. (2008), and Johnes et al. (2014), who further elaborated that total deposits consist of deposits and short-term funding. As for labour input, the researchers used personnel expenses as a proxy in this study, which as a variable is used in previous studies including Denizer et al. (2000) and Kamaruddin et al. (2008).

In the empirical modelling, total equity is included as an input to reflect risk-taking in the banking sector, which is rationalised on the grounds that Charnes (1994) proposed to integrate an indicator of risk-taking into every model of banking efficiency by the inclusion of loan-loss provision as an input. Furthermore, equity is better suited for the study of Islamic banks in Malaysia since most of the non-full-fledged Islamic banks share their assets with their conventional counterpart. Previous studies that include equity as part of their inputs can be found in Mostafa (2007) and Johnes et al. (2014).

4.2 Malmquist productivity index

Malmquist Total Factor Productivity (TFP) or simply Malmquist Productivity Index is a method that relies on the Data Envelopment Analysis (DEA), which evaluates the productivity change between two data points by calculating ratios of a particular value (increase/decrease rate) between two periods (Coelli et al., 2005).

Ramesh et al. (2006) demonstrated the Malmquist Productivity Index by using distance functions. The Malmquist Productivity Index gauges the movement between two data points by computing the ratio of the distances of each data point comparative to a common technology.

The Malmquist (output-oriented) TFP change index between period t (the base period) and period *t*+1 is given by equation 4;

$$M_0\left(x^{t+1}, u^{t+1}; x^t, u^t\right) = \left[\frac{D_0^t\left(x^{t+1}, u^{t+1} / CRTS\right)}{D_0^t\left(x^t, u^t / CRTS\right)} x \frac{D_0^{t+1}\left(x^{t+1}, u^{t+1} / CRTS\right)}{D_0^{t+1}\left(x^t, u^t / CRTS\right)}\right]^{\frac{1}{2}} \quad (4)$$

where the notation $\mathrm{D}_0^s\left(\mathrm{u}^t, \mathrm{x}^t\right)$ represents the distance from the period *t* observation to the period *S* technology and CRTS stands for the constant rate to scale. In the estimation, a value of *M*R*0*R greater than one will indicate positive TFP growth from period *S* to period *t*. However, a value less than one indicates a TFP decline.

In order to assess the distance functions that are employed in the measurement of the Malmquist Productivity Index, constant returns to scale (CRS) hypothesis is applied to technology (Keskin and Degirmen, 2013). The index evaluates the change in the TFP between two variables by computing comparative distance rate to the common technology of each variable, for which input and output based can be used in the distance functions (Deliktas, 2002). The input-based approach measures the minimum amount of inputs utilisation in a production of output (input minimisation). Conversely, output- based approach gauges the highest possible output production with constant inputs (output maximisation).

The Malmquist TFP Index is segregated into technical efficiency and technological change. The researchers can assess the efficiency change and technological change individually when the equation is separated into two.

Efficiency change: $$\frac{D_0^t\left(x^{t+1}, u^{t+1} / CRTS\right)}{D_0^t\left(x^t, u^t / CRTS\right)} \tag{5}$$

Technical change: $$\left[\frac{D_0^t\left(x^{t+1}, u^{t+1} / CRTS\right)}{D_0^{t+1}\left(x^{t+1}, u^{t+1} / CRTS\right)} \cdot \frac{D_0^t\left(x^t, u^t / CRTS\right)}{D_0^{t+1}\left(x^t, u^t / CRTS\right)}\right]^{\frac{1}{2}} \tag{6}$$

According to Ramesh et al. (2006), efficiency change (EC) measures the catching-up factor with the best practice frontier for each observation between two-time period t and t+1. In addition, the technical change (TC) measures the shift in the frontier of technology (innovation) between two successive periods evaluated at xP^{t}P and xP^{t+1}P. Efficiency and technical change indices exceeding unity indicate gains in those components.

Keskin and Degirmen (2013) further concluded that changes in the TFP index will show the differences between productivity changes, and technological and technical efficiency changes. An index value of being more than one implies that it increases during the shift from (t) period to (i+1) period; conversely, being less than one shows a decrease.

4.3 Sample, data collection and analysis

In terms of data sources, it should be noted that all the variables are readily obtainable from Bankscope and respective bank's annual reports and analysed using DEAP version 2.1 software created by Coelli (1996). Thus, all 16 Islamic banks in Malaysia which are in operation throughout the period of 2008 to 2015 are selected. The number of DMUs in this study is consistent with the recommendation based on the studies mentioned earlier.

In sum, for this study, total financing and other earning assets are chosen as outputs. As for inputs, total deposits, personnel expenses, and total equity are considered input variables in conducting the model. Meanwhile, total number of DMUs selected is 16, which fulfils the requirements set by Boussofiane et al. (1991), Golany and Roll (1989), as well as Dyson et al. (2001) as per earlier discussion.

Change indices in TFP for the Islamic banks in Malaysia are computed for both domestic and foreign Islamic banks via applying panel data for the 2008 to 2015 period. Thus, the Malmquist TFP index presents temporal development of banks' productivity and its sources. Again, DEAP version 2.1 software introduced by Coelli (1996) is employed for the measurement of indices.

5. Empirical Results

In conducting the empirical analysis as described above, the data analysed and grouped into results of DEA and results of Malmquist Productivity Index. The results of the DEA are derived using CRS and VRS respectively based on a multi-stage method. Overall, technical efficiency is the measurement of output of the CRS efficiency. Conversely, by excluding scale inefficiencies, VRS can evaluate pure technical efficiency. The ratio of the estimated CRS to VRS efficiency produces the measurement of scale efficiency. Accordingly, an efficient firm should get an index score of one (100%).

As for the results of the Malmquist Productivity indices, besides the TFP, it also analyses technical efficiency and technological change. When the index value scores more than one, it represents the technological improvement and superior technical efficiency, and if it is less than one, it indicates deterioration. Furthermore, pure technical efficiency change, and scale efficiency change are the elements uncovered from the partition of technical efficiency change. The technical efficiency change index can be observed when the pure technical efficiency change multiplies with scale efficiency change.

Pure technical efficiency measures the competency of management and identifies whether the firm operates and produces its outputs at a proper scale, while distortion of managerial competency causes a reduction in pure technical efficiency. On the other hand, firm's scale problem may influence the decline in scale efficiency.

Table 1. Results of DEA

Bank	CRSTE	VRSTE		SCALE		Return to Scale
		Input oriented	Output oriented	Input oriented	Output oriented	
Affin Islamic	0.826	0.897	0.879	0.921	0.940	irs
Alliance Islamic	0.945	1.000	1.000	0.945	0.945	irs
AmBank Islamic	1.000	1.000	1.000	1.000	1.000	-
BIMB	0.944	1.000	1.000	0.944	0.944	drs
BMMB	1.000	1.000	1.000	1.000	1.000	-
CIMB Islamic	0.953	0.993	0.994	0.960	0.959	drs
Hong Leong Islamic	1.000	1.000	1.000	1.000	1.000	-
Maybank Islamic	1.000	1.000	1.000	1.000	1.000	-
Public Islamic	1.000	1.000	1.000	1.000	1.000	-
RHB Islamic	1.000	1.000	1.000	1.000	1.000	-
Al Rajhi Bank	1.000	1.000	1.000	1.000	1.000	-
Asian Finance Bank	1.000	1.000	1.000	1.000	1.000	-
HSBC Amanah	0.951	0.972	0.971	0.978	0.979	irs
KFH	0.901	0.930	0.926	0.969	0.973	irs
OCBC Al Amin	0.991	1.000	1.000	0.991	0.991	irs
StanChart Saadiq	0.897	1.000	1.000	0.897	0.897	irs
Overall Average	0.963	0.987	0.986	0.975	0.977	
Average domestic	0.967	0.989	0.987	0.977	0.979	
Average foreign	0.957	0.984	0.983	0.973	0.973	

Note: crste = technical efficiency from CRS DEA; vrste = technical efficiency from VRS DEA; scale = scale efficiency = crste/vrste

As depicted in Table 1, based on CRS, domestic Islamic banks slightly outperformed the foreign Islamic banks with the difference of 1% only. This indicates that the foreign Islamic banks have successfully caught up the domestic counterparts in recent years as compared to 17.5% difference based on results for financial year end of 2012 by Basri (2016). Similarly, based on VRS, the domestic Islamic banks surpass the foreign counterpart but with a lower margin of 0.5% and 0.4% based on input orientation and output orientation respectively. As for scale efficiency, the results indicate that the domestic Islamic banks are more efficient than the foreign Islamic banks with the average score of 97.9% and 97.3% respectively.

In terms of individual banks, eight banks are considered efficient under CRS as compared to only four based on finding by Basri (2016), namely AmBank Islamic, BMMB, Hong Leong Islamic, Maybank Islamic, Public Islamic, RHB Islamic, Al Rajhi and Asian Finance Bank. Three most inefficient banks based on CRS include KFH, Standard Chartered Saadiq, and Affin Islamic with scores of 90.1%, 89.7% and 82.6% respectively. The result also shows that BIMB, Affin Islamic, and Standard Chartered Saadiq are the most inefficient banks in terms of optimisation of their size of operations with the score of 94.4%, 94.0% and 89.7% respectively. The scale inefficiency may be contributed from their ambitious projections and end up in over-hiring of employees.

By factoring out the scale inefficiencies, 12 banks are now considered efficient with the inclusion of the Alliance Islamic, BIMB, OCBC Al Amin, and Standard Chartered Saadiq together with the eight Islamic banks mentioned earlier under CRS. Banks with the lowest scores under VRS are HSBC Amanah with 97.1%, KFH with 92.6% and Affin Islamic with the score of 87.9%.

Table 2. Results of Malmquist productivity index

Bank	Technical Efficiency Change	Technological Change	Pure Technical Change	Scale Efficiency Change	Total Factor Productivity (TFP) Change
Affin Islamic	0.990	1.000	0.996	0.994	0.990
Alliance Islamic	0.992	0.990	1.000	0.992	0.982
AmBank Islamic	1.003	1.047	1.002	1.001	1.050
BIMB	1.051	0.983	1.028	1.023	1.033
BMMB	1.019	0.989	1.013	1.007	1.009
CIMB Islamic	0.993	0.997	0.999	0.994	0.990
Hong Leong Islamic	1.012	0.986	1.000	1.012	0.998
Maybank Islamic	1.000	0.934	1.000	1.000	0.934
Public Islamic	1.007	0.983	1.005	1.002	0.990
RHB Islamic	1.004	1.031	1.000	1.004	1.034
Al Rajhi Bank	1.053	0.987	1.031	1.022	1.040
Asian Finance Bank	1.252	1.014	1.000	1.252	1.269
HSBC Amanah	1.017	0.978	1.016	1.001	0.995
KFH	1.004	1.002	1.001	1.002	1.006
OCBC Al Amin	0.999	0.943	1.000	0.999	0.942
StanChart Saadiq	1.003	0.962	1.000	1.003	0.964
Average	1.023	0.989	1.006	1.018	1.012
Average domestic	1.007	0.994	1.004	1.003	1.001
Average foreign	1.055	0.981	1.008	1.047	1.036

Note: All Malmquist index averages are geometric means.

Based on the results depicted in Table 2, the technical efficiency change index indicates that 68.8% or 11 out of 16 Islamic banks increased their average annual technical efficiency. As for banks in a declining state, 25.0% (four banks) of the sample are in this category. Meanwhile, only one bank denotes no change between 2008 and 2015 *i.e.* Maybank Islamic. The results show that among the banks that progress the most in technical efficiency are Asian Finance Bank (25.2%), Al Rajhi (5.3%), and BIMB (5.2%). The results depict that most regressed bank is Affin Islamic with 1%. As for grouped results, the average foreign Islamic banks' score outclassed the domestic Islamic banks with an increment of 5.5% to 0.07%. This is consistent with the result from Basri (2016) who found that the foreign Islamic banks becoming more efficient as compared to the domestic Islamic banks from 2008 to 2012.

As for technological change, as can be seen in Table 2, only four out of 16 banks (25.0%) improved their performance while the rest of them suffered deterioration. For this measurement, the domestic

Islamic banks performed slightly better than the foreign Islamic banks with the score of 99.4% and 98.1% respectively. The most improved banks for technological change are AmBank Islamic (4.7%) and RHB Islamic (3.1%), while the banks registering the greatest decline are Maybank Islamic (6.6%), and OCBC Al-Amin (5.7%).

It should be noted that TFP change is considered the most important measurement of the outputs of Malmquist Productivity Index. For this measurement, as the results indicate, the foreign Islamic banks topped the domestic Islamic banks with the average score of 3.6% and 0.1% respectively. As can be seen, the best performing banks for this measurement are Asian Finance Bank (26.9%), RHB Islamic (3.4%), and BIMB with 3.3%. The results show that the worst performing banks includes Maybank Islamic (6.6%), OCBC Al Amin (5.8%), and Standard Chartered Saadiq with a decline of 3.6%.

The results in Table 2 show that AmBank Islamic, and KFH experienced growth across all measurements under the Malmquist Productivity Index. Meanwhile, CIMB Islamic suffered regression in all aspects for their performance, namely from technical, technological, pure technical, scale and overall efficiency.

6. Conclusion

The DEA results based on CRS suggests that the size of a bank is not relevant when assessing efficiency where eight Islamic banks considered as efficient. However, the CRS entirely ignores the scale operations and will possibly lead to impractical benchmarks. Therefore, the VRS model is more acceptable which is consistent with previous studies conducted by Mostafa (2007), Mokhtar et al. (2008), and Johnes et al. (2014). By looking at the VRS model, almost all Islamic banks make the list of technical efficient banks except Affin Islamic, CIMB Islamic, HSBC Amanah, and KFH. Furthermore, as can be seen from Table 1, there is little difference in the results between input orientation and output orientation. The ranking of the banks remains the same regardless of orientation.

In reflecting upon the results, the DEA results confirm that the domestic Islamic banks were more efficient as compared to the foreign Islamic banks in the country. The findings are incompatible with results from Keskin and Degirmen (2013), as well as Parinduri and Riyanto (2014), whereby the outcome of the DEA of this study implies that the domestic Islamic banks in Malaysia utilised the home field advantage to their gains. The newcomers to the market such as Al Rajhi, KFH, and Asian Finance Bank might have advantage in terms of liquidity, but they were less cost-efficient as compared to the domestic counterparts. On top of that, the domestic Islamic banks perhaps possess better know-how and higher-quality employees unlike the foreign Islamic banks. This situation is similar to the studies by Liao (2009) and Ong et al. (2011) for conventional banks in Taiwan and Malaysia respectively.

Even though the foreign Islamic banks are less profitable and less efficient between 2008 and 2015, the establishment of subsidiary of existing conventional banks in the country, and decision to grant new licenses to foreign entities prior to that have resulted the improvement in overall efficiency of the industry. According to Sufian (2007), the Malmquist TFP of Malaysian Islamic banking industry was in decline state between 2001 and 2004. However, based on the recent findings from this study, it shows that the Malmquist TFP was on the rise between 2008 and 2015. One of the main indicators in Malmquist Productivity Index that is technological change was the most dominant factor in contributing to the growth. The rapid improvement in technology implementation among the banks in the country together with the liberalisation exercise led by BNM proved to be effective in promoting competition and improve the performance of the Islamic banks in Malaysia. The result is consistent with study by Pawlowska (2005), which analysed the Polish banking industry for the period of 1997 to 2012. Mustafa and Mehmood (2015) also suggested that technology and digital reform helps the Pakistan banks to become more efficient.

The lessons learned from these also indicate that the Islamic banks with lower scale efficiency such as Affin Islamic, Alliance Islamic, and Standard Chartered Saadiq should hire lesser staff, and focus more on employing higher quality staff without relying on quantity. A bank can be technically inefficient if hiring too many employees to produce maximum outputs as compared to its competitors. Additionally, smaller banks may focus more on the technology and digital reform to become more competitive.

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