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Input Radial Model VS Slack Based Measure Model of Data Envelopment Analysis in Evaluating Five-Year Efficiency of Malaysia Banking Sector

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The financial system of a country is highly related to the performance of its banks. As Malaysia is moving towards achieving a high income-economy country status by 2020, the performance of its banking sector should be monitored closely. The Data Envelopment Analysis (DEA) technique has been used extensively to measure bank efficiency and one recent study focuses on banks in Malaysia from 2000 to 2010. However, our study analyses amore recent data, that is the five-year data cycle from 2009-2013. Moreover, this paper aims to demonstrate the adoption of two DEA models, the radial input-oriented model and the slack –based measure model to measure the annual efficiency of nine Malaysia commercial banks from 2009 to 2013. Both DEA models measure the efficiency but with different conceptions. The results from the traditional radial input DEA model show that two banks that were fully efficient every year in those five- year periods were BIMB and Maybank, while the highest efficiency average score for the nine banks was achieved in 2009. Results from the SBM-DEA model give a little different picture where only BIMB maintained efficiency annually in that 5-year period, however the highest efficiency average of the banks took place in 2009 as well. The two DEA models can be considered as complementing each other since the traditional radial model measures efficiency based on the distance of any existing decision-making unit (DMU) from the optimal DMUs, while the SBM model measures efficiency of a DMU based on the DMU's weighted average of the DMU's normalized input and output

slacks. The use of two DEA models in measuring efficiency could be extended in other sectors since the results would give a better picture about the performance of the production system under study.

Key words: *Efficiency Measurement, Commercial Bank, Radial, Slack-based, Data Envelopment Analysis.*

Introduction

Evaluating the performance of a financial system is one of the important tasks for the managers. Banks and financial systems are intertwined and the financial system of a country is directly linked to the performance of its banks. As Malaysia is moving towards achieving a high income-economy country status in less than two years, the performance of its banking sector should be measured and monitored closely. Furthermore, high-functioning banking institutions are a condition for favourable economic growth of any country (Diallo 2018; Belke et al. 2016; Zhang et al. 2016; Destefanis et al. 2014; Roghanian et al. 2012; Waheed & Younus 2010). In order to have such a condition, Ferriera (2012) discussed the importance of measuring the efficiency of banks. Efficiency can simply be defined as a ratio of output to input where the output refers to amount of production while input is the cost or resource used to produce the output. In economic language, efficiency is inferred as the maximum potential ratio of the output and the input of the production, which shows the optimal usage of available resources that would allow achieving the maximum potential (Cvilikas & Jurkonyte-Dumbliauskiene 2016).

Data Envelopment Analysis (DEA) which was invented by Charnes, Cooper and Rhodes (1978) has been used extensively to measure bank efficiency, for example Baten, Kasim and Rahman, 2015 and Ab-Rahim in2015. As it is a linear programming (LP) model, and considering multiple inputs and multiple outputs, DEA can measure the efficiency of one decision making unit (DMU), or one bank relative to other banks (Hussain, Grabara, Razimi, & Sharif, 2019; Kamarudin, Sufian, Nassir, Anwar, & Hussain, 2019). Here the weights attached to the inputs and outputs are generated by means of LP (Fenyves et al., 2018). However, each bank to be measured will receive one single efficiency score, and the value is between zero and one. A DMU that receives a score of one means that it is fully efficient while as the value decreases, the efficiency measures of the DMUs are also decreasing (Ahmed, Zin & Majid, 2016; Ali & Haseeb, 2019; Haseeb, Abidin, Hye, & Hartani, 2018; Haseeb., 2019; Suryanto, Haseeb, & Hartani, 2018).

This paper aims to demonstrate the adoption of two DEA models, the radial input-oriented model (Charnes et al., 1978) and the slack-based measure (SBM) DEA model (Tone, 2001; Solana-Ibáñez, Caravaca-Garratón, & Para-González, 2016) to measure the annual efficiency

of nine Malaysia commercial banks from 2009 to 2013. Several efficiency studies in the bank sector have been conducted based on the Tone's (2001) model (Sufian & Kamarudin, 2014; Gee and Karim, 2016; Abuh, Gabriel & Ogwuche 2017).These two models are used together with the first model the traditional model that deals with the optimal linear combination of outputs and inputs as a basis to measure efficiency, while the second model uses the slack measure which represents the difference between the actual linear combination of the outputs and inputs value and the best possible value. Using both DEA models in measuring the efficiency of the banks gives a better comprehensive picture about the performance of these banks. The recent study by Ab-Rahim (2015) focuses on banks in Malaysia from 2000 to 2010. However, our study analyses a more recent data set that is the five-year data available from 2009 to 2013. The following sections discuss the methodology, finding and results, and conclusions.

Methodology

This section discusses the analysis methods and the data used in this paper.

DEA Radial Model

The DEA radial method represented by the CCR model (Charnes et al., 1978), and its input-oriented model deals with proportionate reduction of input resources, and aims to obtain maximum rate of reduction of inputs that can produce current outputs. Let y_{kj} be output *k,* for bank *j*, where k=1,…,*K*, and j = 1,…, *J* and x_{ij} be input *i* for bank *j*, where i = 1, …,*I*. So the LP formulation for DMU *R* is as follows.

$$Max\ h_0 = \frac{\sum u_k y_{kR}}{\sum v_i x_{iR}} \qquad (1)$$

subject to $\frac{\sum u_k y_{kj}}{\sum v_i x_{ij}} \leq 1$ for each DMU *j,* and weights $\geq \varepsilon$.

Where u_k = the weight given to output *k*

v_i = the weight given to input *i*

y_{kj} = amount of output *k* for DMU *j*

x_{ij} = amount of input *i* for DMU *j*.

Equation (1) can be simplified as follows

$$Max\ \sum_{k=1}^{K} u_k y_{kR} \qquad (2)$$

subject to $\sum_{j=1}^{J} v_i x_{ij} = 1,\ \sum_{k=1}^{K} u_r y_{rj} - \sum_{j=1}^{J} v_i x_{ij} \leq 0,\ u_r, v_i \geq 0.$

For j= 1, …, *J*; i = 1, …, *I*, and k = 1, …, *K*.

The DEA slack-based measure

The DEA slack-based measure (SBM) model was developed by Tone (2001).
Let $s_k^+ = \sum_{j=1}^{J} \lambda_j y_{kj} - y_{rR}$ and $s_i^- = x_{iR} - \sum_{j=1}^{J} \lambda_j x_{ij}$ be the degree to which output k can be increased and the degree to which input i can be decreased respectively. The slack values express the distance of a DMU from the best possible DMU. Then, the efficiency formulation for DMU R based on these slacks are as follows.

$$\mu_R = \frac{1 - \sum_{i=1}^{I} w_i^- s_i^- / x_{iR}}{1 + \sum_{k=1}^{K} w_k^+ s_k^+ / y_{kR}} \quad (3)$$

Equation (3) can be simplified as follows

$$Min\ 1 - \sum_{i=1}^{I} w_i^- s_i^- / x_{iR} \quad (4)$$

Equations (2) and (4) were used to analyze the efficiency of nine commercial banks in Malaysia where six of the banks were in the top seven Malaysian brand banks that show strong growth in ASEAN for year 2017 (Rao, 2017). Each bank is assumed to be an independent decision-making unit (DMU). Since the DEA is a LP-based technique, and there are nine DMUs, nine optimizations are needed, that is one for each DMU to be evaluated.

Data sets, the inputs and the outputs

In this paper, we utilize a sample of data from nine Malaysian commercial banks. The five-year data set, 2009-2013, was collected from the annual report of the banks by considering three inputs and two outputs. The inputs are: deposits, fixed assets, and capital (Chen et al., 2013; Chiu et al., 2008). The two outputs are: non-interest income (Chiu et al., 2008), and investments (Asmild & Matthews, 2012; Wyatt,Hoban & Macfarlane 2018). The inputs and outputs of the data set is presented in Table 1 below.

Table 1: Definitions of the input and output factors

Input factor	**Definition**
Deposits (x_1)	Demand deposit, foreign exchange deposit, time deposit
Fixed assets(x_2)	Lands, equipments, structures, etc.
Capital (x_3)	Total value utilising by banks to raise deposits
Output factor	**Definition**
Non-interest income (y_1)	Interest income subtracted from operating revenue
Investment (y_2)	The aggregate value of bonds and stocks that a bank hold

Results and Discussions

This section provides the summary of the the data, results of the efficiency scores of the nine banks under study based the two DEA models and the related discussions. Table 2 below summarizes the mean and the standard deviation of each of the nine banks for each input and output.

Table2: Mean and standard deviation of the inputs and outputs of nine banks for 2009-2013

		AFIN	MYPB	AMMB	BIMB	COMBS	HOLB	HONG	MALY	RHBC
Deposits	mean	17.4442	17.1759	18.1138	17.201	19.2219	18.3819	18.3808	19.4967	18.5346
	std. dev	0.2025	0.1698	0.1073	0.1577	0.178	0.3096	0.3125	0.2606	0.2205
Fixed Assets	mean	17.7427	17.405	18.4753	17.487	19.5184	18.6047	18.6913	19.8525	18.8402
	std. dev	0.1611	0.141	0.1351	0.1748	0.1733	0.3541	0.3491	0.2534	0.227
Capital	mean	15.6385	15.2775	16.4798	14.951	17.6192	16.3173	16.4418	17.8939	16.789
	std. dev	0.1567	0.0654	0.1455	0.1745	0.2285	0.5452	0.5615	0.2865	0.3514
Non-interest income	mean	14.4204	14.2264	15.4885	14.184	16.5232	14.8396	15.1856	16.802	15.4413
	std. dev	2.008	1.9778	1.7999	1.8846	1.7758	2.1104	1.9369	1.7593	2.0008
Investment	mean	13.5515	13.709	14.2237	10.3874	12.9679	15.1397	15.5247	16.4464	15.8589
	std. dev	0.0722	0.3477	0.3241	0.3134	0.2289	0.4097	0.3925	0.3149	0.2832

Source of original data: annual report of the banks

Note: AFIN: AFFIN HOLDINGS, MYPB: Alliance Financial Group, AMMB: AMMB Holdings, BIMB: BIMB Holdings, COMBS: CIMB Group Holdings, HOLB: Hong Leong Bank, HONG: Hong Leong Financial Group, MALY: Malayan Banking, RHBC: RHB Capital.

Tables 3 and 4 below provide the efficiency scores of the the nine banks for each year under study based on the radial DEA model and the SBM-DEA model respectively. Figures 1 and 2 display the graphs of the efficiency scores of the nine banks based on results in Tables 3 and Table 4 respectively. Figure 1 shows that two banks, Bank Islam Malaysia Berhad (BIMB) and Maybank Berhad (MALY) were fully efficient every year with score of one, while

CIMB Group Holdings (COMB), Ambank Berhad (AMMB) and Alliance Fınancial Group (MAYPB) were fully efficient three years, two years and one year only respectively based on the analysis of DEA radial model. The other four banks, AFFIN Holdings (AFFIN), Hong Leong Bank (HOLB), Hong Leong Fınancial Group (HONG) and RHB Capital (RHBC) were inefficient through out the five years with scores of less than one.

Table 3: Efficiency scores of the nine banks based on the radial DEA model

	2009	2010	2011	2012	2013
AFIN	0.992	0.971	0.967	0.956	0.954
MYPB	0.983	0.974	1.000	0.977	0.981
AMMB	0.992	0.987	0.98	0.974	1.000
BIMB	1.000	1.000	1.000	1.000	1.000
COMBS	1.000	1.000	0.995	0.991	1.000
HOLB	0.983	0.975	0.945	0.971	0.97
HONG	0.99	0.991	0.99	0.977	0.983
MALY	1.000	1.000	1.000	1.000	1.000
RHBC	0.991	0.979	0.978	0.969	0.990

Table 4: Efficiency scores of the nine banks based on the SBM- DEA model

	2009	2010	2011	2012	2013
AFIN	0.977	0.947	0.968	0.950	0.947
MYPB	0.973	0.943	1.000	0.974	1.000
AMMB	0.924	0.912	0.937	0.933	0.932
BIMB	1.000	1.000	1.000	1.000	1.000
COMBS	0.950	0.934	0.951	0.947	0.947
HOLB	0.976	0.972	0.951	0.965	0.976
HONG	0.980	0.972	0.962	0.971	0.981
MALY	0.957	0.930	0.944	0.937	0.940
RHBC	0.971	0.950	0.962	0.954	0.958

However, the efficiency results obtained by the DEA-SBM method gives a more uniform result for each bank for the five-year period. The scores for each bank for that period of time were quite consistent but only BIMB was fully efficient for each year in that five-year period. Table 5 below summarizes the average efficiency score for each bank for each year analyzed by the two DEA models, where based on the radial method, two banks received highest scores for all the five years were BIMB and MALY and AFIN was with the lowest average value. However, based on the SBM model, only BIMB received the full score of one for those five year period, and AMMBis with the lowest efficiency score while Table 6 below displays the average efficiency scores for each year for all nine banks under study. Based on

Table 6, both DEA models give the highest average efficiency for all banks was achieved in year 2009.

Figure 1. Five-year Efficiency Scores of Nine Malaysian Commercial Banks Based on Radial DEA model

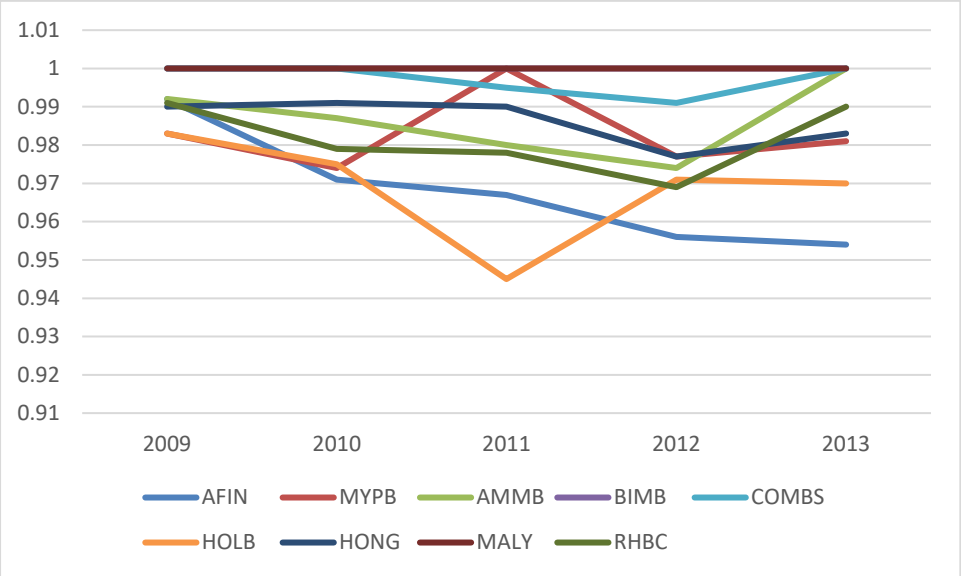

Figure 2. Five-year Efficiency Scores of Nine Malaysian Commercial Banks Based on DEA-SBM model

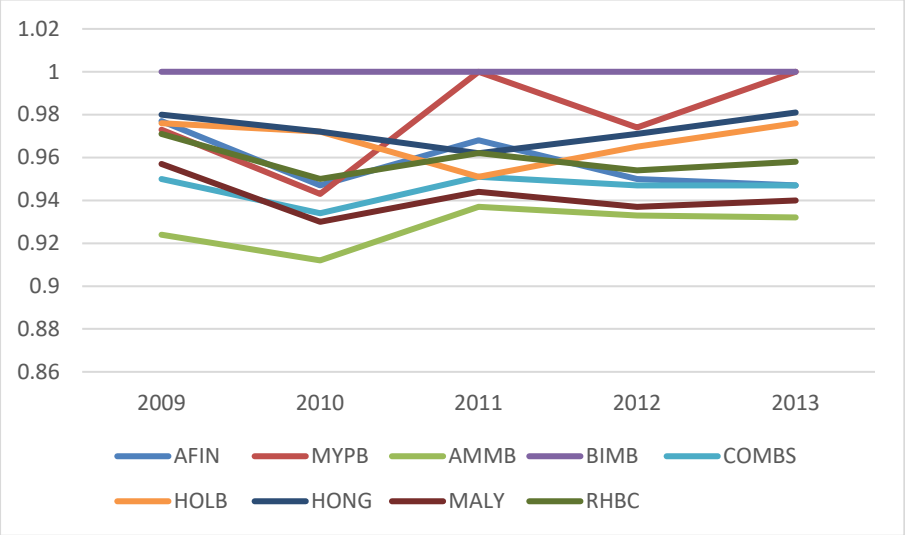

Table 5: Average Efficiency Score for each bank 2009 - 2013 Based on Both DEA Models

	AFIN	MYPB	AMMB	BIMB	COMBS	HOLB	HONG	MALY	RHBC
Radial	0.968	0.983	0.987	1.000	0.997	0.969	0.986	1.000	0.981
SBM	0.958	0.978	0.928	1.000	0.948	0.968	0.973	0.943	0.959

Table 6: Average efficiency scores for all banks for each year under study

	2009	2010	2011	2012	2013
Radial	0.992	0.986	0.984	0.979	0.986
SBM	0.968	0.951	0.964	0.959	0.965

Conclusions

This study employed two DEA models, the radial method that is the traditional method and the slack-based model to evaluate five-year efficiency across a data set specific to the years 2009-2013, of nine commercial banks in Malaysia. Both models measure efficiency with the same interval values from zero to one. However, the SBM-model has a higher discriminant power, where only one bank was fully efficient through-out the five years under study as opposed to two banks were fully efficient when a conclusion is drawn based on the radial DEA method. Moreover, the average efficiency score for each bank for the five-year period based on SBM model was lower than the results based on the traditional method. The same pattern is shown for the average score of all banks for each year under study where results from the SBM model are always lower than results obtained by the radial DEA model. These results show that both methods complement each other as the two methods have different conceptions in measuring efficiency. Hence, the use of these two methods could be extended in measuring performance of other types of DMUs in different sectors because of their ability to give a better picture of the performances of the production system under study.

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