MEASURING THE RISK, EFFICIENCY, AND EFFECTIVENESS OF BANKS IN MALAYSIA USING DATA ENVELOPMENT ANALYSIS MODEL

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Abstract

The banking system plays a significant role in every country by facilitating economic growth and affecting the money supply. However, the phenomenon of rapidly growing foreign banks in Malaysia has led to intense competition between domestic and foreign banks. This scenario has prodded bank managements to improve their performance so as to ensure their banks will remain strong and relevant. The main purpose of this study is to measure and analyze three indicators of profitability, namely the risk, efficiency, and effectiveness of banks in Malaysia from 2015 to 2019 using Data Envelopment Analysis (DEA) method. These three indicators have not been examined together in Malaysian studies that looked at the performance of banks in the country. The study utilized secondary data for eight domestic banks and eight foreign banks in Malaysia. Foreign banks were found to attain slightly higher scores than domestic banks for all the evaluated indicators encompassing risk, efficiency, and effectiveness. Concerning risk, the results can be interpreted as foreign banks were more efficient than domestic banks at managing risk. Overall, foreign banks performed marginally better than domestic banks based on the performance score results.

1. Introduction

The banking system is a key element of the international economy with banks—as the parties that deal with monetary transactions—playing an important role in facilitating the economic growth and development of countries (Ghazi, 2019). Banks serve as the backbone of the financial system and help the country with the utilization of resources. Angeles (2019) defined a bank as a party that channels funds from those who have excess funds to those who need those funds. As the financial institutions and banking system become more effective and stronger, their role in economic development increases through the efficient production of products and services (Abusharbeh, 2017). Given the increasing competition in the financial markets and the need to contribute to the economy, it is imperative that

banks become efficient so as to maintain their business successes. Indeed, an efficient financial system is the main requirement for a nation's economic development as it leads to effective resource allocation, increased productivity, and economic growth (Neves et al., 2020). Meanwhile, an effective financial system indicates how well strategies are accomplished. Banks need to be both efficient and effective to remain competitive and to provide better services to their customers.

The central bank of Malaysia, known as Bank Negara Malaysia (BNM), was established in January 1959. BNM is a statutory body which is wholly owned by the Federal Government of Malaysia. It plays a significant role in the management of the Malaysian economy by promoting monetary and financial stability (BNM, 2018). BNM is responsible for developing the financial system infrastructure so as to ensure all the economic sectors and segments of society have access to financial services. It also serves as the sole authority for the issuance of the national currency and oversees the nation's payment system infrastructure. Its significant role in the growth and development of the economy is evidenced academically and practically in the literature (Osmanovic et al., 2020).

The financial system in Malaysia consists of a diversified range of institutions that serve and cater to the needs of the economy. Commercial banks, Islamic banks, investment banks, and other financial institutions are categorized as banking institutions. The commercial bank category comprises both domestic and foreign banks. There are about 26 licensed commercial banks in Malaysia (BNM, 2019). Malayan Banking Bhd (Maybank), CIMB Group Holdings Bhd, and Public Bank Bhd are recognized by BNM as the top three domestic banks in Malaysia based on the total assets and total net worth of the banks (BNM, 2020). A strong, stable, and efficient banking system is a prerequisite for a sustainable economy as it allows the resources to be allocated efficiently and effectively within the economy. However, the presence of foreign banks in Malaysia has created fierce competition between domestic and foreign banks. Both types of banks are growing rapidly in the country, and these banks compete with each other in producing better products or delivering better services to their customers.

Many recent studies focused on the performance and efficiency of the banking industry (see Amin & Ibn Boamah, 2021; Diallo, 2018; Isshaq & Bokpin, 2012; Le et al., 2022; Lou et al., 2021; Neves et al., 2020; Novickytė & Droždz, 2017; Paradi et al., 2011). Performance is becoming increasingly important for the banks to remain competitive and relevant in the market (Mirzaei et al., 2022). Efficiency estimation in the banking system is useful for individual investment or loan and advances decisions and to judge past and current positions of the banks along with their risk potential. Thus, the efficiency and effectiveness measurements of a bank is linked to bank's performance, and these measurements enable the bank to determine their current performance.

The two-stage data envelopment analysis (DEA) has become a common measurement method for evaluating the performance of the banking industry (Milenković et al., 2022). Most of the recent studies on the banking sector were concerned with only the efficiency and effectiveness measurements, which are important indicators for banking institutions. There is scarce research examining the three indicators of profitability consisting of risk, efficiency, and effectiveness. In running their services and financial activities, banks are also exposed to risk. In fact, risk is one of the indicators that affect the efficiency of banks (Wood & McConney, 2018). Banks face several risks in their operation such as operational risk, credit risk, and liquidity risk. All these risks affect the efficiency of the banking sector. According to Rhanoui and Belkhoutout (2019), the major risks that both Islamic and conventional banks face are operational risk, credit risk, and liquidity risk.

This gap in the literature has motivated the current study to incorporate the risk factor along with efficiency and effectiveness in measuring the performance of banks in Malaysia. This inclusion enables the study to determine the current position of the banks based on two dimensions: performance and risk. Guided by past efficiency studies on the banking sector that mostly used the DEA method, this study also applies DEA to measure risk, efficiency, and effectiveness in a three-stage analysis and to measure the overall performance of the banks.

2. Literature Review

Emrouznejad and Yang (2018) analyzed the most popular keywords in DEA studies from 2015 and 2016, and they found that "two-stage DEA" was the second most popular keyword and the banking sector was one of the most popular fields of study for the application of DEA. This finding shows that two-stage DEA is an emerging and common topic in the literature and that most of the researchers have used it in studies on the banking sector.

The two-stage DEA model consists of several interconnected subprocesses, and classic black box DEA models cannot be used to analyze these subprocess due to their holistic approach (Mohamed, 2020). Therefore, many researchers have implemented various extensions of DEA, such as network DEA, to investigate the performance of different aspects of the banking system. In network DEA, the internal structure of Decision Management Units

(DMUs) is segmented into connected sub-DMUs, and the efficiency is calculated for each sub-DMU (Färe et al., 2007).

Most of the studies on the banking industry in Malaysia employed two-stage DEA models, measuring efficiency at the first stage and effectiveness at the second stage. Efficiency and effectiveness are two inter-related components that are commonly used to assess and measure the performance of organizations (Mouzas, 2006). The performance of both profit and non-profit organizations can be defined as a combination of efficiency and effectiveness. Efficiency measures the ability of an organization to attain the outputs with the minimum level of inputs. Effectiveness measures the ability of the organization to reach its pre-determined goals and objectives which are concerned with matters such as output, sales, quality, innovation, and cost reduction (Mouzas, 2006). Effectiveness is said to describe the policy objectives of the organization are achieved. Thus, effectiveness can be affected by efficiency and can influence efficiency, and it can also have an impact on the overall performance.
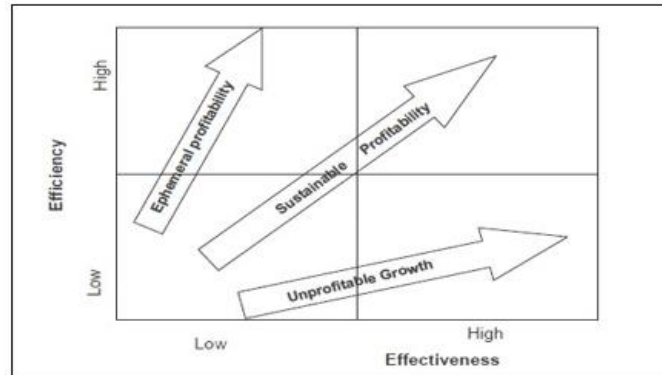

Fig. 1 Efficiency versus effectiveness
Source: Kamarudin et al. (2019)

Figure 1 illustrates the observation on efficiency and effectiveness. It shows that when the organization focuses on efficiency alone and neglects effectiveness, it will gain an ephemeral profitability, which is temporary profit gained. When the organization focuses on effectiveness alone and ignores efficiency, it will experience unprofitable growth and incur losses. Thus, a balance between efficiency and effectiveness is needed so as to attain sustainable profitability and better performance. In this regard, the efficiency and effectiveness of banks require greater attention because these indicators have a substantial impact on banks' productivity, as banks cannot afford to fail due to their importance for producers, consumers, and even to the country (Gupta et al., 2020).

Kamarudin et al. (2014) studied a two-stage DEA model in which deposits and loan were the output of the first stage and became the input for the second stage. Their study investigated how this approach could affect the measurement of efficiency. They found that using deposits as the connecting factor between the first and the second stage substantially impacts efficiency and effectiveness. Later, Kamarudin et al. (2019) conducted research on the performance of Malaysian Islamic banks by using the Constant Return to Scale (CRS) model to assess their effectiveness and efficiency. The study used a two-stage DEA model to determine efficiency and effectiveness in order to calculate the overall performance of 10 selected Islamic banks in Malaysia. In evaluating efficiency at the first stage, assets and expenses were used as the input to produce deposits and loans as the output. Next, the second stage used the previous outputs to evaluate the effectiveness scores for net income and interest income. Their study found that the selected Islamic banks were efficient rather than effective. Ramli et al. (2018) used the same model as Kamarudin et al. (2019) to compare the performance of Islamic banks and conventional banks. Both studies used two stages to evaluate efficiency and effectiveness in order to measure the overall performance of the banks. Ramli et al. (2018) used data from the year 2011 until 2015. The conventional banks showed more remarkable growth than the Islamic banks as evidenced by their higher performance scores. The results obtained indicated that the conventional banks performed better than the Islamic banks.

Another study that evaluated the banking industry in Malaysia was conducted by Yadav and Katib (2015). They applied the two-stage DEA analysis to measure the technical efficiency and the factors affecting the efficiency of development financial institutions (DFIs) from 2006 to 2012. They used two different methods, whereby the efficiency of the DFIs was measured at the first stage using DEA and the factors affecting the efficiency were examined at the second stage using ordinary least squares (OLS) regression analysis. Thus, it seems that the two-stage DEA model has become a common measurement of the efficiency and performance of the Malaysian banking sector.

Moradi-Motlagh et al. (2011) extended the two-stage DEA model by applying a three-stage DEA technique to measure the performance of the Australian banking industry. The study considered the risk factor, efficiency, and effectiveness from 2000 to 2010. The three-stage DEA model produced different results on the overall performance of Australian banks. The study used the DuPont financial ratio analysis method to determine the input and output variables for the DEA model. The DEA model showed that large banks were more effective than small banks. Nonetheless, the small banks achieved higher efficiency scores. For risk, the average risk score of the small banks was greater than that of the large banks during the study period.

Ghebregiorgis and Atewebrhan (2016) conducted a study to evaluate the performance of the banking sector in Eritrea. They measured performance using generated profits, risk, and efficiency. The banks included in their study were the Commercial Bank of Eritrea and the Housing and Commerce Bank of Eritrea, and the sample period was from the year 1997 until 2007. The major financial ratio analysis was employed to evaluate the performance of the banks. The results showed that both banks generally did not record significant improvements in their respective performance throughout the sample period, as indicated by most of the profitability, risk, and efficiency measures. It can be found from previous studies that several bank-specific factors such as size, ownership, capital structure, equity, age, and experience have a significant impact on bank performance.

3. Methodology

Data for this study were obtained from the annual reports of each of the banks from 2015 to 2019 which were available on the respective banks' official websites. The banks used as the decision-making units (DMUs) in this study are listed in Table 1.

Table 1: List of domestic and foreign banks

DMU	Domestic bank	DMU	Foreign bank
1	Affin Bank Berhad	9	Bank of America Malaysia Berhad
2	Alliance Bank Malaysia Berhad	10	Bank of China (Malaysia) Berhad
3	AmBank (M) Berhad	11	Citibank Berhad
4	CIMB Bank Berhad	12	HSBC Bank Malaysia Berhad
5	Hong Leong Bank Berhad	13	Mizuho Bank Berhad
6	Malayan Banking Berhad	14	OCBC Bank (Malaysia) Berhad
7	Public Bank Berhad	15	Standard Chartered Bank Malaysia Berhad
8	RHB Bank Berhad	16	United Overseas Bank (Malaysia) Bhd

Source: Bank Negara Malaysia (2020)

This study uses Dupont financial ratio analysis proposed by Moradi-Motlagh (2011) to decompose the input and output variables for the DEA model. Equation 1 shows that the Dupont analysis requires data on net profit margin, asset turnover, and financial leverage. Since this study uses a three-stage DEA model, the input and output for the first stage are determined by applying the financial leverage concept in Equation 2, where the average assets (output) are divided by equity (input). Hence, equity is regarded as the input to produce assets and employees as output for the first stage. This first stage output will become the input for the second stage. At this stage, the input and output are determined by applying the concept of asset turnover ratio in Equation 3, where revenue or income (output) is divided by the average assets (input). Hence, assets and employees are regarded as inputs to produce net interest income, net non-interest income, and deposit as the outputs of stage two. These second stage outputs will become the inputs for the third stage. At this stage, the input and output are determined by applying the concept of net profit margin in Equation 4. Hence, net interest income, net non-interest income, and deposit are regarded as inputs to generate profit as the output of the third stage. Therefore, the overall inputs and outputs of the variables of the DEA model are in accordance with the DuPont financial ratio analysis.

$$\text{DuPont Analysis} = \text{Net Profit Margin} \times \text{Asset Turnover} \times \text{Financial Leverage} \tag{1}$$

$$\text{Financial Leverage (Equity Multiplier)} = \text{Average Assets} / \text{Average Shareholders' Equity} \tag{2}$$

$$\text{Asset Turnover} = \text{Revenue} / \text{Average Assets} \tag{3}$$

$$\text{Net Profit Margin} = \text{Net Income} / \text{Revenue} \tag{4}$$

The chosen inputs and outputs are shown in Figure 2. In this three-stage DEA model, the first stage evaluates risk to determine the level of usage of borrowed money by the banks. The second stage measures efficiency to determine the ability of the banks to generate income from available assets and resources, and the final stage determines effectiveness to measure the ability of the banks to generate revenue from income. Figure 2 illustrates the stages and the input and output variables of each stage.
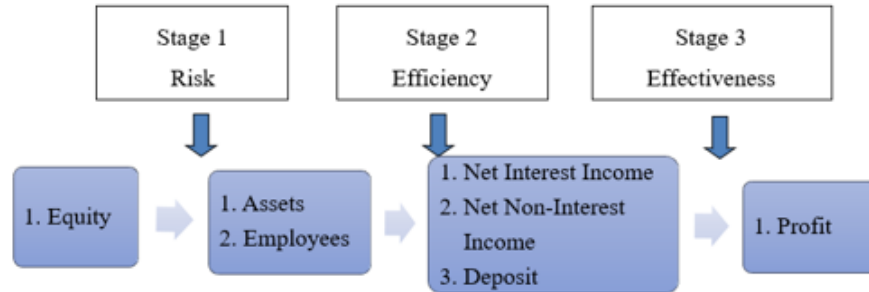

Fig. 2 Input and output variables of the three-stage DEA model

This study uses the DEA model introduced by Banker, Charnes, and Cooper in 1984, also known as the BCC model. This model, which assumes that the reduction in input or increase in output occurs at a non-fixed rate (variable return to scale [VRS]) per unit, is also known as the BCC-VRS model. The model focuses on the value of pure technical efficiency (PTE) score for each unit. In the BCC-VRS model, two orientations are used to measure efficiency, namely input orientation and output orientation. For the input orientation, the perspective is to consider using inputs that can be reduced while trying to maintain the current total output. Meanwhile, the perspective of the orientation output is to consider using output that can be improved while trying to maintain the current amount of input. In this study, the input-oriented DEA is applied.

The BCC model is suitable to be applied due to its flexibility in which the input reduction or output increase occurs at an irregular rate. It uses the VRS method, which provides a clearer picture of the actual situation of the study conducted. The VRS assumption is used not only to determine the efficiency score but also to find out the inefficiency rates which will enable the management to make a detailed analysis of inefficient units and take corrective actions to improve the bank's performance (Wahid, 2016).

The BCC model to calculate PTE under the assumption of VRS is as follows:

$$\text{Maximize} \sum_{r=1}^{s} w_r y_{rj} - u_0$$

Subject to: (5)

$$\sum_{i=1}^{m} v_i x_{ij} = 1$$

$$\sum_{r=1}^{s} w_r y_{rk} - \sum_{i=1}^{m} v_i x_{rk} - u_0 \leq 0$$

$$w_r, v_i \geq 0$$

Under this method, the score of each bank is a number between 0 and 1. The most risky, efficient, and effective banks attain a score of 1, while other banks in the sample gain a score of less than 1. Further, the performance score for each bank is calculated once both scores of efficiency and effectiveness are obtained (Moradi-Motlagh et al., 2011), as per the following equation:

Performance Score = PTE_1 from Stage 2 × PTE_2 from Stage 3 (6)

4. Results and Discussion

4.1 Pure Technical Efficiency (PTE) Score for Stage 1 - Risk

Table 2 presents the risk score results for each bank for the years 2015 to 2019. The banks in Table 2 are categorized into two groups: domestic and foreign banks. The results are obtained using DEAP Version 2.1 software.

Table 2: The PTE Score for Stage 1 (Risk)

Year	2015	2016	2017	2018	2019	
DMU	Score %	Score %	Score %	Score %	Score %	Geometric Mean (DMUs)
Domestic Banks						
1	67.0	72.2	77.1	96.4	88.9	80.0
2	92.3	98.1	93.6	100.0	95.4	95.9
3	70.2	72.7	71.7	85.0	79.9	75.8
4	100.0	100.0	100.0	100.0	100.0	100.0
5	80.8	77.7	76.6	75.1	78.1	77.7
6	100.0	100.0	100.0	100.0	100.0	100.0
7	95.7	98.8	97.9	93.6	96.0	96.4
8	100.0	95.4	90.7	96.1	97.0	95.8
Geometric Mean (Year)	87.2	89.0	88.1	93.1	91.7	
Average of Domestic Bank's Risk Management for 2015 to 2019 = 89.9%						
Foreign Banks						
9	100.0	100.0	100.0	100.0	100.0	100.0
10	76.6	77.8	84.7	91.1	92.6	84.4
11	80.5	90.9	80.5	81.3	80.9	82.8
12	89.7	86.0	80.9	80.8	78.8	83.2
13	81.1	100.0	100.0	100.0	100.0	96.1
14	100.0	100.0	100.0	100.0	100.0	100.0
15	97.8	100.0	96.3	96.8	95.8	97.3
16	90.1	90.3	89.6	93.5	99.4	92.5
Geometric Mean (Year)	89.3	93.0	91.3	92.8	93.3	
Average of Foreign Bank's Risk Management for 2015 to 2019 = 91.9%						
Geometric Mean (All)	88.5	91.0	89.7	92.9	92.5	

Notes: PTE = pure technical efficiency (PTE); PTIE% = Pure technical inefficiency = (1-PTE) × 100; MPSS denotes most productive scale size

The initial phase focuses on determining the level of risk when a bank utilizes the money deposited by its customers. The results show that the banking sector in Malaysia was characterized by small asymmetries between banks regarding PTEs that ranged from 67% to 100%, with an average PTE of 88.5% in 2015 and 92.5% in 2019. Out of the eight domestic banks, CIMB Bank Berhad (DMU$_4$) and Malayan Banking Berhad (DMU$_6$) were the only banks found to be pure technically efficient. Both banks attained the highest risk scores, which could be due to their prominence among the Malaysian financial institutions (Harun et al., 2017). Meanwhile, of the eight foreign banks, Bank of America Malaysia Berhad (DMU$_9$) and OCBC Bank Malaysia Berhad (DMU$_{14}$) were also found to be pure technically efficient, with each bank's PTE score of 100% achieving the unity scale efficiency score.

4.2 Pure Technical Efficiency (PTE) Score for Stage 2 - Efficiency

Table 3 presents the efficiency score results for each bank for the years 2015 to 2019. A score of 100% is interpreted as the bank was efficient, while scores of less than 100% imply inefficiency. Affin Bank Berhad (DMU$_1$) obtained PTE of 95.3% in 2015, which means that DMU$_1$ needed to contract its input by about 4.7% from the actual value in order to operate efficiently in 2015.

Both domestic and foreign banks were observed to be operating with mean values of over 90%. The results also show that foreign banks achieved higher mean (average) PTE scores than domestic banks in 2015, 2016, and 2017. Throughout the study period, the efficiency of the 16 banks ranged from 82.2% to 100%. Further, four domestic banks were constantly efficient, namely CIMB Bank Berhad (DMU$_4$), Hong Leong Bank Berhad (DMU$_5$), Malayan

Banking Berhad (DMU$_6$), and Public Bank Berhad (DMU$_7$). In contrast, only two foreign banks were efficient, which were Bank of America Malaysia Berhad (DMU$_9$) and Citibank Berhad (DMU$_{11}$). Hence, domestic banks had a greater number of fully efficient banks than foreign banks.

Table 3: The PTE Score for Stage 2 (Efficiency)

Year	2015	2016	2017	2018	2019	
DMU	Score %	Score %	Score %	Score %	Score %	Geometric Mean (DMUs)
Domestic Banks						
1	95.3	95.3	88.6	95.7	94.3	93.8
2	100.0	100.0	100.0	99.4	99.1	99.7
3	85.4	82.2	85.5	86.4	82.6	84.4
4	100.0	100.0	100.0	100.0	100.0	100.0
5	100.0	100.0	100.0	100.0	100.0	100.0
6	100.0	100.0	100.0	100.0	100.0	100.0
7	100.0	100.0	100.0	100.0	100.0	100.0
8	91.8	86.8	89.1	91.2	90.7	89.9
Geometric Mean (Year)	96.5	95.4	95.3	96.5	95.7	
Average of Domestic Bank's Risk Management for 2015 to 2019 = 95.9%						
Foreign Banks						
9	100.0	100.0	100.0	100.0	100.0	100.0
10	100.0	100.0	96.4	93.0	87.3	95.3
11	100.0	100.0	100.0	100.0	100.0	100.0
12	87.8	87.4	86.6	88.5	89.7	88.0
13	100.0	97.4	100.0	100.0	100.0	99.5
14	100.0	100.0	100.0	97.7	98.4	99.2
15	86.5	83.7	91.0	90.8	89.0	88.2
16	100.0	100.0	100.0	98.5	93.5	98.4
Geometric Mean (Year)	96.7	96.0	96.7	96.0	94.7	
Average of Foreign Bank's Risk Management for 2015 to 2019 = 96.0%						
Geometric Mean (All)	96.6	95.7	96.0	96.3	95.2	

Overall, DMU$_4$, DMU$_5$, DMU$_6$, and DMU$_7$ from the domestic bank category and DMU$_9$ and DMU$_{11}$ from the foreign bank category were fully efficient, consistently attaining an efficiency score of 100% for each year. In addition, it is clearly shown in Table 3 that the fully efficient banks managed to transform the multiple inputs into multiple financial services efficiently. The bank with the lowest score is assumed to be the least efficient. In this regard, AmBank Berhad (DMU$_3$) consistently scored the lowest for the VRS assumption during the five-year period.

4.3 Pure Technical Efficiency (PTE) Score for Stage 3 - Effectiveness

Table 4 presents the effectiveness score results for each bank for the years 2015 to 2019. The effectiveness scores show how effective the banks were in transforming the outcome of stage 2 to achieve the banks' objectives. A score of 100% is interpreted as the bank was effective, while scores of less than 100% imply they were ineffective. For example, the results revealed that the level of relative effectiveness of Affin Bank Berhad (DMU$_1$) using the VRS assumption was 40.5% in 2015. This result suggests that DMU$_1$ needed to reduce its inputs by 59.5% in order to be effective in 2015. Previously, DMU$_1$ obtained a high score of 95.3% in 2015 for the efficiency measurement under the VRS assumption. The effectiveness and efficiency scores suggest that DMU$_1$ focused on efficiency but disregarded effectiveness in 2015.

The mean effectiveness score of foreign banks was 84.5%, which was slightly higher than the mean effectiveness score of domestic banks of 84.1%. This trend is similar to stage 2, where the mean efficiency of foreign banks was higher than that of domestic banks (see Table 3). Overall, it can be concluded that foreign banks were more efficient and effective than domestic banks during the review period.

Table 4 shows that there were two effective domestic banks, namely Malayan Banking Berhad (DMU$_6$) and Public Bank Berhad (DMU$_7$), during the study period. Similarly, there were two effective foreign banks, namely Bank of America Malaysia Berhad (DMU$_9$) and Mizuho Bank Berhad (DMU$_{13}$). Some of the findings show inconsistent performance of the banks in stage 3 and stage 2, where the number of foreign banks in efficiency score is higher than domestic banks in the previous analysis. For example, CIMB Bank Berhad (DMU$_4$) and Hong Leong Bank Berhad

(DMU$_5$) were fully efficient but they did not perform well in the effectiveness evaluation. Thus, it can be concluded that they operated efficiently but not effectively. These findings are supported by Kamarudin et al. (2014), which found that efficient banks were not usually effective. Nonetheless, DMU$_6$, DMU$_7$, and DMU$_9$ obtained a perfect score in both stages, indicating that these banks operated efficiently and effectively.

Table 4: The PTE Score for Stage 3 (Effectiveness)

Year	2015	2016	2017	2018	2019	
DMU	Score %	Score %	Score %	Score %	Score %	Geometric Mean (DMUs)
Domestic Banks						
1	40.5	72.1	68.2	68.5	68.6	63.1
2	82.9	89.4	84.4	74.7	82.3	82.7
3	100.0	100.0	100.0	91.8	100.0	98.3
4	47.2	62.9	75.1	91.6	69.5	68.6
5	95.0	96.4	91.3	100.0	100.0	96.5
6	100.0	100.0	100.0	100.0	100.0	100.0
7	100.0	100.0	100.0	100.0	100.0	100.0
8	45.7	61.9	70.3	82.1	84.6	68.3
Geometric Mean (Year)	74.5	84.6	85.7	88.2	87.7	
Average of Domestic Bank's Risk Management for 2015 to 2019 = 84.1%						
Foreign Banks						
9	100.0	100.0	100.0	100.0	100.0	100.0
10	75.2	100.0	90.3	84.0	41.2	76.9
11	93.4	100.0	100.0	100.0	100.0	98.7
12	85.5	94.8	92.1	100.0	93.3	93.1
13	100.0	100.0	100.0	100.0	100.0	100.0
14	82.7	83.6	88.1	78.0	77.3	81.9
15	5.1	55.9	66.5	92.1	77.1	56.1
16	63.1	77.5	75.8	76.6	77.2	74.0
Geometric Mean (Year)	72.6	88.3	88.7	91.1	82.2	
Average of Foreign Bank's Risk Management for 2015 to 2019 = 84.5%						
Geometric Mean (All)	73.5	86.5	87.2	89.7	84.9	

The most ineffective bank was Standard Chartered Bank Malaysia Berhad (DMU$_{15}$), which obtained the lowest score every year. This scenario could be caused by a lack of management focus on the effectiveness aspect. Instead, they focused on efficiency, as supported by the findings in Table 3 where DMU$_{15}$ attained quite high efficiency scores throughout the review period. These findings on efficiency and effectiveness show that the bank was purely efficient but ineffective. Thus, DMU$_{15}$ needs to revamp their management and operation skills to be more efficient and effective so as to sustain their business and remain competitive against other banks.

4.4 Performance Score of Each Bank

Table 5 presents the performance score results for each bank from 2015 to 2019. The performance score is a combination of the efficiency and effectiveness indicators. It expresses the overall performance of a particular bank due to the reality of the relationship between efficiency and effectiveness. A high score is associated with high productivity, indicating that the bank operated efficiently and effectively. The bank that obtained a score of 100% is regarded as the best performing bank and selected as a benchmark for other banks. The lowest score is associated with the worst performance in the banking industry. For example, Standard Chartered Bank Malaysia Berhad (DMU$_{15}$) obtained a score of 4.4% in 2015, indicating poor performance in the bank's operation. This scenario was caused by the bank's focus on efficiency while neglecting effectiveness, as shown in Tables 3 and 4 previously.

The mean performance scores show that foreign banks outperformed domestic banks in most of the years. Overall, foreign banks attained a mean of 81.5% for the five-year period, which was slightly higher (0.8%) than the mean of 80.7% recorded by domestic banks. Thus, it can be concluded that foreign banks outperformed domestic banks during the review period.

As shown in Table 5, two domestic banks and one foreign bank scored 100% for each of the five years, indicating that the banks attained perfect scores in both efficiency and effectiveness measurements. The best performing banks for both stages were Malayan Banking Berhad (DMU$_6$), Public Bank Berhad (DMU$_7$), and Bank of

America Malaysia Berhad (DMU$_9$), as these three banks attained the highest performance score. They can be used as a benchmark by other banks due to their efficient and effective operations. Thus, it can be concluded that they not only focused on generating income but also successfully achieved their objectives.

In this study, among the 16 Malaysian banks, the banks with higher efficiency did not always have higher effectiveness. This finding is consistent with the study of Ho and Zhu (2004) on Taiwanese commercial banks. This model not only determines the position of each bank relative to its rivals but also highlights the opportunities for performance improvement in which the banks can improve their performance by increasing either their efficiency or their effectiveness.
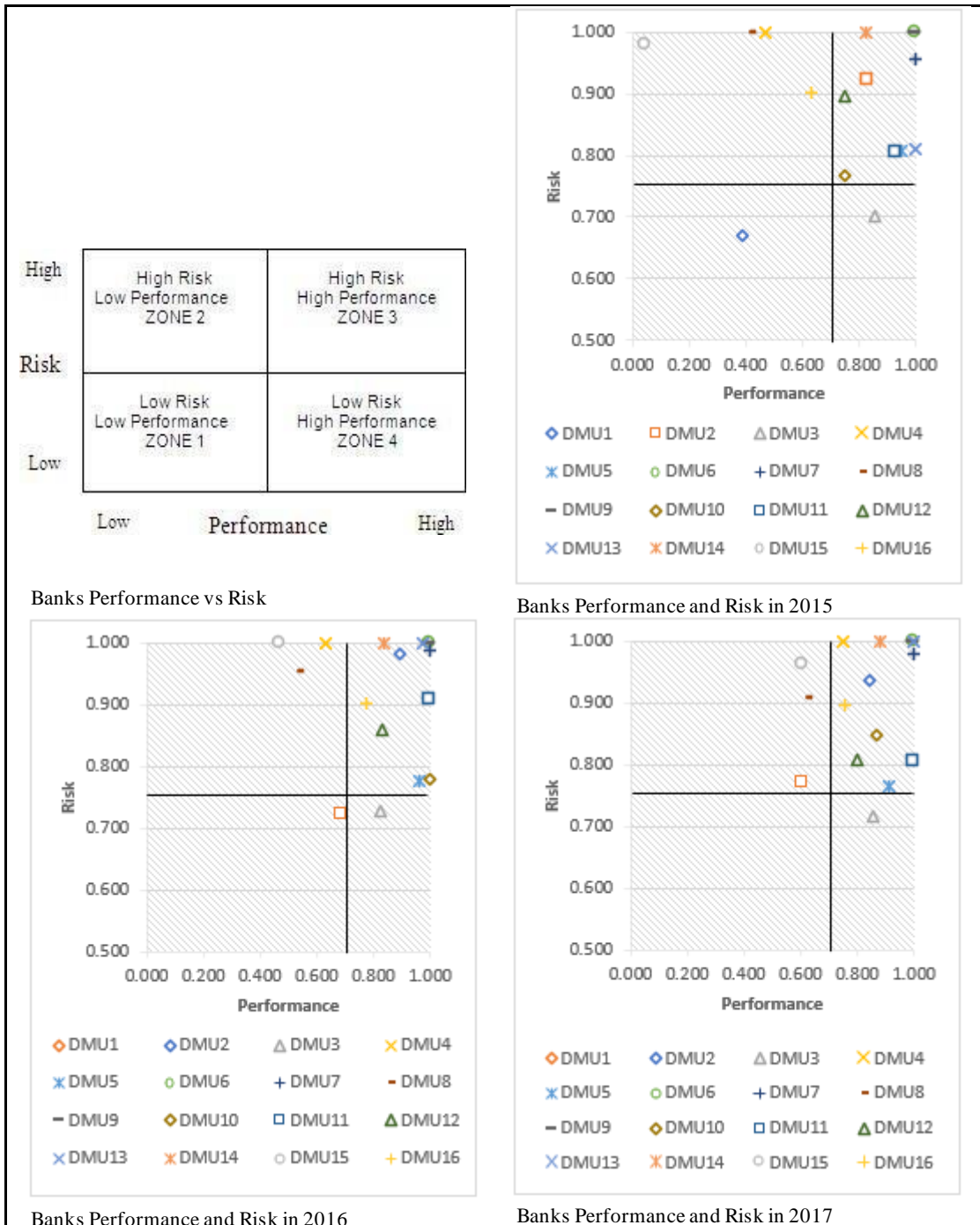
Table 5: The Overall Performance Score

Year	2015		2016		2017		2018		2019		
DMU	Score %	Rank	Score %	Rank	Score %	Rank	Score %	Rank	Score %	Rank	Geometric Mean (DMUs)
Domestic Banks											
1	38.6	15	68.7	13	60.4	16	65.6	16	64.7	15	59.2
2	82.9	8	89.4	8	84.4	10	74.3	15	81.6	9	82.4
3	85.4	7	82.2	11	85.5	9	79.3	10	82.6	8	83.0
4	47.2	13	62.9	14	75.1	13	91.6	7	69.5	13	68.6
5	95.0	5	96.4	7	91.3	6	100.0	1	100.0	1	96.5
6	100.0	1	100.0	1	100.0	1	100.0	1	100.0	1	100.0
7	100.0	1	100.0	1	100.0	1	100.0	1	100.0	1	100.0
8	42.0	14	53.7	15	62.6	14	74.9	14	76.7	10	61.4
Geometric Mean (Year)	72.0		80.9		81.8		85.2		83.9		
Average of Domestic Banks' Performance for 2015 to 2019 = 80.7%											
Foreign Banks											
9	100.0	1	100.0	1	100.0	1	100.0	1	100.0	1	100.0
10	75.2	10	100.0	1	87.0	8	78.1	11	36.0	16	73.8
11	93.4	6	100.0	1	100.0	1	100.0	1	100.0	1	98.7
12	75.1	11	82.9	10	79.8	11	88.5	8	83.7	7	81.9
13	100.0	1	97.4	6	100.0	1	100.0	1	100.0	1	99.5
14	82.7	9	83.6	9	88.1	7	76.2	12	76.1	11	81.3
15	4.4	16	46.8	16	60.5	15	83.6	9	68.6	14	50.1
16	63.1	12	77.5	12	75.8	12	75.5	13	72.2	12	72.7
Geometric Mean (Year)	71.2		85.2		85.9		87.5		78.3		
Average of Foreign Banks' Performance for 2015 to 2019 = 81.5%											
Geometric Mean (All)	71.6		83.0		83.9		86.3		81.1		

4.5 Bank Performance and Risk

Figure 3 illustrates the performance and risk of each bank (DMU) among eight domestic and eight foreign banks in Malaysia from 2015 to 2019. The main contribution of this study is in considering performance and risk together to analyze the position of banks relative to their competitors. Risk is calculated according to the variables in stage 1, and performance is determined by multiplying efficiency and effectiveness (stages 2 and 3).

Figure 3 depicts the position of domestic and foreign banks in terms of performance and risk from 2015 to 2019. To provide a better picture on the real situation, Figure 3 presents an overview of four zones by dividing the average of performance with risk scores of each bank. The zone regions are found to be not identical. The lowest performer among domestic banks was Affin Bank Berhad (DMU$_1$), which was in Zone 1 in 2015. This bank had the lowest performance with changing risk due to its lower scores on efficiency and effectiveness, as presented in Tables 2 and 5. However, consequently, the bank moved its position gradually closer to zone 3 throughout the years. Overall, Figure 3 demonstrates that most of the banks were in zone 3, indicating higher risk and a greater probability of higher performance, as the principle of investment is that high risk is accompanied with high returns.
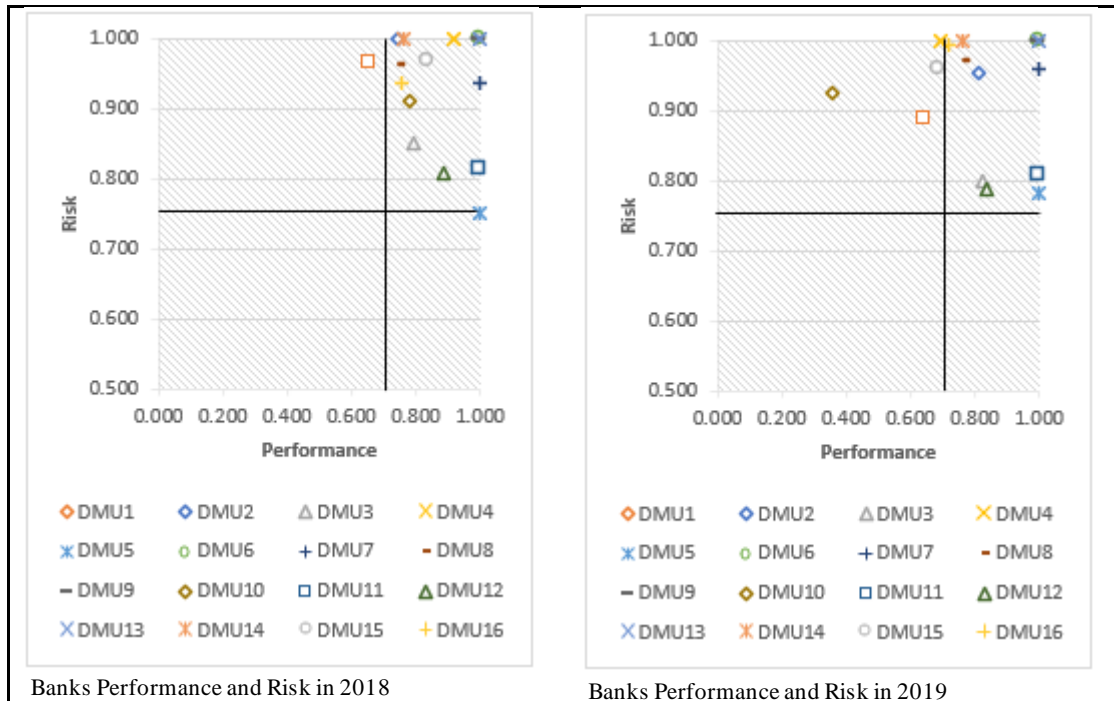
Banks Performance vs Risk

Banks Performance and Risk in 2015

Banks Performance and Risk in 2016

Banks Performance and Risk in 2017

Fig. 3 Malaysian Banks' Performance and Risk from 2015 to 2019

5. Conclusion

Efficient and effective banks lead in providing better services and fulfilling greater customer demand, which enable them to improve their profitability. Unfortunately, the role of the risk indicator has been ignored even though it is one of the important indicators for banking institutions in order to sustain in the long term. In this study, the DEA-BCC model was used to measure the risk, efficiency, and effectiveness of banks in Malaysia. The indicators were chosen due to their importance in determining performance.

The result of this study shows that foreign banks had slightly higher mean risk than domestic banks, with 91.9% and 89.9%, respectively. Foreign banks also scored a higher efficiency score of 96% compared to 95% attained by domestic banks, indicating that foreign banks were more efficient than domestic banks. Similarly, foreign banks seemed to be more effective than domestic banks, with mean values of 84.5% and 84.1%, respectively, during the five-year period. Once the efficiency and effectiveness scores have been obtained, the performance score can be measured. The performance score results also revealed that foreign banks performed marginally better than domestic banks, where the mean performance scores were 81.5% for foreign banks and 80.7% for domestic banks. Through the analysis, this study contributes to two dimensions—risk and performance—in analyzing the performance of banks relative to their competitors in Malaysia. The banks with high risk and high performance may have higher profits due to the link between risk and return.

The findings of this study are important to bank customers who will perceive which banks are more efficient and effective in managing bank assets and resources. Customers will also have an idea which banks perform better, evidenced by the attainment of high performance and risk, which will contribute to the profitability of the banks. The results of this study are also beneficial to both domestic and foreign banks in determining their performance position and benchmarking against the fully efficient banks. The findings may also be useful to the top management in their decision-making process in order to establish the management tools that focus on the risk and efficiency initiatives of banks. The banks will continue to strive for further improvement in their managerial operation to be more efficient and to enhance their product and service offerings to customers. In addition, the findings may be important to Bank Negara Malaysia (BNM) as the banking supervisory body in Malaysia that can implement risk-focused policy and pre-emptive regulation and supervision to the banks. The results may assist BNM to focus on bank improvements in risk management practices and strengthen the governance structures and discipline by making them more efficient. Based on the initiatives taken by BNM, it is important to examine the effects of the risk-focused regulation and improvements on the efficiency of the banks.

6. Authors' Biography

Nur Amira Syifa' Azli received her Bachelor of Administrative Science (Hons) from University Technology MARA and just completed her M. Sc. Quantitative Science in the same university. Her research project is in efficiency measurement in the banking sector. Her interest also includes Supply Chain and Logistics Modelling, Simulation Modeling and Analysis, Applied Data Mining as well as Quality Management and Analysis.

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