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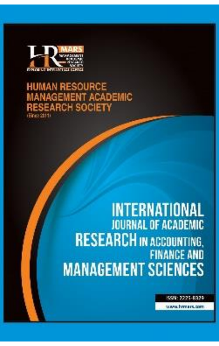

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Wan Nur Irdina binti Muhammad Ghazali, Khairin Nabilah binti Khairollah, Adawiyah binti Tumiran & Zahari bin Md Rodzi

Pusat Pengajian Sains Matematik, Kolej Pengajian Pengkomputeran, Informatik dan Media, Universiti Teknologi MARA Cawangan Negeri Sembilan, Kampus Seremban, Malaysia

Corresponding Author's Email: zahari@uitm.edu.my

Abstract

This study aims to propose the integrated Analytic Hierarchy Process (AHP) with Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS), VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR), and Preference Ranking Organization Method for Enrichment Evaluations II (PROMETHEE II) to calculate the performance of commercial banks in Malaysia before and during covid-19. The information was taken from the financial statements of eight commercial banks in Malaysia for the years 2018 through 2021. Return on Assets (ROA), Return on Equity (ROE), Earnings per Share (EPS), Liquidity, Total Liabilities, and Total Equity are six selected criteria used to evaluate the overall performance of commercial banks. Malayan Banking Berhad (MBB) had the best performance among Malaysian commercial banks, according to the findings of the research. The AHP-VIKOR and AHP-PROMETHEE II methods demonstrated that Malayan Banking Berhad remained number one for four years. Using the TOPSIS methodology, Malayan Banking Berhad is also ranked first for the years 2020 and 2021. In contrast, Alliance Bank had the worst performance among Malaysian commercial banks. Using the AHP-VIKOR and AHP-PROMETHEE II methods, Alliance Bank's ranking has remained unchanged from 2018 to 2021. In addition, the AHP-TOPSIS method only recorded Alliance Bank in last place for 2018 and 2019. The final trend results for the eight commercial banks in AHP-VIKOR and AHP-PROMETHEE II are virtually identical.

Keywords: Commercial Bank, Malaysia, AHP, TOPSIS, VIKOR, PROMETHEE II

Literature Review

The background theory and literature review of the our research will be covered in this section.

AHP

AHP is particularly useful in group decision-making and is used in a wide range of decision-making scenarios around the world, including government, business, industry, healthcare, and education. AHP is a mathematical model that also employs psychology to aid in the analysis and organization of difficult decisions. It differs from other decision-making strategies in that it recommends quantifying the evaluation criteria Thus, the three fundamental functions of AHP technique are structuring complexity, measurement, and synthesis (Skibniewski and Chao, 1992).

The AHP is most useful for solving complex problems with large stakes. It differs from previous decision-making methods in that it quantifies criteria and possibilities that are generally difficult to quantify with clear numbers. Rather than prescribing a "right" answer, AHP assists decision-makers in identifying the option that best fits their beliefs and understanding of the problem. This approach uses a clearly defined scale to quantify those previously qualitative characteristics, allowing the effect of interaction between the parts in the hierarchy to be completely reflected in the decision-making process. Another infrequently used AHP technique was rating, sometimes known as absolute judgment, which can make the AHP application faster and easier (Russo and Camanho, 2015).

TOPSIS

In the year 1981, Hwang and Yoon created the TOPSIS approach. The chosen option should be the furthest away from the negative-ideal solution and the closest to the perfect answer, according to the core rationale behind it (Zulqarnain et al., 2020). The Multiple-Criteria Decision Method (MCDM) such as TOPSIS Method is used to assist decision makers for determining which answer is the best in multiple ways. For dealing with financial difficulties, TOPSIS is the most extensively utilised MCDM approach (Abd Rahim et al., 2020). TOPSIS is a practical and helpful approach for employing distance metrics to rank and choose several externally determined options.

In other studies, the classical TOPSIS technique is based on attribute information from the decision maker and numerical data; the solution is targeted at assessing, prioritising, and choosing, using weights as the only subjective input (Latuszyńska, 2014). The fundamental flaws of TOPSIS are that it lacks weight elicitation and consistency testing for judgements; on the other hand, the application of AHP has been severely limited by human capacity for information processing. From this perspective, TOPSIS eliminates the need for paired comparisons, and the capacity constraint may not have a substantial impact on the process.

VIKOR

The VIKOR technique was developed as an MCDM strategy for dealing with incommensurable and conflicting criteria un a discrete multi-criteria problem. Its purpose is to give a neutral technique to ranking and selecting based on competing criteria. The compromise solution is the most practical choice that is closest to the ideal solution (Opricovic and Tzeng, 2004). Opricovic created VIKOR, which is primarily used for material selection in various industries based on distance-to-target MCDM techniques (Gao et al., 2019). The VIKOR approach was designed as a multi attribute decision making method to tackle a discrete decision-making problem with non-commensurable (different units) and conflicting criteria.

It introduces the multi-criteria ranking index, which is based on a specific measure of "closeness" to the "ideal" answer (distance-to-target). This strategy focuses on ranking and selecting among a group of alternatives and determining a compromise solution for a problem with competing criteria, which can assist decision makers in arriving at a final solution (Sayadi et al., 2009).

PROMETHEE II

PROMETHEE II is a comprehensive MCDM method developed by J.P. Brans and expanded upon by Vincke and Brans in 1982 (Brans and Vincke, 1985). This system has three categories: PROMETHEE I (partial rating), PROMETHEE II (complete ranking), and PROMETHEE III (interval ranking). PROMETHEE II requires highly particular data from analysts and decision-makers to rate the options completely. PROMETHEE II is the most user-friendly and efficient method for dealing with diverse quantitative and qualitative scales, as well as categorising alternatives based on net outranking flow values (Isa et al., 2021).

In other research, the PROMETHEE II technique is used to rank public banks based on criteria for assessing their financial condition (Ceren, 2013). The PROMETHEE II method was chosen for its simplicity and ability to rank public banks based on their financial performance before and throughout the global crisis. The PROMETHEE II complete ranking is based on calculating the net outranking flow value, which represents the balance between the positive and negative outranking flows. As the net flow rises, so does the quality of an alternative.

Return on Asset (ROA) and Return on Equity (ROE)

The impact of Return on Asset (ROA) on the performance of banks has been well researched. According to Lai et al (2015), each bank's financial ratios will be evaluated in their study to identify the level of improvement in each measure of financial performance. They feel this is due to their bank's conservative strategy in dealing with business, although they remain the only bank with a better ROA. For example, a study of six banks in Malaysia exhibited an increase in ROA while just three banks showed a decline. However, all banks have improved their ROE ratio (Lai et al., 2015).

The analysis of financial firms is extremely important to investors in stock market investments (Liew et al., 2016; Jakpar et al., 2017). The amount of success of the firms is measured by their financial performance. The researchers use the TOPSIS method to analyse the financial performance of the banks in Malaysia. They also stated the most ideal alternatives strive to maximise the parameters that must be optimised, such as ROA and ROE. These recent studies have begun to provide into how Return on Asset (ROA) and Return on Equity (ROE) will affect the performance of banks.

Earnings per Share (EPS)

Sulub and Salleh (2019), stated that EPS has been used to assess the financial performance of a bank. The finest ideal alternatives, according to Liew et al (2016), attempt to maximise the EPS. Lai et al (2015) stated that although several merging banks' share values fell, the explanation could have been a conflict of interest between shareholders and management, especially during the post-merger period, when shareholders and management staff did not share the same objective and motif. EPS can be negative if the banks is losing money. Most crucially, commercial banks may choose to spend their revenues in new product development or core business assets. Although the bank keeps some of its earnings in this scenario, the action does not indicate that the bank is in bad financial shape. This reinvestment could result in increased earnings per share in the future. The results of the previous study by Sulub and Salleh (2019) demonstrated that Conventional Banks outperform Islamic Banks in Malaysia, at least for the sample banks picked.

Lai et al (2015)stated that pre-merger EPS data are lower than post-merger EPS figures since Malaysian banking consolidation was badly damaged by the Asian financial crisis, which also hurt the banks' earnings. The growth in EPS indicates that the new bank's earning ability is improving (Jakpar et al., 2017).

Liquidity
The impact of bank liquidity on the bank's performance in Malaysia has been well researched. Financial ratios have been frequently utilized as a tool for financial performance analysis. Zakaria et al (2021a), study shows that banks with large board size and higher average age among board members are positively related to bank performance. They also focus on the effectiveness of board diversity to enhance bank performance in Malaysia. For example, a study based on the performance of six Malaysian commercial banks are negatively affected by bank liquid as they are measured by Net Interest Margin (NIM) and Tobin (Zakaria et al., 2021b). Thus, in terms of bank efficiency, it shows strong negative and significant connection to bank performance in all models. The Hausman test is used to test the hypotheses on fixed effects models in panel data of the performance of Malaysian commercial banks.
According to other studies, the financial ratios calculated were used as the evaluation factors in the multi-criteria decision-making method Technique for Order of Preference by Similarity (TOPSIS) (Gümrah, 2016). As multi-criteria decision-making approaches are widely utilized in selecting the best one among alternatives, some of the researchers utilize TOPSIS which is considered as one of the powerful mathematical models that has ability to solve multi-criteria decision-making problems. The researchers used liquidity in measuring the performance of participation banks by the TOPSIS method. These studies can also compare the ranking result by employing various multi-criteria decision-making models to test their robustness.

Debt Ratio
According to Sulub and Salleh, (2019), the risk of the increased debt is that the bank will go bankrupt and will be unable to meet its commitments on time. A high debt ratio usually suggests an ambitious expansion plan. For investors, this means possibly higher earnings, but also a higher possibility of losing money. The methods used by the researchers in this study are Financial Ratios method and Vector Auto-regression (VAR) method. For example, the debt ratios are positively correlated with total assets respectively. This means that if total assets grow, so will return on equity and debt ratio, and vice versa. The positive link between debt and assets, on the other hand, indicates that larger banks have easier access to capital.

Methodology

This study focused primarily on eight commercial banks in Malaysia. The ROE, ROE, EPS, total liabilities, total equity, and liquidity have been used to evaluate the bank's performance. The information for the years 2018 through 2021 was obtained from each bank's financial report. The study's methodology is depicted in Figure 1.

AHP

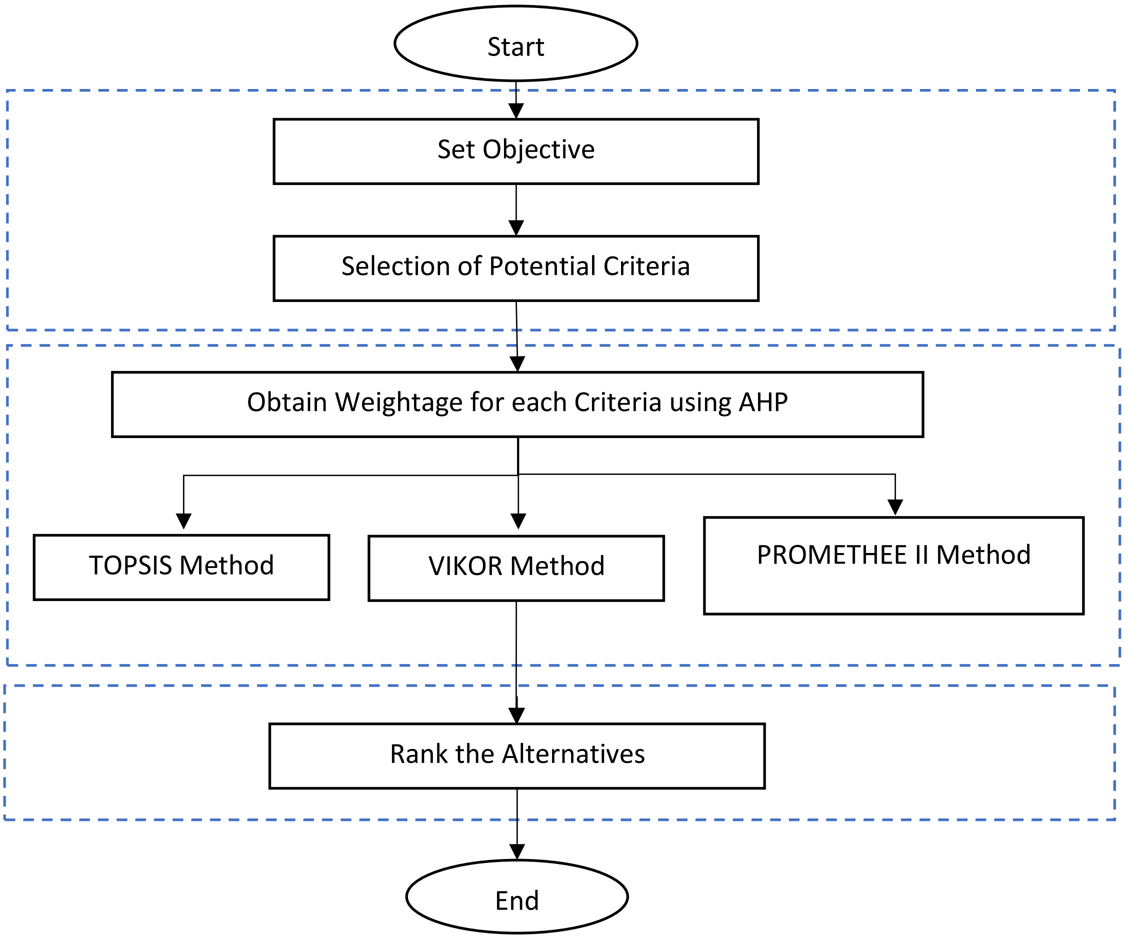

Figure 1. The Methodology

Step 1: Create a Hierarchical Structure to describe the decision issue, with the top level reflecting broad objectives or aims, the intermediate levels representing criteria and sub-criteria, and the bottom level offering choice possibilities (Saaty, 2008).

Step 2: Create a matrix of pairwise comparison. The reciprocal of K_i relative significance over K_j is $K_{ij} = \frac{1}{K_{ij}}$. A reciprocal pairwise comparison matrix A is then formed using K_{ij}, for all *i* and *j*. Note that $K_{jj} = 1$.

$$K'_{ij} = \frac{K_{ij}}{\sum_{j=1}^{6} K_{ij}} \quad (1)$$

$$Weightage = \frac{\sum_{i=1}^{6} K_{ij}'}{6} \quad (2)$$

Step 3: Calculation of the maximal eigenvalue and normalised weight. By dividing each column's entries by the sum of '*A*' column entries, the pairwise comparison matrix is normalised.

$$K''_{ij} = K_{ij} \times \frac{\sum_{i=1}^{6} K_{ij}'}{6} \quad (3)$$

$$Ratio = \frac{\sum_{i=1}^{6} K''_{ij}}{\frac{\sum_{i=1}^{6} K_{ij}'}{6}} \quad (4)$$

$$\lambda max = \frac{Ratio}{6} \quad (5)$$

Step 4: Calculate the consistency ratio (CR) and consistency index (CI). The consistency must be less than 0.10.

$$CI = \frac{\lambda max - n}{n-1} \quad (6)$$

$$CR = \frac{CI}{RI} \quad (7)$$

Step 5: Establish priorities final from the consistent expertise.

TOPSIS

Step 1: Construct a decision matrix.

Construct a matrix with m options and n criteria for evaluating them. The score of each choice in relation to each criterion is x_{ij}, and then a matrix $(x_{ij})_{m\times n}$ is created (Liew et al., 2016).

Step 2: Normalized decision matrix.

Construct a normalised decision matrix $R = (r_{ij})_{m\times n}$ by transforming multiple attribute dimensions into non-dimensional attributes and using the normalising approach as indicated below to allow comparisons across criteria.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, i = 1,2, \dots, m, j = 1,2, \dots, n \quad (8)$$

Step 3: Formation of nominal normalized decision matrix (T).

Calculate the weighted normalized decision matrix as follow:

$$T = (t_{ij})_{m\times n} = (w_i r_{ij})_{m\times n}, i = 1,2, \dots, m \quad (9)$$

Step 4: Determine the best ideal (A_b) solution and the worst ideal (A_w) solution:

$$A_b = \{\langle \min (t_{ij}|i = 1,2, \dots, m)| j \in J_-\rangle, \langle max(t_{ij}|i = 1,2, \dots, m)| j \in J_+\rangle\} \equiv \{t_{bj}| j = 1,2, \dots, n\} \quad (10)$$

$$A_w = \{\langle \max (t_{ij}|i = 1,2, \dots, m)| j \in J_-\rangle, \langle min(t_{ij}|i = 1,2, \dots, m)| j \in J_+\rangle\} \equiv \{t_{wj}| j = 1,2, \dots, n\} \quad (11)$$

where,

$J_+ = \{j = 1,2, \dots n \,|j$ associates with the criteria having a positive impact and

$J \quad = \{j = 1,2, \dots n \,|j$ associates with the criteria having a negative impact and

Step 5: Calculate of separation measures for each alternative.

Determine the separation measures for each alternative. The following formula is used to separate the positive ideal solution from the negative ideal solution:

$$d_{ib} = \sqrt{\sum_{j=1}^{n}\left(t_{ij} - t_{bj}\right)^2}, i = 1,2, \ldots, m \quad (12)$$

The separation from the negative ideal solution is formulated as follow:

$$d_{iw} = \sqrt{\sum_{j=1}^{n}\left(t_{ij} - t_{wj}\right)^2}, i = 1,2, \ldots, m \quad (13)$$

Step 6: Calculate the relative distances to the ideal solution:
Calculation of relative distances to the ideal solution s_{iw} in which s_{iw} represents the relative closeness coefficient. s_{iw}= 0 if and only if the alternative solution has the worst condition whereas $s_{iw} = 1$ if and only if the alternative solution has the best condition.

$$s_{iw} = \frac{d_{iw}}{d_{ib}+d_{iw}}, 0 \leq s_{iw} \leq 1, i = 1,2, \ldots, m \quad (14)$$

Step 7: Alternatives are calculated in the context of existing criteria and ranked depending on their proximity to the ideal solution. Rank the alternatives according $s_{iw} = (i = 1,2, \ldots, m)$in descending order and select the alternative with the highest value of S_{iw} which is closest to 1. The alternative that is closest to the ideal solution is the best alternative.

VIKOR
Step 1: Construct a decision matrix.
Construct a matrix that the score of each choice in relation to each criterion is m_{ij}.
Step 2: Determine best $(m_{ij})max$ and the worst, $(m_{ij})min$ values.
The second step is to determine the objective, and to identify the pertinent evaluation attributes. Also determine the best $(m_{ij})max$ and the worst, $(m_{ij})min$, values of all attributes.
Step 3: Compute the utility measure and the regret measure.
Next calculate the values of $E_i$and F_i where $E_i$and F_i represent the utility measure and the regret measure, respectively and w_j is the weight of the j_{th} criterion.

$$E_i = \sum_{j=1}^{M} w_j \left[m_{ij_{max}} - m_{ij}\right]/\left[m_{ij_{max}} - m_{ij_{min}}\right] \quad (15)$$

$$F_i = Max^m \left\{\sum_{j=1}^{M} w_j \left[m_{ij_{max}} - m_{ij}\right]/\left[m_{ij_{max}} - m_{ij_{min}}\right] \; j = 1,2,3, \ldots. M\right\} \quad (16)$$

Step 4: Compute the performance score values.
After then calculate the value of P_i where $E_i - max$ is the maximum value of E_i, and $E_i - min$ the minimum value of E_i, $F_i - max$ is the maximum value of F_i, and $F_i - min$ is the minimum value of F_i and *v* is introduced as weight of strategy of 'the majority of criteria' (or 'the maximum group utility'), here $v = 0.5$.

$$P_i = v\left[\left(E_i - E_{i_{min}}\right)/\left(E_{i_{max}} - E_{i_{min}}\right)\right] + (1 - v)\left[\left(F_i - F_{i_{min}}\right)/\left(F_{i_{max}} - F_{i_{min}}\right)\right] \quad (17)$$

Step 5: Rank the alternatives sorting by the values E_i, F_i, and P_i .
Arrange the alternatives ascending order, according to the values of P_i. Similarly, arrange the alternatives according to the value of E_i and F_i separately. Thus, three ranking lists can be obtained.
Step 6: Propose as a solution the alternative which is the best ranked (minimum value).

Propose as a compromise solution the alternative which is ranked the best by the minimum *Q* if the following two conditions are satisfied:

C1. "Acceptable advantage":
Q(p'') − Q(p') ≥ DQ, where *p''* is the alternative with second position in the ranking list by *Q*, *DQ* = 1/ (*m* − 1) and *m* is the number of alternatives.

C2. "Acceptable stability in decision making":
Alternative *p'* must also be the best ranked by *E* or/and *F*. This compromise solution is stable within a decision-making process. This compromise solution is stable within a decision-making process, which could be: "voting by majority rule" (when $v > 0.5$ is needed), or "by consensus" ($v \approx 0.5$), or "with vote" ($v < 0.5$). Here, v is the weight of the decision-making strategy "the majority of criteria" (or "the maximum group utility"). If one of the conditions is not satisfied, then a set of compromise solutions is proposed.

PROMETHEE II
Step 1: Construct the decision matrix.
Construct a matrix that the score of each choice in relation to each criterion is X_{ij}.
Step 2: Normalize the decision matrix by using the equation below for beneficial criteria and non-beneficial criteria, respectively.

$$R_{ij} = \frac{[X_{ij} - \min(X_{ij})]}{[\max(X_{ij}) - \min(X_{ij})]},\ i = 1,\ 2, \ldots, m : j = 1,\ 2, \ldots, n \text{ (Beneficial criteria)} \quad (18)$$

$$R_{ij} = \frac{[\max(X_{ij}) - X_{ij}]}{[\max(X_{ij}) - \min(X_{ij})]},\ i = 1,\ 2, \ldots, m : j = 1,\ 2, \ldots, n \text{ (Non-beneficial criteria)} \quad (19)$$

where X_{ij} is the performance measure of i^{th} alternative with respect to j^{th} criterion.

Step 3: Calculate the evaluative differences of i^{th} alternative with respect to another alternative, $d_j(a,b)$ by using:

$$d_j(a,b) = g_j(a) - g_j(b) \quad (20)$$

This step involves the calculation of differences in criteria values between different alternatives pairwise.
Step 4: Calculate the preferences function, $P_j(a,b)$ using:

$$P_j(a,b) = 0 \ \ if \ R_{aj} \le R_{bj} \text{ such that } D(M_a - M_b) \le 0 \quad (21)$$

$$P_j(a,b) = \left(R_{aj} - R_{bj}\right) \ if \ R_{aj} > R_{bj} \text{ such that } D(M_a - M_b) > 0 \quad (22)$$

Step 5: Calculate the aggregated preference function, $\pi(a,b)$ considering the criteria weights.
Aggregated preference function,

$$\pi(a,b) = \frac{\sum_{j=1}^{n} w_j P_j(a,b)}{\sum_{j=1}^{n} w_j} \text{ where } \sum_{j=1}^{n} w_j = 1 \quad (23)$$

Given that $\sum_{j=1}^{n} w_j$ is the sum of the weight for criteria, where w_j is the relative importance (weight) of j^{th} criterion.
Step 6: Determine the leaving and entering outranking flows.
Leaving (or positive) flow for a^{th} alternative,

$$\varphi^{+}(a) = \frac{1}{m-1} \sum_{b=1}^{m} \pi(a,b) \ \ where \ (a \ne b) \quad (24)$$

Entering (or negative) flow for a^{th} alternative,

$$\varphi^{-}(a) = \frac{1}{m-1}\sum_{b=1}^{m} \pi(b,a) \ where \ (a \neq b) \quad (25)$$

where m is the number of alternatives.
Each choice is confronted with $(m-1)$ other possibilities. The leaving flow expresses how much an alternative dominates the other alternatives. Based on these outranking flows, the PROMETHEE I method can provide a partial pre-order of the alternatives, whereas the PROMETHEE II method can give the complete pre-order by using a net flow, though it loses much information of preference relations.
Step 7: Calculate the net outranking flow for each alternative.

$$\varphi(a) = \varphi^{+}(a) - \varphi^{-}(a) \quad (26)$$

Step 8: Determine the ranking of all the considered alternatives depending on the values of $\varphi(a)$. The higher value of $\varphi(a)$, the better is the alternative. Thus, the best alternative is the one having the highest $\varphi(a)$ value.

Results and Discussions
Table 1 shows the overall performance of commercial banks in Malaysia before and after COVID-19 from 2018 to 2021. We can see roughly the ranking of performance of commercial banks in each method we use.

Table 1
Ranking of Commercial Banks from 2018 to 2021

	AHP-TOPSIS				AHP-VIKOR				AHP-PROMETHEE II			
	2018	2019	2020	2021	2018	2019	2020	2021	2018	2019	2020	2021
MBB	2	2	1	1	1	1	1	1	1	1	1	1
CIMB	6	7	8	7	5	6	6	7	2	2	2	2
HLBB	3	3	2	2	4	4	4	3	6	5	5	4
ABMB	8	8	5	6	8	8	8	8	8	8	8	8
ABB	4	5	6	4	7	7	7	6	7	7	7	7
PBB	1	1	3	3	2	2	2	2	3	3	3	3
RHB	7	6	7	8	6	5	5	5	5	6	6	6
AMBB	5	4	4	5	3	3	3	4	4	4	4	5

Overall, MBB recorded the first ranked performance of commercial banks in Malaysia. It can be proven by the AHP-VIKOR and AHP-PROMETHEE II methods, which stated that MBB remained at the number one ranking in these four years. By using AHP-TOPSIS method, MBB also in first rank in 2020 and 2021. Meanwhile, ABMB recorded the last ranked performance of commercial banks in Malaysia. It is because, by using the AHP-VIKOR and AHP-PROMETHEE II methods, ABMB remained the same from 2018 to 2021 in the last rank. In addition, the AHP-TOPSIS method also recorded ABMB in the last rank for the years 2018 and 2019 only.

Conclusions
Analyses of financial performance based on MCDM present a challenging scientific problem. The optimal MCDM method must be selected. The precision of the measurements depends on the mathematical foundations of the techniques and their suitability for the task. Additionally, it is essential to accurately model reality.

This study contrasts and compares the benefits of various MCDM and weighting methods from the perspective of financial data users. Financial decision-makers, including business owners, company managers, suppliers, investors, shareholders, and creditors, require more accurate information regarding a company's actual performance. Users of financial data require a benchmark in order to determine the best company.

The findings of this study indicate that AHP-TOPSIS and AHP-VIKOR are more comparable to one another than PROMETHEE II. As a result, the AHP-TOPSIS and AHP-VIKOR procedures are suggested for use in future MCDM financial issues, as well as the addition of additional criteria such as debt ratio, capital risk, shares, loans, inflation rate, bank size, and management quality to improve the accuracy of rankings.

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