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Research Article

A STUDY COMPARATIVE OF PSI, PSI-TOPSIS, AND PSI-MABAC METHODS IN ANALYZING THE FINANCIAL PERFORMANCE OF STATE-OWNED ENTERPRISES COMPANIES LISTED ON THE INDONESIA STOCK EXCHANGE

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Abstract: This research provides deeper insight into the advantages and disadvantages of each MCDM method in the context of evaluating SOE performance rankings. This research also shows the peformance of PSI which is used singly and integrated with other MCDM methods to determine the company's financial health. Financial health can be reviewed through the company's financial performance based on its financial ratios. The financial ratio criteria used include Current Ratio (CR), Debt to Equity Ratio (DER), Total Asset Turnover (TATO), and Return on Asset (ROA) as the basis for ranking. The *Preference Selection Index* (PSI) method is used to determine the weight of criteria and analyze the company's ranking through the identified criteria, while the *Preference Selection Index-Technique for Order of Preference by Similarity to Ideal Solution* (PSI-TOPSIS) and *Preference Selection Index-Multi-Attributive Border Approximation Area Comparison methods* (PSI-MABAC) is used to continue the weighting process on the PSI method with the results of the rankings of state-owned companies listed on the IDX. The Spearman rank correlation was determined to compare the PSI, PSI-TOPSIS, and PSI-MABAC methods.

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The results of the comparative analysis showed that PSI-TOPSIS and PSI-MABAC had a greater correlation compared to PSI.

Keywords: SOEs, MCDM, Hybrid MCDM, ranking analysis, financial ratios.

MSC: 62C99, 62P05, 90B50, 91B28

1. INTRODUCTION

State-Owned Enterprises (SOEs) have a strategic role in supporting a country's economic development [1]. SOEs play an important role in European countries by providing public goods, supporting infrastructure, reducing market inequality, maintaining economic resilience, and encouraging industrialization [2]. In Indonesia, SOEs play an important role in various economic sectors, including finance, infrastructure, energy, transportation and logistics, basic materials, and health [3]. Despite having a significant strategic role, SOEs in Indonesia face several performance-related problems.

Some of the issues that arise involve issues of operational efficiency, management transparency, and good corporate governance. Weaknesses in SOE management cause suboptimal performance, even causing financial losses. In addition, the issues of corruption, collusion, and nepotism in the management of SOEs are serious obstacles that need to be overcome to improve the integrity and sustainability of company performance [4]. Therefore, understanding the extent of the contribution of SOEs to the economy, its efficiency, and how well the company manages risk needs to be evaluated through financial performance.

Financial analysis is one way to evaluate the performance of SOEs. Financial ratios are often used in this analysis to measure a company's health and sustainability [5][6]. In addition, financial ratios also play a role in helping the decision-making process for stakeholders. This ratio serves as an indicator that allows to assessment such aspects of the company's performance as liquidity, profitability, solvency, and activity. Liquidity ratio interpreted by the *Current Ratio* (CR) indicates the extent to which short-term liabilities can be covered by a company's short-term assets [7]. The profitability ratio interpreted by *Return on Asset* (ROA) evaluates how a company uses its assets to make a profit [7]. Solvency Ratio interpreted by *Debt to Equity Ratio* (DER) has an important role in providing insight into the risk, stability, cost of capital, and investment attractiveness of the company [8]. Activity ratio interpreted by *Total Asset Turnover* (TATO) measures how effectively a company uses its assets to generate sales. TATO provides an understanding of the efficiency and asset management of a company [9].

In complementing SOE financial analysis, decision-making techniques can provide additional holistic dimensions and enable stakeholders to prioritize and assess the financial health of SOEs based on several predetermined criteria. Decision-making is an important process that requires careful and comprehensive analysis in the business world. In the context of state-owned companies, financial performance evaluation is crucial in determining the company's strategic direction [10]. This financial performance evaluation involves several methods developed to identify, analyze, and rank a company's financial performance in support of appropriate decision-making.

The Multi-Criteria Decision-Making (MCDM) method can be used to evaluate financial performance [11]. Decision-making technique (MCDM) is a tool used to make decisions in operations research. MCDM is a scientific discipline that assists decision

makers in selecting or ranking alternatives after qualitative or quantitative assessment of limited criteria in order to achieve optimal choices [12]. The MCDM framework is divided into four elements: alternatives (known as options, objects or choices), criteria (known as attributes or decision factors), weighting on criteria, and ranking alternative performance based on criteria [13].

Criteria weighting in MCDM is one of the main problems often faced in selecting alternatives based on relevant criteria. The problem occurs due to the sensitivity of determining weights that are carried out subjectively. In addition, the relative importance in determining the weights becomes difficult to measure which causes inaccuracies in decision making. Therefore, to handle this weighting problem, an objective weighting method is carried out where in determining the weight of the criteria, there is no need to pay attention to the relative importance between attributes which can be done using the Preference Selection Index (PSI) method. PSI method is an MCDM method developed by K. Maniyaa and M.G. Bhatt [14]. This method uses the concept of preference index by determining the weight of each criterion based on consideration of beneficial and unprofitable attributes (cost) without determining the relative importance between attributes for ranking alternatives. This method is able to optimally determine the weight based on the value of the given decision matrix.

In this study, PSI is used singly and a hybrid approach was carried out by combining PSI with the TOPSIS and MABAC methods. The PSI method provides flexibility in adjusting the weight of criteria according to existing preferences so as to reduce subjectivity in determining weights [15]. PSI-TOPSIS integrates the advantages of PSI in determining the weight of criteria with the TOPSIS method to rank the evaluated alternatives using the concept of the closest distance to the positive ideal solution and the farthest distance to the negative ideal solution. While PSI-MABAC uses PSI in determining the weight of the criteria and the MABAC method to rank each alternative using the concept of distance between each alternative and the approximate boundary area.

Although a number of studies have revealed the advantages and disadvantages of these methods, there has been no research that specifically explores and compares the performance of the three methods, especially in the context of ranking SOEs. This study will also look at PSI's performance and integrate its weighting with other commonly used MCDM methods . Therefore, this study aims to fill the gap by comparing the performance of the PSI, PSI-TOPSIS, and PSI-MABAC methods in ranking SOEs based on financial performance parameters.

This research also contributes to closing the gap in existing literature and practices. Firstly, it fills the void in understanding financial ratio analysis that yields rankings of SOE, particularly highlighting the PSI method and its hybrid forms. This approach enriches perspectives on holistic evaluation and the effectiveness of financial performance analysis in SOE.

Secondly, the research addresses gaps in using MCDM methods and their hybrid variations in the SOE financial domain. Specifically, the PSI method stands out for its simultaneous ability to determine weights and rankings for SOE.

This research is limited to financial report data of state-owned companies listed on the Indonesia Stock Exchange (IDX) in 2022. The analyzed company is a public company. A public company is a company listed on the IDX and is obliged to offer its shares to the public. The analysis in this study is also limited to the financial ratios of *Current Ratio*

(CR), Debt to Equity Ratio (DER), *Total Asset Turnover* (TATO), and *Return on Asset* (ROA).

With this analysis, it can provide deeper insight into the advantages and disadvantages of each method in the context of evaluating SOE performance rankings. The innovative value of this research contribution lies in the integration of MCDM methods with financial ratio analysis of SOE. This study also provides an overview of how the performance of PSI used singly and integrated with other MCDM methods which was then analyzed using the spearman test to determine the correlation between the methods used. Analysis using financial ratio parameters can also provide input to the company to find out the company's financial health so that the company can maintain the sustainability of its company. This can guide decision makers in evaluating company performance effectively and efficiently, as well as considering various aspects in a more holistic decision-making process.

2. LITERATURE REVIEW

2.1. State-Owned Enterprises

State-Owned Enterprises (SOEs) are business entities whose capital is owned by the state and are important actors of economic activities in the national economy. SOEs consist of corporate business entities (persero) and general business entities (perum). Companies listed on the Indonesia Stock Exchange (IDX) are public companies that have the obligation to offer their shares to the public. Meanwhile, a company is a business entity that aims to pursue profits and its capital is not divided into shares. As a body that has a crucial role, SOEs face various challenges in their performance including management stability, long-term planning, and the ability of internal reforms to improve their performance. Therefore, an evaluation needs to be done to maintain the commercial viability and financial health of the company [16].

2.2. Financial Performance Parameters

Financial performance is the company's ability to manage its resources [17]. Financial performance parameters are a key indicator in evaluating company health, these indicators are financial ratios consisting of liquidity, activity, solvency, and profitability.

2.2.1. Liquidity

Liquidity ratio is a ratio that shows the company's ability to meet all its short-term obligations or debts. Current Ratio (CR) is a ratio that can be used to measure the liquidity of a company, CR can be calculated by dividing current assets by current liabilities. A higher CR value indicates that the company is more liquid and able to meet its short-term obligations [18].

2.2.2. Solvency

A solvency ratio is a ratio used to measure a company's ability to meet its financial obligations and debts. Common solvency ratios are Debt to Equity Ratio (DER). DER shows the amount of the company's financial risk, the higher the DER, the higher the risk of the company going bankrupt.

2.2.3. Activity

Activity ratio is a ratio used to measure the effectiveness and efficiency of a company in using its assets to generate sales or revenue. Total Asset Turnover (TATO) is used to measure the activities of a company which shows that the higher the value, the more effective the company's operations.

2.2.4. Profitability

The profitability ratio is A measure used to evaluate a company's ability to generate profits from its operations. Return on Assets (ROA) is used to measure the company's ability to use all assets owned to generate profits. A higher ROA value indicates a high return relative to the assets owned.

2.3. Hybrid MCDM in Financial Ratio Analysis

Hybrid MCDM is an approach taken by integrating several MCDM methods to make better decisions in financial ratio analysis. In the context of decision making, a single MCDM approach method sometimes does not provide an optimal solution, so method integration is used to take advantage of the advantages of each method. Hybrid MCDM provides a stronger framework for evaluating a company's financial health. Therefore, through this approach, decision makers can make more informed and accurate decisions and increase the relevance of analysis results in the context of the company's financial ratios.

In MCDM, weighting is key in measuring the performance of alternatives and their ratings. Weight determination methods are categorized into two categories, namely subjective and objective.

3. MATERIALS AND METHODOLOGY

Researchers will identify the ranking of all SOEs in Indonesia through financial ratios. This study was conducted on state-owned companies listed on the Indonesia Stock Exchange (IDX). The ranking is carried out with one MCDM method and two hybrid MCDM methods, namely PSI, PSI-TOPSIS, and PSI-MABAC. The results were then compared by determining the spearman rank correlation coefficient using IBM SPSS 26. Figure 1 presents a schematic representation of the methodology applied in the study.

3.1. Materials

3.1.1. Alternative Identification and Criteria

Alternative refers to the state-owned company to be assessed. The company consists of 24 companies that are public companies listed on the IDX.

While the criteria used to evaluate alternatives are financial ratios. Determination of criteria is carried out by identifying relevant criteria to evaluate the financial performance of state-owned companies. The criteria chosen are CR, DER, TATO, and ROA. In determining the criteria, it is considered based on the type that is profitable (benefit) and the type that is not profitable (cost). CR, TATO, and ROA criteria include the type of benefit criteria where a greater value is desired, while the DER criterion is included in the cost criterion where a lower value is desired.

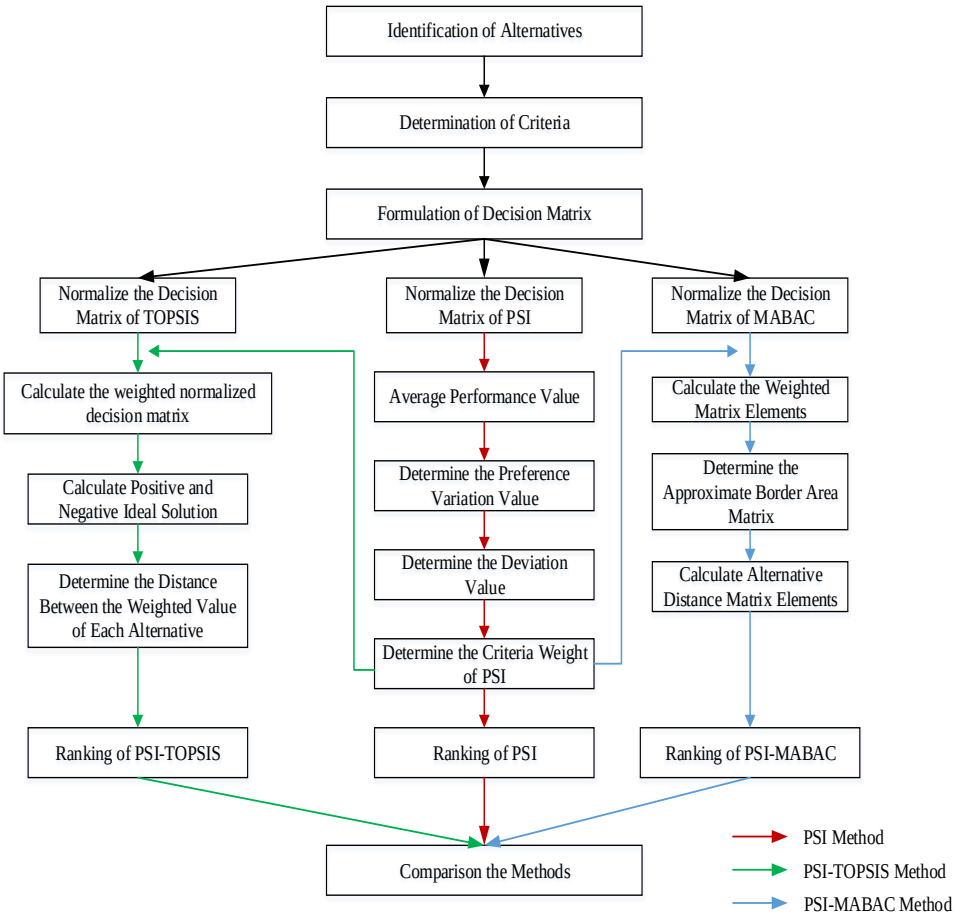

Figure 1: A schematic representation of the methodology

3.1.2. Forming a Decision Matrix

A decision matrix is formed after all alternative data and criteria have been identified, then the data is organized into matrix form, with alternatives as rows and criteria as columns.

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1c} \\ x_{21} & x_{22} & \cdots & x_{2c} \\ \cdots & \cdots & \cdots & \cdots \\ x_{a1} & x_{a2} & \cdots & x_{ac} \end{bmatrix}. \quad (1)$$

3.2. Methodology

3.2.1. Preference Selection Index (PSI)

The Preference Selection Index (PSI) method was developed by K. Maniya and M.G. Bhatt in 2010 [14]. This method will identify the relationship of financial ratios to existing companies. Comparison between state-owned companies and financial ratios provides information about the company's financial health to assist decision makers in decision making. The evaluation techniques carried out are as follows:

1. Normalize the decision matrix. The normalization of the decision matrix is divided into 2 conditions, that is, if the criterion is a favorable type (benefit), then the normalized value is formulated as
   $$\bar{X}_{ij} = \frac{x_{ij}}{x_{ij}^{\max}} \quad (2)$$
   And if the criterion is of unfavorable type (cost), then the normalized value is formulated as
   $$\bar{X}_{ij} = \frac{x_{ij}^{min}}{x_{ij}} \quad (3)$$
2. Next, the average performance value of the normalized value is determined. The average value of such performance is determined using the following equation:
   $$N_j = \frac{1}{n}\sum_{i=1}^{m} \bar{X}_{ij}, \quad (4)$$
   where n is the number of companies to be analyzed.
3. Then determine the preference variation value. Preference variation values require matrix normalization values ($\bar{X}_{ij}$) and performance mean values, so they can be determined using the following equation:
   $$\emptyset_j = \sum_{i=1}^{m}\left(\bar{X}_{ij} - N_j\right)^2 \quad (5)$$
4. Next, the deviation value is determined using the equation
   $$\Omega_j = 1 - \emptyset_j \quad (6)$$
5. By comparing the value of the preference variation against the number of deviation values, it can be determined the weight for each criterion with the equation
   $$w_j = \frac{\emptyset_j}{\sum_{j=1}^{n} \Omega_j} \quad (7)$$
6. Finally, the PSI value is determined for each company using the equation
   $$\theta_i = \sum_{j=1}^{n} \bar{X}_{ij}\, w_j \quad (8)$$
   After the PSI value is obtained, the ranking is carried out from the largest to the smallest PSI value.

3.2.2. Preference Selection Index-Technique for Order of Preference by Similarity to Ideal Solution (PSI-TOPSIS)

The TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method is an MCDM method developed by Yoon and Hwang in 1981 [19]. Yoon and Hwang base this method on the idea that the chosen alternative should be closest to the positive ideal solution and furthest from the negative ideal solution. A positive ideal solution refers to the alternative that has the best value for each criterion, while a negative ideal solution represents the alternative that has the worst value for each criterion [20]. The

PSI-TOPSIS method integrates the weighting obtained from PSI with the steps in the TOPSIS method which consists of:

1. Normalize the decision matrix. The normalization of the matrix is determined by the equation

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m}(x_{ij})^2}} \quad (9)$$

Where:
$i = 1,2,3, \ldots 24$
$j = 1,2,3,4$
x_{ij} = matrix to be normalized.

2. Make a weighted normalized decision matrix. Calculating the weighted decision matrix is done by multiplying the normalized decision matrix by the weighted criteria (w_j) obtained from PSI, with the equation:

$$y_{ij} = r_{ij} w_j \quad (10)$$

for $i = 1,2,3, \ldots 24$ dan $j = 1,2,3,4$.

3. Calculates positive ideal solutions and negative ideal solutions by finding the maximum and minimum values of each weighted decision matrix column. To calculate the ideal solution of positive and negative is determined by the equation:

$$A^+ = (y_1^+, y_2^+, y_3^+, \ldots, y_n^+) \quad (11)$$

$$A^- = (y_1^-, y_2^-, y_3^-, \ldots, y_n^-) \quad (12)$$

Provided that:

$$y_j^+ = \begin{cases} \max\limits_i y_{ij} \text{ ; if } j \text{ is benefit} \\ \min\limits_i y_{ij} \text{ ; if } j \text{ is cost} \end{cases}$$

$$y_j^- = \begin{cases} \min\limits_i y_{ij} \text{ ; if } j \text{ is benefit} \\ \max\limits_i y_{ij} \text{ ; if } j \text{ is cost} \end{cases}$$

4. Determine the distance between the weighted value of each alternative with a positive ideal solution and a negative ideal solution. Calculating the distance between each alternative with a positive ideal solution is obtained by rooting the square of the sum of all y_j^+ subtracted y_{ij} values obtained by the equation:

$$D_i^+ = \sqrt{\sum_{j=1}^{n}\left(y_{ij} - y_j^+\right)^2} \quad (13)$$

As for calculating the distance between each alternative with a negative ideal solution is obtained by rooting the square of the sum of all y_{ij} subtracted y_j^- values shown by the following equation:

$$D_i^- = \sqrt{\sum_{j=1}^{n}\left(y_{ij} - y_j^-\right)^2} \quad (14)$$

5. Calculates the preference value for each alternative. The preference value is obtained by comparing the distance between each alternative negative ideal solution to the distance between each alternative negative ideal solution plus the distance between each alternative positive ideal solution shown in the equation:

$$V_i = \frac{D_i^-}{D_i^- + D_i^+} \quad (15)$$

An alternative A_i is selected if the value V_i is the largest value.

3.2.3. Preference Selection Index-Multi-Attributive Border Approximation Area Comparison (PSI-MABAC)

The MABAC (Multi-Attributive Border Approximation Area Comparison) method is an MCDM method developed at the University of Defense in Belgrade by Pamucar and Cirovic [21]. This method is used to evaluate and rank alternatives based on several criteria. The MABAC method can solve complex and uncertain decision-making problems by calculating the distance between each alternative and the border approximation area (BAA) [22]. MABAC has a simple calculation process, systematic procedures, and sound logic that represents the rationale of human decision making [23]. Using the MABAC method we can assess the pros and cons of an option efficiently through calculations [24]. The PSI-MABAC approach consists of several steps by integrating PSI weights for each criterion, where the steps are:

1. Normalize the matrix (N). The normalization of matrix elements is determined using the equation:
   a. For benefit criteria:
   $$t_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-} \quad (16)$$
   b. For cost criteria:
   $$t_{ij} = \frac{x_{ij} - x_i^+}{x_i^- - x_i^+} \quad (17)$$
   $x_i^+ = \max(x_1, x_2, \dots, x_m)$ is the maximum value of the observed criteria according to the alternative.
   $x_i^- = \min(x_1, x_2, \dots, x_m)$ is the minimum value of the observed criteria according to the alternative.
2. Calculates the elements of a weighted matrix (V). The elements of the weighted matrix are calculated by the equation:
   $$V_{ij} = (w_j . t_{ij}) + w_j \quad (18)$$
   Where w_j is the weight of the criteria obtained from the PSI and t_{ij} is a normalized matrix element.
3. Determines the matrix of the approximate border area (G). The matrix of the approximate area of the border is determined by the equation:
   $$g_i = \left[\prod_{j=1}^{m} V_{ij}\right]^{\frac{1}{m}} \quad (19)$$
   Where V_{ij} is the element of the weighted matrix and m is the alternate total.
4. Calculates the matrix element of the alternate distance from the approximate border area (Q). An alternative distance from the approximate area of the border is obtained by subtracting the elements of the weighted matrix matrix of the approximate area of the border presented with the equation:
   $$Q = V - G \quad (20)$$
   Alternatives A_i can include the border forecast area (G), the upper forecast area (G^+) or the lower forecast area (G^-). The G^+ area presents the area where the ideal alternative is located (A^+), while G^- it presents the area where the anti-ideal alternative is located (A^-).

5. Alternative ranking (S). Ranking is done by looking at the results of the calculation of the final number of border estimate areas (Q), where the highest value occupies the top position and so on.

$$S_i = \sum_{j=1}^{n} Q_{ij} \quad (21)$$

Where $i = 1,2,\dots,m$ and $j = 1,2,\dots,n$; m is the number of alternatives and n is the number of criteria.

4. RESULT AND DISCUSSION

At the beginning of the presentation of the study, the value of financial ratios is displayed according to the CR, DER, TATO and ROA of each company presented in Table 1.

Table 1 is obtained from the financial statements of each company in 2022 listed on the IDX. The value obtained is in the form of elements of each financial component such as current assets and current liabilities for CR, liabilities and equity for DER, net income and total assets for TATO, and net income and total assets for ROA.

Table 1: Financial Ratio Data

Alternative	CR (C_1)	DER (C_2)	TATO (C_3)	ROA (C_4)	Alternative	CR (C_1)	DER (C_2)	TATO (C_3)	ROA (C_4)
BBTN (A1)	0.1766	13.5618	0.0076	0.0076	ELSA (A13)	1.4970	1.1461	0.0428	0.0428
BBRI (A2)	0.2107	4.9634	0.0274	0.0276	PGAS (A14)	2.2289	1.0905	0.0453	0.0558
BBNI (A3)	0.1777	6.3456	0.0178	0.0179	PTBA (A15)	2.2830	0.5687	0.2771	0.2817
BMRI (A4)	0.1706	6.1214	0.0207	0.0226	GIAA (A16)	0.4766	-5.0616	0.5995	0.5993
WSKT (A5)	1.5583	5.8961	-0.0193	-0.0170	WSBP (A17)	0.3425	-3.8355	0.1133	0.1133
ADHI (A6)	1.2021	3.5317	0.0020	0.0044	ANTM (A18)	1.9584	0.4186	0.1136	0.1136
WTON (A7)	1.1236	1.5970	0.0172	0.0181	TINS (A19)	2.2122	0.8556	0.0797	0.0797
PTPP (A8)	1.2103	2.8872	0.0047	0.0063	KRAS (A20)	0.4470	4.7230	0.7079	0.0072
WIKA (A9)	1.0968	3.2914	-0.0008	0.0002	SMGR (A21)	1.4454	0.7043	0.0285	0.0301
PPRO (A10)	1.7834	3.7882	0.0009	0.0011	SMBR (A22)	1.7227	0.6882	0.0182	0.0182
JSMR (A11)	1.0283	2.5572	0.0301	0.0255	INAF (A23)	0.8765	16.7652	-0.2793	-0.2793
TLKM (A12)	0.7822	0.8437	0.0754	0.1006	KAEF (A24)	1.0586	1.1794	-0.0084	-0.0046

4.1. Results

4.1.1. Ranking with PSI Method

There are 24 state-owned companies listed on the Indonesia Stock Exchange (IDX). All of these companies will be analyzed simultaneously to determine the company's ranking through four financial ratios, namely CR, DER, TATO, and ROA.

Matrix normalization $\left(\sum \bar{X}_{ij}\right)$ is done by comparing the value of the matrix with the maximum value if the benefit criterion, or the minimum value of the matrix value if the cost criterion is then added up to the entire value. The benefit criterion reflects the extent to which an alternative can provide benefits, the higher the value of the benefit criterion, indicating that an alternative is more desirable because it makes a positive contribution. While the cost criterion reflects the extent to which an alternative involves a loss, the lower the value of the cost criterion, indicating that an alternative is more desirable because it represents a lower loss. In determining the average value (N), it is done by calculating the comparison of the sum of all normalized values of the matrix of each ratio with the number of companies. Then, the determination of the value of preference variation (ϕ_j) is done by squaring the reduction of the matrix value and the average value. After that, the entire value of the variation in preference of each ratio is calculated $\left(\sum \phi_j\right)$. To determine the deviation of the preference value $\left(\Omega_j\right)$, 1 is subtracted by the sum of the preference variation values. Finally, in weight determination $\left(w_j\right)$ is calculated by dividing the deviation of the preference value by the total deviation of the preference value.

After the data is collected, a value is obtained for each parameter on the Table 2. Then, a ranking of companies with the highest PSI value occupies the top position while companies with the lowest PSI value occupy the bottom position. Based on the ranking results on Table 3, A17 companies occupy the top position with the highest PSI value of 1.3080, while the lowest position company is A18 with a PSI value of -11.9658.

In determining the weight for each criterion, the weight is determined objectively based on the data contained in the decision matrix, where the highest range of criteria values is in the DER, which is 21.8269. This happens to company A23 which has a maximum value against company A16 on the DER criteria. Then followed by the CR criteria which has a value range of 2.1124, TATO which has a range of 0.9872, and finally ROA which has a value range of 0.8786. Furthermore, matrix normalization is carried out by comparing the types of criteria against the value of the decision matrix, CR, TATO, and ROA criteria are types of benefit criteria so that the matrix value of each alternative is compared with the maximum value of the matrix. For the DER criterion, which is a type of cost criterion, to get the normalized value, a comparison of the minimum value of the matrix of each alternative with the matrix value is carried out. The final result obtained is indicated in Table 2 2nd column.

The total number of normalized values that have been obtained will then be used to calculate the average value of each criterion by comparing that value against the number of alternatives identified. The average value of each criterion that has been obtained is shown on Table 2 3rd column. By squaring the normalized value subtracted by the average value of the criteria, the value of the preference variation of each criterion is calculated and then summed the value of each alternative presented on the Table 2 4th column. Furthermore, by subtracting 1 from the total value of the preference variation of each criterion, we obtain the deviation of the preference value and the total of the deviation of the preference value presented at Table 2 5th column. Thus, the weight of each criterion is obtained by comparing the deviation of the preference value to its total amount. The weight of each of these criteria is presented on Table 2 6th column. Where is the weight for each criterion C_1, C_2, C_3, C_4 each is . The weight obtained from this method will then be used in determining the ranking that will be carried out by the TOPSIS and MABAC methods. $0.004, 0.991, 0.003, 0.002$The amount of weight for each criterion is influenced by the

values in the decision matrix, where the criteria that have the largest range of values will get a large weight as well.

Table 2: PSI Method Parameters

	$\sum \bar{X}_{ij}$	N	$\sum \phi_j$	Ω_j	w_j
C_1	11.86	0.49	2.09	-1.09	0.004
C_2	-74.93	-3.12	258.13	-257.13	0.991
C_3	2.71	0.11	1.81	-0.81	0.003
C_4	2.12	0.09	1.39	-0.39	0.002
$\sum \Omega_j$				-259.42	

Table 3: Company Ranking Based on PSI Method

Alternative	PSI Value	Ranking	Alternative	PSI Value	Ranking	Alternative	PSI Value	Ranking
A17	1.30942	1	A20	-1.0583	9	A13	-4.3741	17
A16	0.99619	2	A10	-1.321	10	A14	-4.5962	18
A23	-0.2996	3	A6	-1.4183	11	A19	-5.8589	19
A1	-0.3695	4	A9	-1.5222	12	A12	-5.9443	20
A3	-0.7901	5	A8	-1.7353	13	A21	-7.1203	21
A4	-0.8191	6	A11	-1.9598	14	A22	-7.2868	22
A5	-0.8481	7	A7	-3.1392	15	A15	-8.8162	23
A2	-1.0102	8	A24	-4.2518	16	A18	-11.981	24

PSI values range from 1.30942 (for the highest-ranked companies) to -11.981 (for the lowest-ranked companies). Company ranking based on the PSI method provides insight into the relative financial performance of companies. The higher the PSI value, the better the company's financial performance. The companies that rank bottom in this analysis have a negative PSI value indicating poor financial performance.

4.1.2. Ranking with PSI-TOPSIS Method

Using the weighted criteria obtained in the PSI method, the next step is to determine the normalized value of the matrix, calculate the weighted matrix, calculate the positive ideal solution and negative ideal solution, calculate the distance between the weighted value of the positive ideal solution and the negative ideal solution, and the last stage is to determine the preference value for each alternative. After all parameters are obtained, a ranking of companies is carried out as in Table 4.

After obtaining the results of all parameters, a ranking of companies based on the largest to smallest preference values as presented in Table 4.

From the table, it is known that A16 is the best state-owned company with the highest value, namely 0.9985 and A23 became the worst state-owned company with a value of 0.0006.

Table 4: Company Ranking Based on PSI-TOPSIS Method

Alternative	Preference Value	Ranking	Alternative	Preference Value	Ranking	Alternative	Preference Value	Ranking
A16	0.9985	1	A14	0.7181	9	A10	0.5945	17
A17	0.9437	2	A13	0.7156	10	A20	0.5517	18
A18	0.7489	3	A24	0.7141	11	A2	0.5407	19
A15	0.7420	4	A7	0.6949	12	A5	0.4980	20
A22	0.7366	5	A11	0.6509	13	A4	0.4876	21
A21	0.7358	6	A8	0.6358	14	A3	0.4774	22
A12	0.7294	7	A9	0.6173	15	A1	0.1468	23
A19	0.7289	8	A6	0.6063	16	A23	0.0006	24

4.1.3. Ranking with PSI-MABAC Method

This analysis is carried out in two stages, the first is to determine the weight of each criterion using the PSI method, the second stage is to rank companies using the MABAC method by calculating the normalization of initial matrix elements (X), calculating weighted matrix elements (V), determining the border estimated area matrix (G), and the last is calculating alternative distances from the border estimated area (Q). After each parameter is obtained, company ranking is carried out based on the PSI-MABAC method given to Table 5.

Table 5: Company Ranking Based on PSI-MABAC Method

Alternative	Q	Ranking	Alternative	Q	Ranking	Alternative	Q	Ranking
A16	0.387	1	A14	0.1093	9	A10	-	17
A17	0.329	2	A13	0.1052	10	A20	-	18
A18	0.139	3	A24	0.1026	11	A2	-	19
A15	0.134	4	A7	0.0839	12	A5	-	20
A22	0.126	5	A11	0.0402	13	A4	-	21
A21	0.125	6	A8	0.0254	14	A3	-	22
A19	0.120	7	A9	0.0068	15	A1	-	23
A12	0.117	8	A6	-	16	A23	-	24

Company A16 has the best rating with a value of 0.3878, while company A23 occupies the lowest position with a value of -0.6068.

4.1.4. Ranking Comparison with PSI, PSI-TOPSIS, and PSI-MABAC Methods

In making decisions, evaluating and ranking companies is an important step. This study aims to compare three decision-making methods (PSI, PSI-TOPSIS, and PSI-MABAC) used to examine 24 state-owned companies listed on the IDX. Using these methods, the study will provide an in-depth picture of company rankings based on CR, DER, TATO, and ROA criteria.

In this analysis, PSI is used to determine the weight of each criterion and produce a ranking for each company, then the PSI-TOPSIS and PSI-MABAC methods also produce a ranking for each company using the weights obtained from PSI. So this study will show differences and similarities in the ranking results of 24 companies using three different methods in the context of CR, DER, TATTOO and ROA criteria. The ranking results of the three methods are presented on Table 6.

Table 6: Results of PSI, PSI-TOPSIS, and PSI-MABAC Method Ranking

Alternative	Ranking PSI	Ranking PSI-TOPSIS	Ranking PSI-MABAC	Alternative	Ranking PSI	Ranking PSI-TOPSIS	Ranking PSI-MABAC
A1	4	23	23	A13	17	10	10
A2	8	19	19	A14	18	9	9
A3	5	22	22	A15	23	4	4
A4	6	21	21	A16	2	1	1
A5	7	20	20	A17	1	2	2
A6	11	16	16	A18	24	3	3
A7	15	12	12	A19	19	8	7
A8	13	14	14	A20	9	18	18
A9	12	15	15	A21	21	6	6
A10	10	17	17	A22	22	5	5
A11	14	13	13	A23	3	24	24
A12	20	7	8	A24	16	11	11

The PSI method shows alternative ratings based on predefined criteria values. The results showed that A17 companies ranked highest by criteria value [0.3425, -3.8355, 0.1133, 0.1133], with each criterion ranking 20th, 2nd, 5th, 4th and A16th ranking second highest by its criterion value [0.4766, -5.0616, 0.5995, 0.5993] and ranking 18th, 1st, 2nd, 1st respectively. This indicates that both companies are the top preferences in decision making based on the weight of criteria. A15 and A18 companies ranked lowest with 23rd and 24th respectively. With criteria values [2.2830, 0.5687, 0.2771, 0.2817] ranked 1st, 4th, 3rd, 2nd and A18 companies respectively with criteria values [1.9584, 0.4186, 0.1136, 0.1136] ranked 4th, 3rd, 4th, 3rd. This is due to several small criteria values that place the two companies in the lowest position. In determining alternative ranking, the weight of the PSI method occurs because PSI has a lack of data with negative values in the cost type criteria.

In the PSI-TOPSIS method, the ranking of the company is determined based on proximity to the ideal solution. The results show that A16 and A17 companies ranked in the top two. Both of these companies have a tendency to value high criteria and have the closest distance to the ideal solution based on the analyzed criteria, thus making the company the highest ranking. The A16 criteria values [0.4766, -5.0616, 0.5995, 0.5993] are sequentially ranked 18th, 1st, 2nd, 1st and for A17 the criteria values [0.3425, -3.8355, 0.1133, 0.1133] are ranked 20th, 2nd, 5th, 4th. As for companies that are ranked second lowest, namely A1 and A23, the value of the criteria tends to be small, making these two companies at the lowest level and have the longest distance with ideal solutions. The criteria values on A1

[0.1766, 13.5618, 0.0076, 0.0076] which ranks 23rd, 23rd, 17th, 16th and on A23 have the criteria values [0.8765, 16.7652, -0.2793, -0.2793] sequentially in order 16th, 24th, 24th, 24th.

In the PSI-MABAC method, the company's rating is determined based on the comparison area approach. The results set A16 and A17 companies as the highest-ranking. This happens because the A16 criteria value [0.4766, -5.0616, 0.5995, 0.5993] ranks 18th, 1st, 2nd, 1st and the A17 criterion value [0.3425, -3.8355, 0.1133, 0.1133] ranks 20th, 2nd, 5th, 4th which tends to be large so that the two companies approach a larger comparison area in the relevant criteria. For companies ranked in the two lowest, namely A1 and A23, this is due to smaller criteria values, namely A1 criteria values [0.1766, 13.5618, 0.0076, 0.0076] which rank 23rd, 23rd, 17th, 16th and A23 criteria values [0.8765, 16.7652, −0.2793, −0.2793] which are ranked 16th, 24th, 24th, 24th, 24th, so that both companies approach smaller comparison areas in the relevant criteria.

The results of the three methods are then compared to find out the extent to which the ratings produced by the three methods (PSI, PSI-TOPSIS, and PSI-MABAC) have similarities or differences. A comparative analysis was performed using IBM SPSS Statistics 26 software to determine the correlation coefficient of spearman rank (r) and *p*-value to test the acceptance rate of significance with a *p*-value less than 0.05.

Table 7: Rank Correlation and p-value

Methods	r-value	p-value
PSI vs PSI-TOPSIS	-0.541	0.006
PSI vs PSI-MABAC	-0.540	0.006
PSI-TOPSIS vs PSI-MABAC	0.999	0

Table 7 shows the correlation of rank as well as p-value from comparative analysis. From the table it can be seen that between the three methods there is a significant correlation between the resulting rankings. The correlation coefficient between PSI-TOPSIS and PSI-MABAC rankings is very strong, while PSI has a strong but negative correlation to both methods. A very high correlation value (0.999) indicates that the rankings generated by the two are almost identical. These results indicate that PSI-TOPSIS and PSI-MABAC give very similar ratings in company evaluations, while PSI assigns significantly different rankings.

4.2. Discussion

Based on CR criteria, the company ranked first is A15 and the last is occupied by A4. DER criteria, the company occupying the first position is A16 and the last is A23. For the TATO criteria, the company that ranks first is A20 and the last is A23. Finally, for the ROA criteria, the company that ranks first is A16 and the last is A23. From these results, it is known that A16 is ranked first in the two DER and ROA criteria and A23 is consistently ranked last in the three DER, TATO, and ROA criteria.

PSI is a very simple method (involving less calculation) than other methods. In this method, the overall preference value is obtained using statistical concepts taking into account favorable and unfavorable attributes [25]. However, this method does not effectively deal with negative numbers. The analysis showed that of the 24 companies evaluated, 22 companies had the same ranking with the PSI-TOPSIS and PSI-MABAC methods. A16 companies followed by A17 can be considered as the best choice of

companies for financial performance. A very strong correlation is found in these two methods.

All proposed methodologies are good quantitative approaches. However, each method has its advantages and disadvantages. The main advantage of PSI-TOPSIS is that it provides the best and worst solutions in relation to the criteria considered important and provides an absolute evaluation of all alternatives [26]. In contrast, PSI-MABAC deliver consistent results against the value of the criterion is based on the determination of alternative distances from the approximate boundary area [27]. Both PSI-TOPSIS and PSI-MABAC, have comprehensive concepts, ease and good computational efficacy compared to other techniques.

5. CONCLUSION

This research provides a more comprehensive insight into the MCDM method integrated with PSI in evaluating the financial performance of SOEs in the context of ranking. The weighting of criteria carried out by PSI has been carried out carefully and effectively, making a significant contribution in providing the right weight for each criterion used in the process of evaluating the financial performance of SOEs.

This study shows the ability of MCDM and its hybrid methods consisting of PSI, PSI-TOPSIS, and PSI-MABAC to get a ranking of the given alternatives. Case studies are illustrated to select the best state-owned companies based on different criteria such as CR, DER, TATO, and ROA. Almost similar rankings are obtained from the PSI-TOPSIS and PSI-MABAC methods. In this study, the latest in giving objective weight through PSI and the use of the integration of PSI-TOPSIS and PSI-MABAC methods in evaluating the performance of SOEs through financial ratios in the context of ranking.

The weighting of criteria carried out by PSI shows the values of CR, DER, TATO, and ROA respectively, namely 0.004, 0.991, 0.003, and 0.002. The weight then gives almost similar ranking results by the PSI-TOPSIS and PSI-MABAC methods, where the company at the top is shown by company A16 and the company at the bottom is shown by company A23. From the ranking results obtained by the PSI, PSI-TOPSIS, and PSI-MABAC methods, a correlation test was carried out using Spearman rank where the results showed that PSI-TOPSIS and PSI-MABAC gave a very high correlation value of 0.999 which represented the correlation of the two methods that were almost identical.

In this study, the data used is only limited to the financial statements of state-owned companies listed on the IDX in 2022 and the financial ratios used only focus on the ratio of CR, DER, TATO, and ROA. For future research, researchers can conduct a more in-depth analysis of other financial performance parameters with a wider sample coverage. In addition, researchers can use trend data in financial performance evaluation to determine the company's performance in the next few years. Other objective criteria weighting analysis such as the entropy method can also provide valuable insights in the exploration of weighting to determine the effectiveness of a weighting method in the context of ranking with the MCDM method.

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REFERENCES

[1] V. S. Panicker, R. S. Upadhyayula, and S. Sivakumar, "Internationalization of hybrid state-owned enterprises from emerging markets: Institutional investors as enablers," *Journal of Business Research*, vol. 151, pp. 409–422, 2022. doi: 10.1016/j.jbusres.2022.07.018.

[2] K. Szarzec, Á. Dombi, and P. Matuszak, "State-owned enterprises and economic growth: Evidence from the post-Lehman period," *Economic Modelling*, vol. 99, 2021. doi: 10.1016/j.econmod.2021.03.009.

[3] E. W. Astami, G. Tower, R. Rusmin, and J. Neilson, "The effect of privatisation on performance of state-owned-enterprises in Indonesia," *Asian Review of Accounting*, vol. 18, no. 1, pp. 5–19, 2010. doi: 10.1108/13217341011045971.

[4] V. Dahoklory, "Dinamika Pengelolaan Keuangan BUMN Perihal 'Dilema' Antara Kerugian Negara Ataukah Kerugian Bisnis," *Jurnal Rechts Vinding: Media Pembinaan Hukum Nasional*, vol. 9, no. 3, p. 349, 2020. doi: 10.33331/rechtsvinding.v9i3.457.

[5] H. Borhan, R. Naina Mohamed, and N. Azmi, "The impact of financial ratios on the financial performance of a chemical company," *World Journal of Entrepreneurship, Management and Sustainable Development*, vol. 10, no. 2, pp. 154–160, 2014. doi: 10.1108/WJEMSD-07-2013-0041.

[6] L. A. Jackson and D. Singh, "Environmental rankings and financial performance: An analysis of firms in the US food and beverage supply chain," *Tourism Management Perspectives*, vol. 14, pp. 25–33, 2015. doi: 10.1016/j.tmp.2015.02.002.

[7] R. Mao, "Verify the Relationship Between a Company's Earning per Share, Return on Equity, Return on Asset, Sales Growth, Price to Earning Ratio, Current Ratio, Gross Profit Margin, Quick Ratio, Asset Turnover and Its Stock Price," *SHS Web of Conferences*, vol. 163, p. 03003, 2023. doi: 10.1051/shsconf/202316303003.

[8] M. Education, "The Influence of Current Ratio, Debt to Equity Ratio and Company Size on Return On Assets," *Journal not specified*, vol. 12, no. 8, pp. 1702–1709, 2021.

[9] T. N. Nariswari and N. M. Nugraha, "Profit Growth: Impact of Net Profit Margin, Gross Profit Margin and Total Assets Turnover," *International Journal of Finance & Banking Studies*, vol. 9, no. 4, pp. 87–96, 2020. doi: 10.20525/ijfbs.v9i4.937.

[10] H. Wang, W. Wang, and S. E. A. Alhaleh, "Mixed ownership and financial investment: Evidence from Chinese state-owned enterprises," *Economic Analysis and Policy*, vol. 70, pp. 159–171, 2021. doi: 10.1016/j.eap.2021.02.006.

[11] P. J. Gudiel Pineda, J. J. H. Liou, C. C. Hsu, and Y. C. Chuang, "An integrated MCDM model for improving airline operational and financial performance," *Journal of Air Transport Management*, vol. 68, pp. 103–117, 2018. doi: 10.1016/j.jairtraman.2017.06.003.

[12] S. Greco, E. Matthias, and F. Jose Rui, *Multiple Criteria Decision State of the Art Surveys*, 2016. [Online]. Available: http://www.springer.com/series/6161

[13] Y. Li, X. He, L. Martínez, J. Zhang, D. Wang, and X. A. Liu, "Comparative analysis of three categories of multi-criteria decision-making methods," *Expert Systems with Applications*, vol. 238, p. 121824, 2024. doi: 10.1016/j.eswa.2023.121824.

[14] K. Maniya and M. G. Bhatt, "A selection of material using a novel type decision-making method: Preference selection index method," *Materials and Design*, vol. 31, no. 4, pp. 1785–1789, 2010. doi: 10.1016/j.matdes.2009.11.020.

[15] D. P. Miloš Madić, J. Antucheviciene, and M. Radovanović, "Determination of laser cutting process conditions using the preference selection index method," *Optics and Laser Technology*, vol. 89, pp. 214–220, 2017. doi: 10.1016/j.optlastec.2016.10.005.

[16] Asian Development Bank, *Unlocking the Economic and Social Value of Indonesia's State-Owned Enterprises*, Dec. 2020. [Online]. Available: https://www.adb.org/sites/default/files/publication/843421/economic-social-value-indonesia-state-owned-enterprises.pdf

[17] M. Mahrani and N. Soewarno, "The effect of good corporate governance mechanism and corporate social responsibility on financial performance with earnings management as mediating variable," *Asian Journal of Accounting Research*, vol. 3, no. 1, pp. 41–60, 2018. doi: 10.1108/AJAR-06-2018-0008.

[18] B. N. Lalithchandra and N. Rajendhiran, "Liquidity ratio: An important financial metrics," *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, vol. 12, no. 2, pp. 1113–1114, 2021.

[19] C.-L. Hwang and K. Yoon, "Basic Concepts and Foundations," in *Multiple Attribute Decision Making: Methods and Applications*, pp. 16–57, 1981. doi: 10.1007/978-3-642-48318-9_2.

[20] F. Ciardiello and A. Genovese, "A comparison between TOPSIS and SAW methods," *Annals of Operations Research*, vol. 325, no. 2, pp. 967–994, 2023. doi: 10.1007/s10479-023-05339-w.

[21] D. Pamučar and G. Ćirović, "The selection of transport and handling resources in logistics centers using Multi-Attributive Border Approximation area Comparison (MABAC)," *Expert Systems with Applications*, vol. 42, no. 6, pp. 3016–3028, 2015. doi: 10.1016/j.eswa.2014.11.057.

[22] J. Wang, G. Wei, C. Wei, and Y. Wei, "MABAC method for multiple attribute group decision under q-rung orthopair fuzzy environment," *Defence Technology*, 2019. doi: 10.1016/j.dt.2019.06.019.

[23] Y. Xue, J. You, X. Lai, and H. Liu, "An interval-valued intuitionistic fuzzy MABAC approach for material selection with incomplete weight information," *Applied Soft Computing Journal*, vol. 38, pp. 703–713, 2016. doi: 10.1016/j.asoc.2015.10.010.

[24] W. Liang, G. Zhao, H. Wu, and B. Dai, "Risk assessment of rockburst via an extended MABAC method under fuzzy environment," *Tunnelling and Underground Space Technology*, vol. 83, pp. 533–544, 2019. doi: 10.1016/j.tust.2018.09.037.

[25] S. Yadav, V. K. Pathak, and S. Gangwar, "A novel hybrid TOPSIS-PSI approach for material selection in marine applications," *Sādhanā – Academy Proceedings in Engineering Sciences*, vol. 44, no. 3, pp. 1–12, 2019. doi: 10.1007/s12046-018-1020-x.

[26] A. Siva Bhaskar and A. Khan, "Comparative analysis of hybrid MCDM methods in material selection for dental applications," *Expert Systems with Applications*, vol. 209, p. 118268, 2022. doi: 10.1016/j.eswa.2022.118268.

[27] A. E. Torkayesh, E. B. Tirkolaee, A. Bahrini, D. Pamucar, and A. Khakbaz, "A systematic literature review of MABAC method and applications: An outlook for sustainability and circularity," *Informatica*, vol. 34, no. 2, pp. 415–448, 2023. doi: 10.15388/23-INFOR511.