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Application of the AHP-TOPSIS Method to Support Stock Investment Decisions Based on Financial Ratio Analysis

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Abstract

Stock is one form of investment that is currently popular, both for young people, parents, and industry. This can be seen from the increasing number of investors and companies listed on the Indonesia Stock Exchange (IDX). This makes investors confused in determining the best stock choices. Analysis of stock selection needs to be done before someone invest so that the selected stock does not lose and can generate optimal profits. This study discusses the recommendation for alternative stocks from the IDX30 index. The parameters for selecting alternative stocks considered include the criteria of Earning Per Share (EPS), Return on Assets (ROA), Return on Equity (ROE), and Net Profit Margin (NPM). Then the weight of each criterion will be searched using the Analytical Hierarchy Process (AHP) method and sorted using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method to produce stock recommendations from companies listed on the Indonesia Stock Exchange. The results showed that the Earning Per Share (EPS) criteria became the first priority with a weight of 0.2927, then Return on Equity (ROE) with a weight of 0.2728, followed by Net Profit Margin (NPM) with a weight of 0.2583, and Return on Assets (ROA) with a weight 0.1759. Then alternative results are obtained based on the preference value and ranking 14 companies that have a preference value above 0.5 and can be used as a consideration in making investment decisions, with BBCA as a priority alternative.

Keywords: Investment, stock, AHP, TOPSIS, financial ratio, decision

1. Introduction

Investment is an activity of investing capital in the form of money or valuable assets, directly or indirectly with the hope of obtaining profits in the future. Stock investment is one of the many investment options that are increasingly in demand by various groups, from young people to the elderly (Paksi et al., 2017). From year to year the number of investors and investment value in Indonesia has increased, supported by the development of digital technology. Seeing the increase in investment that has occurred in Indonesia, IDX provides a stock index as a statistical measure that measures stock performance to help investors see price movements. Currently, there are forty-two stock indices listed on the IDX, one of which is the IDX30 index (IDX, 2022). IDX30 measures the price performance of thirty issuers with high liquidity, good stock fundamentals, and large market capitalization. This means, IDX30 is a stock index that is widely observed by investors.

The number of companies listed on the IDX is one of the factors that make it difficult for investors to choose stocks, so proper fundamental analysis is needed to support decision making by analyzing the company's financial statements to determine the weaknesses, strengths and future performance of a company (Drakopoulou, 2015).

One of the main approaches in fundamental analysis that are often used by security analysts to assist investment decision-making is the help of financial ratio analysis that related to profitability. In financial ratio analysis, there are many ratios with criteria that commonly used such as Net Profit Margin (NPM), Return on Assets (ROA), Earning per Share (EPS), and Return on Equity (ROE).

Each criterion used based on financial ratios is processed to obtain the weight of each criterion which is then used in the decision-making process using the methodAnalytical Hierarchy Process (AHP) and methodsTechnique for Order Preference by Similarity to Ideal Solution (TOPSIS). The AHP method in decision analysis is used to solve complex problems by evaluating the weight of each criterion used (Musthafa, 2017). Then, when the weight of each

criterion has been obtained, the TOPSIS method is used to find solutions through ranking or ranking. TOPSIS is a method that uses input model adaptation from other methods. The AHP method was chosen to provide input values needed by TOPSIS as initial capital for further calculations. The use of the TOPSIS method in calculating proximity values and preference values and compared with the weights obtained from the process AHP method can produce more objective values (Sylvia, 2021).

2. Literature Review

Financial ratio analysis is a tool used in analyzing opportunities and conditions for company performance based on data contained in the company's financial reports to see the company's future development (Marginingsih, 2017). There are many financial ratios in analyzing financial reports. In this study, four financial ratios are used in stock selection policies to generate profits, including, Net Profit Margin (NPM), Return on Assets (LONG), Return on Equity (ROE), andEarning Per Share (EPS). The four ratios used are financial ratios related to company profits as a criterion that is often used as a consideration in making investment decisions.

Net Profit Margin (NPM)

Net Profit Margin (NPM) is a ratio that shows the company's ability to generate net profit on sales made on sales, assets, and share capital. Net Profit Margin is the ratio between net income and sales. Mathematically, you can use the equation (Safitri & Mukaram, 2018):

$$\text{Net Profit Margin} = \frac{\text{Net Profit}}{\text{Sale}} \tag{1}$$

Return on Assets (ROA)

Return on Assets (ROA) shows an indicator of the financial health of a company in generating profits needed in assessing potential changes in economic resources in the future. This ratio is used to predict the company's capacity to generate cash and to determine the company's effectiveness in utilizing additional resources. The greater the value of Return on Assets, means the more efficient use of company resources in generating profits. Mathematically you can use the equation (Safitri & Mukaram, 2018):

$$\text{Return on Asset} = \frac{\text{Net Profit}}{Total\ Asset} \tag{2}$$

Return on Equity (ROE)

Return on Equity (ROE) is a ratio used to show a company's ability to generate profits or profits for shareholders from all of its equity. Where if the profits and profits obtained are high, then the position of the shareholder is also getting better. Mathematically you can use the equation (Safitri & Mukaram, 2018):

$$\text{Return on Equity} = \frac{\text{Net Profit}}{Total\ Equity} \tag{3}$$

Earning per Share (EPS)

Earning per Share is a ratio that shows the company's success or ability to generate profit or profit on each share owned by a shareholder. A high ratio value means that the company has succeeded in obtaining a high rate of return and satisfying the shareholders. The higher the value Earned per Share, the more the company's profit increases and the company's performance improves. Mathematically you can use the equation (Safitri & Mukaram, 2018):

$$\text{Earning per Share} = \frac{\text{Net Profit} - \text{Share Deviden}}{Number\ of\ Shares} \tag{4}$$

One of the decision-making methods that is often used in solving complex multi-criteria problems to be simpler is the methodAnalytic Hierarchy Process (AHP). AHP method (Analytic Hierarchy Process) was developed by Saaty. The method is used to obtain a single score based on different indicators or criteria. It simplifies the decision-making process by breaking down complex problems into a series of structured steps, assuming that each element of the criteria hierarchy is independent of the others (Saaty, 1990).

TOPSIS is a multicriteria decision analysis method originally developed by Hwang and Yoon in 1981. The method is based on the concept that the chosen alternative must have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution. The TOPSIS method is often used to complete decision making because it is easy to calculate, easy to understand, computationally efficient, and allows evaluation of the relative performance of alternative decisions with a simple mathematical model (Sylvia, 2021).

There have been many studies on the use of AHP and TOPSIS methods as decision support methods. Research by Mahmoodzadeh et al. (2007) with the title "Project Selection by Using Fuzzy AHP and TOPSIS Technique" combines two multi-criteria decision methods to find more efficient solutions to various financial challenges that require a stronger approach. The first strategy uses the AHP method to calculate the relative weight and investment of each option. The second strategy uses a preference technique based on similarity to the ideal solution (TOPSIS) to evaluate projects and select the right solution when calculating these weights.

Jony's research (2021) with the title "LQ45 Stock Selection Recommendation System Using the TOPSIS Method on Banking" which has the aim of assisting investors in providing recommendations for the best stock alternatives in making a profit. The results of the study provide information in managing the selection of LQ45 stocks based on ranking and BBCA is the selected stock based on the TOPSIS method in banking (Jony, 2021).

Vasquez's research (2022) entitled "AHP-TOPSIS Methodology for Stock Portfolio Investments" aims to find a balance between profitability and risk in the process of making investment decisions in stocks in the Colombian stock market. The results obtained from this study are that combining criteria provides more accurate results to find significant profits for investors and reduce the risk of loss (Vasquez, 2022).

Based on previous studies, this research is entitled "Application of the AHP-TOPSIS Method to Support Stock Investing Decisions Based on Financial Ratio Analysis". The factors that differentiate this research from previous research are the weighting criteria, methods, and data used. The method used as decision support in this study is the AHP-TOPSIS method with the criteria Return on Equity (ROE), Return on Assets (ROA), Net Profit Margin (NPM), and Earning Per Share (EPS) from the IDX30 stock index. Each of these criteria is processed to determine the weight of each criterion using the AHP method then the ranking order is determined using the TOPSIS method. This research uses secondary data from the financial statements of companies (issuers) listed on the Indonesia Stock Exchange index and has passed the audit, so that the validity and accuracy of the data used is guaranteed. Applying the use of AHP and TOPSIS methods to financial ratio analysis is expected to help investors in making decisions on stock investment choices more effectively and efficiently.

3. Materials and Methods

3.1. Materials

The object of this research is company listed on the IDX with audited financial statements and indexed IDX30 shares from https://www.idx.co.id. In this study, the type of data used is secondary data from observations obtained directly from the official website of the Indonesia Stock Exchange (IDX) and primary data in determining the weight of the AHP method is obtained from a questionnaire with 30 respondent. The tools used for this research are Microsoft Excel.

3.2. Methods

The data analysis method used to assist decision-making in investing in this research is the AHP-TOPSIS method. In determining the weight of each existing criterion, it is carried out using the AHP method by looking for the pairwise comparison matrix. Then these weights are used in ranking on the TOPSIS method by multiplying the weight of the criteria with the criteria from the financial statements of each company.

Analytical Hierarchy Process (AHP)

a) Structure Hierarchy
The first stage when forming a hierarchical structure is to determine the main problems and objectives, then arrange levels and hierarchies of existing problems.

b) Pairwise Comparison Matrix
Conducting AHP, an assessment is carried out using pairwise comparisons based on the level of importance of an alternative to each criterion to determine the order of importance of each existing element. The results of this pairwise comparison contain the level of importance of each criterion for each alternative in the form of a pairwise comparison matrix.
The data used in the pairwise comparison matrix is ratio data with distances that are not necessarily constant, so the geometric average is used (Geometric Mean) in combining the pairwise comparison values.

$$G_m = \sqrt[r]{x_{1m} \cdot x_{2m} \cdot \ldots \cdot x_{rm}} \quad (5)$$

The geometric mean value obtained is then used in the pairwise comparison matrix in the form of a square M. Elements of the upper triangular matrix in the pairwise comparison matrix are the geometric average values that have been obtained and the reciprocal nature applies.

c) Then do the weighting of each criterion by normalizing the pairwise comparison matrix to obtain a total weight value of one.

$$r_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \quad (6)$$

d) From the normalized matrix obtained, column vectors are then generated by weighting the criteria.

$$w_i : \frac{1}{n}\sum_{i=1}^{n} r_{ij} \quad (7)$$

e) After finding the weight of the criteria, then a consistency test is carried out to see the consistency of the judgment by the decision maker. In finding the eigenvalues maks the first thing to do is to determine the eigenvalues.

$$\lambda_i = \frac{\sum_{j=1}^{n} a_{ij}.w_i}{w_i} \quad (8)$$

then look for the eigenvaluesm which is used to test consistency

$$\lambda_m = \frac{1}{n}\sum_{i=1}^{n} \lambda_i \quad (9)$$

Furthermore, a consistency test is carried out to detect possible inconsistencies in the data input process. In the AHP method, the consistency ratio (CR) obtained is10%. Where every comparative assessment can be said to be consistent when testing consistency10%.

$$CI = \frac{(\lambda_m - n)}{(n-1)} \quad (10)$$

$$CR = \frac{CI}{RI} \quad (11)$$

Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

In the TOPSIS method, several steps are carried out, namely (Mahmoodzadeh et al., 2007).

a) Determining Linguity Value
Aims to provide a value for each alternative used against the criteria used.

b) Create a Normalized Decision Matrix
In the TOPSIS method, the normalized decision matrix contains values according to the linguistic values used.

$$N = \begin{bmatrix} x_{11} & x_{11} & \cdots & x_{1j} \\ x_{21} & x_{22} & \dots & x_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{nm} \end{bmatrix}; \; i = 1,2,3,\dots,n \text{ dan } j = 1,2,3,\dots,m \quad (12)$$

The TOPSIS method requires a performance level of each alternative against each normalized criterion in making uniform data from different data that meet a certain standard.

$$R_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \quad (13)$$

c) Creating a Weighted Normalized Decision Matrix
Obtained by multiplying the weight of the criteria w which has been obtained on the AHP method with a working rating.

$$v_{ij} = w_i.R_{ij} \quad (14)$$

d) Determine the Ideal Solution Matrix
The TOPSIS method has two ideal solutions, namely the positive ideal solution matrixA+ and the negative ideal solution matrixA- based on the normalized weight.

$$A^+ = (v_1^+, v_2^+, v_3^+, \dots, v_n^+) \quad (15)$$

$$A^- = (v_1^-, v_2^-, v_3^-, \dots, v_n^-) \quad (16)$$

e) Determining the Distance Between Ideal Solutions
Where the selected alternative is the alternative with the longest distance to the negative solution and has the shortest distance to the positive ideal solution. To find out the distance between alternatives with positive and negative ideal solutions, it can be obtained by using the following equation.

$$D_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2}; i = 1,2,3,\dots,n) \quad (17)$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} \left(v_j^- - v_{ij}\right)^2}; i = 1,2,3,\dots,n) \quad (18)$$

f) Define Preference Values
In the TOPSIS method, the preference value is in the range of 0 to 1, where the preference value indicates that the alternative performance is getting better when the preference value is close to 1.

$$\widehat{C}_\iota = \frac{D_i^-}{D_i^+ + D_i^-} \tag{19}$$

g) Choosing Alternatives
The selected alternative is an alternative that has value Ci≥0,5, where 0.5 is the median of 0 and 1. The selected alternatives are sorted by preference index value from largest to smallest.

4. Results and Discussion

The stock data used in this study are shares that are traded on the Indonesian capital market through the Indonesia Stock Exchange (IDX) and are indexed IDX30. The total companies used as samples for this study were 18 companies that had financial reports for the 2019-2022 period and were listed as IDX30 indexed for 6 periods within 3 years from 2019-2022. Of the 18 companies obtained as research samples, then a financial ratio analysis was carried out based on the values of ROA, ROE, NPM, and EPS from the company's financial statements.

In this paper, processing and discussion were carried out using the stages in the AHP method as follows:

The initial stage of processing the AHP method is to create a hierarchical structure, which in this study consists of objectives, criteria and alternatives used. The hierarchical structure can be seen in Figure 1.

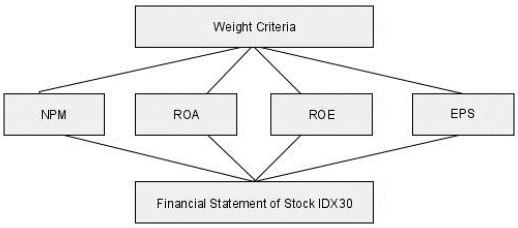

Figure 1: The hierarchical structure of research criteria and alternatives

Determination of the weight of each existing criterion is obtained by using a questionnaire filled out by young investors who use financial reports in making investments. From the questionnaire, then the value of the pairwise comparison matrix is determined based on the comparison scale. Pairwise comparisons are carried out by calculating *geometric mean* to fill the upper triangular matrix and is reciprocal to the lower triangular matrix in Table 1.

Table 1: Pairwise comparison matrix

	NPM	ROA	ROE	EPS
NPM	1	2.05	0.92	0.65
LONG	0.49	1	0.58	0.88
ROE	1.09	1.73	1	0.88
EPS	1.53	1.14	1.14	1
TOTAL	4.10866	5.91893	3.62968	3.41016

Then, the values of the pairwise comparison matrices that have been obtained in Table 1 are normalized to get the weight of each criterion. The normalized pairwise comparison matrix is obtained as shown in Table 2.

$$r_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}$$

$$r_{11} = \frac{1}{4.10866} = 0.24$$

$$r_{12} = \frac{0{,}49}{4.10866} = 0.11$$

Using the same method, the results are given in Table 2.

Table 2: Normalized pairwise comparison matrix

	NPM	ROA	ROE	EPS	Total
NPM	0.243388116	0.34605468	0.252163319	0.191926539	1.033532655
LONG	0.118825834	0.168949234	0.159434268	0.256634132	0.703843467
ROE	0.265918134	0.291947696	0.275505643	0.258198545	1.091570019
EPS	0.371867916	0.19304839	0.31289677	0.293240784	1.171053859
TOTAL	1	1	1	1	

After the pairwise comparison matrix has been normalized, then each criterion is weighted. The weighting of each criterion produces the column vector as follows.

$$w_i : \frac{1}{n}\sum_{j=1}^{n} r_{ij}$$

$$w_1 : \frac{1}{4}(1.0335) = 0.2583$$

$$w_2 : \frac{1}{4}(0.7038) = 0.1759$$

$$w_3 : \frac{1}{4}(1.0915) = 0.2728$$

$$w_4 : \frac{1}{4}(1.1710) = 0.2927$$

$$w = \begin{bmatrix} 0.2583 \\ 0.1759 \\ 0.2728 \\ 0.2927 \end{bmatrix}$$

From the calculation of the weighting of the criteria, the weight of each criterion is obtained, Earning Per Share (EPS) has a weight of 0.2927, Return on Equity (ROE) has a weight of 0.2728, Net Profit Margin (NPM) has a weight of 0.2583, and Return on Asset (ROA) has a weight of 0.1759.

After obtaining the weight of each criterion, the results obtained using the AHP method are accepted if the values obtained are from the consistency test ≤ 10%. The first thing to do in the consistency test is to find the eigenvalues λ_m. In determining λ_m first search λ_i.

$$\lambda_i = \frac{\sum_{j=1}^{n} a_{ij} \times w_i}{w_i}$$

$$\lambda_1 = \frac{(1 \times 0.25) + (2.05 \times 0.17) + (0.92 \times 0.27) + (0.65 \times 0.29)}{0.25} = \frac{1.06}{0.25} = 4.103$$

$$\lambda_2 = \frac{(0.49 \times 0.25) + (1 \times 0.17) + (0.58 \times 0.27) + (0.88 \times 0.29)}{0{,}17} = \frac{0.71}{0.17} = 4.070$$

$$\lambda_3 = \frac{(1.09 \times 0.25) + (1{,}73 \times 0.17) + (1 \times 0.27) + (0.88 \times 0.29)}{0{,}27} = \frac{1.11}{0.27} = 4.093$$

$$\lambda_4 = \frac{(1.53 \times 0.25) + (1.14 \times 0.17) + (1.14 \times 0.27) + (1 \times 0.29)}{0.29} = \frac{1.19}{0.29} = 4.093$$

$$\lambda_i = \begin{bmatrix} 4.103 \\ 4.070 \\ 4.093 \\ 4.093 \end{bmatrix}$$

Then, find λ_m as follows.

$$\lambda_m = \frac{1}{n}\sum_{i=1}^{n} \lambda_i = \frac{1}{4}(4.103 + 4.070 + 4.093 + 4.093) = 4.0902$$

After obtaining the eigenvalues, a consistency test is then carried out to determine consistency by determining the CI and CR as follows.

$$CI = \frac{(\lambda_m - n)}{(n-1)} = \frac{(4.0902 - 4)}{(4-1)} = 0.03006$$

$$CR = \frac{CI}{RI} = \frac{0.3006}{0.9} = 0.0334$$

Because of value $CR = 0.0334 \leq 0{,}10$, so that the pairwise comparison assessment matrix obtained using the AHP method is consistent and the criteria weight obtained can be used for TOPSIS method.

The TOPSIS method is then used in ranking and selecting the selected alternatives. In processing data with the TOPSIS method, this study uses the weights obtained from the AHP method according to the criteria. The alternative used is financial report data with the IDX30 index from 2019 to 2022 according to the criteria used in the study. The decision matrix is obtained from financial ratio analysis based on financial report data on the criteria. The table is then processed based on the linguistic table and financial report data given in Table 3.

Table 3: Decision matrix

NO	Code	Stock Company	Criteria			
			NPM	ROA	ROE	EPS
1	ADRO	Adaro Energy Indonesia Tbk.	4	4	3	2
2	ANTM	Aneka Tambang Tbk.	1	3	1	1
3	ASII	Astra International Tbk.	2	3	3	4
4	BBCA	Bank Central Asia Tbk.	5	2	4	5
5	BBNI	Bank Negara Indonesia (Persero) Tbk.	4	1	2	4
6	BBRI	Bank Rakyat Indonesia (Persero) Tbk.	5	2	3	2
7	BMRI	Bank Mandiri (Persero) Tbk.	5	1	3	4
8	CPIN	Charoen Pokphand Indonesia Tbk	2	4	4	3
9	ICBP	Indofood CBP Sukses Makmur Tbk.	3	4	5	4
10	INDF	Indofood Sukses Makmur Tbk.	2	3	2	5
11	INKP	Indah Kiat Pulp & Paper Tbk.	3	3	2	5
12	KLBF	Kalbe Farma Tbk.	3	5	4	1
13	PGAS	Perusahaan Gas Negara Tbk.	1	1	1	1
14	PTBA	Bukit Asam Tbk.	4	5	5	3
15	SMGR	Semen Indonesia (Persero) Tbk.	1	2	1	3
16	TLKM	Telkom Indonesia (Persero) Tbk.	5	5	5	2
17	UNTR	United Tractors Tbk.	3	4	4	5
18	UNVR	Unilever Indonesia Tbk.	4	5	5	3

Furthermore, after the value of the decision matrix is obtained, the matrix is normalized that contains values 0 to 1 which are the results of processing the decision matrix data for each alternative to the criteria used. The normalized decision matrix can be seen in Table 4 where the value x_{ij}obtained from Table 3.

$$R_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}}$$

$$R_{11} = \frac{4}{\sqrt{215}} = 0.27$$

$$R_{21} = \frac{1}{\sqrt{215}} = 0.07$$

$$R_{31} = \frac{2}{\sqrt{215}} = 0.14$$

Using the same method, the results are given in Table 4.

Table 4: Normalized decision matrix

NO	Code	Stock Company	Criteria			
			NPM	ROA	ROE	EPS
1	ADRO	Adaro Energy Indonesia Tbk.	0.27	0.27	0.20	0.14
2	ANTM	Aneka Tambang Tbk.	0.07	0.20	0.07	0.07
3	ASII	Astra International Tbk.	0.14	0.20	0.20	0.27
4	BBCA	Bank Central Asia Tbk.	0.34	0.14	0.27	0.34
5	BBNI	Bank Negara Indonesia (Persero) Tbk.	0.27	0.07	0.14	0.27
6	BBRI	Bank Rakyat Indonesia (Persero) Tbk.	0.34	0.14	0.20	0.14
7	BMRI	Bank Mandiri (Persero) Tbk.	0.34	0.07	0.20	0.27
8	CPIN	Charoen Pokphand Indonesia Tbk	0.14	0.27	0.27	0.20
9	ICBP	Indofood CBP Sukses Makmur Tbk.	0.20	0.27	0.34	0.27
10	INDF	Indofood Sukses Makmur Tbk.	0.14	0.20	0.14	0.34
11	INKP	Indah Kiat Pulp & Paper Tbk.	0.20	0.20	0.14	0.34
12	KLBF	Kalbe Farma Tbk.	0.20	0.34	0.27	0.07
13	PGAS	Perusahaan Gas Negara Tbk.	0.07	0.07	0.07	0.07
14	PTBA	Bukit Asam Tbk.	0.27	0.34	0.34	0.20
15	SMGR	Semen Indonesia (Persero) Tbk.	0.07	0.14	0.07	0.20
16	TLKM	Telkom Indonesia (Persero) Tbk.	0.34	0.34	0.34	0.14
17	UNTR	United Tractors Tbk.	0.20	0.27	0.27	0.34
18	UNVR	Unilever Indonesia Tbk.	0.27	0.34	0.34	0.20

Furthermore, the previously obtained weights from the AHP method are used to obtain values from the weighted normalization matrix. The weight value of each criterion obtained from the AHP method is NPM of 0.26, ROA of 0.18, ROE of 0.27, and EPS of 0.29.

$$v_{ij} = w_i \times R_{ij}$$
$$v_{11} = 0.26 \times 0.27 = 0.070$$
$$v_{21} = 0.26 \times 0.07 = 0.018$$
$$v_{31} = 0.26 \times 0.14 = 0.035$$

Using the same method, the results are given in Table 5.

Table 5: Weighted normalized decision matrix

NO	KODE	Stock Companies	Kriteria			
			NPM	ROA	ROE	EPS
1	ADRO	Adaro Energy Indonesia Tbk.	0.070	0.048	0.056	0.040
2	ANTM	Aneka Tambang Tbk.	0.018	0.036	0.019	0.020
3	ASII	Astra International Tbk.	0.035	0.036	0.056	0.080
4	BBCA	Bank Central Asia Tbk.	0.088	0.024	0.074	0.100
5	BBNI	Bank Negara Indonesia (Persero) Tbk.	0.070	0.012	0.037	0.080
6	BBRI	Bank Rakyat Indonesia (Persero) Tbk.	0.088	0.024	0.056	0.040
7	BMRI	Bank Mandiri (Persero) Tbk.	0.088	0.012	0.056	0.080
8	CPIN	Charoen Pokphand Indonesia Tbk	0.035	0.048	0.074	0.060
9	ICBP	Indofood CBP Sukses Makmur Tbk.	0.053	0.048	0.093	0.080
10	INDF	Indofood Sukses Makmur Tbk.	0.035	0.036	0.037	0.100
11	INKP	Indah Kiat Pulp & Paper Tbk.	0.053	0.036	0.037	0.100
12	KLBF	Kalbe Farma Tbk.	0.053	0.060	0.074	0.020
13	PGAS	Perusahaan Gas Negara Tbk.	0.018	0.012	0.019	0.020
14	PTBA	Bukit Asam Tbk.	0.070	0.060	0.093	0.060
15	SMGR	Semen Indonesia (Persero) Tbk.	0.018	0.024	0.019	0.060
16	TLKM	Telkom Indonesia (Persero) Tbk.	0.088	0.060	0.093	0.040
17	UNTR	United Tractors Tbk.	0.053	0.048	0.074	0.100
18	UNVR	Unilever Indonesia Tbk.	0.070	0.060	0.093	0.060

After obtaining the weighted normalization matrix, the values of the positive and negative ideal solution matrices are determined. The positive and negative ideal solution values are obtained in Table 6.

Table 6: Matrix of positive and negative ideal solutions

	NPM	ROA	ROE	EPS
A+	0.088	0.060	0.093	0.100
A-	0.018	0.012	0.019	0.020

From the positive ideal solutions and negative ideal solutions that have been obtained in Table 6, the distance between the positive and negative ideal solutions is determine. the distance between solutions is obtained as shown in Table 7.

$$D_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2}$$
$$D_{ADRO}^+ = \sqrt{(0.070 - 0.088)^2 + (0.048 - 0.060)^2 + (0.056 - 0.093)^2 + (0.040 - 0.100)^2} = 0.074$$
$$D_{ANTM}^+ = \sqrt{(0.018 - 0.088)^2 + (0.036 - 0.060)^2 + (0.019 - 0.093)^2 + (0.020 - 0.100)^2} = 0.132$$
$$D_i^- = \sqrt{\sum_{j=1}^{n} \left(v_j^- - v_{ij}\right)^2}$$
$$D_{ADRO}^- = \sqrt{(0.018 - 0.070)^2 + (0.012 - 0.048)^2 + (0.019 - 0.056)^2 + (0.020 - 0.040)^2} = 0.077$$
$$D_{ANTM}^- = \sqrt{(0.018 - 0.018)^2 + (0.012 - 0.036)^2 + (0.019 - 0.019)^2 + (0.020 - 0.020)^2} = 0.024$$

Using the same method, the results are given in Table 7.

Table 7: The distance between ideal solutions

No	Stock	D+	D-
1	ADRO	0.074	0.077
2	ANTM	0.132	0.024
3	ASII	0.072	0.077
4	BBCA	0.041	0.121
5	BBNI	0.078	0.082
6	BBRI	0.079	0.083
7	BMRI	0.064	0.100
8	CPIN	0.070	0.079
9	ICBP	0.042	0.108
10	INDF	0.081	0.087
11	INKP	0.070	0.092
12	KLBF	0.089	0.082
13	PGAS	0.139	0.000
14	PTBA	0.044	0.111
15	SMGR	0.116	0.042
16	TLKM	0.060	0.115
17	UNTR	0.042	0.110
18	UNVR	0.044	0.111

Furthermore, after obtaining the distance between solutions, the preference value of each alternative is sought. The results of the preference value of each alternative are then ranked, where the preference value is 0 to 1, where the preference value that is closer to 1 has better performance. he results of determining preference values in Table 8.

$$\widehat{C}_i = \frac{D_i^-}{D_i^+ + D_i^-}$$

$$\widehat{C_{ADRO}} = \frac{0.077}{0.074 + 0.077} = 0.510$$

Using the same method, the results are given in Table 8.

Table 8: Preference values

No.	Stock	$\widehat{C}_i$
1.	ADRO	0.510
2.	ANTM	0.154
3.	ASII	0.516
4.	BBCA	0.749
5.	BBNI	0.512
6.	BBRI	0.512
7.	BMRI	0.609
8.	CPIN	0.532
9.	ICBP	0.719
10.	INDF	0.520
11.	INKP	0.568
12.	KLBF	0.478
13.	PGAS	0.000
14.	PTBA	0.717
15.	SMGR	0.265
16.	TLKM	0.657
17.	UNTR	0.725
18.	UNVR	0.717

Then from the preference values that have been obtained, the ranking of the selected alternatives that have a preference value of > 0.5 where the highest rank is the alternative with the greatest preference value and close to 1.The alternative that is selected can be seen in Table 9.

Table 9: The results of the ranking of the selected alternatives

Stock	$\widehat{C}_i$	Rank
BBCA	0.749	1
UNTR	0.725	2
ICBP	0.719	3
UNVR	0.717	4
PTBA	0.717	5
TLKM	0.657	6
BMRI	0.609	7
INKP	0.568	8
CPIN	0.532	9
INDF	0.520	10
ASII	0.516	11
BBRI	0.512	12
BBNI	0.512	13
ADRO	0.510	14

5. Conclusion

The weight and priority order of each criterion obtained from calculations with the Analytical Hierarchy Process (AHP) method, namely Earning Per Share (EPS) ranks first with a weight of 0.2927, Return on Equity (ROE) with a weight of 0.2728, then Net Profit Margin (NPM) with a weight of 0.2583. The last is Return on Asset (ROA) with a weight of 0.1759. Where the weight value of each criterion obtained is consistent and can be used in data processing with the TOPSIS method.

Stock alternatives selected using the AHP-TOPSIS method based on financial ratio analysis are 14 companies out of 18 companies that can be used as investment decision considerations, in the order BBCA, UNTR, ICBP, UNVR, PTBA, TLKM, BMRI, INKP, CPIN, INDF, ASII, BBRI, BBNI, and ADRO.

References

Drakopoulou, V. (2015). *A Review of Fundamental and Technical Stock Analysis Techniques Journal of Stock & Forex Trading*. *5*(1), 1–8. https://doi.org/10.4172/2168-9458.1000163

Mahmoodzadeh, S., Shahrabi, J., Pariazar, M., & Zaeri, M. S. (2007). *10.1.1.193.3578.Pdf*. 333–338.

Marginingsih, R. (2017). Penilaian kinerja perusahaan dengan menggunakan analisa rasio keuangan pada perusahaan Telekomunikasi Di Indonesia. *Cakrawala Vol. XVII No.1*, 14-21.

Musthafa. (2017). *Manajemen keuangan.* Yogyakarta: CV. Andi Offset.

Paksi, A. B., Utami, E., & Henderi. (2017). Penerapan SAW-TOPSIS Dalam Analisis Rasio Keuangan. *Seminar Nasional Teknologi Informasi Dan Multimedia*, *2010*, 19–24.

Saaty, T. (1990). How to make a decision: the analytical hierarchy process. *European Journal of Operational Reaserch, 48*, 9-26.

Safitri, A. M., & Mukaram. (2018). Pengaruh ROA, ROE, dan NPM terhadap pertumbuhan laba pada perusahaan sektor industri barang konsumsi yang terdaftar di Bursa Efek Indonesia. *Jurnal Riset Bisnis & Investasi*, 4(1).

Sylvia, T. (2021). Distribution strategies analysis using AHP and TOPSIS: a distribution company case's study in special region of Yogyakarta, Indonesia. *Journal od Science and Applicative Technology*, 361-370.