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Analyzing Financial Performances of the Artificial Intelligence Firms by Using the AHP-TOPSIS Method

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Abstract
This study was carried out to evaluate the financial performance of artificial intelligence companies, which could not be found to be examined in the literature, by using the Analytic Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). For this purpose, the weights of the liquidity, financial structure, profitability and operating ratios criteria and the weights of the sub-criteria (current ratio, cash ratio, acid test ratio, long-term debt to capital ratio, debt to assets ratio, debt to equity ratio, net profit margin, return on equity (ROE), return on assets (ROA), return on investment (ROI), inventory turnover, asset turnover, receivable turnover) were determined by using the AHP method. As a result of the AHP analysis performed for the criteria, it was concluded that the criterion with the highest weight (n=0.533) was the profitability ratio (C3). In the analysis of all sub-criteria, it was understood that the sub-criterion with the highest global weight (n=0,186) was ROE (C3c). As a result of the TOPSIS analysis of the financial performance of the artificial intelligence companies selected between 2022-2019, it was understood that the artificial intelligence company that achieved the highest score in 2022, 2020 and 2019 was Firm 3. In 2021, it was concluded that Firm 2 achieved the highest score. This study is thought to provide helpful information to researchers and practitioners.

Keywords: Artificial Intelligence, Financial Performance, AHP, TOPSIS

1. INTRODUCTION

In today's highly competitive environment, decisions must be effective and correct for those who must make decisions, especially managers. Wrong decisions can sometimes cause irreversible damage. In this case, using mathematical applications can benefit institutions' decision-making. The AHP is among the most inclusive systems assisting multi-criteria decision-making (Stofkova et al., 2022, p. 1; Taherdoost, 2017, p. 244).

Technological development has become a vital aspect of most industries. The widespread use of digital technologies and the internet has greatly boosted the international artificial intelligence market in recent years. The international AI market had a value of USD 69.25 billion in 2022 and is projected to reach USD 1,871.2 billion by 2032, with a 39.1% CAGR from 2023 to 2032 (Precedence Research, 2023). AI has brought about a significant change in the technology industry. Its tools and applications have become more prevalent in various sectors for individuals and businesses at various levels (Prentice, 2023). The AI industry includes important competing businesses. Table 1 exhibits the top ten artificial intelligence firms with the highest market values on 10.07.2023.

Table 1. The top ten artificial intelligence firms' market values

Rank	Firm	Country	Market Capitalization
1	Microsoft	The United States of America	$2.550 T
2	Alphabet (Google)	The United States of America	$1.498 T
3	NVIDIA	The United States of America	$1.028 T
4	Tesla	The United States of America	$880.07 B
5	IBM	The United States of America	$119.85 B
6	Mobileye	Israel	$31.61 B
7	Palantir	The United States of America	$31.57 B
8	Dynatrace	The United States of America	$14.74 B
9	UiPath	The United States of America	$8.71 B
10	C3 AI	The United States of America	$4.31 B

Source: Companies Market Cap (2023)

It has been understood that the artificial intelligence company with the highest market value is Microsoft. It has been understood that other artificial intelligence companies with a market value of over 1 trillion dollars are Alphabet (Google), and Nvidia, respectively.

In the literature, many studies evaluate the AHP and TOPSIS methods together. Among these studies, appropriate machine selection (Karim & Karmaker, 2016), software-defined network controller selection (Durkadevi et al., 2022), best supplier selection (Huang et al., 2023; Nizar et al., 2023), portfolio investments selection (Vásquez et al., 2022), internet platform selection (Li et al., 2022), assessment of multi-skilled workforce, improvement of the recruitment process (Cahigas et al., 2021). In the literature, different analysis methods have been used together with AHP and TOPSIS in some studies, such as evaluating the risk of controlled flight to land (CFIT) for airlines and applying AHP and Entropy for safe and efficient airline operations (C. Guo et al., 2023), smart airport, application of AHP and Fuzzy inference system for the evaluation of technologies and performance standards for the smart logistics region (Göçmen, 2021), application of CRITIC, Entropy and TOPSIS methods to measure the job satisfaction levels of airport workers (Kalvakolanu et al., 2022), sustainable aviation fuel production paths application of PROMTHEE, TOPSIS, and VIKOR methods to evaluate (Ahmad et al., 2021).

Considering its opportunities and growth opportunities, evaluating the financial performance of artificial intelligence companies with AHP and TOPSIS methods is important. The purpose of this study is to evaluate the financial performance of artificial intelligence companies, which could not be found to be examined in the literature, by using AHP and TOPSIS methods.

2. LITERATURE REVIEW

In 1956, during the Dartmouth Summer Research Project on AI, McCarthy, Minsky, and Shannon coined the term artificial intelligence at Dartmouth College (Biswas & Wang, 2023, p. 14). Artificial intelligence is the subject of science with the possibilities it offers. When we look at the studies in the literature, it is understood that there are studies in many fields, such as robotics (e.g., Dirican, 2015; Guzman & Lewis, 2019; Kunze et al., 2018), telecommunications (e.g., Cayamcela & Lim, 2018; Li et al., 2017; Yao et al., 2019), management (e.g., Cao et al., 2021; Raisch & Krakowski, 2021; Strohmeier & Piazza, 2015), communication (e.g., Flores-Vivar, 2019; Galloway & Swiatek, 2018; Natale, 2021), education (e.g., Chassignol et al., 2018; Huang, 2021; Kavitha & Lohani, 2019), health (Brian et al., 2018; Parikh et al., 2019; Shaban-Nejad et al., 2018) and tourism (e.g., Sharma et al., 2022; Yang, 2019; Zhang, 2021).

It attracts attention to the many possibilities offered by artificial intelligence. Artificial intelligence can have a structure protected against errors if successful programming is provided. It can help to make the most optimal use of existing opportunities. Various standards can provide automation of tasks that need to be repeated continuously. It can create an opportunity for employees to focus on more innovative work. It can enable to analyze extensive data in a very short time and to obtain inferences. With the rapid feedback it provides, artificial intelligence can help decision-makers to make the most appropriate and correct decisions. It can avoid possible costs by taking part in the execution of works that can cause many costs if done incorrectly. Artificial intelligence can improve the incomes and business performances obtained with the opportunities it offers (Jenis et al., 2023; Maheshwari, 2023).

In the literature, many studies on AHP and TOPSIS analyze artificial intelligence. Among these studies, the use of PF-AHP and PF-CoCoSo methods for adopting artificial intelligence technologies (Nguyen et al., 2022), the use of Fuzzy AHP (FAHP) to determine the criteria and sub-criteria that affect customers' experience with AI-enabled financial services (Arora et al., 2023), using Delphi and AHP in determining the risk framework for human-centered artificial intelligence in education (Shijin & Xiaoqing, 2023), using AHP and VIKOR method for strategy selection problem in artificial intelligence (Ren et al., 2019), using AHP in the creation of an artificial intelligence strategy algorithm for identifying talented rowing athletes (J.-W. Liu et al., 2023), using AHP in determining the criteria for the adoption of news articles produced by artificial intelligence (Kim & Kim, 2020), using AHP and TOPSIS to rank art design and applications of machine learning and artificial intelligence (Xu & Nazir, 2022), a performance analysis model based on Gray clustering and AHP to evaluate the application impact of artificial intelligence in art teaching (Kong, 2020), using AHP to identify the challenges of adopting artificial intelligence in the health sector (Al Badi et al., 2021), the use of AHP-Fuzzy Comprehensive Evaluation to provide a measurable scientific evaluation method for organizational knowledge management performance evaluation of artificial intelligence (Huang et al., 2021), compared to FAHP in prioritizing the impact of AI-based visual communication for long-term learning (Y. Liu et al., 2023), using AHP in the design of a psychological health service system based on artificial intelligence technology for university students (Wang & Gong, 2021), FAHP in determining the criteria that prevent the adoption of artificial intelligence and virtual assistants in retail (Kamoonpuri & Sengar, 2023), using FAHP to evaluate the role of machine learning and artificial intelligence in music teaching (Hong Yun et al., 2022), using AHP to create an intelligent evaluation system for education applications with artificial intelligence technology (Tang & Hai, 2021), using AHP to identify factors affecting teachers' adoption of AI-based teaching and learning solutions (Du & Gao, 2022; Gupta & Bhaskar, 2020), using AHP for AI-based renewable energy solutions for farms (de Oliveira et al., 2023), using the Bayesian network and voting AHP to analyse the role of AI in building production flexibility (Dohale et al., 2022), conducting independent ERP and business intelligence-based marketing management system research using fuzzy TOPSIS (Tao et al., 2021), evaluating the role of artificial intelligence-based smart sensors in smart cities using MOORA and AHP (Khan & Nazir, 2023).

3. METHODOLOGY

The process of multiple criteria decision-making “efficiently arranges and resolves complex decision-making and planning problems that encompass multiple standard” (L. Guo et al., 2023). The AHP is among the essential techniques used in decision-making. The AHP developed by T. L. Saaty in the early 1970s can enable the quantification of judgments in multi-criteria decision-making (Li et al., 2023, p. 2; Tavana et al., 2021). The AHP tool is a popular and adaptable method for making decisions. It uses ratio scales derived from basic eigenvectors and a consistency index based on basic eigenvalues. This allows for a numerical weight to be assigned to each element in the hierarchy, enabling comparison between diverse and often incomparable elements rationally and consistently (Krenicky et al., 2022, p. 305; Sharma, 2018, p. 3141). AHP is “an effective decision-making method that combines qualitative and quantitative analysis to determine the weightings of critical factors in complex systems. Its widespread usage is due to its ability to provide a dominant solution for intricate problems” (Shi et al., 2019, p. 853).

There are main steps to apply the AHP method: “creating a matrix for comparing pairs, calculating the eigenvector and weighting coefficient, and determining the consistency ratio” (Nikhil et al., 2021, p. 10). Once the decision network matrix is created, we must rank the criteria through paired comparisons. Each criterion must be assigned a value ranging from “1” to “9”, as devised by Saaty, based on its level of importance. Pairwise comparisons will be made, with values of “1” indicating equal importance, “3” indicating slightly more importance, “5” indicating strong importance, “7” indicating dominance, and “9” indicating the highest level of validity. The values “2”, “4”, “6”, and “8” will be used to indicate compromise when choosing between two consecutive judgments (Saaty, 2008, p. 85; Shalini et al., 2022, p. 1789). The consistency index and eigenvector calculation, which takes place in the stages in AHP, is done as follows.

The matrix eigenvector for the pairwise comparison is calculated as follows (Oubahman & Duleba, 2022, p. 4):

$$A.w = \lambda_{max}.w \quad (1)$$

$$(A - \lambda_{max} I).w = 0 \quad (2)$$

To get the comparative weights, you can multiply the eigenvector w with λmax. Where "A" represents a consistent matrix, "w" is the eigenvector, "λ_{max}" is the maximum eigenvalue, and "*I*" is a quadratic matrix with a diagonal equal to 1 (Nong & Ha, p. 30; Oubahman & Duleba, 2022, p. 4).

To calculate the Consistency Ratio (CR) and Consistency Index (CI), follow these steps (Wubalem, 2023, p. 6):

$$CR = \frac{CI}{RI} \quad (3)$$

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (4)$$

Random Index (RI) is included in Table 2.

Table 2. Random index (RI)

Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49	1,51	1,48	1,56	1,57	1,59

Source: Londa and Tute (2020, pp. 53-54)

The Saaty scale is used to determine the average value of "CI" for random matrices, which is represented by "RI". A matrix is considered consistent if its CR value is less than 0.1 (Pradhan et al., 2021, p. 533).

The TOPSIS method, developed by Hwang and Yoon in 1981 (Guan & Zhao, 2022, p. 6), is based on the principle that the best choice should be close to the positive ideal solution and far away from the negative ideal solution in terms of geometric distance (Shafiee, 2022, p. 7). The TOPSIS method is a widely used and comprehensive assessment approach (L. Guo et al., 2023). The stages of the TOPSIS method, the formulas used and their explanations are as follows (Chowdhury et al., 2022, pp. 11-12; Hussain et al., 2022):

To begin, a decision matrix (DM) is created.

$$DM = \begin{matrix} A_1 \\ . \\ . \\ . \\ A_m \end{matrix} \begin{bmatrix} C_1 & \cdots & C_n \\ w_1 & \cdots & w_n \\ a_{11} & \cdots & a_{1n} \\ \vdots & \cdots & \vdots \\ a_{m1} & \cdots & a_{nm} \end{bmatrix} \quad (5)$$

Step 1: Formulating a normalized decision matrix:

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} (a_{ij})^2}} \quad (6)$$

Step 1 will yield the subsequent matrix R.

$$R = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} \quad (7)$$

Step 2: Development of a decision matrix that has been weight-normalized

$$v_{ij} = r_{ij} w_j \text{ where } i = 1,2, \dots m \text{ and } j = 1,2, \dots n. \quad (8)$$

V is the decision matrix that has been weight-normalized in the current step.

$$V = \begin{bmatrix} v_{11} & \cdots & v_{1n} \\ \vdots & \ddots & \vdots \\ v_{m1} & \cdots & v_{mn} \end{bmatrix} \quad (9)$$

Step 3: Calculating both the ideal and negative ideal solutions.

$$A^* = \{(max_i v_{ij} | j \in J), (min_i v_{ij} | j \in J^-), i = 1,2, \dots, m\} = \{v_1^*, v_2^*, \dots, v_n^*\} \quad (10)$$

$$A^- = \{(min_i v_{ij} | j \in J), (max_i v_{ij} | j \in J^-), i = 1,2, \dots, m\} = \{v_1^-, v_2^-, \dots, v_n^-\} \quad (11)$$

A^* is the ideal solution, while A^- is the negative ideal solution.

Step 4: The calculation of the separation measure.

$$S_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2}, for\ i = 1,2, \dots, m \quad (12)$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}, for\ i = 1,2, \dots, m \quad (13)$$

In this context, S_i^- represents the distance between the ith alternative and the negative ideal solution, while S_i^* represents the distance between the ith alternative and the ideal solution. 505

Step 5: Determine how relatively close the solution is to the ideal.

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^*}, i = 1,2, \dots, m\ and\ 0 \le C_i^* \le 1 \quad (14)$$

Step 6: Rank alternatives based on their proximity to the perfect solution.

To find the best solution, it is preferable to identify the shortest distance to A^* and the longest distance to A^-.

In this study, AHP and TOPSIS analyses were used. Microsoft Excel 2010 was used for AHP and TOPSIS analysis.

4. FINDINGS

In analyzing the financial performance evaluation of artificial intelligence companies using AHP and TOPSIS methods, the weights of criteria and sub-criteria were determined with AHP.

4.1. AHP Analysis

Financial ratios such as liquidity ratio, financial structure ratio, profitability ratio and operating ratio as financial performance criteria are among the financial ratios used in the studies

(Bloomenthal, 2023; Ishiaku et al., 2017; Mateos-Ronco & Mas, 2011). In light of the studies in the literature, the criteria to be used in the AHP comparison matrix were determined. Table 3 shows the criteria and sub-criteria used in AHP analyses.

Table 3. Criteria and sub-criteria used in AHP analyzes

Criteria and references	Criteria code	Selected sub-criteria and references	Sub-criteria code	Ideal direction
Liquidity ratio (Bloomenthal, 2023; Mateos-Ronco & Mas, 2011)	C1	Current Ratio: Current Assets / Current Liabilities (Hammond et al., 2022; Madushanka & Jathurika, 2018; Mateos-Ronco & Mas, 2011; Rudžionienė et al., 2022)	C1a	Maximum
		Acid Test Ratio (Quick Ratio): Current Assets - Inventories / Current Liabilities (Hammond et al., 2022; Madushanka & Jathurika, 2018; Mateos-Ronco & Mas, 2011; Rudžionienė et al., 2022)	C1b	Maximum
		Cash Ratio: Cash and Cash Equivalent / Current liabilities (Hammond et al., 2022; Mateos-Ronco & Mas, 2011)	C1c	Maximum
Financial structure ratio (Bloomenthal, 2023; Mateos-Ronco & Mas, 2011)	C2	Long-term Debt to Capital (Long-term Debt / Capital) Ratio (Ling, 2022)	C2a	Minimum
		Debt to Equity (Debt / Equity) Ratio (Hammond et al., 2022; Rudžionienė et al., 2022)	C2b	Minimum
		Debt to Assets (Debt / Assets) Ratio (Rudžionienė et al., 2022)	C2c	Minimum
Profitability ratio (Bloomenthal, 2023; Mateos-Ronco & Mas, 2011)	C3	Gross Margin: Gross profit/Revenue (Hammond et al., 2022; Rudžionienė et al., 2022; Sano & Yamada, 2021)	C3a	Maximum
		Net Profit Margin: Net Profit / Sales (Hammond et al., 2022; Rudžionienė et al., 2022)	C3b	Maximum
		Return on Equity (ROE): Net Profit After tax / Total Equity x 100 (Madushanka & Jathurika, 2018; Rudžionienė et al., 2022)	C3c	Maximum
		Return on Assets (ROA): Net Profit After tax / Total Assets x 100 (Madushanka & Jathurika, 2018; Rudžionienė et al., 2022)	C3d	Maximum
		Return on Investment (ROI): (Gain from Investment – Cost of Investment) / Cost of Investment (Sompolgrunk et al., 2023)	C3e	Maximum
Operating ratio (Ishiaku et al., 2017)	C4	Asset Turnover: Total Sales/Total Assets (Ahmad et al., 2023)	C4a	Maximum

	Inventory Turnover: Cost of Sales / Inventory (Hammond et al., 2022; Sano & Yamada, 2021)	C4b	Maximum
	Receivable Turnover: Sales / Account Receivables (Hammond et al., 2022)	C4c	Maximum

The criteria used to evaluate financial performance in the AHP comparison matrix consist of liquidity ratio, financial structure ratio, profitability ratio and operating ratio and their sub-criteria.

Expert (n=8) evaluations were taken for the criteria and sub-criteria used to determine financial performance with the comparison matrix created. Table 4 shows the pairwise comparison matrix for the financial performance criteria.

Table 4. Pairwise comparison matrix for the financial performance criteria

Criteria	C1	C2	C3	C4	% Weight	% Consistency ratio
C1	1,000	1,769	0,354	3,644	0,237	0,012
C2	0,565	1,000	0,342	2,769	0,165	
C3	2,828	2,928	1,000	7,288	0,533	
C4	0,274	0,361	0,137	1,000	0,065	

C1: Liquidity Ratio, C2: Financial Structure Ratio, C3: Profitability Ratio, C4: Operating Ratio

As a result of the analysis, it was concluded that the profitability ratio (C3) criterion had the highest weight (n=0.533). The CI value was calculated as 0.011. Table 5 shows the pairwise comparison matrix for financial sub-criteria (liquidity ratio).

Table 5. Pairwise comparison matrix for financial sub-criteria (liquidity)

Criteria	C1a	C1b	C1c	% Local weight	% Consistency Ratio
C1a	1,000	0,672	1,542	0,318	0,002
C1b	1,488	1,000	2,328	0,476	
C1c	0,648	0,429	1,000	0,206	

C1a: Current ratio, C1b: Quick ratio, C1c: Cash ratio

As a result of the analysis, it was concluded that the quick ratio (C1b) sub-criterion had the highest weight (n=0.476). The CI value was calculated as 0.001. Table 6 shows the pairwise comparison matrix for financial sub-criteria (financial structure ratio).

Table 6. Pairwise comparison matrix for financial sub-criteria (financial structure)

Criteria	C2a	C2b	C2c	% Local weight	% Consistency ratio
C2a	1,000	0,518	1,000	0,257	0,002
C2b	1,929	1,000	1,682	0,474	
C2c	1,000	0,595	1,000	0,269	

C2a: Long-term Debt to Capital, C2b: Debt to Equity, C2c: Debt to Assets

As a result of the analysis, it was concluded that the debt to equity (C2b) sub-criterion has the highest weight (n=0.474). The CI value was calculated as 0.001. Table 7 shows the pairwise comparison matrix for financial sub-criteria (profitability ratio).

Table 7. Pairwise comparison matrix for financial sub-criteria (profitability ratio)

Sub-criteria	C3a	C3b	C3c	C3d	C3e	% Local weight	% Consistency ratio
C3a	1,000	0,388	0,369	0,500	0,500	0,096	
C3b	2,577	1,000	0,269	0,351	0,595	0,129	
C3c	2,711	3,722	1,000	1,682	1,834	0,349	0,042
C3d	2,000	2,852	0,595	1,000	1,542	0,245	
C3e	2,000	1,682	0,545	0,648	1,000	0,181	

C3a: Gross margin ratio, C3b: Net profit margin ratio, C3c: Return on equity, C3d: Return on assets, c3e: Return on investment

As a result of the analysis, it was concluded that the ROE (C3c) sub-criterion had the highest weight (n=0.349). The CI value was calculated as 0.047. Table 8 shows the pairwise comparison matrix for financial sub-criteria (operating ratio).

Table 8. Pairwise comparison matrix for financial sub-criteria (operating ratio)

Criteria	C4a	C4b	C4c	% Local weight	% Consistency ratio
C4a	1,000	1,488	1,682	0,434	
C4b	0,672	1,000	1,929	0,349	0,027
C4c	0,595	0,518	1,000	0,217	

C4a: Asset turnover ratio, C4b: Inventory turnover ratio, C4c: Receivable turnover ratio

As a result of the analysis, it was concluded that the asset turnover ratio (C4a) sub-criterion had the highest weight (n=0.434). The CI value was calculated as 0.016. Table 9 shows the weights and ranks of the financial performance criteria and sub-criteria obtained as a result of the AHP analysis. 508

Table 9. Weights and ranks of financial performance criteria and sub-criteria

Criteria	# Ranking	% Weight	Sub-criteria	% Global weight	% Local weight
Liquidity ratio (C1)	2	0,237	C1a	0,075	0,318
			C1b	0,113	0,476
			C1c	0,049	0,206
Financial structure ratio (C2)	3	0,165	C2a	0,042	0,257
			C2b	0,078	0,474
			C2c	0,044	0,269
Profitability ratio (C3)	1	0,533	C3a	0,051	0,096
			C3b	0,069	0,129
			C3c	0,186	0,349
			C3d	0,131	0,245
			C3e	0,096	0,181
Operating ratio (C4)	4	0,065	C4a	0,028	0,434
			C4b	0,023	0,349
			C4c	0,014	0,217

As a result of the AHP analysis for the financial performance criterion (CR=0.012, CI=0.011), it was concluded that the first criterion with the highest weight (n=0.533) was the profitability ratio (C3). When the global weight of all sub-criteria was calculated, it was understood that the sub-criterion with the highest global weight (n=0.186) was ROE (C3c).

4.2. TOPSIS Analysis

Considering the criterion weights obtained from AHP, the TOPSIS method was applied to the financial performance of 5 influential companies in artificial intelligence. In some studies, TOPSIS stages were made by selecting a sample year, and then the TOPSIS results between the determined years were compared (e.g., Öngel, 2022). The financial data and ratios of the companies included in the study were obtained from websites (Companies Market Cap, 2023; Macrotrends, 2023). The companies included in the analysis are coded as "Firm 1-5". Afterwards, TOPSIS scores for 2022-2019 were compared. Financial ratios are considered sub-criteria for the chosen artificial intelligence firms. Table 10 contains the TOPSIS decision matrix.

Table 10. TOPSIS decision matrix for 2022

Sub-criteria	C1a	C1b	C1c	C2a	C2b	C2c	C3a	C3b	C3c	C3d	C3e	C4a	C4b	C4c
Weight	0,08	0,11	0,05	0,04	0,08	0,04	0,05	0,07	0,19	0,13	0,10	0,03	0,02	0,01
Firm 1	1,78	1,75	1,10	0,22	0,30	0,18	68,40	36,69	43,68	19,94	34,06	0,54	16,74	4,48
Firm 2	2,38	2,34	1,64	0,05	0,06	0,08	55,38	21,20	23,41	16,42	22,14	0,77	47,27	7,03
Firm 3	6,65	6,05	2,03	0,29	0,41	0,29	64,93	36,23	36,65	22,07	25,97	0,61	3,62	5,79
Firm 4	1,53	1,05	0,84	0,03	0,07	0,04	25,60	15,45	27,67	15,29	26,73	0,99	4,72	27,60
Firm 5	0,92	0,88	0,28	0,68	2,31	0,42	54,00	2,71	8,10	1,40	2,61	0,48	17,94	8,23

After creating the TOPSIS decision matrix, the normalized matrix was created. Table 11 includes the TOPIS normalized matrix.

Table 11. TOPSIS normalized matrix for 2022

Sub-criteria	C1a	C1b	C1c	C2a	C2b	C2c	C3a	C3b	C3c	C3d	C3e	C4a	C4b	C4c
Weight	0,08	0,11	0,05	0,04	0,08	0,04	0,05	0,07	0,19	0,13	0,10	0,03	0,02	0,01
Firm 1	0,24	0,26	0,37	0,28	0,13	0,33	0,55	0,63	0,64	0,53	0,62	0,34	0,31	0,15
Firm 2	0,32	0,34	0,55	0,06	0,03	0,15	0,44	0,37	0,34	0,44	0,40	0,49	0,88	0,23
Firm 3	0,89	0,88	0,68	0,37	0,17	0,53	0,52	0,63	0,54	0,59	0,47	0,39	0,07	0,19
Firm 4	0,20	0,15	0,28	0,04	0,03	0,07	0,21	0,27	0,41	0,41	0,48	0,63	0,09	0,90
Firm 5	0,12	0,13	0,09	0,88	0,98	0,77	0,43	0,05	0,12	0,04	0,05	0,31	0,33	0,27

After the normalized matrix was created, a weighted normalized matrix was created. Table 12 includes the TOPSIS weighted normalized matrix.

Table 12. TOPSIS weighted normalized matrix for 2022

Sub-criteria	C1a	C1b	C1c	C2a	C2b	C2c	C3a	C3b	C3c	C3d	C3e	C4a	C4b	C4c
Firm 1	0,02	0,03	0,02	0,01	0,01	0,01	0,02	0,04	0,13	0,08	0,07	0,01	0,01	0,00
Firm 2	0,03	0,04	0,03	0,00	0,00	0,00	0,01	0,02	0,07	0,07	0,04	0,01	0,02	0,00

Firm 3	0,08	0,10	0,04	0,01	0,01	0,02	0,02	0,03	0,11	0,09	0,05	0,01	0,00	0,00
Firm 4	0,02	0,02	0,02	0,00	0,00	0,00	0,01	0,01	0,08	0,06	0,05	0,02	0,00	0,01
Firm 5	0,01	0,01	0,01	0,03	0,05	0,02	0,01	0,00	0,02	0,01	0,01	0,01	0,01	0,00
V+	0,08	0,10	0,04	0,00	0,00	0,00	0,02	0,04	0,13	0,09	0,07	0,02	0,02	0,01
V-	0,01	0,01	0,01	0,03	0,05	0,02	0,01	0,00	0,02	0,01	0,01	0,01	0,00	0,00

As a result of the TOPSIS analysis, the artificial intelligence company with the best score in 2022 was determined. Compared to results from 2022-2019. Table 13 shows the TOPSIS final scores of artificial intelligence companies for 2022-2019.

Table 13. TOPSIS final scores of the artificial intelligence firms between 2022-2019

Year	2022			2021			2020			2019		
Score	S_i^+	S_i^-	C_i^+	S_i^+	S_i^-	C_i^+	S_i^+	S_i^-	C_i^+	S_i^+	S_i^-	C_i^+
Firm 1	0,09	0,16	0,63	0,06	0,13	0,71	0,09	0,18	0,67	0,11	0,17	0,61
Firm 2	0,10	0,12	0,55	0,05	0,14	**0,75**	0,11	0,13	0,56	0,13	0,14	0,52
Firm 3	0,04	0,18	**0,80**	0,07	0,12	0,64	0,06	0,18	**0,75**	0,02	0,25	**0,91**
Firm 4	0,12	0,12	0,51	0,12	0,09	0,41	0,19	0,07	0,27	0,24	0,03	0,11
Firm 5	0,20	0,01	0,06	0,16	0,02	0,12	0,18	0,06	0,25	0,18	0,13	0,42

As a result of the TOPSIS analysis, it was understood that Firm 3 was the artificial intelligence company that achieved the highest score in 2022, 2020 and 2019. In 2021, it was determined that Firm 2 was the artificial intelligence company with the highest score.

5. CONCLUSION

In this study, which was carried out to evaluate the financial performances of artificial intelligence companies, which could not be determined to have been examined in the literature before, by using AHP and TOPSIS methods, the weights of financial performance criteria were determined primarily by using AHP. Based on the criteria weights obtained from the AHP analysis, the financial performance of the artificial intelligence firms included in the analysis was analyzed with the TOPSIS method.

As a result of the AHP analysis for financial performance criteria, it was understood that the criterion with the highest weight was the profitability ratio criterion. When the other criteria with the highest weight were examined, it was concluded that the profitability ratio criterion was followed by the liquidity, financial structure, and operating ratios criteria, respectively. Profitability ratios are important because financial ratios are used to evaluate companies' ability to make a profit. In the analysis made among all sub-criteria, it was understood that ROE was the sub-criterion with the highest global weight. ROE is one of the important financial performance indicators that can affect many factors, such as stock returns (Mudzakar & Wardanny, 2021) and firm value (Sutomo & Budiharjo, 2019).

Especially in recent years, the impact of artificial intelligence companies on global life has increased significantly. In the current situation, it can be understood that the financial performance of artificial intelligence companies is also affected. As a result of the TOPSIS analysis, it was understood that Firm 3 was the artificial intelligence company that achieved the highest score in 2022, 2020 and 2019. In 2021, it was concluded that Firm 2 achieved the highest score. It can be understood that Firm 3 can provide a stable advantage in terms of financial performance compared to its other competitors, except for 2021.

This study is thought to provide helpful information to researchers and practitioners. It is understood that researchers can carry out their own studies by using this study's analysis method as a guide in their research. It is thought that practitioners can have an idea about which criteria are important to consider in financial performance analysis and how effective these criteria can be on the financial performance of companies. The period in which the study was conducted, the selected criteria and sub-criteria and the method applied are the limitations of the study. In future research, companies in artificial intelligence can undergo financial performance analysis using various methods such as Mairca and Fucom. Analyzing involving financial evaluation for popular and promising sectors such as Metaverse and ChatGPT may be useful.

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