Science of Law, 2025, No. 3, pp. 388-394
DOI: 10.55284/5g66k181

Application of Python-Based Topsis Method for Financial Performance Assessment of Idx Companies

Herti Diana Hutapea[1*], Erlina[2], Iskandar Muda[3], Dio Agung Herubaw[4], Windi Astuti[5]

[1,2,3,4,5]Faculty of Economics and Business, Universitas Sumatera Utara, Indonesia; herti.hutapea@uhn.ac.id

Keywords:
Finansial,
Perfomance assessment,
Python,
Topsis.

Abstract. This study applies the Python-based TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method to assess the financial performance of companies listed on the Indonesia Stock Exchange (IDX) during the period. In the context of an ever-growing and digitalized economy, objective assessment of financial performance is very important for strategic decision making. This study uses financial ratio data such as Return on Assets (ROA), Return on Equity (ROE), Current Ratio, Debt to Equity Ratio (DER), and Net Profit Margin (NPM) which are grouped into three main categories: liquidity, solvency, and profitability. Each ratio is given a criterion direction (benefit/cost) and weight based on its level of importance. The analysis process includes data pre-processing, normalization, weighting, determining positive and negative ideal solutions, calculating distances, and calculating preference values or Closeness Coefficients (CC). The results of the study show that LPPS companies have the best financial performance (CC: 0.699214), while TIRT is ranked lowest (CC: 0.476411). This study proves that the Python-based TOPSIS method is able to provide systematic, efficient, and reliable financial performance evaluations, and can be a valuable tool for investors, analysts, and management in decision making.

1. INTRODUCTION

The digital revolution has reshaped the landscape of industries, not only in how businesses operate but also in how they innovate, make decisions, and compete (Omar Al-Kasasbeh, 2024; Sallapalli, 2024). Companies had to modify their operational models, financial structures, and investment strategies in order to survive and thrive under these unprecedented circumstances (Kocot, 2023).

In this evolving economic climate, the ability to assess a company's financial performance accurately and efficiently has become more crucial than ever (Sulkifli et al., 2023). Therefore, Multi-Criteria Decision Making (MCDM) methods, particularly the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), offer a structured and comprehensive framework for financial performance assessment (Katrancı et al., 2025; Lam et al., 2023).

TOPSIS is a decision-making method that evaluates multiple alternatives against several criteria, identifying the best option based on its proximity to an ideal solution (Zulqarnain et al., 2020)(Verdyansyah Pratama, 2024). When applied to financial performance analysis, TOPSIS enables a more balanced evaluation by considering the relative importance (weights) and direction (benefit or cost) of each financial rasio (A. A. Ali et al., 2024).

To facilitate large-scale data analysis with precision and efficiency, Python has emerged as a powerful tool (Kabir et al., 2024). By leveraging libraries such as Pandas, NumPy, and SciPy, Python provides robust functionality for data preprocessing, normalization, weighting, and distance calculations. This study utilizes a Python-based implementation of the TOPSIS method to assess the financial performance of companies listed on the Indonesia Stock Exchange (IDX) over a four-year period from 2020 to 2023. Each ratio is assigned a criterion direction—either 'Benefit' or 'Cost'—based on its influence on performance, and a corresponding weight to reflect its strategic importance (Temple Akpa et al., 2024).

Despite the existing literature on financial analysis, there remains a gap in the practical application of the Python-based TOPSIS method specifically within the Indonesian market context. This study addresses that gap by providing a practical and replicable approach to evaluating the financial health of IDX-listed companies using objective, data-driven methodologies. Ultimately, the goal is to empower stakeholders—including investors, analysts, and company management—with actionable insights for strategic decision-making.

2. METHOD

This research approach employs the Python-based TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method to assess and rank the financial performance of companies listed on the Indonesia Stock Exchange (IDX) from 2020 to 2023. This method was selected for its capacity to evaluate multiple criteria concurrently and generate objective decisions based on the relative closeness of an alternative to the optimal solution.

This research methodology comprises three primary components: input, process, and output, as illustrated in the flowchart. This study utilizes the financial dataset of IDX companies from 2020 to 2023. This dataset comprises quantitative data from financial statements featuring critical indicators such as Return on Assets (ROA), Return on Equity (ROE), Current Ratio, Debt to Equity Ratio, Net Profit Margin, and additional metrics that signify a company's financial performance. The TOPSIS approach is methodically executed during the process stage through a series of technical procedures.

*Corresponding author.

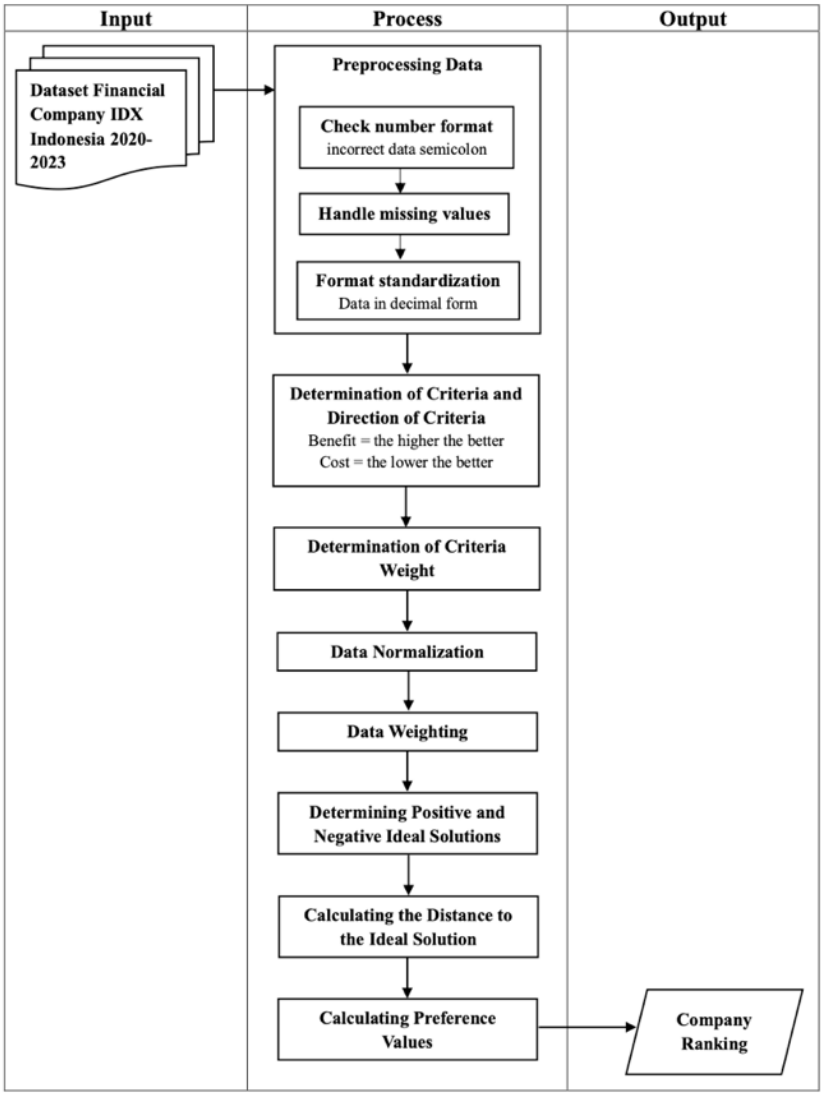

Figure 1. Research Flow.

2.1. Preprocessing Data

The preliminary phase involves data preprocessing, which entails preparing and validating the data to ensure its suitability for analysis (Jamshed et al., 2019).

2.2. Check Number Format

Check Number Format aims to ensure that all numeric data has a consistent format and can be processed mathematically.

2.3. Handle Missing Value

In the TOPSIS approach, each numerical datum significantly impacts the processes of normalization, weighting, and the computation of the distance to the ideal solution. Consequently, addressing missing values is an essential step to ensure the analytic process operates effectively and without errors.

2.4. Format Standrdization

Format standardization is to guarantee that all numeric data possesses a consistent format prior to its computation in the TOPSIS method. This is a crucial phase in data pre-processing due to the frequent inconsistencies in financial data types (Dehdasht et al., 2020; Ran et al., 2025).

2.5. Determination of Criteria and Direction of Criteria

Upon the completion of data preparation, the parameters and guidelines for each criterion are established (Barman et al., 2024). Certain factors are deemed advantageous (higher values are preferable), whereas others are classified as detrimental (lower values are preferable), based on their influence on corporate performance (Rane et al., 2023).

2.6. Determination of Criteria Weight

The next step entails evaluating the weight of each criterion based on its importance. This weight can be evaluated subjectively through expert judgment or objectively using statistical techniques such as entropy.

2.7. Data Normalization

Subsequently, the data is normalized to mitigate the influence of unit disparities among criteria on the analytical outcomes.

2.8. Data Weighting

Followed by data weighting, which entails multiplying the normalized values by their corresponding criteria weights. A weighted decision matrix is created at this stage, forming the basis for further calculations.

2.9. Determination Positive and Negative Ideal Solution

The objective of identifying the Positive and Negative Ideal Solutions in the TOPSIS pre-process is to ascertain the optimal solution (positive ideal / A^+) and the suboptimal solution (negative ideal / A^-) for each criterion, thereby providing a comparative benchmark for evaluating the performance of each alternative.

2.10. Calculating the Distance to the Ideal Solution

The positive ideal solution represents the optimal value (e.g., the maximum for ROE), whereas the negative ideal solution signifies the least favorable value (e.g., the minimum for debt ratio). The Euclidean distance formula is employed to determine the proximity of each option (business) to the optimal solution.

2.11. Calculating Preference Values

The concluding phase of this process involves calculating the preference value, which indicates the proximity of each company to the positive ideal solution relative to the negative ideal solution. The result of the TOPSIS procedure is a hierarchy of companies determined by their financial performance.

2.12. Company Rangking

The company with the highest preference value is deemed to exhibit superior performance, since its position is nearest to the positive ideal solution and farthest from the negative ideal solution. This entire process is executed using the Python programming language, which offers numerous modules for data processing, statistical analysis, and result visualization, facilitating precise, efficient, and reproducible research.

3. RESULTS AND DISCUSSION

3.1. Preprocessing Data

3.1.1. Check Number Format

Before proceeding to further analysis, a crucial step in data preprocessing is to ensure that all numerical values are in a consistent and valid format (Gaur, 2019). This includes verifying that decimal separators are correctly standardized and that no non-numeric characters are present in fields expected to contain numeric data

Table 1. Result of Check Number Format.

Symbol	Ratio	Type	2020	2021	2022	2023
AALI	Cash Ratio	Liquidity	0.486272	0.631559	0.514806	0.482815
AALI	Current Ratio	Liquidity	3.312619	1.579460	3.600013	1.833576
AALI	DER	Solvency	0.299903	0.276267	0.186947	0.181915
AALI	Debt Ratio	Solvency	0.202436	0.187382	0.138593	0.138841
AALI	GPM	Profitability	0.157541	0.198585	0.175096	0.133570

As shown, all financial ratios across the four years (2020–2023) are now properly represented in decimal format. This ensures:

a. Accuracy in subsequent mathematical operations (e.g., normalization, weighting).
b. Data consistency across rows and columns.
c. Prevention of runtime errors during numeric computations.

This validation step is essential because any inconsistencies in numeric formatting—such as misplaced commas, incorrect decimal points, or mixed data types—can lead to incorrect analysis results or processing failures.

Having verified and corrected these formats, the dataset is now suitable for standardized evaluation methods like TOPSIS, which rely on precise numerical inputs for ranking and scoring.

3.2. Handle Missing Value

The Handle Missing Value process is an important part of data pre-processing before TOPSIS analysis is carried out. This stage is carried out to overcome missing values in the dataset so that they do not interfere with calculations in the next stage.

Table 2. Result of Handle Missing Value.

Symbol	Ratio	Type	2020	2021	2022	2023
AALI	Cash Ratio	Liquidity	0.486272	0.631559	0.514806	0.482815
AALI	Current Ratio	Liquidity	3.312619	1.579460	3.600013	1.833576
AALI	DER	Solvency	0.299903	0.276267	0.186947	0.181915
AALI	Debt Ratio	Solvency	0.202436	0.187382	0.138593	0.138841
AALI	GPM	Profitability	0.157541	0.198585	0.175096	0.133570

3.3. Format Standardization

Format standardization is a vital preprocessing step to ensure that all numerical data, especially financial ratios from 2020 to 2023, are presented in a consistent and valid decimal format. This is necessary because raw data may contain regional formatting differences, such as commas or semicolons used as decimal separators.

Table 3. Result of Format Standardization.

Symbol	Ratio	Type	2020	2021	2022	2023
AALI	Cash Ratio	Liquidity	0.486272	0.631559	0.514806	0.482815
AALI	Current Ratio	Liquidity	3.312619	1.579460	3.600013	1.833576
AALI	DER	Solvency	0.299903	0.276267	0.186947	0.181915
AALI	Debt Ratio	Solvency	0.202436	0.187382	0.138593	0.138841
AALI	GPM	Profitability	0.157541	0.198585	0.175096	0.133570

Standardizing these to periods (.) prevents parsing errors and enables accurate mathematical operations in subsequent analyses like normalization and TOPSIS. The standardization process involves cleaning the data and converting all values into proper float types to maintain analytical integrity.

Determination of Criteria and Direction of Criteria

Criteria and Direction Determination Criteria is the process of determining whether a financial ratio is Benefit (the bigger the better) or Cost (the smaller the better).

Table 4. Result of Determination of Criteria and Direction of Criteria.

Symbol	Ratio	Type	2020	2021	2022	2023	Kriteria
AALI	Cash Ratio	Liquidity	0.486272	0.631559	0.514806	0.482815	Benefit
AALI	Current Ratio	Liquidity	3.312619	1.579460	3.600013	1.833576	Benefit
AALI	DER	Solvency	0.299903	0.276267	0.186947	0.181915	Cost
AALI	Debt Ratio	Solvency	0.202436	0.187382	0.138593	0.138841	Cost
AALI	GPM	Profitability	0.157541	0.198585	0.175096	0.133570	Benefit

This classification is added to the dataset through the 'criteria' column and is important for analysis methods such as TOPSIS, as it affects the calculation of the ideal solution and the final ranking.

3.4. Determination of Criteria Weight

Determination of Criteria Weight is the process of assigning weights to each financial ratio based on its main categories, such as Liquidity, Solvency, and Profitability. These weights reflect the level of importance of each category to the evaluation of the company's performance (S. I. Ali et al., 2024; OVA, 2022).

Table 5. Result of Determination of Criteria Weight.

symbol	ratio	type	2020	2021	2022	2023	Kriteria	Bobot
AALI	Cash Ratio	Liquidity	0.486272	0.631559	0.514806	0.482815	Benefit	0.3
AALI	Current Ratio	Liquidity	3.312619	1.579460	3.600013	1.833576	Benefit	0.3
AALI	DER	Solvency	0.299903	0.276267	0.186947	0.181915	Cost	0.2
AALI	Debt Ratio	Solvency	0.202436	0.187382	0.138593	0.138841	Cost	0.2
AALI	GPM	Profitability	0.157541	0.198585	0.175096	0.133570	Benefit	0.5

For example, the ratio in the Profitability category is given a greater weight (0.5), because it is considered to have the most influence on the company's success, compared to Liquidity (0.3) and Solvency (0.2). These weight values are then added to a new column called 'weight' in the dataset, and used in the weighting stage of decision-making methods such as TOPSIS.

3.5. Data Normalization

Data normalization is the process of scaling financial ratio values to be in a uniform range, so that they can be compared fairly between criteria (Kim et al., 2024). In this study, normalization is carried out using the vector method, namely dividing each value by the square root of the sum of the same column. This step aims to eliminate differences in scale between ratios and prepare data for weighting and calculation in the TOPSIS method.

Table 6. Result of Data Normalization.

Symbol	Ratio	Type	2020	2021	2022	2023	Kriteria	Bobot
AALI	Cash Ratio	Liquidity	00.00	00.00	3,16E+00	4,92E+00	Benefit	00.03
AALI	Current Ratio	Liquidity	00.00	00.00	2,21E+02	1,87E+01	Benefit	00.03
AALI	DER	Solvency	00.00	00.00	1,15E+01	1,86E+00	Cost	00.02
AALI	Debt Ratio	Solvency	00.00	00.00	8,50E-01	1,42E+01	Cost	00.02
AALI	GPM	Profitability	00.00	00.00	1,07E+01	1,36E+01	Benefit	00.05

3.6. Data Weighting

Data Weighting is the process of assigning specific weights to each criterion based on its importance in the analysis (bin Abu Seman et al., 2020; Łopatka et al., 2023). In this case, ratios related to 'Profitability' have a higher weight (0.5), while 'Liquidity' and 'Solvency' have weights of 0.3 and 0.2, respectively. The goal is to ensure that more important factors have a greater impact on the final analysis.

Table 7. Result of Data Weighting.

Symbol	Ratio	Type	2020	2021	2022	2023	Kriteria	Bobot
AALI	Cash Ratio	Liquidity	00.00	00.00	9,47E-01	1,48E+01	Benefit	00.03
AALI	Current Ratio	Liquidity	00.00	00.00	6,62E+00	5,61E+00	Benefit	00.03
AALI	DER	Solvency	00.00	00.00	2,29E+00	3,71E+00	Cost	00.02
AALI	Debt Ratio	Solvency	00.00	00.00	1,70E+00	2,83E-01	Cost	00.02
AALI	GPM	Profitability	00.00	00.00	5,37E-01	6,81E-01	Benefit	00.05

After applying the weights, the data values are adjusted accordingly to reflect their importance in subsequent calculations, such as the TOPSIS method. The weights are stored in the "bobot" column and will be used in further steps.

3.7. Determining Positive and Negative Ideal Solutions

Determining Positive and Negative Ideal Solutions is an essential step in the TOPSIS method (Waqas Arshad & Rahmanto, 2024). The Positive Ideal Solution (A+) represents the best outcomes, where for 'Benefit' criteria, the maximum values across all companies and years are selected, and for 'Cost', the minimum values are chosen.

```
Solusi Ideal Positif (A+):
          2020  2021          2022          2023
Benefit    0.0   0.0  1.872160e-12  4.264110e-12
Cost      -0.0  -0.0 -2.778431e-13 -1.184824e-14

Solusi Ideal Negatif (A-):
          2020  2021          2022          2023
Benefit   -0.0  -0.0 -3.686752e-12 -8.057514e-12
Cost       0.0   0.0  8.373619e-14  2.389542e-13
```

Figure 2. Result of Determining Positive and Negative Ideal Solutions.

The Negative Ideal Solution (A-) represents the worst outcomes, where for 'Benefit' the minimum values are selected, and for 'Cost', the maximum values are chosen. These ideal solutions are used as benchmarks to compare each company's performance, helping to calculate distances to the best and worst solutions in the analysis.

3.8. Calculating the Distance to the Ideal Solution

Calculating the Distance to the Ideal Solution in TOPSIS measures how far each company is from the best (A+) and worst (A-) possible outcomes (Sadabadi et al., 2020; Wu et al., 2022). D_plus represents the distance to the Positive Ideal Solution (A+), with smaller values indicating better performance. D_minus represents the distance to the Negative Ideal Solution (A-), with smaller values showing closer proximity to the worst-case scenario. These distances are key to determining the closeness coefficient (CC) in the subsequent steps.

Table 8. Result of Calculating the Distance to the Ideal Solution.

Symbol	Ratio	D_Plus	D_Minus
AALI	Cash Ratio	4,66E+03	8,86E+03
AALI	Current Ratio	4,65E+04	8,87E+03
AALI	DER	2,78E+03	2,53E+02
AALI	Debt Ratio	2,78E+02	2,53E+02
AALI	GPM	4,66E+03	8,86E+02

3.9. Calculating Preference Values

Calculating the Preference Values, or Closeness Coefficient (CC), is the final step in the TOPSIS method. The CC measures how close each company is to the best possible outcome (Positive Ideal Solution) relative to the worst-case scenario (Negative Ideal Solution). A higher CC indicates better performance, meaning the company is closer to the ideal and farther from the worst case.

Table 9. Result of Calculating Preference Values.

Symbol	Ratio	D_Plus	D_Minus	Cc
AALI	Cash Ratio	4,66E+03	8,86E+03	0.6556224988064961
AALI	Current Ratio	4,65E+04	8,87E+03	0.6560726005572699
AALI	DER	2,78E+02	2,53E+02	0.4759322019540849
AALI	Debt Ratio	2,78E+02	2,53E+02	0.47608990658000716
AALI	GPM	4,66E+03	8,86E+02	0.6555563479094974

The CC values help rank companies, with those having higher CC values being considered better. For example, a CC of 0.656073 for "Current Ratio" suggests that the company's performance is close to the best possible outcome.

3.10. Company Ranking

The Company Ranking results show the performance of each company based on the Closeness Coefficient (CC) values calculated using the TOPSIS method. The CC reflects how close a company's financial performance is to the best possible outcome (Positive Ideal Solution) and how far it is from the worst-case scenario (Negative Ideal Solution).

Table 10. Result of Company Ranking.

Symbol	CC	Ranking
LPPS	0.6992137200661307	1
FUJI	0.6597275485298096	2
IIKP	0.6574436501443925	3
RIGS	0.6565837512698632	4
....	.....	...
ARTO	0.5660296120365023	600
BEKS	0.5660178432029944	601
BBYB	0.5659725231825646	602
HDTX	0.5265221929417812	603
TIRT	0.4764111547659998	604

In the table, companies are ranked from the highest to the lowest CC value. The company LPPS ranks first with a CC value of 0.699214, indicating it is the closest to the ideal financial performance among the 604 companies evaluated. This suggests LPPS demonstrates superior performance across the evaluated financial criteria.

On the contrary, TIRT is ranked last at position 604 with a CC value of 0.476411, showing it is the farthest from the ideal condition and potentially in need of financial improvement. Other high-ranking companies include FUJI (2nd, CC: 0.659728), IIKP (3rd, CC: 0.657444), RIGS (4th, CC: 0.656584), and FILM (5th, CC: 0.656154), all of which are considered to have strong financial positions relative to their peers. This ranking offers a comprehensive comparison for investors, stakeholders, or company management to assess performance, allocate resources, and identify areas requiring strategic attention.

4. CONCLUSION

This research successfully applied the Python-based TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method to assess the financial performance of 604 companies listed on the Indonesia Stock Exchange (IDX) over the 2020–2023 period. Through a series of processes such as data preprocessing, determining the direction and weight of criteria, normalization, weighting, to calculating ideal solutions and closeness coefficients, this study produces a ranking of company financial performance based on the Closeness Coefficient (CC) value. The results show that the companies with the best financial performance are: LPPS with a CC value of 0.699214 (rank 1), followed by FUJI (0.659728), IIKP (0.657444), RIGS (0.656584), and FILM (0.656154). Meanwhile, the companies with the lowest rankings include: TIRT (CC: 0.476411, ranked 604), HDTX (0.526522), BBYB (0.565973), BEKS (0.560018), and ARTO (0.566030). This finding proves that the TOPSIS method implemented in Python is able to provide an objective and comprehensive evaluation of a company's financial performance, and can be a valuable tool for investors, analysts, and management in making strategic decisions amidst the ever-changing economic dynamics.

REFERENCES

Ali, A. A., Numaan, M. M., & Ismail, N. N. (2024). Impact of seasonal changes on groundwater quality for irrigation purposes in Al-Sharqat, Iraq: A GIS and IWQI approach. *Edelweiss Applied Science and Technology, 8*(6), 9206–9218. https://doi.org/10.55214/25768484.v8i6.3975

Ali, S. I., Lalji, S. M., Zhang, L., Husain, N., Ali, A. Y., Yahya, A., Burney, M., Jamil, T., & Arfeen, Z. A. (2024). Selection of best apshaltene controlling chemical additive for crude oil using strategic sensitivity of weight criteria importance in TOPSIS method. *Journal of Industrial and Engineering Chemistry*. https://doi.org/10.1016/j.jiec.2024.08.005

Barman, J., Biswas, B., Ali, S. S., & Zhran, M. (2024). The TOPSIS method: Figuring the landslide susceptibility using Excel and GIS. *MethodsX, 13*, 102622. https://doi.org/10.1016/j.mex.2024.102622

bin Abu Seman, A., binti Alias, N., & binti Ibrahim, N. (2020). Implementing TOPSIS method in selecting the best bus transportation services. *Journal of Computing Research and Innovation (JCRINN), 5*(3), 54–62. [DOI/URL not found]

Dehdasht, G., Salim Ferwati, M., Zin, R. M., & Abidin, N. Z. (2020). A hybrid approach using entropy and TOPSIS to select key drivers for a successful and sustainable lean construction implementation. *PLOS ONE, 15*(2), e0228746. https://doi.org/10.1371/journal.pone.0228746

Gaur, B. (2019). Data preprocessing: A step-by-step guide for clean and usable data. *Turkish Journal of Computer and Mathematics Education, 10*(2), 229–242. [DOI not found]

Jamshed, H., Khan, M. S. A., Khurram, M., Inayatullah, S., & Athar, S. (2019). Data preprocessing: A preliminary step for web data mining. *3C Tecnología. Glosas de innovación aplicadas a la pyme, Special Issue*(2), 206–221. https://doi.org/10.17993/3ctecno.2019.specialissue2.206-221

Kabir, M. A., Ahmed, F., Islam, M. M., & Ahmed, M. R. (2024). Python for data analytics: A systematic literature review of tools, techniques, and applications. *Academic Journal on Science, Technology, Engineering & Mathematics Education, 4*(4), 134–154. https://doi.org/10.69593/ajsteme.v4i04.146

Katrancı, A., Kundakcı, N., & Pamucar, D. (2025). Financial performance evaluation of firms in BIST 100 index with ITARA and COBRA methods. *Financial Innovation, 11*(1), 13. https://doi.org/10.1186/s40854-024-00704-5

Kim, Y.-S., Kim, M. K., Fu, N., Liu, J., Wang, J., & Srebric, J. (2024). Investigating the impact of data normalization methods on predicting electricity consumption in a building using different artificial neural network models. *Sustainable Cities and Society, 112*, 105570. https://doi.org/10.1016/j.scs.2024.105570

Kocot, M. (2023). Organizational agility and surviving crisis situations during the COVID-19 pandemic. *Zeszyty Naukowe Wyższej Szkoły Humanitas. Zarządzanie, 24*(3), 47–62. https://doi.org/10.5604/01.3001.0054.0077

Lam, W. H., Lam, W. S., Liew, K. F., & Lee, P. F. (2023). Decision analysis on the financial performance of companies using integrated entropy-fuzzy TOPSIS model. *Mathematics, 11*(2), 397. https://doi.org/10.3390/math11020397

Łopatka, P., Tłuczak, A., & Jadach, R. (2023). Multi-criteria decision support methods for the selection of the optimum contractor: A case study of a passenger transfer centre. *Journal of Sustainable Development of Transport and Logistics, 8*(2), 219–228. https://doi.org/10.14254/jsdtl.2023.8-2.16

Omar Al-Kasasbeh. (2024). The transformation of the economy: Exploring the impacts and opportunities of the digital economy. *Organize: Journal of Economics, Management and Finance, 3*(1), 10–17. https://doi.org/10.58355/organize.v3i1.75

Ova, A. (2022). Evaluation of Turkish factoring company performances using TOPSIS method. *Yönetim Bilimleri Dergisi, 20*(43), 29–47. https://doi.org/10.35408/comuybd.836726

Ran, J., Li, M., Rong, J., Zhao, D., Kadir, A., & Luo, Q. (2025). Evaluation of adjustment effects of highway guide signs based on the TOPSIS method. *Applied Sciences, 15*(9), 4949. https://doi.org/10.3390/app15094949

Rane, N. L., P, S., & Choudhary. (2023). Fuzzy AHP and fuzzy TOPSIS as an effective and powerful multi-criteria decision-making (MCDM) method for subjective judgements in selection process. *International Research Journal of Modernization in Engineering Technology and Science, 5*(7), 4797–4804. https://doi.org/10.56726/irjmets36629

Sadabadi, S. A., Hadi-Vencheh, A., Jamshidi, A., & Jalali, M. (2020). A new index for TOPSIS based on relative distance to best and worst points. *International Journal of Information Technology & Decision Making, 19*(3), 695–719. https://doi.org/10.1142/S0219622020500145

Sallapalli, N. (2024). Digital transformation: Reshaping industries through technology. *International Journal for Multidisciplinary Research (IJFMR), 6*(6), 1–9. https://www.ijfmr.com

Sulkifli, Machmud, M., & Hasan, H. (2023). Navigating financial fortitude: Insights from 2020–2022 performance analysis. *Indonesian Journal of Law and Economics Review, 18*(3), 56–70. [DOI not found]

Temple Akpa, I. I., Okpara, O. M. A., Oladosu, T. N., & Okolo, J. U. (2024). Leverage ratio and corporate performance: Do marginal cost and marginal benefit of debt matter? *International Journal of Science and Research Archive, 12*(1), 3014–3024. https://doi.org/10.30574/ijsra.2024.12.1.1057

Verdyansyah Pratama, R. (2024). Development of a smartphone recommendation system based on the TOPSIS method for multi-criteria selection. *Jurnal Multidisiplin Indonesia, 4*(1), 45–56. [DOI not found]

Waqas Arshad, M., & Rahmanto, Y. (2024). Combination of TOPSIS method and PIPRECIA weighting for best hotel selection. *International Journal of Informatics and Data Science, 1*(2), 67–75. https://journals.adaresearch.or.id/ijids/index

Wu, X., Zhu, Z., Chen, C., Chen, G., & Liu, P. (2022). A monotonous intuitionistic fuzzy TOPSIS method under general linear orders via admissible distance measures. *IEEE Transactions on Fuzzy Systems, 31*(3), 797–810. https://doi.org/10.1109/TFUZZ.2022.3205435

Zulqarnain, R. M., Saeed, M., Ali, B., Abdal, S., Saqlain, M., Ahamad, M. I., & Zafar, Z. (2020). Generalized fuzzy TOPSIS to solve multi-criteria decision-making problems. *New Theory, 36*, 1–15. http://www.newtheory.org