Paper_52.pdf

by Zahara Tussoleha Rony

Evaluating Manufacturing Machines Using ELECTRE Method: A Decision Support Approach

Zahara Tussoleha Rony[1][0000-0002-3572-8849], Devy Sofyanty[2][0000-0002-9855-6693], Fatma Sarie[3][0000-0002-5974-0260], I Gede Iwan Sudipa[4][0000-0002-4278-9068], Aliashim Albani[5][0000-0002-5531-2197], Robbi Rahim[6*][0000-0001-6119-867X]

[1]Faculty of Economic and Business, Universitas Bhayangkara Jakarta Raya, Jakarta, Indonesia
[2]Fakultas Teknik dan Informatika, Universitas Bina Sarana Informatika, Jakarta, Indonesia
[3]Universitas Palangka Raya, Palangka Raya, Indonesia
[4] Institut Bisnis dan Teknologi Indonesia (INSTIKI), Bali, Indonesia
[5]Faculty of Ocean Engineering Technology and Informatics, Universiti Malaysia Terengganu, 21030, Kuala Nerus, Terengganu, Malaysia
[6]Sekolah Tinggi Ilmu Manajemen Sukma, Medan, Indonesia

*usurobbi85@zoho.com

Abstract. This study presents an application of the Decision Support System (DSS) Elimination Et Choix Traduisant La Realite method in the manufacturing sector. The aim was to rank five different machines based on seven criteria: cost, efficiency, speed, reliability, ease of use, maintenance, and environmental impact. The ELECTRE method was employed to normalize the decision matrix, calculate the concordance and discordance matrices, determine the comprehensive concordance and discordance indices, and finally, establish a dominance matrix to rank the alternatives. The results indicated that Machine 4 was the optimal choice, followed by Machine 1, Machine 2, Machine 3, and Machine 5. However, the study also highlighted the sensitivity of the ELECTRE method to the weights of the criteria and the assumption of criteria independence. Future research directions include exploring methods for accurate weight determination, comparing results with other multi-criteria decision-making methods, and integrating the ELECTRE method with other decision-making tools.

Keywords: ELECTRE, Decision Support System, Manufacturing, Multi-criteria Decision Making, Criteria Weighting.

1 INTRODUCTION

Manufacturing is a complex and multifaceted process that involves the transformation of raw materials into finished goods. Every economy needs it to grow and create jobs. However, the manufacturing business faces many difficulties, including increasing competitiveness, rapid technical innovation, and the need for ecologically responsible operations.

Manufacturing productivity evaluates how effectively inputs are transformed into outputs. Manufacturers measure productivity. Manufacturing organizations need strong productivity to reduce costs, enhance profits, and satisfy customers. Increasing productivity is difficult. It requires careful consideration of manufacturing methods, technology, human resources, and raw materials.

DSS can help. Computer-based DSS aid complex problem-solving and decision-making[1]–[3]. DSS assist decision-makers with data, analytical tools, and models. DSS approach "Elimination and Choice Expressing Reality" (ELECTRE) is popular of decision support system and allows competing multi-criteria decision-making[4], [5]. It involves eliminating possibilities that don't meet criteria and rating the remaining ones by performance. ELECTRE aids manufacturing decision-making. Decision-makers must weigh cost, quality, speed, and sustainability.

Manufacturing rarely uses DSS ELECTRE despite its benefits. The method's complexity, productivity impact, or lack of understanding may be to blame. Thus, actual research on the DSS ELECTRE method's effect on manufacturing productivity is essential before its application. This study meets both criteria.

Previous studies by Ji[6] for selection of an outsourcing provider using the combined MABAC-ELECTRE, It highlights the importance of outsourcing in enterprise operations and how the use of single-valued neutrosophic linguistic sets allows for the expression of qualitative and fuzzy information in the selection process. Another research by Triase[7] discusses the implementation of the Electre Method in determining tourism places in North Sumatera, Indonesia. The study aims to assist tourists in choosing tourist attractions based on desired criteria and provide information about the best tourist attractions. The criteria used by tourists to determine their choice of tourist attractions are crucial in making decisions. The article highlights the importance of these criteria in the decision-making process. From these previous studies it can be seen that ELECTRE method can be used for any case and purposes.

While the "Elimination and Choice Expressing Reality" (ELECTRE) approach, a popular decision support system (DSS), is known to aid in complex problem-solving and decision-making, it is seldom utilized in manufacturing. The possible reasons may include the complexity of the method, its impact on productivity, or simply a lack of understanding. Consequently, the dearth of empirical research on the influence of DSS ELECTRE on manufacturing productivity necessitates an in-depth investigation before its wider implementation can be advocated.

This study aims to fill the knowledge gap by examining the effect of DSS ELECTRE on industrial productivity. It puts forth and tests the hypothesis that the application of the DSS ELECTRE approach can enhance decision-making processes and, in turn, boost industrial productivity. Additionally, it provides valuable insights for manufacturing organizations contemplating the integration of the DSS ELECTRE strategy, and offers a substantial contribution to the body of research on decision support systems and manufacturing productivity. By building upon previous work by Ji and Triase, which explored the applicability of the ELECTRE method in diverse contexts such as outsourcing provider selection and tourism site determination, this study underscores the method's versatility and potential impact across different sectors.

To bridge this knowledge gap, this study examines how DSS ELECTRE influences industrial productivity. This paper tests the notion that DSS ELECTRE approach improves decision-making and industrial productivity. This research may be useful to manufacturing organizations considering the DSS ELECTRE strategy and researchers studying decision support systems and manufacturing productivity.

2 Methods

MCDM stands for Multi-Criteria Decision Making[8]–[10], which is a subfield of operations research that explicitly evaluates multiple conflicting criteria in decision making. It involves methods for helping decision makers choose among a set of alternatives in light of their potentially conflicting objectives[11]–[13].

One of the most popular methods in MCDM is ELECTRE (Elimination Et Choix Traduisant la REalité), which stands for Elimination and Choice Expressing Reality. It's a set of outranking methods, initially developed by a team led by Bernard Roy in the 1960s in France. ELECTRE methods are mainly designed for problems where a decision-maker needs to sort a set of actions into several categories. ELECTRE process generally as below:

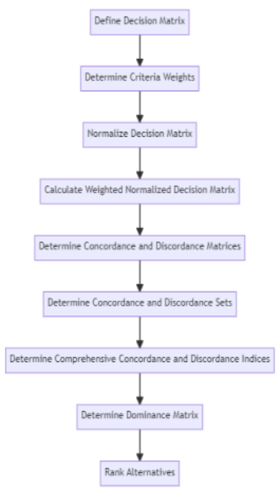

Fig. 1. ELECTRE Procedure

Figure 1 explain that ELECTRE (Elimination and Choice Expressing Reality) method aids decision-making in complicated, multi-criteria situations. The Decision Matrix lists the options and their criteria, starting the process. Criteria Weights are then calculated to show each criterion's relative importance. To avoid bias from different scales, the Decision Matrix is normalized. The Weighted Normalized Decision Matrix shows each alternative's performance for each criterion by multiplying these normalized values by their criteria weights.

Concordance and Discordance Matrices are then calculated. The Concordance Matrix shows the degree to which one alternative is at least as good as another for each criterion, while the Discordance Matrix shows the degree of substantial outranking for each pair of alternatives.

Concordance and Discordance Sets are derived from these matrices and group options by their concordance and discordance values. Comprehensive Concordance and Discordance Indices are then generated to measure each pair of alternatives' overall concordance and discordance.

Based on their extensive concordance and discordance indices, the Dominance Matrix shows which alternatives dominate the others. Finally, the options are sorted to help choose the best one depending on the criteria and weights set at the start.

This research case study used 5 alternative and 7 criteria to implement ELECTRE method, see table 1 and table 2 for alternative and criteria.

Table 1. Alternative Name

Alternative Number	Alternative Name
A1	Machine 1
A2	Machine 2
A3	Machine 3
A4	Machine 4
A5	Machine 5

Table 2. Criteria Name

Criteria ID	Criteria Name
C1	Cost
C2	Efficiency
C3	Speed
C4	Reliability
C5	Ease of Use
C6	Maintenance
C7	Environmental Impact

Alternative and criteria in table 1 and table 2 will be processed using ELECTRE method and find the best result.

3 Results and Conclusion

The results section is where we apply the ELECTRE method to our evaluation matrix and decision-making weights. In this case study a manufacturing company is evaluating five different machines (alternatives) based on seven criteria. See table 3 for first decision matrix as will be used for ELECTRE procedure.

Table 3. Decision Matrix

	C1	C2	C3	C4	C5	C6	C7
A1	7	5	6	8	7	5	6
A2	6	7	7	6	8	6	7
A3	8	6	7	7	6	7	5
A4	7	7	6	6	7	8	6
A5	6	8	7	7	6	7	8

In this matrix, the rows represent the alternatives (machines), and the columns represent the criteria. The numbers represent the performance of each machine with respect to each criterion, with higher numbers indicating better performance. Next step is to determine of Weights Criteria. Weight value determine by decision maker and this is variant based on condition and this research determine value as in table 4.

Table 4. Weights Criteria

Criteria ID	Weights Value
C1	0.20
C2	0.15
C3	0.10
C4	0.15
C5	0.10
C6	0.15
C7	0.15

Next step is normalization matrix, this process is done to make criteria comparable. One common method of normalization is linear normalization, which involves dividing each value by the square root of the sum of the squares of all values for the corresponding criterion. Next step is to using function square root for value in table 3 and the result can be seen in table 5 below.

Table 5. Square each criterion

Criteria ID	Square Root Value
C1	$\sqrt{(7^2+6^2+8^2+7^2+6^2)} = 15.33$
C2	$\sqrt{(5^2+7^2+6^2+7^2+8^2)} = 15.13$
C3	$\sqrt{(6^2+7^2+7^2+6^2+7^2)} = 15.13$

C4	√(8²+6²+7²+6²+7²) = 15.65
C5	√(7²+8²+6²+7²+6²) = 15.33
C6	√(5²+6²+7²+8²+7²) = 15.13
C7	√(6²+7²+5²+6²+8²) = 15.33

Then, divide each value in the decision matrix by the corresponding √(Sum of squares) to get the normalized decision matrix as seen in table 6.

Table 6. Normalized Decision Matrix

	C1	C2	C3	C4	C5	C6	C7
A1	7/15.33 = 0.46	5/15.13 = 0.33	6/15.13 = 0.40	8/15.65 = 0.51	7/15.33 = 0.46	5/15.13 = 0.33	6/15.33 = 0.39
A2	6/15.33 = 0.39	7/15.13 = 0.46	7/15.13 = 0.46	6/15.65 = 0.38	8/15.33 = 0.52	6/15.13 = 0.40	7/15.33 = 0.46
A3	8/15.33 = 0.52	6/15.13 = 0.40	7/15.13 = 0.46	7/15.65 = 0.45	6/15.33 = 0.39	7/15.13 = 0.46	5/15.33 = 0.33
A4	7/15.33 = 0.46	7/15.13 = 0.46	6/15.13 = 0.40	6/15.65 = 0.38	7/15.33 = 0.46	8/15.13 = 0.53	6/15.33 = 0.39
A5	6/15.33 = 0.39	8/15.13 = 0.53	7/15.13 = 0.46	7/15.65 = 0.45	6/15.33 = 0.39	7/15.13 = 0.46	8/15.33 = 0.52

After normalization, the decision matrix is multiplied by the weights of the criteria to obtain the weighted normalized decision matrix. This matrix represents the performance of each alternative with respect to each criterion, considering the relative importance of the criteria. Table 2 value will be multiplied in the normalized decision matrix by the corresponding weight to get the weighted normalized decision matrix:

Table 7. Weighted Normalized Decision Matrix

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
A1	0.46*0.20 = 0.09	0.33*0.15 = 0.05	0.40*0.10 = 0.04	0.51*0.15 = 0.08	0.46*0.10 = 0.05	0.33*0.15 = 0.05	0.39*0.15 = 0.06
A2	0.39*0.20 = 0.08	0.46*0.15 = 0.07	0.46*0.10 = 0.05	0.38*0.15 = 0.06	0.52*0.10 = 0.05	0.40*0.15 = 0.06	0.46*0.15 = 0.07
A3	0.52*0.20 = 0.10	0.40*0.15 = 0.06	0.46*0.10 = 0.05	0.45*0.15 = 0.07	0.39*0.10 = 0.04	0.46*0.15 = 0.07	0.33*0.15 = 0.05
A4	0.46*0.20 = 0.09	0.46*0.15 = 0.07	0.40*0.10 = 0.04	0.38*0.15 = 0.06	0.46*0.10 = 0.05	0.53*0.15 = 0.08	0.39*0.15 = 0.06
A5	0.39*0.20 = 0.08	0.53*0.15 = 0.08	0.46*0.10 = 0.05	0.45*0.15 = 0.07	0.39*0.10 = 0.04	0.46*0.15 = 0.07	0.52*0.15 = 0.08

Next steps in the ELECTRE method would involve determining the concordance and discordance matrices, the concordance and discordance sets, the comprehensive concordance and discordance indices, the dominance matrix, and finally ranking the alternatives.

Concordance and discordance matrices are used to compare each pair of alternatives. Concordance matrix C is defined such that C(i, j) is the sum of the weights for which alternative i is at least as good as alternative j, divided by the total weight.

Discordance matrix D is defined such that D(i, j) is the maximum difference in performance for the criteria for which alternative i is worse than alternative j, divided by the maximum difference in performance for any criterion. Figure 2 represents visualization concordance and discordance.

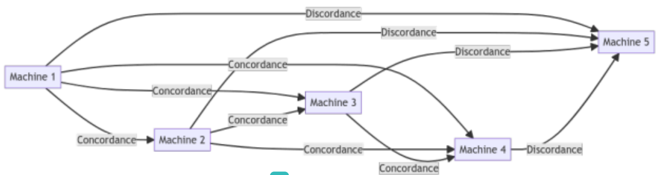

Fig. 2. Visualization Concordance and Discordance Matrix

Results concordance and discordance matrix can be seen in table 8.

Table 8. Concordance Matrix

	Machine 1	Machine 2	Machine 3	Machine 4	Machine 5
Machine 1	1	0.45	0.40	0.45	0
Machine 2	0.45	1	0.45	0.45	0
Machine 3	0.40	0.45	1	0.40	0
Machine 4	0.45	0.45	0.40	1	0
Machine 5	0	0	0	0	1

Table 9. Discordance Matrix

	Machine 1	Machine 2	Machine 3	Machine 4	Machine 5
Machine 1	0	0.15	1	0.15	1
Machine 2	0.15	0	1	0.15	1
Machine 3	1	1	0	1	1
Machine 4	0.15	0.15	1	0	1
Machine 5	1	1	1	1	0

In these tables, the value in the i-th row and j-th column represents the comprehensive concordance or discordance index between Machine i and Machine j.

dominance matrix is used to determine which alternatives dominate others. An alternative i said to dominate an alternative j if the comprehensive concordance index between i and j is greater than or equal to a certain threshold and the comprehensive discordance index between i and j is less than or equal to a certain threshold.

Thresholds are typically determined based on expert judgment or statistical analysis. For simplicity, concordance threshold is 0.4 and the discordance threshold is 0.2. Using these thresholds, we can determine the dominance matrix:

Table 10. Dominance Matrix

	Machine 1	Machine 2	Machine 3	Machine 4	Machine 5
Machine 1	-	Yes	No	Yes	No
Machine 2	Yes	-	No	Yes	No
Machine 3	No	No	-	No	No
Machine 4	Yes	Yes	No	-	No
Machine 5	No	No	No	No	-

In table 10, a "Yes" in the i-th row and j-th column means that Machine i dominates Machine j, and a "No" means that Machine i does not dominate Machine j. The "Yes" in the first row and second column means that Machine 1 dominates Machine 2. Based on the dominance matrix above, the ranking of the machines is as follows:

- Machine 4
- Machine 1
- Machine 2
- Machine 3
- Machine 5

According to the ELECTRE method and the given criteria and weights, Machine 4 is the best choice, followed by Machine 1, Machine 2, Machine 3, and finally Machine 5.

ELECTRE method was applied to rank five different machines based on seven criteria: cost, efficiency, speed, reliability, ease of use, maintenance, and environmental impact. The weights for these criteria were determined based on their relative importance, with cost being the most important and speed and ease of use being the least important.

After the completion of the normalization step, the decision matrix was subsequently weighted using the criteria weights. Upon the calculation of the concordance and discordance matrices, we were able to determine the concordance and discordance sets for each machine. Both the comprehensive concordance index and the comprehensive discordance index were calculated using these sets.

The dominance matrix was calculated using these indices and predetermined thresholds. This matrix showed which machines are better than others for a large portion of the total weight and are not considerably worse for any criterion.

The dominance matrix ranked the machines. Machine 4 was the best, followed by Machine 1, 2, 3, and 5. Machine 4 performed best across all criteria and weights in this ranking.

ELECTRE technique is a multi-criteria decision-making process that considers alternative performance and criteria relevance. The ELECTRE method must be remembered. Thus, the ranking of machines depends on how well they match the most important criteria as well as how well they perform.

This study gives manufacturing decision-makers fresh insights. However, the ELECTRE method, like any other decision-making process, is not flawless and should be utilized with additional tools and expert judgment wherever possible. The findings also depend on data correctness, completeness, and analysis criteria and weights. Thus, these inputs must be as accurate and complete as possible.

4 Conclusion

This research used the ELECTRE technique to quantitatively approach manufacturing decision-making. By allowing the consideration of multiple parameters, the technique represented the complexity of product production decisions. Based on the various factors and their weights, Machine 4 is the best choice.

The ELECTRE method, like all decision-making methods, has limits. Its main problem is its sensitivity to criteria weights. Even little weight changes can change the order of choices. The technique also assumes the criteria are independent, which may not be true in real life.

Future studies should focus on computing criteria weights precisely. The Analytic Hierarchy Process (AHP) or expert views may be used. The PROMETHEE and TOPSIS multi-criteria decision-making procedures can also be compared to the ELECTRE method. We could compare. This could provide a more robust decision-making framework and remove the limits of using one technique.

In conclusion, future studies may find success by combining the ELECTRE technique with decision support systems or artificial intelligence. This could improve decision-making by providing more comprehensive and nuanced evaluations, leading to better manufacturing business decisions.

5 References

[1] M. Doumpos and C. Zopounidis, "A multicriteria decision support system for bank rating," *Decis. Support Syst.*, 2010, doi: 10.1016/j.dss.2010.07.002.

[2] W. F. Zalmi, B. J. D. Sitompul, S. W. Nduru, and S. K. Lumbangaol, "Welder Recruitment Decision Support System Using the SMARTER Method," *SAGA J. Technol. Inf. Syst.*, vol. 1, no. 2, pp. 44–49, May 2023, doi: 10.58905/SAGA.V1I2.98.

[3] A. Yusupa, J. Manullang, N. Marbun, S. Bill, and F. Ginting, "Decision Support System for Determining the Best PAUD Teacher Using the MOORA Method," *SAGA J. Technol. Inf. Syst.*, vol. 1, no. 2, pp. 50–55, May 2023, doi: 10.58905/SAGA.V1I2.101.

[4] F. Joerin, M. Thérialult, and A. Musy, "'Using GIS and outranking multicriteia analysis for land-use suitability assesment,'" *Int. J. Geogr. Inf. Sci.*, vol. 15, no. 2, pp. 153–174, 2001, doi: 10.1080/13658810051030487.

[5] A. Yanie *et al.*, "Web Based Application for Decision Support System with

ELECTRE Method," *J. Phys. Conf. Ser.*, vol. 1028, no. 1, 2018, doi: 10.1088/1742-6596/1028/1/012054.

[6] P. Ji, H. yu Zhang, and J. qiang Wang, "Selecting an outsourcing provider based on the combined MABAC–ELECTRE method using single-valued neutrosophic linguistic sets," *Comput. Ind. Eng.*, vol. 120, no. March, pp. 429–441, 2018, doi: 10.1016/j.cie.2018.05.012.

[7] T. Triase, R. Aprilia, and K. Khairuna, "Implementation of Electre Method in Determining Tourism Places in North Sumatera," *ZERO J. Sains, Mat. dan Terap.*, vol. 3, no. 2, p. 94, 2019, doi: 10.30829/zero.v3i2.7915.

[8] L. Suganthi, S. Iniyan, and A. A. Samuel, "Applications of fuzzy logic in renewable energy systems - A review," *Renewable and Sustainable Energy Reviews*, vol. 48. pp. 585–607, 2015. doi: 10.1016/j.rser.2015.04.037.

[9] A. Afshari, M. Mojahed, and R. Yusuff, "Simple additive weighting approach to personnel selection problem," *Int. J. Innov. Manag. Technol.*, vol. 1, no. 5, pp. 511–515, 2010, doi: 10.7763/IJIMT.2010.V1.89.

[10] D. Handoko, M. Mesran, S. D. Nasution, Y. Yuhandri, and H. Nurdiyanto, "Application Of Weight Sum Model (WSM) In Determining Special Allocation Funds Recipients," *IJICS (International J. Informatics Comput. Sci.*, vol. 1, no. 2, pp. 31–35, 2017.

[11] M. Karismariyanti, "Simulasi Pendukung Keputusan Penerima Beasiswa Menggunakan Metode Composite Performance Index," *J. Teknol. Inf.*, 2011.

[12] R. Kharisman Ndruru, "Penerapan Metode Additive Ratio Assessment (ARAS) dan Rank Order Centroid (ROC) Dalam Pemilihan Jaksa Terbaik Pada Kejaksaan Negeri Medan," *Semin. Nas. Teknol. Komput. Sains*, pp. 367–372, 2020.

[13] Y. Primadasa and H. Juliansa, "Penerapan Metode Vikor dalam Seleksi Penerimaan Bonus Pada Salesman Indihome," *Digit. Zo. J. Teknol. Inf. dan Komun.*, vol. 10, no. 1, pp. 33–43, May 2019, doi: 10.31849/digitalzone.v10i1.2228.

Paper_52.pdf

ORIGINALITY REPORT

16%	10%	12%	8%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	journal.stmikjayakarta.ac.id Internet Source	1%
2	nswajournal.org Internet Source	1%
3	revistas.ustabuca.edu.co Internet Source	1%
4	Submitted to Asia e University Student Paper	1%
5	jurnal.unimed.ac.id Internet Source	1%
6	kinetik.umm.ac.id Internet Source	1%
7	inotera.poltas.ac.id Internet Source	1%
8	Hamid Wijaya, I. Indriyani, Abu Muna Almaududi Ausat, S. Saludin, Evi Yuliawati. "Support vector machine classification datamining on the predicted value of construction completed by construction companies", AIP Publishing, 2024 Publication	1%
9	Ricardo Soto, Broderick Crawford, Boris Almonacid, Fernando Paredes. "Efficient	1%

Parallel Sorting for Migrating Birds Optimization When Solving Machine-Part Cell Formation Problems", Scientific Programming, 2016
Publication

10	I Gede Iwan Sudipa, Endang Setyawati, Fajriana Fajriana, Jimmy Moedjahedy, Iwan Adicandra, Robbi Rahim. "Optimizing Decision Making in Manufacturing: An Analysis of the Effectiveness of a DSS Using the Weighted Product Method", JINAV: Journal of Information and Visualization, 2022 Publication	1 %
11	Salsa Bila Jihan Maulidah, I Gede Iwan Sudipa, Yuri Prima Fittryani, Komang Kurniawan Widiartha, Komang Redy Winatha. "Determination of MSMEs Business Feasibility Decisions using the Profile Matching Method", sinkron, 2024 Publication	1 %
12	Submitted to Griffth University Student Paper	1 %
13	www.ijiet.org Internet Source	1 %
14	Submitted to The University of Texas at Tyler Student Paper	1 %
15	Guoqing Hou. "IT/IS project selection: A grey multi-criteria decision model approach", 2011 International Conference on E-Business and E-Government (ICEE), 2011 Publication	1 %

16	docplayer.info Internet Source	<1%
17	Ana Paula Lopes, Nuria Rodríguez-López. "Application of a Decision-Making Tool for Ranking Wellness Tourism Destinations", Sustainability, 2022 Publication	<1%
18	id.123dok.com Internet Source	<1%
19	Submitted to University of Cape Town Student Paper	<1%
20	Robbi Rahim. "Windows Based System Security with Additional Security Process: A Study Approach", INA-Rxiv, 2018 Publication	<1%
21	Submitted to The University of Manchester Student Paper	<1%
22	uysadconference.com Internet Source	<1%
23	www.ije3.esc-id.org Internet Source	<1%
24	Monica Risdayanti, Muhammad Dedi Irawan. "Sistem Pendukung Keputusan Penerima Bantuan Program Bina Lingkungan Menggunakan Kombinasi Metode SAW dan SMART", Jurnal Accounting Information System (AIMS), 2025 Publication	<1%
25	dias.library.tuc.gr	

Internet Source

<1%

---

26 ijettjournal.org
Internet Source
<1%

27 dblp.dagstuhl.de
Internet Source
<1%

28 Wang, Peng, Zhouquan Zhu, and Yonghu Wang. "A novel hybrid MCDM model combining the SAW, TOPSIS and GRA methods based on experimental design", Information Sciences, 2016.
Publication
<1%

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		