The Effect and Impact of the Electre Method for Sensitivity Testing Based on the Case Study Selection of Outstanding Students

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***Abstract*—A Decision Support System (DSS) is a computer-based system that provides a selection of alternative options to assist management in making decision with structured or unstructured difficulties by employing the information. One of the DSS approaches used is the Elimination Et Choix Traduisant La Realité (Electre) methodology. The Electre method is a multi-criteria decision-making strategy that examines pairs of options based on each relevant criterion. The Electre approach can be used when alternatives that do not satisfy the requirements are eliminated and acceptable alternatives are generated. The Electre technique was employed in this study to achieve the selection of student data that had previously been processed using the Simple Additive Weighting (SAW) method. This study is helpful for studying the outcomes of a decision made using the Electre approach based on predefined criteria and alternatives. The results of these computations will be used in a prototype application. In addition, the results of the decision between the SAW technique and the Electre method will be examined for sensitivity in order to assess the sensitivity value of the two techniques.**

Keywords—decision support system, electre, saw

I. INTRODUCTION

A Decision Support System (DSS) is a computer-based system that leverages the information to present a plethora of alternative solutions to help management cope with structured or unstructured difficulties. DSS's purpose is to aid decision makers to pick the best option from the results of data processing by applying the models of decision-making [1].

The Elimination Et Choix Traduisant La Realite (Electre) method is one of numerous used in decision-making. This method is multi-criteria decision-making system that compares some options pairings based on each criterion. The Electre method may be used in circumstances where alternatives that do not meet the requirements are eliminated, resulting in an acceptable alternative. Electre can be used in circumstances when there are multiple options but just a few criteria are used [2]. There is also SAW approach or weighted method in addition to the Electre method. This technique is to compute the weighted sum of the performance ratings for each option across all criteria [3].

This study will be conducted in the instance of calculating data for choosing excellent students using the Electre approach. The data were already investigated utilizing the SAW approach in earlier research. The purpose of this research was to compare adequacy of the end results obtained by the Electre and SAW procedures, as well as to assess the findings obtained by the two methods using a sensitivity test.

II. LITERATURE REVIEW

A. Decision Support System

Li (2021) states that DSS is a computer-based information system for generating several substitute options to aid managers in dealing with semi-structured and unstructured situations using the information [4][5]. Hipel (2021) reveals that DSS is a sort of information system that enables the modeling and manipulation of data [6].

B. Simple Additive Weighting (SAW)

The SAW approach is also known as the weighted addition method, according to Painem. The SAW method's core idea is to find the weighted sum of the performance ratings on each alternative across all criteria. The SAW approach necessitates normalizing the decision matrix (X) to a scale that can be compared to all current alternative rating scales [7][8].

C. Elimination Et Choix Traduisant La Realite (Electre) Method

$$rij = \frac{Min\ x_{ij}}{x_{ij}}, \text{ if } j \text{ is attribute cost} \quad (1)$$

Fei states that Electre is a multi-criteria decision-making process that compares pairs of options based on each relevant criterion [7] using in (1).

D. Sensitivity Test

A sensitivity test is a procedure for determining the outcomes of a technique comparison in problem solving. The goal of this approach is to determine how sensitive the method is when used to solve an issue [9].

III. METHODOLOGY

A. Abbreviations and Acronyms

The data of this study come from previous research used SAW method entitled "Decision Support System of Selection for Outstanding Students at Madrasah Aliyah 45 Gianyar Using the Simple Additive Weighting (SAW) Method" conducted by Riska Riani, Wahyudin, and Andi Saryoko [10][11]. This study uses assessment criteria as the decision making references, namely Attendance (C1), Academic

Values (C2), Skills (C3), and Attitudes (C4) with alternatives, namely several students and weight: W = [0.30, 0.35, 0.15, 0.20]. Table I is the criteria and alternative data used.

TABLE I. ALTERNATIVES AND CRITERIA

Alternative	Criteria			
	C1	C2	C3	C4
A1	5	4	4	5
A2	5	5	4	5
A3	5	4	3	4
A4	5	4	4	4
A5	4	4	4	5
A6	5	4	2	5
A7	5	4	4	3
A8	4	3	4	4
A9	4	4	4	4
A10	5	5	3	4

B. Simple Additive Weighting (SAW) Method

Equation (2) and (3) are for the SAW method:

$$rij = \frac{x_{ij}}{Max\ x_{ij}}, \text{ if } j \text{ is profit attribute} \quad (2)$$

$$rij = \frac{Min\ x_{ij}}{x_{ij}}, \text{ if } j \text{ is cost attribute} \quad (3)$$

Description:
Rij: normalized work rating score.
Xij: attribute value of each criterion.
Max Xij: the highest score of each criterion.
Min Xij: the lowest score of each criterion.
Benefits: if the highest score is the best.
Cost: if the lowest score is the best.
i: declare alternative
j: declare criteria

Calculation of (V_i) can use (4).

$$V_i = \sum_{j=1}^{n} w_j r_{ij} \quad (4)$$

Information:
Vi: each alternative rank.
Wi: each criterion weight.
Rij: rating value of normalized performance.
If the value of V_i which is larger, the alternative Ai can be selected [12].

There some stages in SAW method:

a. Decide the alternatives.
b. Decide the Ci criteria for decision making.
c. Decide the importance level (W) for each criterion.
d. Suitability rating can be decided on each criterion for each alternative.
e. Create the decision matrix (X) referred to criteria (Ci). After that perform the normalization of the matrix referred to the formulation on the type of benefit attribute to get the normalized matrix (R).
f. The addition of the normalized matrix multiplication R with the weight vector may result in the ranking procedure. The answer is the best alternative (Ai) with the highest value [13][14].

Table II shows the final result of the SAW method's manual computation.

TABLE II. SAW METHOD CALCULATION RESULTS

Name	Alternative	The final result	Ranking
Rahmi Ayuningsih	A2	1	1
Tasya Erina Rahman	A1	0.93	2
Siti Rumiah	A10	0.9225	3
Fitri Andaniharkat	A4	0.89	4
Jikri Romadhoni	A5	0.87	5
Ria Astuti	A6	0.8555	6
Siti Rumiyah	A3	0.8525	7
Febri Abdul Faqih	A7	0.85	8
Syamsul Anwar	A9	0.83	9
Ihwan Azmi	A8	0.82	10

Based on the above calculation, the ranking results that get the largest score is 1, so that A2 (Rahmi Ayuningsih) is ranked 1 (achievable student).

C. Elimination of Et Choix Traduisant La Realite (Electre) Method

There are some stages in Electre method to solve the problem [15][16].

1. Form a pairwise comparison of each alternative on each criterion and normalized into a scale that can be compared using (5).

$$r_{ij} = \frac{xij}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (5)$$

for i = 1,2,3,…, m; and j = 1,2,3,…, n
r: Normalization;
x: Value
m: Number of alternatives
n: Number of criteria

2. Assign a weight to each criterion that expresses its relative importance (W_i) using (6).

$$w = w_1, w_2, \ldots, w_n \text{ ; with } \sum_{j=1}^{n} W_j = 1 \quad (6)$$

w: Weight of criteria

by multiplying each column of the X matrix with the determined weight by the decision maker using (7).

$$V_{ij} = W_j . X_{ij} \quad (7)$$

v: Weighted Normalization

3. Decide the concordance and discordance

The j criteria is set by each pair of alternatives k and l (k_l =1,2,3,,…,m and $k \neq l$) and it is divided into two subsets such as concordance and discordance using (8) and (9) respectively. The alternative criterion is concordance if:

$$C_{kl} = \{j \mid V_{kj} \geq V_{lj}\}; \text{ for } j = 1,2,3,,\ldots, n \quad (8)$$

the complement of this subset is discordance, i.e. if:

$$D_{kl} = \{j \mid V_{kj} < V_{lj}\}; \text{ for } j = 1,2,3, \ldots, n \quad (9)$$

4. Determine the concordance and discordance matrix.

To calculate the value of the items in the concordance matrix, sum the weights shown in the concordance subset using (10).

$$C_{kl} = \sum j \epsilon Ckl\ W_j; \text{ for } j = 1,2,3, \dots, n \quad (10)$$

The components in the discordance matrix are determined by dividing the largest difference in the criteria score in the dissonance subgroup by the maximum deviation in the values of all existing criteria, as shown in (11).

$$D_{kl} = \frac{max\{|Vkj - Vlj|\}\ j \epsilon Dkl}{max\{|Vkj - Vlj|\} \forall j} \quad (11)$$

D: Discordance Matrix

5. Determine the matrix of prevailing concordance and discordance.

The threshold value is used to build the dominance of the concordance matrix. It is done by conducting the comparation between threshold value and concordance matrix. For instance, A_k may dominate A_l if the corresponding C_{kl} concordance index has the value at least a certain c threshold value.

$$C_{kl} \geq \underline{c} \quad (12)$$

c: Concordance Matrix

The determination of Threshold value can use the average index *concordance* with the c threshold value using (13).

$$\underline{c} = \frac{\sum_{k=1}^{m} \sum_{l=1}^{m} C_{kl}}{m(m-1)} \quad (13)$$

c: Threshold Concordance

6. Determine the dominant aggregate matrix (matrix E) with (14)

$$e_{kl} = f_{kl} \times g_{kl} \quad (14)$$

e: Dominant Aggregate Matrix

The following equation may be used to determine each member of the F matrix as the dominant concordance matrix based on the threshold value using (15)

$$f_{kl} = 1, \text{ if } C_{kl} \geq \underline{c}$$
$$f_{kl} = 0, \text{ if } C_{kl} < \underline{c} \quad (15)$$

f: Dominant Matrix Concordance

The discordance matrix G is also used the $\underline{d}$ threshold value and d can be obtained with (16).

$$\underline{d} = \frac{\sum_{k=1}^{m} \sum_{l=1}^{m} D_{kl}}{m(m-1)} \quad (16)$$

d: Threshold Discordance

The G matrix of the discordance dominant can be obtained with (17).

$$g_{kl} = 1, \text{ if } D_{kl} \geq \underline{d}$$
$$g_{kl} = 0, \text{ if } D_{kl} < \underline{d} \quad (17)$$

g: Dominant Discordance Matrix

7. Eliminating Alternative

Matrix E has the optional choice for the alternatives with the value of $e_{kl} = 1$ and the A_k is a better option than A_l. The elimination at the number $e_{kl} = 1$ after the row in matrix E. The best alternative is the domination of other alternatives [17][18].

Table III is a table of the results of manual calculation of the dominant aggregate matrix of the Electre method.

Matrix E gives the order of choice in each alternative, that is, if $e_{kl} = 1$, The alternative A_k is the better choice than Al and matrix E. In this scenario, the row in matrix E with the fewest e kl = 1 can be removed. Thus, the sixth option (A6) is favoured above the other alternatives since it outperforms them, so that in this Electre technique, the choice will be made in favor of the sixth alternative, namely a student called Ria Astuti as an exceptional student.

TABLE III. ELECTRE METHOD MANUAL CALCULATION RESULTS

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
A1	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	1	0	1	1	0	0	0
A4	1	0	0	0	1	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0
A6	1	0	1	1	1	0	1	1	1	0
A7	1	0	1	1	1	1	0	0	1	0
A8	0	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	1	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0

D. Sensitivity Test

To obtain the sensitivity (s_j) degree of each attribute there are some steps [19]:

1. Decide the weights attribute, $w_j = 1$ (initial weight), where j = 1, 2, ..., total attributes.
2. Change of weights attribute in the range 1 – 2, as well as by increasing the weight value by 0.1 while the other attribute weights are still valued at 1.
3. Apply to both methods (SAW, and Electre) for the formed attribute weights.
4. Calculate ranking changes by comparing the ranking change in same weight. (weight = 1).

IV. RESULT AND DISCUSSION

This part shows the manual calculations using the Electre method to an application prototype. Then the results of these calculations were analyzed using a sensitivity test.

A. Authors and Affiliations

The comparison between the manual and prototype calculation as Table IV. Table IV showed the similarities between manual and prototypes calculation results.

B. Sensitivity Test

Sensitivity testing is used to identify the sensitivity of method applied. In this case, performing the sensitivity on Electre and SAW methods and the results are in Table V. The weights (W) used for each criterion are:

C1 = 0.30, C2 = 0.35, C3 = 0.15, C4 = 0.20. Thus, it can be written as follows: W = [0.30, 0.35, 0.15, 0.20].

The steps to perform a sensitivity test are as follows:

1. The first step is to increase the weight of criteria C1 by 0.5 so that now the weight is W = [0.80, 0.35, 0.15, 0.20]

TABLE IV. COMPARISON OF MANUAL AND PROTOTYPE RESULTS

Alternative	Manual Calculation Results	Prototype Calculation Results
A1	0	0
A2	0	0
A3	3	3
A4	2	2
A5	0	0
A6	7	7
A7	6	6
A8	0	0
A9	1	1
A10	0	0

TABLE V. RESULTS BEFORE SENSITIVITY TEST

Alternative	SAW Final Result	Electre Final Result (Amount of oak = 1)
A1	0.93	0
A2	1	0
A3	0.8525	3
A4	0.89	2
A5	0.87	0
A6	0.855	7
A7	0.85	6
A8	0.82	0
A9	0.83	1
A10	0.9225	0
MAX	1	7

2. Then furthermore the weight (w) on the C1 criteria is increased by 1 so that now the weight becomes W = [1.30, 0.35, 0.15, 0.20]
3. The next step is for C2 criteria, the same thing is done, namely increasing the weight by 0.5 so that now the weight becomes W = [0.30, 0.85, 0.15, 0.20]
4. Then the weight (w) on the C2 criteria is increased by 1 so that the weight becomes W = [0.30, 1.35, 0.15, 0.20].
5. Next is the C3 criteria, the same thing is done, namely increasing the weight by 0.5 so that now the weight becomes W = [0.30, 0.35, 0.65, 0.20]
6. Then the weight (w) on the C3 criteria is increased by 1 so that now the weight is W = [0.30, 0.35, 1.15, 0.20]
7. Next is the C4 criteria, the same thing is done, namely increasing the weight by 0.5 so that now the weight becomes W = [0.30, 0.35, 0.15, 0.70]
8. Then furthermore the weight on the C4 criteria is increased by 1 so that now the weight becomes W = [0.30, 0.35, 0.15, 1.20]

Table VI is the result of the difference between the calculation of the sensitivity test on the SAW method and the Electre method. Table VI showed:

1. When adding weights from 0.5 to 1, both methods have shown a change in the final value.
2. In the SAW method, when given additional weights of 0.5 and 1, each criterion produces the same pattern of value changes, namely when added 0.5 will produce a difference of 0.5 and when added 1 will produce a difference of 1.

TABLE VI. SENSITIVITY TEST RESULTS

Criteria	SAW	Electre
Criterion 1 +(0,5)	0.5	-2
Criterion 1 +(1)	1	-2
Criterion 2 +(0,5)	0.5	-1
Criterion 2 +(1)	1	-1
Criterion 3 +(0,5)	0.5	-3
Criterion 3 +(1)	1	-3
Criterion 4 +(0,5)	0.5	-4
Criterion 4 +(1)	1	-4
Amount	6	-20

3. In the Electre method, when given additional weights of 0.5 and 1 on criterion 1, it gives the same change in value, as well as when added weight to other criteria. It's just that the pattern of changes in the difference in the value of each criterion is different.
4. From the change in value, the SAW method produces a total difference in the value of 6 changes, and the Electre method produces a total difference in the change value of -20.
5. When the weight value is added In the sensitivity test, then in the case with this research data it would be better to calculate it using the SAW method because it produces a larger change in value with a positive value, while Electre produces a smaller value with a negative value.

There are some differences of the two method results, it can be caused by the difference in the final value of the two methods. The Electre method produces a value from the aggregate process, which is between 0 or 1, then the results with a value of 1 from each alternative will be added up. Whereas in the SAW method, the inclusion of normalized matrix multiplication with the weights is carried out and then then acquired the end result, without going through the aggregate process.

V. CONCLUSION

Further research will be an appropriate reference in the selection of methods in DSS. The conclusions obtained from this study are as follows:

1. The Electre method is useful for selecting the outstanding students. This method can eliminate the students out of the criteria.
2. The concept of pairwise comparisons between alternatives is carried out by concordance and discordance processes in this method, so that the advantages of each alternative can be seen.
3. Based on the calculations of the two methods, SAW and Electre give different results, because in determining the

final result the Electre method goes through an aggregate process, while SAW does not go through that process.

4. The testing and implementation for the calculation process using the Electre method obtained the same calculation results between calculations with prototypes and manual calculations.
5. Based on the results of the sensitivity test, when given an additional weight value, the SAW method will produce a better value, which is positive, while Electre does not because it produces a negative value.

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