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Submission date: 19-Jul-2022 12:09PM (UTC+0700)
Submission ID: 1872492221
File name: Conference_ICOIACT_2022_eng_-_rev_1_with_author.docx (49.48K)
Word count: 3974
Character count: 19044

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*—This Decision support system (DSS) is a computer-based system that produces various alternative decisions to assist management in dealing with structured or unstructured problems using data and models. There are several methods used for DSS, one of which is the Elimination Et Choi Traduisant La Realite (Electre) method. The Electre method is a multi-criteria decision-making method based on the concept of outranking by comparing pairs of alternatives based on each appropriate criterion. The Electre method can be used in conditions where alternatives that do not appropRiate with the criteria are eliminated and produce suitable alternatives. In this study, the implementation of the Electre method was carried out on the selection data of achieving students which in previous research had been processed using the Simple Additive Weighting (SAW) method. This study is useful for knowing the results of the decision from the calculation process using the Electre method based on predetermined criteria and alternatives. The results of these calculations will be implemented in a prototype application. In addition, the results of the decision between the SAW method and the Electre method will be analyzed using sensitivity testing to determine the sensitivity value of the two methods.**

Keywords—decision support system, electre, SAW

I. INTRODUCTION

Decision support system (DSS) is a computer-based system that produces various alternative decisions to assist management in dealing with structured or unstructured problems using data and models. DSS has the aim of providing support to decision makers, choosing the best alternative from the results of information processing using decision-making models[1].

There are several methods used in the decision-making process, one of which is the Elimination Et Choix Traduisant La Realite (Electre) method. Electre is a multi-criteria decision-making method based on the concept of outranking by comparing pairs of alternatives based on each appropriate criterion. The application of the Electre method can be used in conditions where alternatives that do not meet the criteria are eliminated, resulting in a suitable alternative. Electre can be used in cases that have many alternatives, but only use a few criteria[2]. In addition to the Electre method, there is also the Simple Additive Weighting (SAW) method which is also known as the weighted addition method. The basic concept of the SAW method is to find the weighted sum of the performance ratings for each alternative on all attributes[3].

This research will be carried out in the case of calculating the data for selecting outstanding students by implementing the Electre method. In previous research, the data has been studied using the SAW method. The purpose of this study was to determine the suitability of the final results between the Electre and SAW methods, and to analyze the results of the two methods using a sensitivity test.

II. LITERATURE REVIEW

A. Decision Support System

According to Li (2021), a decision support system is defined as a computer-based information system that produces various alternative decisions to assist managers in dealing with various problems, both semi-structured and unstructured using data and models [4][5]. Meanwhile, according to Hipel (2021) Decision Support System is an information system that provides information, modeling and manipulating data[6].

B. Simple Additive Weighting (SAW)

According to Painem (2019) the SAW method is often also known as the weighted addition method. The basic concept of the SAW method is to find the weighted sum of the performance ratings on each alternative in all attributes. The SAW method requires the process of normalizing the decision matrix (X) to a scale that can be compared with all existing alternative ratings[7][8].

C. *Metode Elimination Et Choix Traduisant La Realite (Electre)*

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

According to Fei (2019) Elimination Et Choix Traduisant La Realite (Electre) is a multi-criteria decision-making method based on the concept of outranking by comparing pairs of alternatives based on each appropriate criterion.[7].

D. Sensitivity Test

Sensitivity test is a process to find out the results of the comparison of methods in solving problems. This method has the aim of knowing how sensitive the method is when applied in solving a problem[9].

III. METHODOLOGY

A. Abbreviations and Acronyms

The data of this study comes from previous research using the SAW method with the title "Decision Support System for Selection of 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 that are used as references in decision making, 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 1 is the criteria and alternative data used.

TABLE I. TABLE TYPE STYLES

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. Metode Simple Additive Weighting (SAW)

Here is the formula for the SAW method:

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

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

Information:
rij = normalized work rating value.
Xij = attribute value owned by each criterion.
Max Xij = the largest value of each criterion.
Min Xij = the smallest value of each criterion.
Benefits = if the largest value is the best.
Cost = if the smallest value is the best.
i = declare alternative
j = declare criteria

Preference value for each alternative (V_i) is calculated using the formula:

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

Information:
Vi = rank for each alternative.
Wi = weight value of each criterion.
rij= normalized performance rating value.
If the value of V_i which is larger, it indicates that alternative Ai is more chosen[12].

The steps taken to solve the problem using the SAW method are as follows:

a. Determine alternatives.
b. Determine the criteria that will be used as a reference in decision making, namely Ci.
c. Determine the preference weight or level of importance (W) of each criterion.
d. Determine the suitability rating of each alternative on each criterion.
e. Make a decision matrix (X) based on the criteria (Ci), then normalize the matrix based on the equation that is adjusted to the type of benefit attribute or cost attribute, so that a normalized matrix (R) is obtained.
f. The final result will be obtained from the ranking process, namely the addition of the normalized matrix multiplication R with the weight vector, so that the largest value is chosen as the best alternative (Ai) as the solution.[13][14].

Table 2 is the final result of the manual calculation of the SAW method.

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	0.855	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 Et Choix Traduisant La Realite (Electre) Method

The steps taken in solving the problem using the Electre method are as follows[15][16].

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

$$r_{ij} = \frac{xij}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \text{ for } i = 1,2,3,..,m; \text{ and } j = 1,2,3,\ldots,n \quad (5)$$

2. Assigns a weight to each criterion that expresses its relative importance (W_i).

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

by means of each column of the X matrix multiplied by the weights determined by the decision maker.

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

3. Determine the set of concordance and discordance

For each pair of alternatives *k* and *l* (k_J=1,2,3,…,*m* and $k \neq l$) the set of criteria *j* is divided into two subsets, namely concordance and discordance. A criterion in an alternative is concordance if:

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

On the other hand, the complement of this subset is discordance, i.e. if

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

4. Determine the concordance and discordance matrices

To determine the value of the elements in the concordance matrix is to add up the weights included in the concordance subset, mathematically as follows:

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

To determine the value of the elements in the discordance matrix is to divide the maximum difference in the value of the criteria included in the discordance subset by the maximum difference in the values of all existing criteria, mathematically as follows:

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

5. Determine the dominant concordance and discordance matrix

The dominance of the concordance matrix is built using the threshold value for the concordance index, namely by comparing each element value of the concordance matrix with the threshold value. For example, A_k will only have a chance to dominate A_l if the corresponding C_{kl} concordance index exceeds at least a certain threshold value of c.

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

Threshold value can be determined as the average index *concordance*, with a threshold value of $\underline{c}$ is:

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

6. Determine the dominant aggregate matrix (matrix E) with the formula:

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

Based on the threshold value, the value of each element of the F matrix as the dominant concordance matrix is determined as follows:

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

Similarly, the dominance of the discordance matrix G is defined using the threshold value $\underline{d}$, where $\underline{d}$ is defined as follows:

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

The value of each element for the G matrix as the discordance dominant matrix is determined as follows:

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

7. Eliminating Alternative

Matrix E gives the order of choice in each alternative, that is $e_{kl} = 1$ then alternatve A_k is a better choice than A_l. After that the row in the matrix E which has the number $e_{kl} = 1$ at least can be eliminated. Thus, the best alternative is the one that dominates the other alternatives [17][18].

Information:
r = Normalization
f = Dominant Matrix Concordance
x = Value
g = Dominant Discordance Matrix
w = Weight of criteria
e = Dominant Aggregate Matrix
v = Weighted Normalization
m= Number of alternatives
c = Concordance Matrix
d = Discordance Matrix
$\underline{c}$= Threshold Concordance
$\underline{d}$= Threshold Discordance
n = Number of criteria
i = 1,2,…,m
j = 1,2,…,n
k = 1,2,…,m
l = 1,2,…,m

Table 3 is a table of the results of manual calculation of the dominant aggregate matrix of the Electre method.

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
A	0	0	0	0	0	0	0	0	0	0

Matrix E gives the order of choice in each alternative, that is, if e_kl = 1, then alternative Ak is a better choice than A1. In this case, the row in the matrix E that has the least number of e_kl = 1 can be eliminated. Thus, the sixth alternative (A6) is preferred over the other alternatives, because it dominates the other alternatives, so that in this Electre method the decision making will take the sixth alternative, namely a student named Ria Astuti as an outstanding student.

D. Sensitivity Test

The degree of sensitivity (sj) of each attribute is obtained through the following steps[19]:

1. Determine all attribute weights, wj = 1 (initial weight), where j = 1, 2, ..., the number of attributes.
2. Change the attribute weights 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 attribute weights that have been formed.
4. Calculate ranking changes by comparing how many ranking changes occur when compared to conditions when the weights are the same (weight = 1).

IV. Result And Discussion

The results of this study include the application of 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

Table 4 is a comparison of the final results of the Electre method between manual calculations and calculations on the application prototype.

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

Based on the results above, it can be seen that the final results of manual calculations and prototypes have similarities.

B. Sensitivity Test

Sensitivity testing is used to find out how sensitive a method is if it is applied to a case. In this case, the sensitivity test will be carried out on the SAW method and the Electre method. Table 5 is the final result of the SAW method and the Electre method before the sensitivity test is carried out as shown in the table.

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

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]
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 6 is the result of the difference between the calculation of the sensitivity test on the SAW method and the Electre method.

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

Based on the results of the data above, it can be seen that:

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.
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. Based on the results of sensitivity testing, when the weight value is added, 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.

The difference in the results of the two methods 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 addition of the normalized matrix multiplication with the weights is carried out and then the final result is obtained, 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. In the case of selecting outstanding students in this study, the Electre method can be used to find the best

alternative by eliminating alternatives that do not meet the criteria.

2. In the process of the Electre method, the concept of pairwise comparisons between alternatives is carried out by concordance and discordance processes, 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. Based on the results of 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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