MCDM Approach for Locating Automatic Teller Machines: An Application in Turkish Banking Sector

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Abstract: - Although there is an increase in the use of alternative channels through which the service offered by bank ATMs (Automated Teller Machine) can be met due to technological developments, branching remains important for banks in terms of increasing the loyalty of existing customers to the bank, acquiring new customers and maintaining communication with all customers. The location to be determined for ATM placement may vary depending on many factors. In this study, a simple and easily usable method is presented to find the most suitable location for bank branches. The purpose of this study report is to compare the solutions of the case analysis with PROMETHEE II method used in the selected article and the other method which is ELECTRE II. PROMETHEE II method was solved by the authors of the selected article, ELECTRE method by the authors of this report. The case study was conducted with data from the decision maker in a transformer manufacturing organization in India. Methods give different results for 3 identified sustainable concepts (S1, S2, S3).

Key-Words: - Location Selection, ATM Location, ELECTRE, ELECTRE II, PROMETHEE

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1 Introduction

Nowadays, the decision-making process for the business world or personal preferences is getting harder because of available various alternatives. Multiple criteria decision making (MCDM) is considered as a complex decision-making tool that includes both quantitative and qualitative factors [1]. MCDM has grown as part of operations research on the design of computational and mathematical tools to support the subjective assessment of performance criteria by decision makers [2]. MCDM has the potential to improve all decision-making areas in engineering from design to manufacturing. MCDM provides a basis for selecting, sorting and prioritizing alternatives such as materials or orientations and assists in the overall evaluation [3]. Practical problems are often characterized by a number of conflicting criteria, and there may be no solution that meets all criteria at the same time.

The purpose of this study report is to compare the solutions of the case analysis with PROMETHEE II method used in the selected article and the other method which is ELECTRE II. PROMETHEE II method was solved by the authors of the selected article, ELECTRE method by the authors of this report. The case study was conducted with data from the decision maker in a transformer manufacturing organization in India. Methods give different results for 3 identified sustainable concepts (S1, S2, S3).

This study deals with the sustainable concept selection in manufacturing organization and multiple criteria must be taken into account in this selection process, hence it is a typical multi criterion decision making problem. Outranking method is applicable for this concept selection, due to the concept selection should be based on the pair wise comparison. PROMETHEE II, an outranking method, is used for determining the best proper concept. The originality of this study report is that it is an attempt to select the best sustainable concept using PROMETHEE.

Considering the literature review, there are several studies by various authors on sustainable production, multi criteria decision making applications of sustainable manufacturing and PROMETHEE method.

There is a research gap on examining multi criteria decision making methods for sustainable concept selection. For that reason, in this study an efficient and simply computable selection methodology has been used to improve sustainability in the manufacturing company by changing and prioritizing material, product and process orientations.

Among the large number of multi criteria decision making methods, outranking methods have an expeditious progression due to their adjustability to the most real decision situations. PROMETHEE method is the most known and widely applied outranking method for pair wise comparison of the alternatives in each separate criterion. PROMETHEE II was chosen for the evaluation as the decision maker always desired to have the exact rankings. This method starts with the formulation of alternatives and a set of criteria then it is formed as an m x n decision matrix. It recommends six types of preference functions to state how significant the relative difference between alternatives is for given criteria. 16 evaluation criteria were settled such as adaptability, simplification and safety.

The case study took place at a transformer manufacturing organization located in India. The organization is in the process of performing certain sustainable concepts to raise awareness and concern about the environmental effects of economic growth and the global spread of trade. The decision maker found it appropriate that PROMETHEE could be used to choose the best sustainable concept, and inputs were collected from who is responsible for carrying out sustainable concepts in the case organization. In this case study sustainability orientations are decided as production methodology, material and product design and they are named as S1, S2 and S3.

With the PROMETHEE II method, when the alternatives are evaluated by making pair wise comparisons based on the preference functions through the selected criteria, alternative concept S2 reaches the highest net flow value.

Using the given inputs, PROMETHEE II calculation and analysis is performed with the help of Excel spread sheets. The concept with greater outranking value will be selected as the best sustainable concept. Material change is chosen as the best concept to be applied in case organization. Material selection should be considered in the first phase of these three changes to ensure the overall sustainability of the product. Initially, the materials should be searched, and suitable material should be found for the product. Then, the design changes for the selected material should be included. Finally, the selection of appropriate manufacturing processes should be made.

Industrial companies are currently implementing sustainable concepts in different orientations such as product orientation, process orientation or material orientation. PROMETHEE is used in this study to show the best orientation among many concepts. It is concluded that material change is recommended as the best approach to improve sustainability in case organization under the given conditions.

The rest of the study is organized as follows. Section 2 outlines the preliminaries. Section 3 illustrates the numerical example and finally concluding remarks and future research directions are provided in Section 4.

2 Preliminaries

2.1. Electre Method

The word ELECTRE consists of the initials of the words Elimination Et Choix Traduisant la Reality and means elimination and selection that reflects the reality [4]. ELECTRE method is a method developed by Bernard and Roy that makes a selection based on the superiority of alternatives (ranking relations) to each other on the concepts of harmony and incompatibility [5]. The ELECTRE method is based on the evaluation of the alternatives in terms of the fit index and the mismatch index defined for each of the alternatives [6].

There are ELECTRE I, II, III, IV, IS, TRI methods in the literature under the name of ELECTRE Method, which is one of the mathematical programming methods for optimization. Although these methods contain small differences from each other, the basis of all of them is to compare alternatives with each other and to choose the superior option [7]. Thanks to these methods listed, the decision maker can include a large number of quantitative and qualitative criteria in the decision-making process, entertain the criteria in line with their purposes, and determine the most suitable alternative at the end of a series of steps [8]. Solutions for selection, sorting and assignment problems can be found with ELECTRE methods. In ELECTRE I and ELECTRE IS selection problems, and ELECTRE II, III and IV sequencing problems, ELECTRE TRI is used in assignment problems [9].

2.2. Proposed Decision Approach

The application stages of the ELECTRE II method are given below.

Step 1: Creating the Decision Matrix (A): In the rows of the decision matrix, there are alternatives whose advantages are to be listed, and the evaluation criteria to be used in decision making are included in the columns. Matrix A is the initial matrix created by the decision maker. Decision matrix is shown as follows [10]:

In A_{ij} matrix, m gives the number of alternatives, n gives the number of evaluation criteria.

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \vdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix}$$

Step 2: Creating the Normalized Decision Matrix (*X*): Normalized Decision Matrix is calculated using the elements of matrix A. Different for cost and benefit criteria normalization formulas are used.

For the cost criteria; $x_{ij} = \frac{\frac{1}{a_{ij}}}{\sqrt{\sum_{i=1}^{m}\left(\frac{1}{a_{ij}}\right)^2}}$

$i = 1, 2, K,.,m \quad j = 1, 2, K,..n$ (1)

For the benefit criteria; $x_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a^2{}_{kj}}}$

$i = 1, 2, K,.,m \quad j = 1, 2, K,.,n$ (2)

formula is used. At the end of the calculations, the *X* matrix is obtained as follows [11].

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \vdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

Step 3: Creating a Weighted Decision Matrix (V): The decision maker first should determine the weights of the evaluating criteria (W_j), $(\sum_{i=1}^{n} w_i = 1)$

By multiplying the weights of the criteria, a weighted normalized matrix is obtained [10].

$V_{ij} = W_i * X_{ij}$ $J = 1,\ldots,J;$ $i = 1,\ldots,n$ (3)

$$V_{ij} = \begin{bmatrix} w_1x_{11} & w_2x_{12} & \cdots & w_3x_{1n} \\ w_1x_{21} & w_2x_{22} & \vdots & w_3x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ w_1x_{m1} & w_2x_{m2} & \cdots & w_3x_{mn} \end{bmatrix}$$

Step 4: Determination of Concordance (C_{kl}) and Disconcordance (D_{kl}) Sets: Criteria for each pair of alternatives comparison are divided into two separate sets. In cases where the alternative or alternatives that are sought and that will solve the problem are not "the best" according to all criteria, they are asked to be "good" according to most of these criteria and binary comparisons are made and A_k and A_1 (1,2, ..., m and In the k ≠ l) concordance set, the A_k alternative is preferred to A_1.

$$C_{kl} = \{j, y_{kj} \geq y_{lj}\} \quad (4)$$

If the A_k alternative is a worse alternative than A_1, the "disconcordance" cluster is created [12].

$$D_{kl} = \{j, V_{kj} < V_{lj}\} \quad (5)$$

The formula is basically based on comparing the size of row elements with respect to each other. The number of concordance sets in a multiple decision problem is $(m.m - m)$. Because when creating concordance sets, k ≠ l must be for k and l indices. The maximum number of evaluation criteria in a concordance set can be (n) [13].

In the ELECTRE II method, one disconcordance set (D_{kl}) corresponds to each concordance set (C_{kl}). In other words, there are as many disconcordance sets as there are concordance sets. Disconcordance set elements consist of j values that do not belong to the relevant concordance set [14].

Step 5: Creating the Concordance and Disconcordance Matrices: Concordance sets are used to create the concordance matrix (C). Matrix C is of mxm size and takes no value for k = l. The elements of the C matrix are calculated with the help of the relationship shown in the formula below [14].

$$C_{kl} = \sum_{i \in C_{kl}} w_j \quad (6)$$

and C matrix is shown below

$$C = \begin{bmatrix} - & c_{12} & c_{13} & \cdots & c_{1m} \\ c_{21} & - & c_{23} & \vdots & c_{2m} \\ \vdots & \vdots & - & \ddots & \vdots \\ c_{m1} & c_{m2} & c_{m3} & \cdots & - \end{bmatrix}$$

The elements of the disconcordance matrix (D) are calculated using the following formula:

$$d_{kl} = \frac{\max_{j \in D_{kl}} y_{kj} - y_{lj}}{\max_{j} y_{kj} - y_{lj}} \quad (7)$$

Like matrix C, matrix D matrix is of mxm dimension and takes no value for k = l The D matrix is shown below [13].

$$D = \begin{bmatrix} - & d_{12} & d_{13} & \cdots & d_{1m} \\ d_{21} & - & d_{23} & \vdots & d_{2m} \\ \vdots & \vdots & - & \ddots & \vdots \\ d_{m1} & d_{m2} & d_{m3} & \cdots & - \end{bmatrix}$$

Step 6: Determination of Concordance ($\underline{c}$) and Disconcordance ($\underline{d}$) Threshold Values: Concordance threshold value ($\underline{c}$) is obtained with the help of the following formula [14]:

$$\underline{c} = \frac{1}{m(m-m)} \sum_{k=1}^{m} . \sum_{l=1}^{m} c_{kl} \quad (8)$$

m shows the number of decision points in the formula, the value of $\underline{c}$ is equal to the product of $\frac{1}{m(m-m)}$ and the sum of the elements that structure the matrix *C*. The disconcordance threshold value ($\underline{d}$) is established using the following formula:

$$\underline{d} = \frac{1}{m(m-m)} \sum_{k=1}^{m} . \sum_{l=1}^{m} d_{kl} \quad (9)$$

The value of $\underline{d}$ is equal to the product of $\frac{1}{m(m-m)}$ and the sum of the elements that structure the matrix D [14].

Step 7: Determining the Superiority of Decision Points with respect to Each Other: For *m* decision points, all elements of *C* and *D* matrices are compared with their own threshold values respectively. Comparing decision point *p* with decision point *q*, if $Cpq \geq C$ and $Dpq < D$ than *p* decision point is superior to *q* decision point [13].

3 Numerical Example

In this case study sustainability orientations are taken as production methodology, material and product design and they are stated as S1, S2 and S3. The criteria considered for the concept selection is indicated in Table 1.

Table 1: Evaluation criteria

C1	Adaptability
C2	Simplification
C3	Survival
C4	Workforce engagement
C5	Profits
C6	Safety
C7	Community development
C8	Technological feasibility
C9	Wastage
C10	Facility requirements
C11	Non-value adding cost
C12	Maintenance
C13	Social problems
C14	Environmental degradation
C15	Implementing cost
C16	Consumption of resources

The decision matrix created by the decision maker is obtained from the study which will be analysed comparatively can be seen in Table 2.

Table 2: Decision matrix consisting of criteria values of sustainable manufacturing concepts

Evaluation criteria	S1	S2	S3
C1	60	70	80
C2	50	50	60
C3	40	50	60
C4	3	4	5
C5	20	20	30
C6	50	60	50
C7	4	5	6
C8	3	4	5
C9	20	30	20
C10	30	20	30
C11	0.5	0.6	0.4
C12	3	4	5
C13	3	4	6
C14	3	5	6
C15	4	5	6
C16	5	6	7

Normalized decision matrix that is shown at Table 3 is calculated according to equation in step 2.

Table 3: Decision matrix consisting of normalized criteria values of sustainable manufacturing concepts

Evaluation criteria	S1	S2	S3
C1	0.49	0.57	0.66
C2	0.54	0.54	0.65
C3	0.54	0.65	0.54
C4	0.46	0.57	0.68

C5	0.42	0.57	0.71
C6	0.36	0.6	0.72
C7	0.46	0.57	0.68
C8	0.48	0.57	0.67
C9	0.64	0.43	0.64
C10	0.49	0.73	0.49
C11	0.55	0.46	0.69
C12	0.72	0.54	0.43
C13	0.74	0.56	0.37
C14	0.69	0.55	0.46
C15	0.72	0.54	0.43
C16	0.64	0.64	0.43

Criteria weight and type matrix created by the decision maker is obtained from the study which will be analyzed comparatively can be seen in Table 4.

Weighted normalized decision matrix that is shown at Table 5 is calculated according to equation in step 3.

Table 4: Standard matrix consisting of criteria weight and type

Evaluation criteria	Criteria type	Criteria weight
C1	max	6
C2	max	8
C3	max	8
C4	max	9
C5	max	8
C6	max	9
C7	max	7
C8	max	8
C9	min	9
C10	min	8
C11	min	9
C12	min	7
C13	min	7
C14	min	7
C15	min	8
C16	min	7

Table 5: Decision matrix consisting of weighted normalized criteria values of sustainable manufacturing concepts

Evaluation criteria	S1	S2	S3
C1	0.02	0.03	0.03
C2	0.03	0.03	0.04
C3	0.03	0.04	0.03
C4	0.03	0.04	0.05
C5	0.03	0.04	0.05
C6	0.03	0.04	0.05
C7	0.03	0.03	0.04
C8	0.03	0.04	0.04
C9	0.05	0.03	0.05
C10	0.03	0.05	0.03
C11	0.04	0.03	0.05
C12	0.04	0.03	0.02
C13	0.04	0.03	0.02
C14	0.04	0.03	0.03
C15	0.05	0.03	0.03
C16	0.04	0.04	0.02

Concordance and disconcordance sets that are shown at Table 6 are calculated according to equation in step 4.

Table 6: Concordance and disconcordance sets

Concordance Sets	
S1-S2	2,9,11,12,13,14,15,16
S1-S3	3,9,10,12,13,14,15,16
S2-S1	1,2,3,4,5,6,7,8,10,16
S2-S3	3,10,12,13,14,15,16
S3-S1	1,2,3,4,5,6,7,8,9,10,11
S3-S2	1,2,4,5,6,7,8,9,11
Disconcordance Sets	
S1-S2	1,3,4,5,6,7,8,10
S1-S3	1,2,4,5,6,7,8,11
S2-S1	9,11,12,13,14,15
S2-S3	1,2,4,5,6,7,8,9,11
S3-S1	12,13,14,15,16
S3-S2	3,10,12,13,14,15,16

Concordance and disconcordance matrices that are shown at Table 7 and Table 8 are calculated according to equations in step 5.

Table 7: Concordance matrix

C	S1	S2	S3
S1	-	0,5	0,49
S2	0,62	-	0,42
S3	0,71	0,58	-

Table 8: Disconcordance matrix

D	S1	S2	S3
S1	-	1,00	1,00
S2	0,89	-	1,00
S3	0,81	0,93	-

Concordance threshold value and disconcordance threshold value that are shown below are calculated according to equations in step 6.

Concordance threshold value is calculated below:
$\underline{c} = \frac{1}{3\times2} \times (0{,}5 + 0{,}49 + 0{,}62 + 0{,}42 + 0{,}71 + 0{,}58) = 0{,}55$

Disconcordance threshold value is calculated below:
$\underline{d} = \frac{1}{3\times2} \times (1 + 1 + 0{,}89 + 1 + 0871 + 0{,}93) = 0{,}94$

Superiority of decision points with respect to concordance threshold value, to disconcordance threshold value and to each other are shown in Table 9, Table 10 and Table 11.

Table 9: Superiority of decision points with respect to concordance threshold value

C12	<	$\underline{c}$
C13	<	$\underline{c}$
C21	>	$\underline{c}$
C23	<	$\underline{c}$
C31	>	$\underline{c}$
C32	>	$\underline{c}$

Table 10: Superiority of decision points with respect to disconcordance threshold value

D12	>	$\underline{d}$
D13	>	$\underline{d}$
D21	<	$\underline{d}$
D23	>	$\underline{d}$
D31	<	$\underline{d}$
D32	<	$\underline{d}$

Table 11: Superiority of decision points with respect to each other.

S3	>	S1
S3	>	S2
S2	>	S1

By employing the users' inputs, the ELECTRE II calculation and the analysis are carried out using Excel spread sheets. The concept which outranked the other concepts will be selected as the best sustainable concept. Consequently, from Table 10, it is shown that the concept 3 (product design) is selected as the best concept to be implemented in the case. Therefore, it indicates that the product design attains a high preference rather than the production methodology and the material design. Similarly, material design attains a high preference rather than the production methodology.

4 Conclusion

In this study, the selection of the appropriate sustainable concept for manufacturing organization in India is conducted. This choice is based on multi-criteria decision-making method such as ELECTRE II. The purpose of the decision problem is to choose the appropriate sustainable concept. This selection was made from three sustainable concepts based on 16 criteria. This study was realized with data from the decision maker in a transformer manufacturing organization in India. In the selected study the alternatives are evaluated by making pair wise comparisons based on the preference functions through the selected criteria, alternative concept S2 reaches the highest net flow value. Material change is chosen as the best concept to be applied in case organization with the PROMETHEE II method.

In our study, we use ELECTRE II method and obtain the rankings according to superiorities of three alternatives. Evaluation method of the technique is based on pairwise comparison of alternatives by concordance & discordance principle. According to our study results product design is selected as the best concept.

In the PROMETHE II method calculations are deepened with preference functions and preference parameters but, ELECTRE II method does not have any calculations about preference. We think that excluding the decision maker's preference data causes a difference between the results of the two methods. This shows that if preference data is available for our multi-criteria decision-making problem, the study using the PROMETHEE method will provide more reliable results.

Future research directions will focus on selecting the most appropriate alternative by employing a fuzzy multi-criteria decision making technique.

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