Applications of Multi Attribute Decision making problem

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Abstract. The method of generating intention with the scope of impact is called the decision making. It is the process which an unique or a group evaluates solutions and alternatives in order to found the most politic option while inspecting the problems or situations.Multi-attribute decision-making (MADM)MADM approaches are designed to discover the most satisfying of numerous comparison choices or to rank possibilities based on their connection to the analysed target. The strategies are utilized to identify the suitable alternative/solution when none of the evaluation parameters are the best.The Multi-attribute decision making theory offers a formal base for the establishment of a model, in which the key criteria is the interconnectedness of assessments according to the individual parameters that result in an integrated assessment.MADMis a strategy for evaluating decisions with numerous co-attribute options in a complete and effective manner. The most appropriate options are ranked from most to least, and MADM methods are frequently used to get the best solution.In this paper, the decision-making algorithm is suggested and applied to purchase a new bike with the maximin method.

1 Introduction

Making decisions has become an essential element of daily living. Multiple and contradicting evaluation standards are common in most decision-making challenges. Divergent viewpoints among decision-makers are the primary source of conflict in the decision-making process. [3, 9] Almost all choice problems have many criteria, which are frequently in conflict. It's been a huge challenge to figure out how to solve such issues. Methodologies and their applications are published in a variety of professional journals. The issues will becategorized in two groups: MADM and MODM (Multiple Objective Decision Making). [8] MADM helps to get abetter result between various courses of action. As a result, most decision-making issues classified as MADM problems, and MADM solution methods should be used to address them. MADM is a complicated and dynamic process that involves two levels of management and engineering. [1, 4]

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MADM will be a popular method for making decisions. The key benefit of MADM is that it provides managers with a wide range of dimensions to assess linked elements and evaluate all feasible solutions to varying degrees. The maximin technique is based on the notion that "a chain is powerful as its feebleconnection". [2, 7] Thisprocess effectively assigns a valuefor every alternative based on the energy of thatpowerless connection, where the "joins"will be qualities. As a result, performance in all attributes must either be assessed in comparable units (unusual the MADM issues) (or)normalizedbefore using the algorithm. Applications of MADM in real life such as medicaldiagnosis, financial investment, purchase new things or places, e-learning, training providers, technologies, time analysis and so on. [5, 6]

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method was introduced by Hwang and Yoon in the year 1981. [11, 12, 13] TOPSIS is based on the simple notion that the selected option must be as near the ideal alternative as feasible while remaining as much away from the negative-ideal solution as appropriate. The best performance values demonstrated by any alternative for each characteristic are combined to generate the optimal solution. The poorest performance numbers are combined to generate the negative-ideal solution. Each attribute having the option of being weighted and closeness to every one of these efficiency poles is quantified in the Euclidean notion. [9, 14]

2 Preliminaries

2.1 Normalization values [9]

Normalise eachattribute value a_{ij}in the decision matrix and make inter-attribute comparisons easier, we utilise the following formulas.

- Benefit attributes = $\frac{x_{ij}}{\sum x_{ij}}$ (1)
- Cost attributes = $\frac{\frac{1}{x_{ij}}}{\sum \frac{1}{x_{ij}}}$(2)

2.2 Weight vector [9]

The weight matrix of attributes $w_j \geq 0, j = 1,2,3, \dots, m$ that satisfy the requirement condition is

$$\sum_{j=1}^{n} w_j^2 = 1(3)$$

where $w_j = (w_1, w_2, \dots, w_n)$.

Then we can assess each alternative's total attribute value

$$z_i(w) = \sum_{j=1}^{n} r_{ij} w_j^2(4)$$

2.3 Normalization Value [9, 10]

For NV add each column and divide with each cell from same columns. It has benefit and cost type criteria.

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

2.4 Weight Normalization [9, 10]

The WN decision matrix will be evaluated the modified ratings

$$v_{ij} = w_j \times d_{ij}^N$$

where $\sum_{j=1}^{n} w_j = 1$ and w_j will be a weight such that $w_j \geq 0$ $(j = 1,2,3, \dots, n)$.

2.5 Ideal Separation [2, 8]

Ideal solutions are derived by two categories that is positive ideal solution (PIS) and negative ideal solution (NIS) is given below:

$$PIS = S_i^+ = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^+\right)^2}$$

$$NIS = S_i^- = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^-\right)^2}$$

2.6 Relative Closeness [9, 10]

The RC coefficient for the alternative S_i with respect to S_i^+ and S_i^- is

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-}$$

3 Algorithm for MADM problem using Maximin Method

Step 1: Transfer the linguistic terms in a scale of 1-n.
Step 2: Categorize the attributes in the following ways.

Benefit-Type Attributes

Cost-Type attributes

Step 3: Use any appropriate normalization method. Here we are using the "Large scale transformation Sum Method".
Step 4: After getting the normalised decision making. Find the minimum values for each row.
Step 5: Find the maximum value from the minimum values.
Step 6: Finally, we get the result for best bike.

3.1 Numerical Example

Letthe clientwants to purchase a bike. There are four categories to choose a bike (alternatives) l_m(where m = 1, 2, 3, 4) accessible. The buyer chosen four attributes to determine.

u_1: Fuel Efficiency
u_2:Rate
u_3: Looks
u_4: Comfort

From these attributes rates are cost-type and others are benefit-types. The decision maker evaluates the bikes l_m under the attributes of u_n (m = n = 1, 2, 3, 4).

Scale for looks and comfort

Table 1. Fix value for the grade

Moderate	Qualify	High Qualify	Extremely Qualify
1	2	3	4

Table 2. Different bike's data

Alternatives	Fuel Efficiency (km/Lit)	Rate (in lakhs)	Looks	Comfort
Bike 1	55	1.5	Good	Good
Bike2	65	1	Average	Average
Bike3	28	2.8	Excellent	Excellent
Bike4	23	4	Good	Average

Table 3. Scale transformation

Alternatives	**Fuel Efficiency (km/Lit)**	**Rate (in lakhs)**	**Looks**	**Comfort**
Bike 1	55	1.5	2	2
Bike2	65	1	1	1
Bike3	28	2.8	4	4
Bike4	23	4	2	1

Table 4. Divide the Rate with 1

Alternatives	**Fuel Efficiency**	**Rate (In lakhs)**	**Looks**	**Comfort**

	(km/Lit)			
Bike 1	55	0.67	2	2
Bike2	65	1	1	1
Bike3	28	0.36	4	4
Bike4	23	2.28	2	1

Table 5. Add each column

Alternatives	**Fuel Efficiency (km/Lit)**	**Rate (In lakhs)**	**Looks**	**Comfort**
Bike 1	55	0.67	2	2
Bike2	65	1	1	1
Bike3	28	0.36	4	4
Bike4	23	2.25	2	1
Sum	171	2.28	9	8

Table 6. Normalized Values

	Normalized Value			
Alternatives	**Fuel Efficiency (km/Lit)**	**Rate (In lakhs)**	**Looks**	**Comfort**
Bike 1	0.32	0.29	0.22	0.25
Bike2	0.38	0.44	0.11	0.13
Bike3	0.16	0.16	0.44	0.50
Bike4	0.13	0.11	0.22	0.13

Table 7. Minimum value for each row

	Normalized Value				
Alternatives	**Fuel Efficiency (km/Lit)**	**Rate (In lakhs)**	**Looks**	**Comfort**	**Min**
Bike 1	0.32	0.29	0.22	0.25	0.22

Bike2	0.38	0.44	0.11	0.13	0.11
Bike3	0.16	0.16	0.44	0.50	0.16
Bike4	0.13	0.11	0.22	0.13	0.11

Max (0.22, 0.11, 0.16, 0.11) = 0.22

4 Algorithm for MADM problem using Median Ranking Method

Step 1: Transfer the linguistic terms in a scale for look and comfort 1-5 (or) 1-10.

Step2: Ranking of all options for different attributes according to the preference values. We give the optional rank from 1 to m. In case of tie at m^{th} and $(m+1)^{th}$ place $\frac{m+n}{2}$ assigned for both.

Step3: Suppose it tie occurs for the position m, $m+1$ and $m+2$. Then assign $\frac{m+n+o}{3}$ to find the average value. If price is low give the value 1 and others provide 1 for high.

Step 4: Add each row and choice the low value for better option.

Table 8. Data for Bikes.

Alternatives	**Fuel Efficiency (km/Lit)**	**Rate (In lakhs)**	**Looks**	**Comfort**
Bike 1	55	1.5	Good	Good
Bike2	65	1	Average	Average
Bike3	28	2.8	Excellent	Excellent
Bike4	23	4	Good	Average

Table 9. Position and Average position for each place.

Alternatives	**Fuel Efficiency (km/Lit)**	**Rate (In lakhs)**	**Looks**	**Comfort**
Bike 1	2	2	2.5	3
Bike2	1	1	4	1.5
Bike3	3	3	1	4
Bike4	4	4	2.5	1.5

Table 10. Add each row

Alternatives	**Fuel Efficiency (km/Lit)**	**Rate (in lakhs)**	**Looks**	**Comfort**	$\sum m_i$
Bike 1	2	2	2.5	3	9.5
Bike2	1	1	4	1.5	7.5
Bike3	3	3	1	4	11
Bike4	4	4	2.5	1,5	12

Finally, the Median ranking value is 7.5.

From the above calculation result of the median ranking methodis 7.5. Therefore, the bike 1 is better.

5 Algorithm for MADM problem using TOPSIS Method

Step 1: Normalize the benefit and cost types in the decision matrix.
Step 2: Determine the weight for the normalised decision matrix.
Step 3: Identifying the ideal positive and negative solutions.
Step 4: Evaluate the separation metrics for each alternative using the PIS and NIS.
Step 5: Determine the PIS and NIS for RC coefficient.
Step 6: Rank the options.

5.1 Numerical Examples

A client wants to purchase a home, and there are four alternatives available: Q_i ($i = 1,2,3,4$). The client analyses the options using the P_i ($i = 1,2,3,4$) indices (attributes),

P_1 = distance between work place to house (km)
P_2 = Price (10^3\$)
P_3 = Environment
P_4 = residential area (m^2)
P_5 = Water facility

where P_3, P_4, P_5 are benefit types and P_1, P_2 are cost types.

Alternatives	P_1	P_2	P_3	P_4	P_5
Q_1	20	1.8	11	50	4
Q_2	10	3.0	7	100	2
Q_3	12	2.2	9	70	1
Q_4	8	2,5	5	80	2
Q_5	26	3.3	10	110	3

Alternatives	P_1	P_2	P_3	P_4	P_5
Q_1	20	1.8	11	50	4
Q_2	10	3.0	7	100	2
Q_3	12	2.2	9	70	1
Q_4	8	2,5	5	80	2
Q_5	26	3.3	10	110	3
$\sum x_{ij}$	37.20	5.85	19.39	189.47	5.83

Alternatives	P_1	P_2	P_3	P_4	P_5
Weight	0.47	0.40	0.34	0.33	0.57
Q_1	20	1.8	11	50	4
Q_2	10	3.0	7	100	2
Q_3	12	2.2	9	70	1
Q_4	8	2,5	5	80	2
Q_5	26	3.3	10	110	3

Alternatives	P_1	P_2	P_3	P_4	P_5
Weight	**0.47**	**0.40**	**0.34**	**0.33**	**0.57**
Q_1	0.254	0.124	0.194	0.086	0.393
Q_2	0.127	0.204	0.122	0.175	0.193
Q_3	0.150	0.152	0.156	0.122	0.097
Q_4	0.103	0.172	0.088	0.139	0.193
Q_5	0.329	0.224	0.177	0.191	0.291

Alternatives	P_1	P_2	P_3	P_4	P_5
Type	Cost	Cost	Benefit	Benefit	Benefit
Q_1	0.254	0.124	0.194	0.086	0.393

Q_2	0.127	0.204	0.122	0.175	0.193
Q_3	0.150	0.152	0.156	0.122	0.097
Q_4	0.103	0.172	0.088	0.139	0.193
Q_5	0.329	0.224	0.177	0.191	0.291
v_j^+	0.103	0.124	0.194	0.191	0.393
v_j^-	0.329	0.224	0.088	0.086	0.097

Alternatives	P_1	P_2	P_3	P_4	P_5	s_i^+	s_i^-
Weight	0.47	0.40	0.34	0.33	0.57		
Q_1	0.254	0.124	0.194	0.086	0.393	0.184	0.338
Q_2	0.127	0.204	0.122	0.175	0.193	0.228	0.243
Q_3	0.150	0.152	0.156	0.122	0.097	0.311	0.207
Q_4	0.103	0.172	0.088	0.139	0.193	0.237	0.257
Q_5	0.329	0.224	0.177	0.191	0.291	0.268	0.238

Alternatives	P_1	P_2	P_3	P_4	P_5	C_i
Type	Cost	Cost	Benefit	Benefit	Benefit	
Q_1	0.254	0.124	0.194	0.086	0.393	0.648
Q_2	0.127	0.204	0.122	0.175	0.193	0.516
Q_3	0.150	0.152	0.156	0.122	0.097	0.399
Q_4	0.103	0.172	0.088	0.139	0.193	0.520
Q_5	0.329	0.224	0.177	0.191	0.291	0.470

According to C_i the rank of all alternatives is
$Q_1 > Q_4 > Q_2 > Q_5 > Q_3$.
Above comparison of TOPSIS Q_1 will be the best house to purchase.

5.2 SimilarityAnalysis

The proposed approach to liken the traditional model in Harish G., Abazar K., and Hassan M.N. [15], and the outcomes are the similar even if the proposed techniques are varies.

6 Conclusion and Future Works

The paper regarded MADM techniques as a crucial component of the theory of optimization techniques. In this paper we compared the four different bikes and five

different houses to purchase by using MADM elementary method of Maximin and TOPSIS to identified the best result.The issue has been carefully examined utilising MADM throughout the entire paper in accordance with the stages of decision-making. Future research should examine the sorting uncertainty of TOPSIS procedures in the context of many other ambiguous decision-making processes, such as interval-valued fuzzy settings, type-2 fuzzy settings, and intuitionistic fuzzy environments. Furthermore, investigations are more possible to productive and cost-effective supplemental approaches to form a more advanced updated fuzzy TOPSIS algorithm and the research canexplore the other methods like Maximax, Minimax, conjunctive, disjunctive, VIKOR and so on.

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