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A FACILITY LOCATION SELECTION PROBLEM BY FUZZY TOPSIS

Pelin Alcan
Hüseyin Başlıgil

Yildiz Technical University
Faculty of Mechanical Engineering
Industrial Engineering Department
Yıldız, İstanbul. Turkey

ABSTRACT
Decision making is the process of finding the best option among the feasible alternatives. In classical multiple attribute decision making (MADM) methods, the ratings and the weights of the criteria are known precisely. Since human judgements including preferences are often vague and cannot be expressed by exact numerical values, the application of fuzzy concepts in decision making is deemed to be relevant. Fuzzy TOPSIS (technique for order preference by similarity to ideal solution) has become one of the most widely used fuzzy MADM methods. This work presents a fuzzy TOPSIS model under group decisions for solving the facility location selection problem in Turkey.
Keywords: multiple attribute decision making, fuzzy TOPSIS, human judgements.

1. INTRODUCTION
Decision making is the process of finding the best option among the feasible alternatives. Many terminologies have been proposed for the categorization of MCDM problems. The dominant terms are the one of Multi-Criteria Decision Analysis (MCDA) or Multi-Attribute Decision Making (MADM), for problems in which the DM must choose from a finite number of explicitly available alternatives characterized by a set of multiple attributes (or criteria) and the one of Multi-Objective Mathematical Programming (MOMP) or Multi-Objective Decision Making (MODM) that deal with decision problems characterized by multiple and conflicting objective functions that are to be optimized over a feasible set of decisions [2]. The MCDA methods can be divided into two main categories; the outranking methods [1] and the multi-attribute utility and value theories.Technique for order preference by similarity to an ideal solution (TOPSIS), known as a classical MADM method, has been developed by Hwang and Yoon (1981) [3] for solving the MADM problem. It is based on the idea that the chosen alternative should have the shortest distance from the positive ideal solution, and, on the other side, the farthest distance from the negative ideal solution. If the assessment values are known to have various types of vagueness/imprecision or subjectiveness, then the classical decision making techniques are not useful for such problems [4]. In section two, fuzzy TOPSIS methodology is mentioned. In Section three, fuzzy TOPSIS application is presented. Finally, concluding remarks are provided in Section four.

2. FUZZY TOPSIS METHODOLOGY
Fuzzy numbers represent a number of whose value we are somewhat uncertain. They are a special kind of fuzzy set whose members are numbers from the real line, and hence are infinite in extent [5]. Fuzzy set theory introduced by Zadeh in 1965 [7], represents uncertainty and vague data and characterized by a continuum of grades of membership, which assigns to each object a grade of

membership ranging between 0 and 1. Symbol, which placed below, represents a fuzzy set. A triangular fuzzy number (TFN) 'M' is shown in Fig. 1.

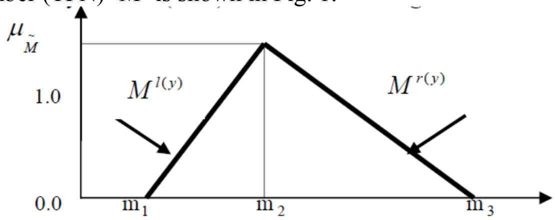

Figure 1. A triangular fuzzy number, M

Fuzzy TOPSIS methodology bases upon the concept that the chosen alternative should have the shortest distance from the Positive Ideal Solution (PIS), the solution that maximizes the benefit criteria and minimizes the cost criteria; and the farthest from the Negative Ideal Solution (NIS), the solution that maximizes the cost criteria and minimizes the benefit criteria. In classical MCMD methods, including classical TOPSIS, the ratings and the weights of the criteria are known precisely [6]. Considering the fuzziness in the decision data and group decision making process, linguistic variables are used to assess the weights of all criteria and the ratings of each alternative with respect to each criterion. It is often difficult for a decision-maker to assign a precise performance rating to an alternative for the attributes under consideration. The merit of using a fuzzy approach is to assign the relative importance of attributes using fuzzy numbers instead of precise numbers. The fuzzy TOPSIS procedure is then defined as follows:

Definition 1: Select the linguistic ratings $(\tilde{x}_{ij}, i = 1,2,\ldots,m, j = 1,2,\ldots,n)$ for alternatives with respect to criteria and the appropriate linguistic variables for the weight of the criteria.

Definition 2: Devise the weighted normalized fuzzy decision matrix. The weighted normalized value is calculated.

Definition 3: Describe positive ideal (A^*) and negative ideal (A^-) solutions.

$$A^* = (x_1^*, \ldots\ldots, x_j^*, \ldots\ldots, x_n^*) \quad (1)$$

$$A^- = (x_1^-, \ldots\ldots, x_j^-, \ldots\ldots, x_n^-) \quad (2)$$

Definition 4: Compute separation measures. The distance of each alternative from (A^*) and (A^-) have to be calculated.

$$d_i^* = \sum_{j=1}^{n} d(v_{ij}, v_j^*), \qquad j = 1,2,\ldots,m \quad (3)$$

$$d_i^- = \sum_{j=1}^{n} d(v_{ij}, v_j^-) \qquad j = 1,2,\ldots,m \quad (4)$$

Definition 5: Compute similarities to ideal solution.

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-} \qquad i = 1,2,\ldots,m \quad (5)$$

3. APPLICATION

One of the facilities in Istanbul in Turkey wants to select the best location. Alternatives are A1, A2, A3, A4, A5 and A6. Alternatives are Trabzon, Bursa, Samsun, İstanbul, Ankara and İzmir. During the evaluation, six main criteria (C1: investment cost, C2: proximity to stock, C3: transportation opportunity, C4: labor force, C5: market opportunity, C6: growth probability) have been selected. Finally, the best location selection among six alternatives has been investigated. The hierarchy of the selection of facility location can be seen from Fig 2.

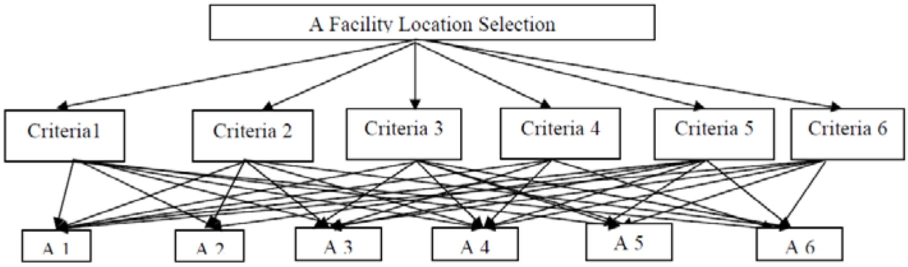

Figure 2. Hierarchy for the facility location selection

The decision makers use the linguistic weighting variables to assess the importance of the criteria. They use the linguistic rating variables (shown in Table 1) to evaluate the rating of alternatives with respect to each criterion. The linguistic evaluations (shown in Table 2 and 3) are converted into symmetric triangular fuzzy numbers in order to construct the fuzzy decision matrix. The (normalized) fuzzy decision matrix and the weighted normalized fuzzy decision matrix is constructed.

Table 1. Linguistic Variables for the Importance and Linguistic Variables For The Weight of Each Criterion Ratings

VL	Very low	0	0.0	0.1
L	Low	0.0	0.1	0.3
ML	Medium low	0.1	0.3	0.5
M	Medium	0.3	0.5	0.7
MH	Medium high	0.5	0.7	0.9
H	High	0.7	0.9	1
VH	Very high	0.9	1.0	1

VP	Very poor	0	0	1
P	Poor	0	1	3
MP	Medium poor	1	3	5
F	Fair	3	5	7
MG	Medium good	5	7	9
G	Good	7	9	10
VG	Very good	9	10	10

Table 2. The Importance Weight of Each Criterion Given by Decision Makers (DM) for the Numerical Example

Criterion	DM 1	DM 2	DM 3	DM 4	DM 5
C1	H	VH	H	H	H
C2	VH	H	H	VH	H
C3	MH	H	M	M	M
C4	H	M	ML	M	M
C5	MH	H	MH	H	H
C6	H	MH	H	MH	MH

Table 3. Linguistic Variables for the Ratings Given by Decision Makers for the Numerical Example

Criterion	Alternatives	Decision Makers				
		DM1	DM2	DM3	DM4	DM5
C1	A1	G	G	MG	G	G
	A2	MG	F	G	MG	P
	A3	G	G	VG	G	VG
	A4	MG	F	P	MG	G
	A5	MG	F	G	G	G
	A6	VG	VG	G	G	G
C2	A1	F	P	P	P	VP
	A2	VG	G	VG	G	G
	A3	F	F	P	VP	VP
	A4	VG	G	VG	VG	G
	A5	G	F	G	G	VG
	A6	VG	G	G	VG	VG
C3	A1	G	F	F	MG	G
	A2	G	G	VG	G	VG
	A3	G	G	MG	MG	G
	A4	VG	VG	VG	VG	VG

	A5	G	G	MG	MG	G
	A6	VG	G	G	VG	VG
C4	A1	G	G	F	G	F
	A2	G	G	G	VG	VG
	A3	G	G	MG	MG	MG
	A4	VG	VG	VG	VG	VG
	A5	G	MG	MG	G	G
	A6	G	G	VG	G	VG
C5	A1	P	MP	P	P	VP
	A2	VG	G	VG	G	G
	A3	P	MP	F	F	MP
	A4	G	VG	G	VG	VG
	A5	F	MP	G	G	G
	A6	G	G	VG	G	G
C6	A1	MG	MP	F	MP	F
	A2	G	G	VG	G	G
	A3	MG	F	F	MP	F
	A4	VG	VG	G	VG	VG
	A5	G	G	MG	MG	MG
	A6	MG	G	G	MG	G

Table 4. The Fuzzy Mean Numbers of the Alternatives

	C1	C2	C3	C4	C5	C6
A1	6.2, 8.2, 9.6	6.6, 8.4, 9.4	5, 7, 8.6	7.4, 9.2, 10	0.6, 1.6, 3.4	2.6, 4.6, 6.6
A2	6.2, 8.2, 9.6	3, 5, 7	7.8, 9.4, 10	5.8, 7.8, 9.4	7.8, 9.4, 10	7.4, 9.2, 10
A3	7.8, 9.4, 10	1.2, 2.2, 3.8	4, 5.8, 7.6	5.8, 7.8, 9.4	1.6, 3.4, 5.4	7.8, 9.4, 10
A4	0.2, 1.2, 3	8.2, 9.6, 10	5.2, 7, 8.4	9, 10, 10	8.2, 9.6, 10	8.6, 9.8, 10
A5	9, 10, 10	4, 5.8, 7.6	6.2, 8.2, 9.6	6.2, 8.2, 9.6	5.8, 7.8, 9.2	7.8, 9.4, 10
A6	7.8, 9.4, 10	8.2, 9.6, 10	8.2, 9.6, 10	7.8, 9.4, 10	5.4, 7.4, 8.8	6.6, 8.6, 9.8

Table 5. d_i^* and d_i^- values of the Alternatives CC_i

Alternatives	d_i^*	d_i^-	CC_i
A1	3,85	2,08	0,36
A2	3,01	3,21	0,51
A3	3,98	2,57	0,39
A4	3,38	6,02	0,64
A5	3,03	3,41	0,54
A6	3,22	3,68	0,53

Finally, the best facility location selection is candidate A4 (Istanbul) having a greater closeness coefficient.

4. CONCLUSION

In this paper a fuzzy TOPSIS approach has been presented to solve the facility location selection problem in Turkey. According to the final score, Istanbul is the most appropriated location because it has the highest priority weight and Ankara is the second one.

5. REFERENCES

[1] Roy B. : Aide multicritère à la décision, méthodes et cas. Paris: Economica. 1993.,

[2] Kelemenis A., Askounis D.: A new TOPSIS-based multi-criteria approach to personnel selection, Expert Systems with Applications 37, 4999–5008, 2010,

[3] Hwang C.L., Yoon K.: Multiple Attributes Decision Making Methods and Applications, Springer, Berlin, Heidelberg, 1981.,

[4] Mahdavi I., Mahdavi N. A., Heidarzade A., Nourifar R.:Designing a model of fuzzy TOPSIS in multiple criteria decision making, Applied Mathematics and Computation 206, 607–617, 2008,

[5] Siler W., Buckley J.J.:Fuzzy expert systems and fuzzy reasoning. New Jersey, NJ: Wiley, 2005,

[6] Saghafian S., Hejazi S.R.: Multi-criteria Group Decision Making Using A Modified Fuzzy TOPSIS Procedure, Computer Society, 2005.,

[7] Zadeh L.A.: Fuzzy sets, Inform. and Control, 8 pp., 338-353, 1965.