Chemical Technology. Control and Management

Volume 2018
Issue 3 *SPECIAL ISSUE 4-5* | Article 13

10-19-2018

Facility location problem by using fuzzy topsis method.

Kamala. Aliyeva
Azerbaijan State Oil and Industry University, Azadlig Ave., AZ1010, Baku, Azerbaijan, kamalann64@gmail.com

Facility location problem by using fuzzy topsis method.

Cover Page Footnote

Tashkent State Technical University, SSC «UZSTROYMATERIALY», SSC «UZKIMYOSANOAT», JV «SOVPLASTITAL», Agency on Intellectual Property of the Republic of Uzbekistan

Erratum

??????

ISSN 1815-4840
CHEMICAL TECHNOLOGY.
CONTROL AND MANAGEMENT
2018, Special issue №4-5 (82-83) pp.55-59
International scientific and technical journal
journal homepage: ijctcm.com
Since 2005

FACILITY LOCATION PROBLEM BY USING FUZZY TOPSIS METHOD

Kamala Aliyeva

Azerbaijan State Oil and Industry University,
Azadlig Ave., AZ1010, Baku, Azerbaijan
E-mail: kamalann64@gmail.com

Abstract. *Facility location problems are long-term decision making problems for selection best geographical location to begin the operations of a new facility or for expansion of existing facilities. These are strategic investment decision including many factors that may be inconsistent in nature. To solve this problems, some alternatives based on different criteria's need to be selected. To make a decision on such fuzzy problems, fuzzy multiple criteria decision making can be applied. In this paper, fuzzy multiple criteria decision making with TOPSIS and weighted product (WP) methods is used to select the best location of company facility. The results of solving represent that TOPSIS and Weighted Product fuzzy multiple criteria decision making methods can be used to select the most suitable place for new facility or for expansion of existing facilities.*

Key words: *Type-2 Fuzzy Sets, TOPSIS, Fuzzy Numbers, Multicriteria decision making, Uncertainty.*

Introduction

A facility location problem consists in defining the position of a set of facilities within a given location area on the basis of the distribution of demand to be allocated to the facilities. In the practical applications either in private or in public sector, these problems deal with strategic and long term decisions involving huge investment costs. Selecting the right place with some common factors exist that influence facility location method. The Fuzzy TOPSIS method represents relatively favorable practice samples, especially in realistic problems where individual opinions are defined by linguistic data. For this goals a fuzzy multi factor decision making method, which is an extension of the Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) approach is used. TOPSIS was suggested by Hwang and Yoon in 1981 [1]. In this method, the basic concept is that the most preferred alternative should have the shortest distance from the Positive Ideal Solution (PIS) and the longest distance from the Negative Ideal Solution (NIS) [2]. Based on Wang and Elhag [3], positive ideal personal is the one that maximizes the benefit criteria and minimizes the cost criteria, while the negative ideal personal functions in the opposite way. As distinction to the original supplementation, of TOPSIS where the weight of the attribute and the ratings of alternatives are known exactly, many decision problems are compared with unquantifiable, imperfect and unapproachable information [4] that make precise judgment impossible. This is when fuzzy TOPSIS comes into play where the criteria weights and alternative ratings are given by linguistic variables, expressed by fuzzy numbers. TOPSIS was extended by Chen [5] to fuzzy environments, which used a fuzzy linguistic value as a substitute for the directly given crisp value in the grade assessment. From our results, the business climate, living conditions, transportation, infrastructure, supplies are the most important in facility location. Fuzzy TOPSIS, that used by this paper presents a solution for decision makers when dealing with real data that are usually multi attributes and involves a complex decision making process. In this work, using this method is demonstrated in the facility location problem.

1.Preliminaries

Definition 1. Decision-makers define some alternatives that will be selected following several attributes or criteria. A fuzzy set $\tilde{A}$ in variable X is determined by a membership function $\mu_{\tilde{A}}(x)$ which each element x in X a real number in the interval [0,1].The value $\mu\tilde{A}(x)$ is called the grade of membership function of x in $\tilde{A}$ [6].

Definition 2. In TOPSIS, the realization of each alternative requires to be sorted with x- decision matrix; i=1,2, … ,m; and j=1,2, … ,n. An element r_{ij}- of the normalized decision matrix R can be rated as follows [5]

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

Definition 3 . Input data are defined in the decision matrix format. A configuration of weights W = (w$_1$, w$_2$, w$_3$, ...,w$_N$), (where: $\sum w_i = 1$) determined by the mangers is provided to the decision matrix to create the weighted normalized matrix V as follows [5]:

$$V = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & w_3 r_{13} & \cdots & w_N r_{1N} \\ w_1 r_{21} & w_2 r_{22} & w_3 r_{23} & \cdots & w_N r_{2N} \\ . & & & & . \\ . & & & & . \\ . & & & & . \\ w_1 r_{V1} & w_2 r_{M2} & w_3 r_{M3} & \cdots & w_N r_{MN} \end{bmatrix} \quad (2)$$

$r_{ij} = 1$

Definition 4. The weighted normalized fuzzy decision matrix positive ideal solution A* and negative ideal solution A^- can be defined on base of the weighted normalized rating. Positive ideal solution matrix is calculated with function (3), where the negative ideal solution matrix based on function (4):

$$A^* = \left\{ (\max_i v_{ij} \middle| j \in J), (\min_i v_{ij} \middle| j \in J) \right. \quad (3)$$
$$\left| i = 1,2,3,...,M \right| = \left\{ v_{1*}, v_{2*}, ..., v_{N*} \right\}$$

and the negative-ideal A^- solutions are determined as follows:

$$A^- = \left\{ (\min_i v_{ij} \middle| j \in J), (\max_i v_{ij} \middle| j \in J) \right. \quad (4)$$
$$\left| i = 1,2,3,...,M \right| = \left\{ v_{1-}, v_{2-}, ..., v_{N-} \right\}$$

For this aim a fuzzy multi factor decision making method, which is an evolution of the fuzzy technique for order preference by similarity to ideal solution (FTOPSIS) method is used.

Definition 5. The Euclidean distance method is used to grade the separation distances of each alternative to the positive ideal solution and negative-ideal solution [5].

$$S_{i^*} = \sqrt{\sum (v_{ij} - v_j^*)^2}, \text{ i=1,2,3,…,M,}$$

Definition 6 . The relative closeness to the ideal solution of an alternative $\boldsymbol{A_i}$ with respect to the ideal solution A^* is defined as follows where 0 ≤ Ci ≤ 1, that is, alternative i is closer to the fuzzy positive ideal reference point and far from the fuzzy negative ideal reference point as Ci approaches. [5]:

Evidently, $C_{i^*} = 1$ if $A_i = A^*$ and $C_{i-} = 0$ if $A_i = A^-$

2.Statement of the problem

Suppose that an multi attribute decision problem involves 5 criteria - C_1, C_2, C_3, C_4 and 4 alternatives - A_1, A_2, A_3, A_3. C_1 - Business climate ; C_2 -Living conditions ; C_3 -Transportation ; C_4 - Infrastructure; C_4 5- Supplies (Table 1). The relative weights of the 5 criteria were determined to be

W1=0.35, W2=0.25, W3=0.20, W4=0.10, W5=0.10

Decision matrix gives the linguistic performance in terms of Type-2 fuzzy numbers. These linguistic performance rating are presented in Table 2.

Very high = < 0.8, 0.9, 1, 1>

High = < 0.6, 0.7, 0.8, 0.9>

Average = < 0.4, 0.5, 0.6, 0.7>

Low= < 0.2, 0.3, 0.4, 0.5>

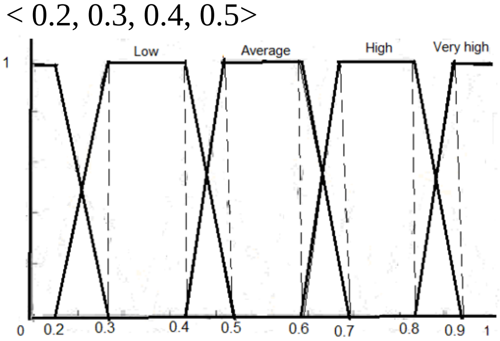

Fig.1.Interval-valued approximation to fuzzy number.

3.Solution of the problem

Step 1: We determine the decision matrix of fuzzy ratings of alternatives with respect to criteria and the weights of criteria.

Step 2: In this step we construct the normalized decision matrix. A set of weights W = (w_1, w_2, w_3, ...,w_N), (where: $\sum w_i = 1$) determined by the decision maker to create the weighted normalized matrix V as follows(Table 3):

Table 1.

Linguistic performance rating

Attribute	Location A1	Location A2	Location A3	Location A4
C_1 -(Business climate)	Very high	High	Average	High
C_2 -(Living conditions)	Average	High	Very high	High
C_3 -(Transportation)	High	Average	Average	Average
C_4 -(Infrastructure)	High	High	High	Very high
C5- (supplies)	Low	Average	High	Low

Table 2.

Fuzzy decision matrix and fuzzy weight of four candidates

	C1	C2	C3	C4	C5
W	**0.35**	**0.25**	**0.20**	**0.10**	**0.10**
A1	0.8,0., 1,1	0.4,0.50.6,0.7	0.6,0.7, 0.8,0.9	0.6,0.7, 0.8,0.9	0.2,0.3, 0.4,0.5
A2	0.6,0.7, 0.8,0.	0.6,0.70.8,0.9	0.4,0.5,0.6,0.7	0.6,0.7, 0.8,0.9	0.4,0.5 0.6,0.7
A3	0.4,0.5, 0.6,0.7	0.8,0.91,1	0.4,0.5,0.6,0.7	0.6,0.7, 0.8,0.9	0.8,0.9, 1,1
A4	0.6,0.7, 0.8,0.9	0.6,0.70.8,0.9	0.4,0.5,0.6,0.7	0.8,0.9, 1,1	0.2,0.3, 0.4,0.5

Table 3

Fuzzy normalized weighted decision matrix of four candidates

	C1	C2	C3	C4	C5
A1	0.28,0.31, 0.35,0.35	0.1,0.12, 0.15,0.17	0.12,0.14, 0.16,0.18	0.06,0.07, 0.08,0.09	0.02,0.03, 0.04,0.05
A2	0.21,0.24, 0.28,0.31	0.15,0.17, 0.2,0.18	0.08,0.1, 0.12,0.14	0.06,0.07, 0.08,0.09	0.04,0.05, 0.06,0.07
A3	0.14,0.17, 0.21,0.24	0.2,0.22, 0.25,0.25	0.08,0.1, 0.12,0.14	0.06,0.07, 0.08,00.9	0.08,0.09, 0.1,0.1
A4	0.21,0.24, 0.28,0.31	0.15,0.17, 0.2,0.18	0.08,0.1, 0.12,0.14	0.08,0.09, 0.1,0.1	0.02,0.03, 0.04,0.05

Step 3: In this step we determine the positive and the negative ideal solutions. The ideal A* and the negative ideal A^- solutions are determined as follows:

$$A^* = \left\{ (\max_i v_{ij} \middle| j \in J), (\min_i v_{ij} \middle| j \in J) \middle| i = 1,2,3,...,M \right\}$$
$$= \{ v_{1*}, v_{2*}, ..., v_{N*} \}$$

and the negative-ideal A^- solutions are defined as follows:

$$A^- = \left\{ (\min_i v_{ij} \middle| j \in J), (\max_i v_{ij} \middle| j \in J) \middle| i = 1,2,3,...,M \right\} =$$
$$= \{ v_{1-}, v_{2-}, ..., v_{N-} \}$$

For example ,

0.28, 0.21, 0.14, 0.21- ideal is 0.28, negative is 0.14.

0.31, 0.24, 0.17, 0.24- ideal is 0.31, negative is 0.17.

0.35, 0.28, 0.21, 0.28- ideal is 0.35, negative is 0.21.

0.35, 0.31, 0.24, 0.31- ideal is 0.35, negative is 0.24(Table 4)

Table 4.

The Ideal and the Negative-ideal Solutions

	C_1	C_2	C_3	C_4	C_5
A*	0.28,0.31, 0.35,0.35	0.2,0.22, 0.25,0.25	0.12,0.14, 0.16,0.18	0.08,0.09, 0.1,0.1	0.08,0.09, 0.1,0.1
A^-	0.14,0.17, 0.21,0.24	0.1,0.12, 0.15,0.17	0.08,0.1 ,0.12,0.14	0.06,0.07, 0.08,0.09	0.02,0.03, 0.04,0.05

Step 4. The Euclidean distance method is next applied to measure the separation .
distances of each alternative to the positive ideal solution and negative-ideal solution

$$S_{i^*} = (\sum (v_{ij} - v_j^*)^2)^{1/2},$$

$i = 1,2,3,...,M \;\; i = 1,2,3,...,M$

The separation distances of each alternative to the positive ideal solution and negative-ideal solution is represented in Table 5.
For example

$$S_{11^8} = ((0.28-0.28)^2 + (0.31-0.31)^2 + $$
$$+ (0.35-0.35)^2 + (0.35-0.35))^2 = 0$$

$$S_{11^-} = ((0.28-0.14)^2 + (0.31-0.17)^2 + $$
$$+ (0.35-0.21)^2 + (0.35-0.24))^2 = 0.26$$

$$S_{12^8} = ((0.21-0.28)^2 + (0.24-0.31)^2 + $$
$$+ (0.28-0.35)^2 + (0.31-0.35))^2 = 0.12$$

$$S_{12^-} = ((0.21-0.14)^2 + (0.24-0.17)^2 + $$
$$+ (0.28-0.21)^2 + (0.31-0.24))^2 = 0.13$$

$$S_{13^*} = ((0.14-0.28)^2 + (0.17-0.31)^2 + $$
$$+ (0.21-0.35)^2 + (0.24-0.35))^2 = 0.21$$

$$S_{13^-} = ((0.14-0.14)^2 + (0.17-0.17)^2 + $$
$$+ (0.21-0.21)^2 + (0.24-0.24))^2 = 0$$

$$S_{14^*} = ((0.21-0.28)^2 + (0.24-0.31)^2 + $$
$$+ (0.28-0.35)^2 + (0.31-0.35))^2 = 0.14$$

$$S_{14^-} = ((0.21-0.14)^2 + (0.24-0.17)^2 + $$
$$+ (0.28-0.21)^2 + (0.31-0.24))^2 = 0.13$$

Table 5.

The separation distances of each alternative to the positive ideal solution and negative-ideal solution.

	C_1				C_2			
	A1	A2	A3	A4	A1	A2	A3	A4
A*	0	0.12	0.21	0.14	0.19	0.08	0	0.08
A^-	0.26	0.13	0	0.13	0	0.11	0.19	0.11
	C_3				C_4			
	A1	A2	A3	A4	A1	A2	A3	A4
A*	0	0.08	0.08	0.08	0.03	0.03	0.03	0
A^-	0.08	0	0	0	0	0	0	0.03
	C_5							
A*	0.11	0.075	0	0.11				
A^-	0	0.04	0.10	0				

Step 5. Calculate the Relative Closeness to the Ideal Solution. The relative closeness of an alternative A_i with respect to the ideal solution A^* is defined as follows:

$$C_{i^*} = \frac{S_{i-}}{S_{i^*} + S_{i-}}, 0 \le C_{i^*} \le 1$$

For example ,

$C_{1^*} = S_{1^-}/(S_{1^*}+S_{1^-})$

=[0.26/(0.26+0)+0/(0.19+0)+0.08/(0+0.08)+ +0/(0.03+0)+0/(0.11+0)]/4=0.5

C_{2^*}=[0.13/0.25+0.11/0.19+0/0.8+0/0.3 +0.04/0.115]= [0.52+0.57+0.35]/4=0.36

C_{3^*}=[0+1+0+0+1]/4=0.5

C_{4^*}=[0.48+0.578+0+1+0]/4=0.52

From this calculations we get that

C_{i*}=(0.5, 0.36, 0.5, 0.52)

Step 6. Next step is **r**anking the precedence order**.** The best place for facility can be determined by using preference rank order of C_{i*}. The best place is the one that has the smallest distance to the ideal solution. The relationship of alternatives represents that any alternative which has the smallest distance to the ideal solution is guaranteed to have the longest distance to the negative-ideal solution(Table 6).

Table 6.

Rank the preference order

	A_1	A_2	A_3	A_4
C_{i*} =	0.5	0.36	0.5	0.52

By using fuzzy TOPSIS method the order ranking we determine that

$A_4 > A_1 = A_3 > A_2$.

The result shows that place (A_4) is the best location and (A_2) is the poor place for facility location.

3. Conclusion

In this paper, fuzzy TOPSIS was used in the selection of the best place according to five criteria’s for facility location. First criteria is business climate, second criteria is living conditions, third criteria is transportation, fourth criteria is infrastructure and fifth criteria is supplies. Results determined from the relative closeness to the ideal solutions were used to rank the preference order in the selection of place for facility location.

REFERENCES

1. Hwang, C.L, Yoon, K. : Multiple Attributes Decision Making Methods and Applications, Springer, Berlin Heidelberg, 1981.
2. Opricovick, S., Tzeng, G.H. : Compromise Solution by MCDM Methods : A Comparative Analysis of VIKOR and TOPSIS. European Journal of Operational Research, 2004, 156,- pp. 445 – 455
3. Wang, Y.M, Elhag, T.M.S. : Fuzzy TOPSIS Method Based on Alpha Level Sets with an Application to Bridge Risk Assessment. Expert Systems with Applications, 2006, 31, -pp. 309 – 319
4. Olcer, A.I, Odabasi, A.Y. : A New Fuzzy Multiple Attributive Group Decision Making Methodology and its Application to Population/Maneuvering System Selection Problem. European Journal of Operational Research, 2005, 166, pp.93 – 114.
5. Chen, C-T. : Extension of the TOPSIS for Group Decision-Making Under Fuzzy Environment. Fuzzy Sets and Systems, 2000, 114, pp.1–9.
   Zadeh, L.A. Fuzzy Sets, Information and Control, 1965, 8, pp. 338 – 353.