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A Decision Support Model for Bank Branch Location Selection

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Abstract

Location selection is one of the most important decision making process which requires to consider several criteria based on the mission and the strategy. This study's object is to provide a decision support model in order to help the bank selecting the most appropriate location for a bank's branch considering a case study in Turkey. The object of the bank is to select the most appropriate city for opening a branch among six alternatives in the South-Eastern of Turkey. The model in this study was consisted of five main criteria which are Demographic, Socio-Economic, Sectoral Employment , Banking and Trade Potential and twenty one sub-criteria which represent the bank's mission and strategy. Because of the multi-criteria structure of the problem and the fuzziness in the comparisons of the criteria, fuzzy AHP is used and for the ranking of the alternatives, TOPSIS method is used.

Keywords
MCDM, Fuzzy AHP,TOPSIS, location selection.

1. Introduction
Location selection has a strategic importance for many companies .The general procedure for making location decisions usually consists of the following steps: Decide on the criteria that will be used to evaluate location alternatives; select the criteria that are important; develop location alternatives and select the alternatives evaluated. [22] Selecting a location is very important decision for firms because they are costly anda difficult to reverse. A poor choice of location might result in excessive transportation costs, lost of qualified labor, competitive advantage or some similar condition that would be detrimental to operations.[22]. Each organization should consider meaningful criteria for location selection suitable to its misson and strategy in order to make an efficient and effective strategic decision. The location decision may differ with regard to type of business. Thus, the factors considered vary from business to business but it is emphasized that the objective of the decision is to maximize the benefit of location of the firm [10]. Location selection is a multi-criteria decision because it requires to take into consideration both qualitative and quantitative factors. The literature including bank branch location has also shown that that the selection process is a multi-staged process having different criteria in each level. In the litterature, several approaches can be seen to handle multi-criteria problems. The analytic hierarchy process (AHP) developed by Saaty[21] is used methodolgy for his type of problems [14],[17]. AHP allows to structure multi criteria problem hierarchically and to combine the results obtained at each level of the hierarchy but cannot reflect the human thinking style which is uncertain and imprecise. Therefore,fuzzy AHP is used to obtain the judgments for the decision making process. In the litterature, different approaches to fuzzy AHP such as Laarhoven and Pedrcyz [15], Buckley[5],Chang[9],Leung and Cao[16] and Buckley et al.[6]. In this study, Chang's extent analysis method is used to compare the alternatives. The autors have used this fuzzy approach to compare the catering services companies in Turkey[13],to develop a framework for quality function deployment (QFD) planning process using analytic network approach[14], to valuate machine tool alternatives [1], for the selection among computer integrated manufacturing systems [4], for the operating system selection using fuzzy replacement analysis and analytic hierarchy process[23] . The TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method as firstly proposed Hwang and Yoon [11]. According to this technique, the best alternative would be one that is nearest to the positive ideal solution and farthest from the negative ideal solution [2]. The positive ideal solution is a solution that maximizes the benefit citeria and minimizes the cost criteria, whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria [42]. The remainder of this study is organised is as follows: In the second section Chang's extent analysis on FAHP is summarised. In the third section TOPSIS method is tried to be explained. The fourth section introduces the decison support model for the branch location selection and the application process. And finally, in section five results of the application are presented and this section concludes this study.

2. Extent Analysis Method On Fuzzy AHP

In this study, Chang's[9] extent analyis method on fuzzy AHP,therefore triangular fuzzy numbers (TFN). Triangular fuzzy numbers are represented as l/m, m/u, (or (l,m,u) in which l,m and u refer to, respectively, th lower value, modal value and upper value. Let $X = \{x_1, x_2, x_3, ..., x_n\}$ an object set and $G = \{g_1, g_2, g_3, ..., g_n\}$ be a goal set.Then each object is taken and extent analysis for each goal is performed respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$M_{gi}^1, M_{gi}^2, ..., M_{gi}^m, \qquad i=1,2,\ldots n$$

Where M_{gi}^j (j=1,2,…,m) all are TFNs. The steps of Chang's [9] extent analysis can be given as following:

- Step 1: The value of fuzzy synthetic extent with respect to the ith object is defined as

$$S_i = \sum_{j=1}^{m} M_{gi}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right]^{-1} \qquad (1)$$

To obtain $\sum_{j=1}^{m} M_{gi}^j,$ the fuzzy addition operation of m extent analysis values for a particular matrix is performed such as:

$$\sum_{j=1}^{m} M_{gi}^j = (\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j) \qquad (2)$$

and to obtain $\left[\sum_{j=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right]^{-1}$, the fuzzy addition operation of M_{gi}^j (j=1,2,…,m) values is performed such as :

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j = (\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i) \qquad (3)$$

And then inverse of the vector above is computed , such as:

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right) \qquad (4)$$

- Step 2: As $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ are two triangular fuzzy numbers , the degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is defined as :

$$V(M_2 \geq M_1) = \sup_{y \geq x} \left[\min(\left(\mu_{M_1}(x), \mu_{M_2}(y)\right)) \right]$$

(5)

And can be expressed as follows:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1 & ,if \quad m_2 \geq m_1 \\ 0 & ,if \quad l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & ,if \quad otherwise \end{cases}$$

Where d is the ordinate of the highest intersection point D between μ_{M_1} and μ_{M_2}. To compare M_1 and M_2, we need both the values of $V(M_1 \geq M_2)$ and $V(M_z \geq M_1)$.

- Step3: The degree possibility for a convex fuzzy number to be greater than k convex fuzzy $M_i (i = 1,2,...k)$ numbers can be defined by

$$V(M \geq M_1, M_2, ...M_K) = V \left[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and...and } (M \geq M_K) \right] = \min V(M \geq M_i) \qquad (7) \qquad i=1,2,\ldots,k$$

Assume that $d(A_i) = \min V(S_i \geq S_K)$ for $k = 1,2,...,n$; $k \neq i$. Then the weight vector is given by

$$W' = (d'(A_1), d'(A_2), ...d'(A_n))^T \qquad (8)$$

where $A_i = (i = 1,2,...,)$ are n elements.

- Step 4: Via normalization, the normalized weight vectors are

$$W = \left(d(A_1), d(A_2), ..., D(A_n)\right)^T \qquad (9)$$

Where W is a non fuzzy number.

3. TOPSIS Method

In this study, TOPSIS method is used for determining the final ranking of the alternatives.

- Step1: Decision matrix is normalised via Eq.(10):

$$r_{ij} = \frac{w_{ij}}{\sqrt{\sum_{j=1}^{J} w_{ij}^2}}, \qquad j = 1,2,3,...J \quad i = 1,...,n \qquad (10)$$

- Step2 : Weighted normalized decision matrix is formed:

$$w_{ij} = w_i * r_{ij} \qquad j = 1,2,3,...J \text{ , } i = 1,...,n \qquad (11)$$

- Step3: Positive ideal solution (PIS) and negative ideal solution (NIS) are determined :

$$A^* = \{v_1^*, v_2^*, ..., v_n^*\} \quad \text{maximum values} \qquad (12)$$

$$A^- = \{v_1^-, v_2^-, ..., v_n^-\} \quad \text{minimum values} \qquad (13)$$

- Step4 : The distance of each alternative from PIS and NIS are calculated

$$d_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2}, \qquad j=1,2,\ldots,J \qquad (14)$$

$$d_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2}\ , \qquad i=1,2,\ldots,J \tag{15}$$

- Step5 : The closeness coefficient of each alternative is calculated

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-} \tag{16}$$

- Step6: By comparing CC_i values , the ranking of alternatives are determined.

4. Developıng a Decision Support Model for Bank Branch Locatıon Selectıon

4.1 Evaluation of the criteria

As mentioned above, the aim of this study is to select the best bank branch location among the alternatives using fuzzy AHP to determine the weights of main and sub-criteria and TOPSIS method to evaluate the potential locations considering weights of the criteria and to rank them.The object of the bank is to decide which city among six alternatives in the South-eastern part of Turkey a branch should be opened based on its vision and strategy. Firstly, the criteria for the selection decision were identified. Considering the studies in the litterature which are [3, 18, 19, 20, 25] and the discussions with the bank's managers in different areas , many criteria were determined, selected, eliminated and the hierarchical structure which was illustrated in Table 1 was constructed.

Table 1: Criteria Table

<table>
<tr><th colspan="3">Criteria</th></tr>
<tr><td colspan="2" rowspan="5">Main criteria</td><td>Demographic</td></tr>
<tr><td>Socio-economic</td></tr>
<tr><td>Sectoral employment</td></tr>
<tr><td>Banking</td></tr>
<tr><td>Trade Potential</td></tr>
<tr><td rowspan="21">Sub-criteria</td><td rowspan="3">Demographic</td><td>Total Population</td></tr>
<tr><td>Urbanization rate</td></tr>
<tr><td>Annual Population Growth Rate</td></tr>
<tr><td rowspan="6">Socio-Economic</td><td>Gross National Product Per Capita(YTL)*</td></tr>
<tr><td>Literacy Rate</td></tr>
<tr><td>Rate of Population with Higher Education</td></tr>
<tr><td>Average Household Size</td></tr>
<tr><td>Employee rate</td></tr>
<tr><td>Employer rate</td></tr>
<tr><td rowspan="4">Sectoral employment</td><td>Agricultural employment rate</td></tr>
<tr><td>Manufacturing employment rate</td></tr>
<tr><td>Construction employment rate</td></tr>
<tr><td>Services employment rate</td></tr>
<tr><td rowspan="6">Banking</td><td>Number of bank</td></tr>
<tr><td>Number of branch</td></tr>
<tr><td>Bank deposit per branch (YTL)*</td></tr>
<tr><td>Credit per branch(YTL)*</td></tr>
<tr><td>Bank deposit per capita(YTL)*</td></tr>
<tr><td>Credit per capita(YTL)*</td></tr>
<tr><td rowspan="2">Trade potential</td><td>Number of firms</td></tr>
<tr><td>Number of organized industrial zone</td></tr>
</table>

* Turkish currency

Table 2: Lınguıstıc scale for ımportance

Linguistic scale	Triangular Fuzzy Numbers
Absolutely more important	(5/2,3,7/2)
Very strongly more important	(2,5/2,3)
Strongly more important	(3/2,2,5/2)
Weakly more important	(1,3/2,2)
Equally important	(1/2,1,3/2)
Just equal	(1,1,1)

As shown in the Table1 , the model contain five main criteria: “demographic”,”socio-economic”, “banking”, “sectoral employment” and “trade potential” which are decomposed twenty one sub-criteria . Once the model was constructed, a questionnaire form was established to obtain the bank managers’ pairwise comparisons for the main criteria and sub-criteria for evaluating the candidate cities. In the form, six bankers indicated their pairwise comparisons to obtain the weights of the main criteria and the sub-criteria using the linguistic scale [14] which is presented in Table 2.

Table 3: The Fuzzy Pairwıse Comparısons

	Demographıc	Socıoeconomıc	Sect.Empl.	Bankıng	Trade Pot.
Demographic	(1.OO,1.OO,1.OO)	(O.75,1.25,1.75)	(1.5,2,2.5)	(0.57,0.80,1.33)	(O.75,1.25,1.75)
Socıoeconomıc	(0.57,0.80,1.33)	(1.OO,1.OO,1.OO)	(0.83,1.33,1.83)	(0.36,0.44,0.57)	(0.36,0.44,0.57)
Employment	(0.40,0.50,0.67)	(0.55,0.75,1.20)	(1.OO,1.OO,1.OO)	(0.32,0.39,0.48)	(0.63,0.93,0.72)
Bankıng	(O.75,1.25,1.75)	(1.75,2.25,2.75)	(2.08,2.58,3.08)	(1.OO,1.OO,1.OO)	(1.42,1.92,2.42)
Trade	(0.57,0.80,1.33)	(1.75,2.25,2.75)	(0.58,1.08,1.58)	(0.41,0.52,0.70)	(1.OO,1.OO,1.OO)

Using the tables 2and3, the values of fuzzy synthetic extent with respect to each main criterion is calculated as follows:

$$S_D = (\ 4.571\ ,\ 6.3,\ 8.333\ ) \otimes \left(\frac{1}{35.16}, \frac{1}{28.54}, \frac{1}{21.92}\right) = (\ 0.13,\ 0.22,\ 0.38\ )$$

$$S_S = (\ 3.129\ ,\ 4.019,\ 5.306\ ) \otimes \left(\frac{1}{35.16}, \frac{1}{28.54}, \frac{1}{21.92}\right) = (\ 0,.09,\ 0.14,\ 0.24\ )$$

$$S_E = (\ 2.904,\ 3.565,\ 5.076\ ) \otimes \left(\frac{1}{35.16}, \frac{1}{28.54}, \frac{1}{21.92}\right) = (\ 0.08,\ 0.12,\ 0.23)$$

$$S_B = (\ 7.000,\ 9.000,\ 11.000) \otimes \left(\frac{1}{35.16}, \frac{1}{28.54}, \frac{1}{21.92}\right) = (\ 0.20,\ 0.32,\ 0.50\ )$$

$$S_T = (\ 4.315,\ 5.651,\ 7.368\ ) \otimes \left(\frac{1}{35.16}, \frac{1}{28.54}, \frac{1}{21.92}\right) = (\ 0.12,0.20,\ 0.34\ )$$

The fuzzy values are compared and the following values are obtained:

$$V(S_D \geq S_S) = 1 \qquad V(S_S \geq S_D) = 0580 \qquad V(S_B \geq S_D) = 1$$

$$V(S_D \geq S_E) = 1 \qquad V(S_S \geq S_E) = 1 \qquad V(S_B \geq S_S) = 1$$

$$V(S_D \geq S_B) = 0.660 \qquad V(S_S \geq S_B) = 0.220 \qquad V(S_B \geq S_E) = 1$$

$$V(S_D \geq S_T) = 1 \qquad V(S_S \geq S_T) = 0.68 \qquad V(S_B \geq S_T) = 1$$

$$V(S_T \geq S_D) \geq 0.900 \qquad V(S_E \geq S_D) = 0.510$$
$$V(S_T \geq S_S) = 1 \qquad V(S_E \geq S_S) = 0.900$$
$$V(S_T \geq S_E) = 1 \qquad V(S_E \geq S_B) = 0.17$$
$$V(S_T \geq S_B) = 1 \qquad V(S_E \geq S_T) = 0.090$$

The priority weights are :

$$d'(D) = \min(1, 1, 0.660, 1) = 0.660$$
$$d'(S) = \min(0.580, 1, 0.220, 0.680) = 0.220$$
$$d'(E) = \min(0.510, 0.900, 0.170, 0.090) = 0.90$$
$$d'(B) = \min(1, 1, 1, 1) = 1$$
$$d'(T) = \min(0.900, 1, 1, 0.55) = 0.550$$

The weight vector is obtained as $W' = (0.66, 0.22. 0.9, 1, 0.55)^T$ an the vector of priority of weight is found by normalization:

$W = (0.262, 0.087, 0.036, 0.397, 0.218)^T$. The result indicates that "banking criterion" is the most important main criterion with the priority of 0.397 for the branch location selection. This criterion is followed by the "Demographic" which has the priority of 0.262, "trade potential " with the priority of 0.218 and "soco-economic t with "0.087". The lowest priority belongs to the criterion "sectoral employment" in the decision makers' judgements. The same method was used to obtain the weights for the sub-criteria.With the decision makers' pair wise comparisons of the sub-criteria with respect to main criteria , the following weight vectors are obtained:

$$W_D = (0.599, 0.353, 0.048)^T$$
$$W_S = (0.340, 0.170, 0.01, 0.01, 0.272, 0.20)^T$$
$$W_E = (0.260, 0.240, 0.230, 0.270)^T$$
$$W_B = (0.120, 0.270, 0.000, 0.020, 0.310, 0.280).^T$$
$$W_T = (0.680, 0.320)^T$$

It's shown that the most important sub-criterion for the "demographic" is "total population" with the weight of 0.599 and it's followed by "urbanization rate" with the weight of 0.353 and "annual population growth rate" with the weight of 0.10. For the "socio-economic", the "gross national product per capita" has the highest weight .which is 0.340. In the sectoral emplyment criterion, services employment rate has the highest weight of 0.270 .In the "banking" criterion, it is obviously seen that bank deposit per capita has the highest weight and is followed by credit per capita and and number of branch.The weights of these criterion are similar. From the vector of the trade potential, the number of firms is more important sub-criterion with the weight of 0.680.

4.2 Evaluation of the alternatives

Afer determining the weights of the criteria with fuzzy AHP, the next step is to rank each candidate city with respect to each sub-criteria and main criteria using their weights. The data of the sub-criteria for candidate cities which were obtained from Bank Associaton of Turkey, State Institute of Statistics and Union of Chambers and Commodity Exchanges of Turkey can be seen in Tables 4, 5, 6, 7, 8, and 9. After the data are obtained, normalization of these values is made via Eq(10). Then weighted normalized matrix is formed by multiplying each value with their weights. All weighted values that form each sub-criterion are aggregated to form Table 9. Then the values in Table 9 and the weights of each main criterion are multiplied to form Table 10.

Table 4: Demographıc Sub-Crıterıa For The Candıdate Cıtıes

	D1	D2	*D3*
City 1	623.811	0,54	*0,351*
City 2	1.362.708	0,60	*0,423*
City3	1.002.384	0,53	*0,257*
City 4	853.658	0,58	*0,326*
City5	705.098	0,55	*0,172*
City6	*1.443.422*	*0,58*	*0,347*

Table 5: Socıoeconomıc Sub-Crıterıa For The Candıdate Cıtıes

	S1	S2	S3	S4	S5	S6
City 1	1112,3	0,8	0,03	6,26	0,25	0,28
City 2	1591	0,7	0,03	6,76	0,35	0,22
City3	1918,7	0,83	0,04	5,57	0,03	0,25
City4	1716	0,85	0,05	5,4	0,03	0,24
City5	1190	0,71	0,03	7,72	0,25	0,20
City6	122	0,68	0,02	6,93	0,24	0,24

Table 6: Employment Rate Sub-Crıterıa For The Candıdate Cıtıes

	E1	E2	E3	E4
City 1	0,73	0,04	0,02	0,21
City 2	0,64	0,04	0,04	0,24
City3	0,67	0,1	0,05	0,21
City4	0,64	0,06	0,03	0,27
City5	0,7	0,03	0,03	0,24
City6	0,73	0,04	0,03	0,20

Table 7: Bankıng Sub-Crıterıa

	B1	B2	B3	B4	B5	B6
City 1	14	30	14.391	20.110	738	1031,2
City 2	16	66	18.160	22.002	803,2	972,8
City3	15	50	22.903	31.599	1112,6	1535
City4	14	40	32.667	26.436	1780,7	1441,1
City5	11	33	11.601	17.263	510	758,9
City6	15	45	15.686	25.895	477	740,2

Table 8: Trade Potentıal Sub-Crıterıa

	T1	T2
City 1	203	3
City 2	331	2
City3	305	1
City4	522	3
City5	171	1
City6	411	4

Table 9: Total Values Of Maıncrıterıa

	D	S	E	B	T
City 1	0,3052	0,4019	0,3365	0,3251	0,3151
City 2	0,4980	0,4665	0,3911	0,4219	0,3675
City3	0,3854	0,3624	0,5160	0,4791	0,2960
City4	0,3676	0,3429	0,4129	0,5241	0,5717
City5	0,3154	0,2938	0,3560	0,1176	0,1882
City6	0,5071	0,3818	0,3589	0,3043	0,5330

Table 10: Total Weighted Values Of Maın Crıterıa

	D	S	E	B	T
City 1	0,080	0,035	0,012	0,129	0,069
City 2	0,130	0,041	0,014	0,167	0,080
City3	0,101	0,032	0,019	0,192	0,065
City4	0,096	0,030	0,015	0,210	0,125
City5	0,083	0,032	0,013	0,047	0,041
City6	0,133	0,033	0,013	0,122	0,116

Positive and negative ideal solution are determined by taking the maximum and minimum values for each criterion :

$$A^{*} = \{0.1330,0.041,0.0190,0.2100,0,1250\} \quad \text{maximum values}$$

$$A^{-} = \{0.080,0.0300,0.0121,0.0470,0.0400\} \text{ minimum values}$$

Then the distance of each candidate city from PIS and NIS with respect to each criterion are calculated with help of Eqs.(14) and (15). Then closeness coefficient of each candidate city is calculated by Eq.(16) and the ranking of the cities are determined according to these alues. The ranking of these cities are shown in Table 11.

Table 11: Rankıngs Of Cıtıes Accordıng To Candıdate Cıtıes

Candidates	CC_i
City4	*0,826*
City2	*0,686*
City3	*0,677*
City6	*0,579*
City1	*0,437*
City5	*0,019*

After the ranking the candidate cities for bank branch location selection by taking into consideration their data obtained from official foundations, the order of the cities are found as in Table11. Beside the data, the decion makers priorities also affect this ranking. If there will be a difference in the priority of decision makers, the ranking may change. For this reason, decision maker should know his priority properly and then determine the weights of the criteria.

5. Conclusıon

Branches have a strategic importance on a bank's performance and competitiveness [12],[18],[19] and the banks must identify meaningful criteria for their location selection considering their missions and strategies. In this study, FAHP and TOPSIS methods are used together . FAHP is utilized for detemining the weights of the criteria and TOPSIS method for determining the ranking of the cities. In the application, the ranking result of the candidate cities is reached by considering their data obtained Bank Associaton of Turkey, State Institute of Statistics and Union of Chambers and Commodity Exchanges of Turkey. A s the weights of the criteria are determined by bank managers from different areas , the result indicates an overall performance ranking. In summary,this studies indicates that both fuzzy AHP and TOPSIS can be used a decision support system by the organizations in order to make effective decision on the bank branch location selection.

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