Analysis of Customer's Expectations and Satisfaction in Zanjan Municipality Using Fuzzy Multi-Criteria Decision Making (FMCDM) Approach

Masoumeh Rahimi[a], Amir Najafi[b,*]
[a] MSc, Department of Management, Zanjan branch, Islamic Azad University, Zanjan, Iran
[b] Assistant Professor, Department of Industrial Engineering, Zanjan branch, Islamic Azad University, Zanjan, Iran
Received 26 January 2015; Revised 08 October 2015; Accepted 17 February 2016

Abstract

Customer satisfaction is the most important step in the process of identifying customer expectations. Identifying customer expectations without any reference to or obtaining personal view of the subject is impossible. In order to identify customer expectations, service suppliers used statistical techniques and surveyed their customers. According to the studies, there is no appropriate framework for expectation model to prioritize regions of organizations and make the favorable selection according to the organization's policies and strategies. In this research, a combination of fuzzy multiple-criteria decision-making is used for the optimal selection. The research method used in this study is of descriptive and applied types, and field method is used to collect data. For Identifying customer expectations, data have been collected from study population (customers of Zanjan municipality), showing 303 people through random sampling method. To rank the dimensions of customer's expectations and make optimal selections for municipality zones, data have been collected from study population (engineer contractor of the municipality), showing 30 people. Questionnaire and interview were used as instruments of data collection, which proved valid. The Expert Choice, Web-based TOPSIS, SPSS, and Excel software products were used for calculations. It is interesting to observe that the choices of the best municipality zone solely depend on the criterion with the maximum priority value. Based on calculations on the stages of the proposed model, "municipality Zone 2" was selected as the optimal region and had the highest rating in response to customer expectations. Results show that the proposed model has a systematic fit with the defined procedures and known inputs.
Keywords: Customer expectations, Multi criteria decision making, Fuzzy analysis network process (FANP), Fuzzy TOPSIS method, Fuzzy ELECTRE method.

1. Introduction

Many different theories and methods of performance have been applied in various organizations over many years for the sake of conducting an evaluation. These approaches include Analytic Hierarchical Process (AHP), Data Envelopment Analysis (DEA), Decision Making Trial and Evaluation laboratory (DEMATEL), Fuzzy Analytic Hierarchical Process (FAHP), Fuzzy Analytic Network Process (FANP), etc. Each method has its own concept, purpose, advantage, and disadvantage. Choice preference for assessing performance depends upon the situation and type of the organizations. However, all successful organizations have some common features, including a positive action and effective performance evaluation.

Achieving customer satisfaction is the main goal of many companies, especially service providers and many managers strive to achieve customer satisfaction. Since customer expectations and satisfaction are dynamic parameters which change over time, we need to regularly assess clients' expectations. By obtaining an understanding of customer requirements, we can determine the necessary steps to meet the clients' needs. Most organizations throughout the country assess customer satisfaction and build strong customer relationships, and many studies have been conducted with the same topic, with different aspects of determining the level of customer satisfaction. Although the position of the municipality in front of its customers is exclusive and one-sided, but according to customer-oriented culture, which leads to changes of the culture and values within the organization, the staff and management within the company turned it (because the customer-centered organization-wide communication networks with rewards are valuable to the municipality and its employees). Also, it has the financial rewards (money, bonuses, etc.) as well has a spiritual dimension (honor, reputation in the country, etc.) both at the individual and organizational levels. So, in this situation, identifying and satisfying

* Corresponding author Email address: anajafi@aut.ac.ir

customer expectations for municipalities with exclusivity is important. Parasuraman, Berry, and Zeithaml (1991) noted that service providers must recognize customer needs in order to fulfill expectations to achieve high customer satisfaction during the service experience. Managing customer expectation is an important approach that will enable customers to have a satisfying experience (Coye, 2004). Service providers can provide customers with appropriate services according to their expectations. The mandates for the municipality are:

- Ensuring the provision of services to communities in a sustainable manner.
- Providing social and economic development.
- Promoting a safe and healthy environment.
- Encourage the involvement of communities and community organizations in matters of local government.

Decision making is the process of defining decision goals, collecting relevant criteria and possible alternatives, evaluating advantages and disadvantages of alternatives, and selecting optimal alternatives (Wu, 2008). Decision-makers always like to know which option is the best of all alternatives. In the category of main information regarding the criteria or attribute of multiple-criteria decision-making methods, alternatives are ranked by their main performance values (Shih, 2008; Chou, 2010).

The purpose of the research is to identify and prioritize customer expectations in the municipality and to rank regions and municipalities on the basis of their response to customers' expectations. Although the position of municipality in front of its customers is exclusive and unilateral, according to customer culture in organizations, the customer-orientation indirectly includes rewards in organizational exchange network that is valuable to the municipality and its employees. So, in this situation, identifying and satisfying customers' expectations, despite being exclusive, is important for municipalities.

Based on interview with some customers (303 customer), research studies could obtain important facts that determine the satisfaction of customers with services of a company. Generally, they include:

1) Physical dimensions and amenities
2) Legitimation
3) Responsibility
4) Warranty and guarantee
5) Service quality and perceived value

And, such items can affect satisfactions with providers.

Successful companies have to pursue customer-centric strategies in order to sustain a competitive advantage. Customer expectation's analysis can play an important role in understanding customer requirements in a new product or service development. In addition, it can provide value for customers, and it can leave the customer with a favorable impression. The customer expectation's analysis can help determine what customers need and predict what they will need in the future. However, different customers have different attitudes toward the same requirement. To deal with this situation, it is proposed to use a group decision-making technique to obtain the importance weights for customer expectations. Then, Fuzzy Analytic Network Process (FANP), Fuzzy TOPSIS, and Fuzzy ELECTRE methods are proposed to be used for rating customer expectations and municipality zones based on customer expectations.

2. Customer Expectations

Customer expectations are the pre-experience beliefs of an actual experience yet to come (Oliver and Winer, 1987). The dynamic of expectations is important to be understood in order to manage the expectations into becoming achievable to obtain a high level of customer satisfaction. When a customer has little prior experience in the service, the expectations are often fuzzy. This means that the customer has a need for change, but cannot state precisely what it is. Further, the customer might not precisely know what type of solution he is looking for or even what problem he has. Therefore, prying out the true issue in these fuzzy expectations is involved. Since the customer will be dissatisfied unless its fuzzy expectations are fulfilled, it is important for the supplier to create a sense of clarity on the issue, even though the customer cannot fulfill his expectations. To get to a successful problem-solving phase, it must, hence, be preceded by a successful problem-formulation stage (Gronroos, 2008). Another important implication is that the company has to manage those expectations appropriately, so that it can match them with its performance (Robledo, 2001). Since expectations are an important aspect of customers´ satisfaction, it is important for suppliers to understand the influence of customer expectations (Coye, 2004). It is further essential for companies to be aware of their influence on customers' expectations and how to manage these influences (Robledo, 2001).

3. Fuzzy Multi-Criteria Decision Making

Multi-Criteria Decision Making (MCDM) techniques are methods that provide the ordering of alternatives and make choices between alternatives by the evaluation of multiple decision criteria (Sengul et al, 2015, 618). A Decision Maker (DM) is required to choose among quantifiable or non-quantifiable options and multiple criteria. The decision maker's evaluations on qualitative criteria are often subjective and imprecise. The objectives are usually conflicting; therefore, the solution is highly dependent upon the preferences of the DM (Hwang and Yoon, 1981). Besides, it is very difficult to develop a selection criterion that can precisely describe the preference of one alternative over another. The evaluation data of subject's alternatives suitability for various subjective criteria and the weights for the criteria are generally expressed in linguistic terms. Some of the studies in this field are as follows. Feizizadeh et al. suggested integrating the Monte Carlo Simulation and Global Sensitivity Analysis with the conventional AHP for analyzing the uncertainty and sensitivity of landslide susceptibility as a function of weights (Feizizadeh et al, 2014). Chakrabortya and Chatterjeeb (2013) solved five material selection problems using three common MCDM techniques (VIKOR, TOPSIS, ELECTRE) to demonstrate the effect of number of criteria on the final rankings of the material alternatives. Dargi et al. (2014) developed a framework to support the supplier selection process in an Iranian automotive industry. They proposed Fuzzy Analytical Network Process (FANP) for weighting the seven measures which were found to be proper for the supplier selection process (Dargi et al, 2014).

3.1. Linguistic variables and fuzzy sets

A linguistic variable is a variable whose values are words or sentences in a natural or artificial language (Zadeh, 1975a). For instance, age is a linguistic variable if its values are assumed to be the fuzzy variables labeled 'not young', 'young', and 'very young' rather than the actual numbers. The concept of a linguistic variable provides a means for the approximate phenomena that are very complex or ill-defined to be amenable to the explanation in conventional quantitative terms. The main applications of the linguistic approach lie outside the realm of human systems, especially in the fields of artificial intelligence, human decision processes, linguistics, pattern recognition, psychology, law, medical diagnosis, data recovery, economics, and related areas (Zadeh, 1975b).

Fuzzy sets and fuzzy logic are powerful mathematical tools for modeling uncertain systems in industry. A fuzzy set is expanded to a crisp set. Crisp set allows only full membership or non-membership, whereas fuzzy sets allow partial membership. A fuzzy number $\widetilde{M}$ is a convex normalised fuzzy set of the real line R (Zimmermann, 1992).

- it exists, such that $x \in R$ with $\mu_{\widetilde{M}}(x) = 1$;
- $\mu_{\widetilde{M}}(x)$ is piecewise continuous.

It is possible to use different fuzzy numbers depending upon the status. In applications, it is often convenient to work with triangular fuzzy numbers due to their computational simplicity, and because they are useful in promoting representation and information processing in a fuzzy environment. Triangular fuzzy numbers (TFNs) can be defined as a triplet (a, b, c), where parameters a, b, c orderly indicate the smallest possible value, the most promising value, and the largest possible value describing a fuzzy event. A triangular fuzzy number $\widetilde{M}$ is shown in Figure 1.

While there are various operations on triangular fuzzy numbers, only the important operations used in this study are shown. If we define two positive triangular fuzzy numbers (a1, b1, c1) and (a2, b2, c2), then

$$(a_1, b_1, c_1) + (a_2, b_2, c_2) = (a_1 + a_2, b_1 + b_2, c_1 + c_2)$$

$$(a_1, b_1, c_1) \times (a_2, b_2, c_2) = (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2)$$

$$(a_1, b_1, c_1) \times k = (a_1 \times k, b_1 \times k, c_1 \times k), \quad \text{where } k > 0.$$

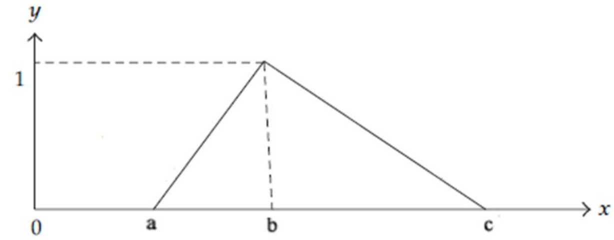

Fig. 1. A TFN $\widetilde{M}$

3.2. The Fuzzy Analytical Network Process (FANP)

The analytic network process (ANP) is a generalization of the analytic hierarchy process (AHP). The AHP was proposed by Saaty in 1980 as a method for solving socioeconomic decision-making problems and was used to solve a wide range of problems. The AHP is a framework of logic and problem-solving that spans the spectrum from instant awareness to fully integrated consciousness by organizing perceptions, feelings, judgments, and memories into a hierarchy of forces, which have influence on decision results. In the AHP approach, the system elements are assumed to be uncorrelated and uni-directionally influenced by a hierarchical relationship (Saaty, 2000).

The AHP approach is one of the MCDM approaches with extensive applications in a wide variety of areas such as selection, evaluation, planning and development, decision-making, forecasting, etc. (Hadi-Vencheh and Mohamadghasemi, 2011). The ANP approach is an extended version of the AHP approach that can be used to assess a dynamic multi-directional relationship between decision attributes (Saaty, 1988; Saaty and Takiawz, 1986). It has been defined as a non-linear network relationship among various factors. It allows for the capability to model more complex and dynamic environments, which are influenced by ever-changing external forces (Meade and Sarkis, 1998). The ANP approach is proposed to overcome the problem of interdependence and feedback between criteria or alternatives. The main difference between AHP and ANP is the ANP's capability of handling interrelationships between decision levels and attributes by obtaining the composite weights through the development of a super matrix (Saaty, 1996; Huang et al., 2005).

Most values of qualitative criteria are not clear, so it is not easy to make decisions with crisp numbers. Fuzzy numbers and linguistic variables support decision-makers to express the subjective judgments. Therefore, the fuzzy ANP approach is thought to be a more suitable approach to obtain realistic results. Some researchers have applied the fuzzy ANP-based approach to solve complex decision-making problems in different areas. A comparison of AHP and ANP methods is presented in Figure 2.

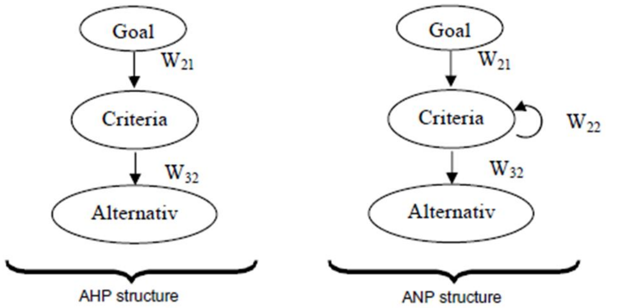

Fig. 2. Comparison of AHP and ANP

The ANP method is based on the same pair-wise comparisons as in the AHP. For pair-wise comparisons, 1–9 scale of Saaty (1980) is used as tabulated in Table 1.

Table 1
Explanation of the pair-wise comparison scale (sevkli et al., 2012)

Intensity of importance definition	Explanation
1 Equal importance	Two activities equally contribute to the object.
3 Moderate importance	Experience and judgment slightly favor one activity over the other.
5 Strong importance	Experience and judgment strongly favor one activity over the other.
7 Very strong importance	An activity is very strongly favored over the other; its dominance is demonstrated in Practice.
9 Extreme importance	The evidence favoring one activity over the other is of the highest possible order of affirmation.
2, 4, 6, 8 For compromise between the above values	Sometimes, one needs to interpolate a compromise judgment numerically because there is no good word to describe it

The ANP method (Saaty, 2001) is comprised of the following four steps:

Step 1: Form the network structure

In the first step, the criteria, the sub-criteria, and the alternatives are identified. Then, the clusters of the elements are determined, and a network is formed based upon the relationship between the clusters and within the elements in each cluster. Several different relationships could be found on a network. Direct relationship is a regular dependency in a standard hierarchy. Indirect relationship is a relationship that flows through other criteria or alternative. The direct relationship between a criterion and itself is characterized by "self-interacting" criteria. Finally, interdependencies are relationships between criteria, which form a mutual effect.

Step 2: Form the pairwise comparison matrices

In the second step, pairwise comparisons are performed on the elements within the clusters as they have influence on each cluster and those that it influences with respect to that criterion. The pairwise comparisons are made with respect to a criterion or sub-criterion of the control hierarchy. Thus, the importance weights for the factors are determined. In a pairwise comparison, decision-makers compare two elements. Then, they determine the contribution to the factors as the result (Saaty, 2001). In ANP, similar to AHP, pairwise comparison matrices are formed using 1–9 scales of relative importance proposed by Saaty (1996). The values of the pair-wise comparisons are assigned to a comparison matrix, and a local priority vector is obtained from the eigenvector which is calculated as follows:

$$Aw=\lambda_{max}\, w \tag{1}$$

In this equation, A, w, and λ_{max} represent the pairwise comparison matrix, the eigenvector, and the eigenvalue, respectively. Saaty and Takizawa (1986) proposed a normalization algorithm for the approximate solution of w (Saaty and Takizawa, 1986). The matrix which shows the comparison between the factors is obtained as follows:

$$A = [a_{ij}]_{n\times n}, \qquad i=\overline{1,n};\ j=\overline{1,n} \tag{2}$$

Step 3: Obtain the priority vector

The significant distribution of the factors as a percentage is obtained as follows:

$$B_i = [bij]_{n\times 1}, \qquad i=\overline{1,n} \tag{3}$$

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{4}$$

$$C = [b_{ij}]_{n\times n}, \qquad i=\overline{1,n};\ j=\overline{1,n} \tag{5}$$

$$w_i = \frac{\sum_{j=1}^{n} c_{ij}}{n} W = [w_i]_{n\times 1} \tag{6}$$

Step 4: Form the super-matrix and limited super-matrix

The overall structure of the super-matrix is similar to the Markov chain process (Saaty, 1996, 2005). To obtain the global priority in a system that has interdependent effects, all local priority vectors are allocated to the relevant columns of the super-matrix. Consequently, the super-matrix is a limited matrix, and every part of it shows the relationship between two elements in the system. The long-term relative impacts of the elements on each other are obtained by raising the super-matrix to a power. To equalize the importance weights, the matrix is raised to (2k + 1)th power, where k is an arbitrary large number (Saaty, 2001). As noted by Lee, Kim, Cho, and Park (2009, p. 897), "Raising the weighted super-matrix to the power 2k + 1, where k is an arbitrarily large number, allowed convergence of the matrix, which means the row values converge to the same value in each column from the matrix."

The new matrix is called the limited Super-matrix (Saaty, 1996). The consistency of the pairwise comparison matrix is checked with the consistency index (CI). For accepted consistency, CI must be smaller than 0.10 (Saaty and Takizawa, 1986).

3.3. The Fuzzy TPOSIS Method

TOPSIS[1] is a linear weighting technique, which was first proposed in its crisp version. Since then, this method has been widely adopted to solve MCDM problems in many different fields (Bottani and Rizzi, 2006). TOPSIS views an MCDM problem with m alternatives as a geometric system and m points in the *n-dimensional* space. This method is based upon the concept that the chosen alternative should have the shortest distance from the positive ideal solution and have the longest distance from the negative ideal solution. TOPSIS defines an index called similarity to the positive ideal solution and the remoteness from the negative ideal solution. Then, the method chooses an alternative with the maximum similarity to the positive ideal solution (Chaghooshi, Fathi and Kashef, 2012). The distances may be either summed up in the Euclidean sense or pondered, hence prioritizing one of the two distances (Bottani and Rizzi, 2006). 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 to the attributes using fuzzy numbers instead of precise numbers (Chaghooshi, Fathi and Kashef, 2012). The concept of Fuzzy TOPSIS mathematics was adapted from Wang and Chang (2007).

Step 1: Determining the weighting of evaluation criteria
Criteria weights are determined by the Fuzzy Analysis Network Process.

Step 2: Constructing the Fuzzy matrix

$$\tilde{D} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \vdots & \tilde{x}_{mn} \end{bmatrix} \end{array}, \ i=1,2,\ldots,m; \ j=1,2,\ldots,n \tag{7}$$

Where $\tilde{x}_{ij}$ is the rating of alternative A_i with respect to criterion C_j evaluated by data from official sites.

Step 3: Normalizing the Fuzzy decision matrix
The normalized Fuzzy decision matrix denoted by $\tilde{R}$ is shown as in the following formula:

$$\tilde{R} = [\tilde{r}_{ij}]_{m\times n}, \ i = 1,2,\ldots,m; \ j = 1,2,\ldots,n \tag{8}$$

Where

$$\tilde{r}_{ij} = \left(\frac{l_{ij}}{c_j^+}, \frac{m_{ij}}{c_j^+}, \frac{u_{ij}}{c_j^+}\right), \ C_j^+ = max_i \, c_{ij} \tag{9}$$

Step 4: Constructing weighted normalized Fuzzy decision matrix
The weighted normalized decision matrix $\tilde{V}$ is defined as:

$$\tilde{V} = [\tilde{v}_{ij}]_{m\times n}, \ i = 1,2,\ldots,m; \ j = 1,2,\ldots,n \tag{10}$$

$$\tilde{v}_{ij} = \tilde{r}_{ij} \otimes \tilde{\mathrm{w}}_{\mathrm{j}} \tag{11}$$

Where $\tilde{\mathrm{w}}_{\mathrm{j}}$ represents the importance weight of criterion C_j.

Step 5: Determining the Fuzzy positive-ideal solution (FPIS) and Fuzzy negative-ideal solution (FNIS)
Because the positive triangular Fuzzy numbers are included in the interval [0, 1], the Fuzzy positive ideal reference point (*FPIS*,A^+) and Fuzzy negative ideal reference point (*FNIS*, A^-), hence can be defined as.

$$A^+ = (\tilde{v}_1^+, \tilde{v}_2^+, \ldots, \tilde{v}_n^+) \tag{12}$$

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \ldots, \tilde{v}_n^-) \tag{13}$$

Where $\tilde{v}_1^+ = (1,1,1,) \ and \ \tilde{v}_1^- = (0,0,0), j = 1,2,\ldots,n.$

Step 6: Calculating the distances of each alternative from FPIS and FNIS
The distances ($d_i^+ \ and \ d_i^-$) of each alternative A^+ from and A^- can be currently calculated by the area compensation method.

$$d_i^+ = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^+), \ i = 1,2,\ldots,m; \ j = 1,2,\ldots,n \tag{14}$$

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-), \ i = 1,2,\ldots,m; \ j = 1,2,\ldots,n \tag{15}$$

Step 7: Obtaining the closeness coefficient and rank the order of alternatives
Once the closeness coefficient is determined, the ranking order of all alternatives can be obtained, allowing the decision-makers to select the most feasible alternative. The closeness coefficient of each alternative is calculated as:

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-}, \ i = 1,2,\ldots,m \tag{16}$$

3.4. The Fuzzy ELECTRE Method

The ELECTRE method originated from Roy in the late 1960s. The ELECTRE method is superior to the study of the relationship on concordance and discordance indices to analyze the outranking relations between the alternatives. Concordance and discordance indicators can be used to measure satisfaction and dissatisfaction that a decision-maker chooses one alternative over another.

Suppose a MCDM problem has m alternatives ($A_1, A_2, \ldots, A_m$), and n decision criteria/attributes ($C_1, C_2, \ldots, C_n$). Each alternative is evaluated with respect to the n criteria. All the values assigned to the alternatives with respect to each criterion form a decision matrix denoted by $X = (x_{ij})_{m\times n}$. Let $W = (w_1, w_2, \ldots, w_n)$ be the relative weight

[1] Technique for Order Preference by Similarity to Ideal Solution

vector about the criteria, satisfying $\sum_{j=1}^{n} w_j = 1$. Then, the ELECTRE method can be summarized as follows (Yoon and Hwang, 1995).

- Normalize the decision matrix $X = (x_{ij})_{m\times n}$ by calculating r_{ij}, which represents the normalized criteria/attribute value/rating,

$$r_{ij} = \frac{1/x_{ij}}{\sqrt{\sum_{i=1}^{m} 1/x_{ij}^2}} \text{ for the minimisation objective, where } i = 1,2,\ldots,m \text{ and } j = 1,2,\ldots,n, \tag{17}$$

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \text{ for the maximisation objective, where } i = 1,2,\ldots,m \text{ and } j = 1,2,\ldots,n \tag{18}$$

- Calculate the weighted normalized decision matrix $V = (v_{ij})_{m\times n}$

$$v_{ij} = r_{ij} \cdot w_j, \text{ where } i = 1,2,\ldots,m \text{ and } j = 1,2,\ldots,n, \tag{19}$$

Where w_j is the relative weight of the jth criterion or attribute and $\sum_{j=1}^{n} w_j = 1$.

- Determine the concordance and discordance sets. For each pair of alternatives A_p and A_q *(p, q =1, 2, . . . ,m and p ≠ q)*, the set of criteria is divided into two distinct subsets. If alternative A_p is preferred to alternative A_q for all criteria, the concordance set is composed. This can be written as:

$$C(p,q) = \{j | v_{pj} > v_{qj}\}, \tag{20}$$

Where v_{pj} is the weighted normalized rating of alternative A_p with respect to the jth criterion. In other words, *C(p, q)* is the collection of attributes where A_p is better than or equal to A_q. The complement of *C(p, q)*, the discordance set, contains all criteria for which A_p is worse than A_q. This can be written as:

$$D(p,q) = \{j | v_{pj} < v_{qj}\}, \tag{21}$$

- Calculate the concordance and discordance indices. The concordance index of *C(p, q)* is defined as:

$$C_{pq} = \sum_{j^*} w_{j^*}, \tag{22}$$

where j^* is attributes contained in the concordance set *C(p, q)*. The discordance index *D(p, q)* represents the degree of disagreement in ($A_p \rightarrow A_q$) and can be defined as:

$$D_{pq} = \frac{\sum_{j^+} |v_{pj^+} - v_{qj^+}|}{\sum_{j} |v_{pj} - v_{qj}|}, \tag{23}$$

Where j^+ is attributes contained in the discordance set *D(p, q)*, and v_{ij} is the weighted normalized evaluation of alternatives i on criterion j.

- Outranking relationship. The method defines that A_p outranks A_q when $C_{pq} \geq \bar{C}$ and $D_{pq} \leq \bar{D}$, where $\bar{C}$ and $\bar{D}$ are the averages of C_{pq} and D_{pq}, respectively.

The basic steps of the fuzzy ELECTRE method proposed by Sevkli (2010) can be described as follows.

Step 1: In the first step, a panel of decision-makers (DMs), who are knowledgeable concerning the municipality's zones selection process, is established. The group has K decision-maker (i.e. $D_1, D_2, \ldots, D_k$) who are responsible for the ranking (y_{jk}) of each criterion (i.e. $C_1, C_2, \ldots, C_n$) in increasing order. Then, the aggregated fuzzy importance weight for each criterion can be described as fuzzy triangular numbers $\tilde{w}_j = (a_j, b_j, c_j)$ for k = *1, 2, . . . ,K* and j = *1, 2, . . . , n*. The aggregated fuzzy importance weight can be determined as follows:

$$a_j = \min_k\{y_{jk}\}, \quad b_j = \frac{1}{K}\sum_{k=1}^{K} y_{jk}, \quad c_j = \max_k\{y_{jk}\} \tag{24}$$

Then, the aggregated fuzzy importance weight for each criterion is normalized as follows:

$$\tilde{w}_j = (w_{j1}, w_{j2}, w_{j3}),$$

Where

$$w_{j1} = \frac{1/a_j}{\sum_{j=1}^{n} a_j}, \quad w_{j2} = \frac{1/b_j}{\sum_{j=1}^{n} b_j}, \quad w_{j3} = \frac{1/c_j}{\sum_{j=1}^{n} c_j} \tag{25}$$

Then, the normalized aggregated fuzzy importance weight matrix is constructed as $\tilde{W} = [\tilde{w}_1, \tilde{w}_2, \ldots, \tilde{w}_n]$.

Step 2: A decision matrix is formed:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{26}$$

Step 3: After forming the decision matrix, normalization is applied. The calculation is performed using formulas (17) and (18). Then, the normalized decision matrix is obtained as below:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{27}$$

Step 4: Considering the different weights of each criterion, the weighted normalized decision matrix is computed by multiplying the importance weight of the evaluation criteria and the values in the normalized decision matrix. The weighted normalized decision matrix $\tilde{V}$ for each criterion is defined as below:

$$\tilde{V} = (\tilde{v}_{ij})_{m\times n} \text{ for } i = 1,2,\ldots,m \text{ and } j = 1,2,\ldots,n,$$
$$\text{where } \tilde{v}_{ij} = r_{ij} \times \tilde{w}_j,$$

and

$$V^1 = \begin{bmatrix} v_{11}^1 & v_{12}^1 & \cdots & v_{1n}^1 \\ v_{21}^1 & v_{22}^1 & \cdots & v_{2n}^1 \\ \cdots & \cdots & \cdots & \cdots \\ v_{m1}^1 & v_{m2}^1 & \cdots & v_{mn}^1 \end{bmatrix}, \quad V^2 = \begin{bmatrix} v_{11}^2 & v_{12}^2 & \cdots & v_{1n}^2 \\ v_{21}^2 & v_{22}^2 & \cdots & v_{2n}^2 \\ \cdots & \cdots & \cdots & \cdots \\ v_{m1}^2 & v_{m2}^2 & \cdots & v_{mn}^2 \end{bmatrix}, \quad V^3 = \begin{bmatrix} v_{11}^3 & v_{12}^3 & \cdots & v_{1n}^3 \\ v_{21}^3 & v_{22}^3 & \cdots & v_{2n}^3 \\ \cdots & \cdots & \cdots & \cdots \\ v_{m1}^3 & v_{m2}^3 & \cdots & v_{mn}^3 \end{bmatrix} \tag{28}$$

Here, $\tilde{v}_{ij}$ denotes normalized positive triangular fuzzy numbers.

Step 5: The concordance and discordance indices are calculated for different weights of each criterion (w_{j1}, w_{j2}, w_{j3}). The concordance index C_{pq} represents the degree of confidence in pairwise judgments ($A_p \rightarrow A_q$). The concordance index C_{pq} for the proposed model is defined as:

$$C^1_{pq} = \sum_{j^*} w_{j1},\ \ C^2_{pq} = \sum_{j^*} w_{j2},\ \ C^3_{pq} = \sum_{j^*} w_{j3} \qquad (29)$$

Where j^* is the attributes contained in the concordance set $C(p, q)$.

Step 6: The discordance index, on the other hand, measures the power of $D(p, q)$. The discordance index $D(p, q)$, which represents the degree of disagreement in ($A_p \rightarrow A_q$), can be defined as:

$$D^1_{pq} = \frac{\sum_{j^+}\left|v^1_{pj^+} - v^1_{qj^+}\right|}{\sum_j \left|v^1_{pj} - v^1_{qj}\right|},\ D^2_{pq} = \frac{\sum_{j^+}\left|v^2_{pj^+} - v^2_{qj^+}\right|}{\sum_j \left|v^2_{pj} - v^2_{qj}\right|},\ D^3_{pq} = \frac{\sum_{j^+}\left|v^3_{pj^+} - v^3_{qj^+}\right|}{\sum_j \left|v^3_{pj} - v^3_{qj}\right|} \qquad (30)$$

Where j^+ is the attributes contained in the discordance set $D(p, q)$, and v_{ij} is the weighted normalized evaluation of alternative i on criterion j.

Step 7: The final concordance and discordance indices are computed using the following formula:

$$C^*_{pq} = \sqrt[z]{\prod_{z=1}^{Z} C^z_{pq}},\ \ D^*_{pq} = \sqrt[z]{\prod_{z=1}^{Z} D^z_{pq}},\ \ \text{where } Z = 3 \qquad (31)$$

This formula can be considered as the defuzzification procedure. The dominant relationship of alternative A_p over alternative A_q becomes stronger with a larger final concordance index C_{pq} and a smaller final discordance index D_{pq}. The outranking relation is obtained by applying the following equation procedure to obtain the kernel, which is the subset of the best alternatives:

$$\text{if } C(p,q) \geq \bar{C} \ and\ D(p,q) \leq \bar{D} \qquad (32)$$

where $\bar{C}$ and $\bar{D}$ are the averages of C_{pq} and D_{pq}, respectively.

The general steps of the fuzzy ELECTRE approach are summarized in Figure 3.

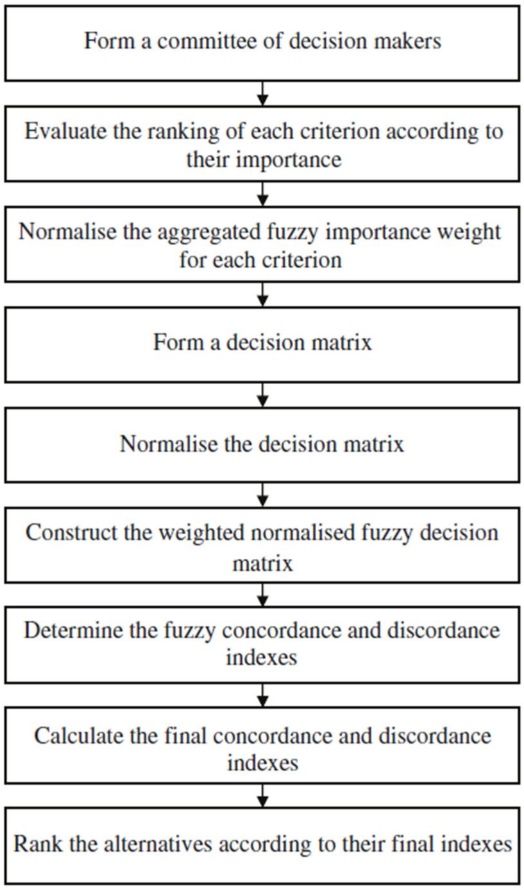

Fig. 3. The steps of the fuzzy ELECTRE method

4. Proposed Method

The research method used in this study is of descriptive and applied types with regard to the subject of study. The independent variables in this study are the five dimensions of the customer's expectation and satisfaction and the dependent variable in the Zanjan municipality zones. Application data are collected via questionnaire and face-to-face interviews conducted on 303 customers and 30 engineering contractors of the municipality, who are active in the self-assessment. Of the 303 total number of respondents (customers), 265 (87.5%) were male and 38 (12.5%) were female customers. The majority of the respondents were between 25-34 (37.6%) years old. In addition, the majority (75.4%) of the respondents had university degree, which we believe is another important characteristic of the customer group who can make reasonable evaluations of expectation and satisfaction questions in the survey. Of the 30 engineering contractors (experts), 17 (56.7%) were male and 13 (43.3%) were female experts. All of the respondents had university degree. The study sampling is of selective and non-probability type. As the sample size is equal to the population size, the former in this study includes 30 people in the statistical population. Test period to collect data and to obtain an acceptable sample is 2014. The spatial scope of the study is limited to Municipality. There are three questionnaires that are the result of information obtained from the list of municipality zones of customer expectations for prioritization and optimal selection. The dimensions of the customer's expectation are used as criteria of the model. Fuzzy ANP and fuzzy TOPSIS methods are used for the design. The questionnaires were completed by using the table of linguistic variables. The validation is confirmed scientifically and by experts (97%), managers, and company engineers (98%). After that, calculation of Cronbach's alpha indicates the model validity that is equal to 0.9, which is higher than the index value of 0.70. The data analysis is based on the integrated model. Expert Choice software, Excel, and SPSS statistical package were used for the calculation and analysis of data.

5. Proposed Model

In this section, we demonstrate the application of this model by numerical example. Through investigating the literature and studying other papers related to customer expectation, five criteria are finally selected. These criteria include physical dimensions and amenities (C1), Legitimation (C2), Responsibility (C3), Warranty and Guarantee (C4), and Service quality and perceived value (C5). In addition, there are three alternatives including A1 (Municipal District 1), A2 (Municipal District 2), and A3 (Municipal District 3).

The proposed model for selecting the best regional municipality is composed of Fuzzy ANP, Fuzzy TOPSIS, and Fuzzy ELECTRE methods (figure 4). This model consists of four basic stages:

- Identifying criteria to use in the model.
- Fuzzy ANP- the weights of each criterion are calculated using Fuzzy Analysis Network Process.
- Fuzzy TOPSIS-Fuzzy TOPSIS is utilized to rank the alternatives (municipality zones).
- Fuzzy ELECTRE-Fuzzy ELECTRE is utilized to select the best municipality zone based on meet customer expectations.

5.1. Fuzzy ANP

In fuzzy ANP, the weights of the criteria can be calculated. In the next step, these weights are used for Fuzzy TOPSIS and Fuzzy ELECTRE calculation for the final evaluation. Figure 5 identifies the dimension and criteria that were found influential in the model. The pair-wise comparison matrix of criteria for ANP can be seen in Table 2.

5.2. Fuzzy TOPSIS

The weights of the criteria have been calculated by fuzzy ANP up to now, and then these values can be used in fuzzy TOPSIS. Thus, decision matrix can be prepared. Decision matrix can be seen from Table 4.

By following fuzzy TOPSIS procedure steps and calculations, the rankings of municipality zones are gained. The results and final rankings are shown in Table 6.

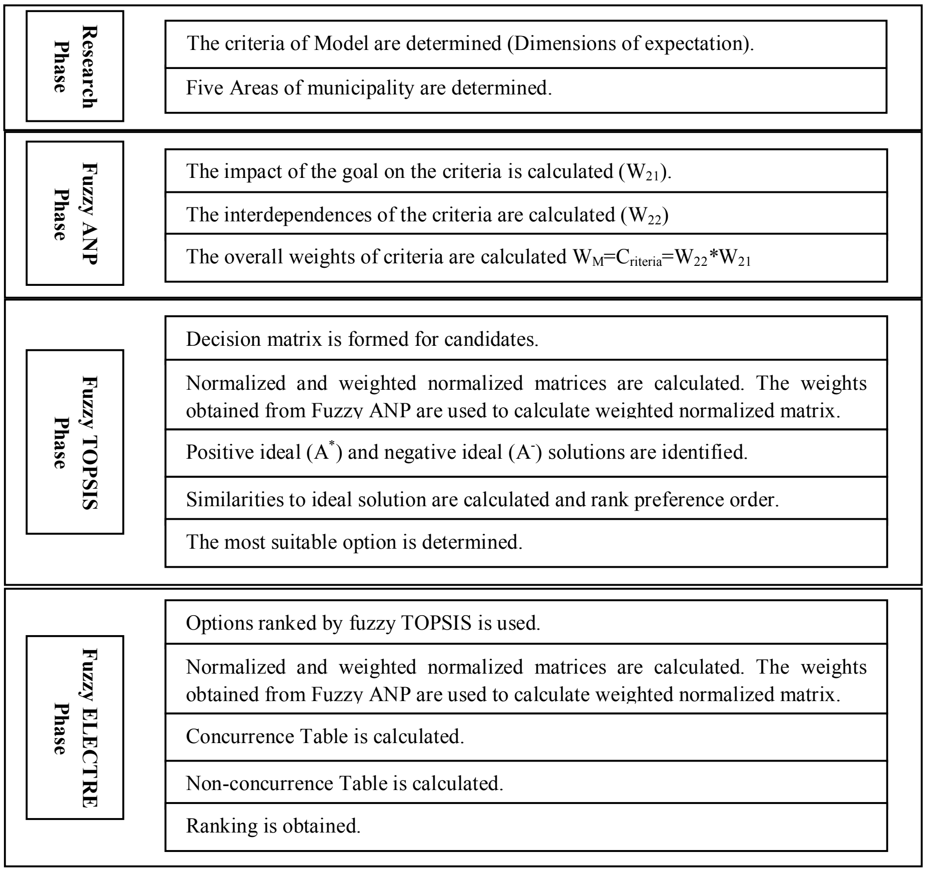

Fig. 4. The proposed Hybrid Model

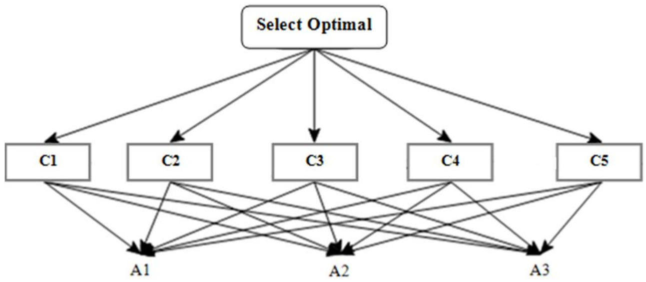

Fig. 5. Network structure of the evaluation framework

Table 2
The pairwise comparison matrix of criteria

criteria	C1	C2	C3	C4	C5
C1	(1,1,1)	(0.917,1.007,1.223)	(1.007,1.155,1.333)	(1.098,1.26,1.481)	(0.944,1.112,1.344)
C2	(0.818,0.993,1.09)	(1,1,1)	(0.752,0.805,0.992)	(0.824, 0.93, 1.126)	(1.012,1.144,1.359)
C3	(0.75,0.866,0.993)	(1.008,1.243,1.33)	(1,1,1)	(1.114,1.273,1.437)	(1.151,1.348,1.514)
C4	(0.675,0.794,0.911)	(0.888,1.076,1.214)	(0.696,0.785,0.898)	(1,1,1)	(1.011,1.097,1.282)
C5	(0.744,0.899,4.06)	(0.736,0.874,0.988)	(0.661,0.742,0.869)	(0.78,0.912,0.989)	(1,1,1)

Table 3
The weights of the criteria (Result of Fuzzy ANP)

criteria	Fuzzy weights	weights
C1	(0.197, 0.22,0.252)	0.221
C2	(0.174,0.193,0.22)	0.194
C3	(0.198,0.225,0.246)	0.224
C4	(0.168,0.187,0.209)	0.188
C5	(0.155,0.175,0.195)	0.175

Table 4
Fuzzy Decision Matrix

	C1	C2	C3	C4	C5
A1	(3.933,4.867,5.8)	(3.2,4.067,4.933)	(3.067,3.933,4.8)	(3.133,4.067,4.933)	(2.2,2.867,3.533)
A2	(3.8,4.733,5.667)	(3.333,4.2,5.067)	(3.067,3.933,4.8)	(3.667,4.6,5.467)	(2.267,3,3.733)
A3	(2.467,3.267,4.067)	(2.733,3.533,4.333)	(2.667,3.533,4.4)	(2.333,3.133,3.933)	(1.933,2.6,3.267)

Table 5
The Normalized Decision Matrix

	C1	C2	C3	C4	C5
A1	(0.15,0.185,0.155)	(0.123,0.156,0.189)	(0.143,0.184,0.224)	(0.108,0.14,0.17)	(0.103,0.134,0.166)
A2	(0.145,0.18,0.216)	(0.128,0.161,0.194)	(0.143,0.184,0.224)	(0.126,0.158,0.188)	(0.106,0.141,0.175)
A3	(0.094,0.124,0.155)	(0.105,0.135,0.166)	(0.124,0.165,0.205)	(0.08,0.108,0.135)	(0.091,0.122,0.153)

Table 6
Final Results of the Fuzzy TOPSIS method

	d^+	d^-	CC	Rank
A1	4.204	0.81	0.162	2
A2	4.18	0.835	0.167	1
A3	4.348	0.667	0.133	3

The fuzzy TOPSIS results are shown in Table 6. The evaluation of municipality zones is realized, and according to the CC_i values, the rankings of municipality zones are A2 – A1 – A3 from the most preferable to the least. If the best one is needed to be selected, then the alternative A2 must be chosen.

5.3. Fuzzy ELECTRE

The weights of the criteria and alternatives have been calculated by fuzzy ANP and fuzzy TOPSIS up to now, and then these values can be used in fuzzy ELECTRE.

Thus, Stage of Concordance and discordance sets can be prepared. This stage can be seen from Table 7.
The fuzzy ELECTRE results are shown in Table 8. After that, we ranked municipality zones based on fuzzy ELECTRE procedure. The results of Fuzzy TOPSIS and Fuzzy ELECTRE are shown in Table 9. According to Fuzzy ELECTRE method, A2 is the best alternative that should be chosen.

Table 7
Stage of Concordance and discordance sets

	C_{jk}			D_{jk}		
	L	M	U	L	M	U
A1-A2	0.293	0.369	0.445	0.383	0.353	0.310
A1-A3	0.698	0.835	0.970	0.000	0.000	0.000
A2-A1	0.503	0.644	0.781	0.128	0.116	0.102
A2-A3	0.648	0.824	0.997	0.000	0.000	0.000
A3-A1	0.000	0.000	0.000	0.273	1.070	0.943
A3-A2	0.000	0.000	0.000	1.159	0.982	0.871

Table 8
Final Results of the Fuzzy ELECTRE method

Alternative	Rank
A1	2
A2	1
A3	3

Table 9
Ranked by Fuzzy TOPSIS and Fuzzy ELECTRE Methods

	Ranking of FTOPSIS	Ranking of FELECTRE
A1	2	2
A2	1	1
A3	3	3

6. Conclusions

In this paper, five dimensions of customer expectations are weighted to show the effect of the weight of criteria on the ranking performance of municipality zones by ANP, TOPSIS, and ELECTRE methods. The determinations of the criteria weights and evaluation of the expectation dimensions are not easy tasks. Therefore, the concept of fuzziness supports decision-makers to make more flexible decisions in uncertain environments. It is interesting to note that the choice of the best zone solely depends on the most important criterion having the maximum priority weight. It can be claimed that the designers may now need not to construct the exhaustive zone selection decision matrices and may only stress on identifying the most important criterion, dictating the entire selection process. Here, the methodology by which the criteria weights are determined may also play an important role. This mathematical approach will substantially reduce the complexity involved in the decision-making process, as the best municipality zone may now be chosen based on a single criterion. The validation of the interesting finding of this paper for other decision-making problems may be a future scope to be investigated by the researchers.

In this study, three types of fuzzy multi-criteria decision-making method (i.e., Fuzzy ANP and Fuzzy TOPSIS, and Fuzzy ELECTRE) are used in the proposed model (Figure 4). According to the research processes, the Fuzzy ANP method is used to weight the criteria of the model (Table 3). The Fuzzy TOPSIS method is used to prioritize and select among 3 municipality zones (Table 6). Finally, “Municipal District 2” in responsibility towards customers has the highest priority by using the Fuzzy ELECTRE method (Table 8).

This model has a systematic fit with the defined procedures and known inputs. The criteria, which have been used as a basis to evaluate municipality zones in this model, were extracted from the exploratory factor analysis that has high integration with the decision maker. In this model, the calculation can be easily performed by software such as Expert Choice, Web-Based TOPSIS, EXCEL, and SPSS. In the group decision-making, this model is preferred to other fuzzy models such as fuzzy AHP. Since the weights of criteria are calculated from the experts’ opinions, the weights obtained are more realistic and more acceptable to decision-makers. In addition, since these weights are not fixed and may vary from one organization to another, the calculation method is of higher validity.

References

Bottani, E., & Rizzi, A. (2006). A Fuzzy TOPSIS methodology to support outsourcing of logistics services. *Supply Chain Management*, 11(4), 294-308.

Chaghooshi, A. J., Fathi, M. R., & Kashef, M. (2012). Integration of Fuzzy Shannon's entropy with Fuzzy TOPSIS for industrial robotic system selection. *J Ind Eng Manag*, 5(1), 102-114.

Chakrabortya, S. & Chatterjee, P. (2013). Selection of materials using multi-criteria decision-making methods with minimum data. *Decision Science Letters*, 2, 135–148.

Chou, C. C. (2010). Application of FMCDM model to selecting the hub location in the marine transportation: A case study in southeastern Asia. *Mathematical and Computer Modeling, 51*, 791-801.

Coye, R. W. (2004). Managing customer expectations in the service encounter. *International Journal of Services Industry Management*, 15(1), 54–71.

Dargia, A., Anjomshoaea, A., Rahiminezhad Galankashia, M., Memaria, A., & Binti Md. Tap, M. (2014). Supplier Selection: A Fuzzy-ANP Approach. *Procedia Computer Science*, 31, 691-700.

Feizizadeh, B., Jankowski, P., & Blaschke, T. (2014). A GIS based spatially-explicit sensitivity and uncertainty analysis approach for multi-criteria decision analysis. *Comput Geosci*, 64, 81-95.

Gr◌onroos, C. (2008). Service Management och marknadsf◌oring: Kundorienterat ledarskap I servicekonkurrensen, 2. ed. Malmo◌: Lider.

Hadi-Vencheh, A., Mohamadghasemi, A. (2011). A fuzzy AHP-DEA approach for multiple criteria ABC inventory classification. *Expert Systems with Applications*, 38, 3346–3352.

Huang, J.J., Tzeng, G.H. & Ong, C.S. (2005). Multidimensional data in multidimensional scaling using the analytic network process. *Pattern Recognition Letters*, 26, 755–767.

Hwang, C.L., Yoon, K. (1981). Multiple Attributes Decision Making Methods and Applications. Berlin Heidelberg: Springer.

Lee, H., Kim, C., Cho, H., & Park, Y. (2009). An ANP-based technology network for identification of core technologies: A case of telecommunication technologies. *Expert Systems with Applications*, 36(1), 894–908.

Meade, L., Sarkis, J. (1998). Strategic analysis of logistics and supply chain management systems using the analytical network process. *Transportation Research Part E: Logistics and Transportation Review*, 34(3), 201–215.

Oliver, R.L. & Winer, R.S. (1987). A Framework for the formation and structure of consumer expectations: review and propositions. *Journal of economic psychology,* 8(4), 469-499.

Ojasalo, J. (2001). Managing customer expectations in professional services. *Managing Service Quality,*11(3), 200-212.

Parasuraman, A., Berry, L. L., & Zeithaml, V. A. (1991). Understanding customer expectations of service. *Sloan Management Review*, 32(3), 39–48.

Robledo, M.A. (2001). Measuring and managing service quality: integrating customer expectations. *Managing service quality,* 11(1), 22-31.

Saaty, T. L. (1980). The Analytic Hierarchy Process. New York: McGraw-Hill.

Saaty, T.L. (1988). *Decision Making: The Analytic Hierarchy Process*. RWS Publication, Pittsburg.

Saaty, T.L. (1996). *Decision Making with Dependence and Feedback: The Analytic Network Process*. Pittsburg: RWS Publications.

Saaty, T.L. (2000). *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process*. RWS Publications, USA.

Saaty, T.L.& Takizawa, M. (1986). Dependence and independence from linear hierarchies to nonlinear networks. *European Journal of Operational Research*, 26 (2), 229–237.

Saaty, T. L. (2001). Decision making with dependence and feedback (2nd Edition). Pittsburg: RWS Publication.

Saaty, T. L. (2005). Theory and applications of the analytic network process: Decision making with benefits, opportunities, costs, and risks. Pittsburg: RWS Publications.

Sengul, U., Eren, M., Eslamian Shiraz, S. H., Gezder, V. & Sengül. A. B. (2015). Fuzzy TOPSIS method for anking renewable energy supply systems in Turkey. *Renewable Energy*, 75, 617-625.

Sevkli, M. (2010). An appliction of fuzzy ELECTRE method for supplier selection. *Internetional Journal of production Research, 48(12)*, 3393-3405.

Sevkli, M., Oztekin, A., Uysal, O., Torlak, G., Turkyilmaz, A., & Delen, D. (2012). Development of a fuzzy ANP based SWOT analysis for the airline industry in Turkey. *Expert Systems with Applications,* 39(1):14-24.

Shih, H. S. (2008). Decision Support Incremental analysis for MCDM with an application to group TOPSIS. *European Journal of Operational Research, 186*, 720–734. http://dx.doi.org/10.1016/j.ejor.2007.02.012

Wang T.C. & Chang T.H. (2007). Application of TOPSIS in evaluating initial training aircraft under a Fuzzy environment. *Expert Systems with Applications*, 33, 870-880.

Wu, W. W. (2008). Choosing knowledge management strategies by using a combined ANP and DEMATEL approach. *Expert Systems with Applications, 35*(3), 828–835. http://dx.doi.org/10.1016/j.eswa.2007.07.025

Yoon, K.P. & Hwang, C.L. (1995). Multiple attribute decision making an introduction. Sage University Paper.

Zadeh, L.A. (1975a). The concepts of a linguistic variable and its applications to approximate reasoning (I). *Information Science*, 8(3), 199-249.

Zadeh, L.A., (1975b). The concepts of a linguistic variable and its applications to approximate reasoning (II). *Information Science*, 8(4), 301-357.

Zimmermann, H.J. (1992). Fuzzy set theory and its applications. Kluwer: Boston.

This article can be cited: Barghi Jond, H., Nabiyev, V. & Benveniste, R (2017). Analysis of Customer's Expectations and Satisfaction in Zanjan Municipality Using Fuzzy Multi-Criteria Decision Making (FMCDM) Approach. *Journal of Optimization in Industrial Engineering.*10(21), 47-57

URL: http://qjie.ir/article_260_37.html