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Ranking and Investigation of Voice of Customer Index by Applying AHP Method in Local Management of Tehran Metropolis

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Abstract

Strategic look is a necessity rather than a choice in management. Knowledge, deep thinking, all over view, realistic look and mature management all are necessary for such a look. By achieving modern methods, custom oriented organizations and institutes permanently try to find solutions so that by using those solutions they can attract more customs, therefore they declare their decisions to senior authorities regarding their profits and attitudes. Future belongs to organizations that coordinate with new realities and its necessities.

By achieving modern methods, customer-oriented organizations and institutes are constantly trying to search for other solutions to inspire more customers so that based on their interests and attitudes, they voice their opinion to the superiors of the organization. Numerous researches all indicate that customers can change the production line. Therefore, organizations and large companies consider "voice of customer" more than before. They are constantly ready to meet customers' demands. In this paper, we study the voice of customer in the municipilties of Tehran. Fuzzy multiple criteria decision making (FMCDM) is one of the suitable models of ranking the key criteria of the voice of customer. In fuzzy analytic hierarchical process (Fuzzy AHP) and Fuzzy decision making trial and evaluation laboratory (Fuzzy DEMATAL), we ranked the key criteria of the voice of customer in Iran Telecommunications Manufacturing Companies (ITMC). In methodological and theoretical view, this research had done based on structuralism and historical-creating analysis in macro and guideline levels. This research had done in library- documentary method and qualitative analysis in several ways and its goal is achieving to optimum methodology.

Keywords: fuzzy DEMATEL, fuzzy AHP, FMCDM, voice of customer

1. Introduction

Many different theories and methods of performance for conducting an evaluation have been applied in various organizations for many years. These approaches include ratio analysis, total production analysis, regression analysis, Delphi analysis, balanced scorecard, analytic hierarchical process (AHP), data envelopment analysis (DEA), decision making trial and evaluation laboratory (DEMATEL), fuzzy AHP(FAHP), fuzzy DEMATEL, etc. Each method has its own basic concept, aim, advantages and disadvantages. Which one to choose for assessing performance depends on the status and type of the organizations? However, all successful enterprises have some common features including a specific vision, positive actions, and effective performance evaluation (Wu et al., 2009).

Decision makers always like to know which option is the best of all alternatives. In the category of cardinal information on the criteria or attribute of multiple criteria decision making (MCDM) methods, alternatives are ranked by their cardinal values of performance (Shih, 2008; Chou, 2010). Although, there are different definitions for MCDM in literature, regardless of the type of MCDM task, two pivotal problems arise; how to compare an alternative? And how to evaluate them? First problem is especially important if the results of evaluations of alternatives are presented by interval or fuzzy numbers (Sevastjanov and Figat, 2007).

Decision making is the most important and popular aspect of application of mathematical methods in various fields of human activities. In real world situations, decisions are nearly always made on the basis of information that is at least partially fuzzy in nature (Vasant et al., 2007). Also Decision making is the process of defining the decision goals, gathering relevant criteria and possible alternatives, evaluating the alternatives for advantages and disadvantages and selecting the optimal alternatives (Wu, 2008).

However, in the real life, the available information in a MCDM process is usually uncertain, vague, or imprecise, and the criteria are not necessarily independent. To tackle the vagueness in information and the essential fuzziness of human judgment or preference, fuzzy set theory was proposed by Zadeh in 1965 and a decision making method in a fuzzy environment was developed by Bellman and Zadeh (Yang et al., 2008; Kahraman, 2007). Fuzzy set theory was developed exactly based on the premise that the key elements in human thought are not numbers, but linguistic terms or labels of fuzzy sets. A fuzzy decision making method under multiple criteria consideration is needed to integrate various linguistic assessments and weights to evaluate location situation and determine the best selection (Chou, 2007).

MCDM may be considered as a complex and dynamic process including one managerial level and one engineering level. The managerial level defines the goals, and chooses the final "optimal" alternative. The multi criteria nature of decisions is emphasized at this managerial level, at which public officials called ‘‘decision makers’’ have the power to accept or reject the solution proposed by the engineering level (Opricovic and Tzeng, 2004).

The DEMATEL technique was used to investigate and work on the complicated problem group. DEMATEL was developed on the belief that pioneering and proper use of scientific research methods could ameliorate comprehension of the specific problematic, the cluster of intertwined problems, and contribute to recognition of practical solutions by hierarchical structure. DEMATEL has been successfully applied in many situations, such as marketing strategies, e-learning evaluation, control systems and safety problems (Chen, 2009). Fuzzy DEMATEL method is used for solving and modeling some of the complex group of decision-making problems such as strategic planning, e-learning evaluation and decision making in RandD projects (Coussement and Poel, 2008).

1.1 Voice of Customers

Richins (1997) and Smith and Bolton (2002) emphasize that emotions differ when the context change; buying a pair of shoes may not generally raise the same kind of motions as do consumption where the amount of the monetary exchange is more considerable and maybe includes risk (Roos et al., 2009).

In systems of the real world, environmental planning and investment in sustainable development industries may essentially be conflicts analyses characterized by sociopolitical, environmental and economic value judgments. Several strategies should be considered and evaluated in terms of many different criteria, resulting in a vast body of data that are often inaccurate or uncertain. However, in many areas such as manufacturing, engineering, medicine, meteorology and human judgment, evaluation and decisions often employ natural language to express thinking and subjective preferences, but when using the word as a label for a set, the boundaries within which objects do or do not belong to the set become fuzzy or vague (Chiou, 2005).

It is now a leading firm strategy to develop a model from customer expectation. The service quality affects all leisure firm service activities. The performances are usually with multiple criteria for many customers' expectations to judge by the best service quality performance. Improving service quality, increasing assessment and reliability occurs while competition ever increases and tries to retain customers. Service quality conditions might influence a firm's competitive advantage by retaining customer patronage and with this comes market share, and ultimate profitability. Service quality has developed for several years. Service quality is measured to assess service performance, diagnose service problems, and manage service delivery. The criteria used for evaluation of service quality effectiveness are numerous and influence one another (Bell et al., 2005; Lin et al., 2009).

In the past, companies focused on selling services and products with little knowledge or strategy concerning the customers who bought the products. Today business is evolving from this "product-centered" to a "customer-centered" environment. Companies need to find ways to capture and enhance market share while reducing costs. Consequently, existing companies must reconsider the business relationships with their customers (Coussement and Poel, 2008b). Customer loyalty is defined as a consumer's intent to stay with an organization (Bell et al., 2005). Since public services are not perceptible, fewer customers can directly evaluate services by comparing the quality of physical products (David et al., 2006). Customers and consumers constantly search for suppliers who provide much better goods and services for them. There are a lot of evidence and documents indicating that in today's competitive world, discovering needs of customers and meeting their demands before competitors is the basic term for enterprises to succeed. Thus, organizations and businesses are to trying to achieve superior situation in comparison with other competitors by obtaining exclusive advantages. One of the most popular approaches to determine the quantity of meeting needs and demands by means of goods and services offered by organizations is assessment of customer's consent.

In customer-oriented organizations usually the customers are the most fundamental means to identify weak and strong points of organizations. During their relations, they can actually advise you to choose the method of communication with customer, production and design of services. The organization can achieve strategies for new services by surveying its customers and analyzing their needs and find out its weak points of the current services. Some authors believe that customers create different levels of making profits and all customers do not create desired income for companies. Therefore, companies have been recommended to develop their relations with beneficial customers and cut relations with non-beneficial customers (Vukmir, 2006).

Based on a study and an interview with some customers, researches could reach at important facts that determine satisfaction of customers with products and services of a company. Generally, the facts include:

1) Stability of provider
2) Following schedule of goods delivery
3) Technical particulars of products
4) Competitive prices
5) Credit policy of the company
6) Warranty and guarantee

And such items can put an effect on satisfactions with providers (Chakraborty et al., 2007).

Internet enables customers to easily express their problems with a product or a service. Consequently, customer complaint management and service recovery are going to become key drivers for improved customer relationships (Coussement and Poel, 2008a). Further studied customer involvement in new product development, especially in the early stage of product conceptualization plays an important role for a successful product (Chen and Yan, 2008). It is well recognized that voice of customer boasts numerous benefits for organizations. They include customer loyalty increases in satisfaction and product evaluation mutual agreeable problem solving improved offerings and prevention of future problems the opportunity to redress the problem customer ‘‘venting’’ to the organization, rather than to others and reduced likelihood of other negative consumer behaviors such as exit and/or negative word-of-mouth (Bove and Robertson, 2005).

Successful companies have to pursue customer-centric strategies in order to sustain a competitive advantage. Voice of customer (VOC) analysis can play an important role in understanding customer requirements in a new product or service development. Moreover, it can provide value to customers and it can leave the customer with a favorable impression. The VOC analysis system can help determine what customers need and predict what they will need in the future. In turn, this can assist in the development of appropriate corporate strategies to meet the needs (Bae et al., 2005). However, different customers or experts have different attitudes toward the same requirement. To cope with this situation proposed to use a group decision-making technique to obtain the importance weights for customer requirements. Then, AHP or DEMATEL are proposed to be used in rating customer requirements analyzed the sensitivity of the voice of customer in QFD (Quality Function Deployment) (Lai et al., 2008).

1.2 Fuzzy Multiple Criteria Decision Making (Fmcdm) and Fuzzy Decision Making Trial and Evaluation Laboratory (Dematel)

Human lives are the sum of their decisions-whether in business or in personal spheres. In daily lives, people often have to make decisions. “When decision is made” is as important as “what is decided”. Everyday life and history are full of lessons that can help people recognize the critical moment. People learn by attempts and by examples. Deciding too quickly can be hazardous; delaying too long can mean missed opportunities. What people need is a systematic and comprehensive approach to decision making (Özdağoğlu and Özdağoğlu, 2007).

Fuzzy set theory introduced by Zadeh was developed for solving problems in which descriptions of activities, observations and judgments are subjective, vague and imprecise (Liu, 2009). Since Bellman and Zadeh (1970) developed the theory of decision behavior in a fuzzy environment, various relevant models were developed and they have been applied to different fields such as control engineering, artificial intelligence, management science and MCDM among others. The concept of combining the fuzzy theory and MCDM is referred to as fuzzy MCDM (FMCDM) (Hung et al., 2010; Shieh et al., 2010).

A FMCDM model is used to assess alternatives versus selected criteria through a committee of decision makers, where suitability of alternatives versus criteria and the importance weights of criteria, can be evaluated in linguistic values represented by fuzzy numbers. Numerous approaches have been proposed to solve fuzzy MCDM problems (Chua and Lin, 2009). Although, the problem of obtaining well-defined criteria for a MCDM problem is well-known for more general results, it is often neglected in MCDM theory, methods, and applications (Gal and Hanne, 2006; Keskin et al., 2010; Yu and Hu, 2010).

Fuzzy set theory is very helpful to deal with the vagueness ofhuman thoughts and language in making decisions.

Decision-makers tend to give assessment according to their past experiences and knowledge and also their estimations are often expressed in equivocal linguistic terms (Lin and Wu, 2008). Many decisions are involving imprecision since goals, constraints and possible actions are not precisely in description. In fuzzy logic, each number between 0 and 1 indicates a partial truth, where as crisp sets correspond to binary logic [0, 1] (Tseng, 2009a). To deal with the vagueness of human thought and expression in making decisions, fuzzy set theory is very helpful. In particular, to tackle the ambiguities involved in the process of linguistic estimation, it is a beneficial way to convert these linguistic terms into fuzzy numbers (Tseng, 2009; Chang and Hung, 2005).

MCDM is a well-known branch of decision making. It is widely used in ranking one or more alternatives from a set of available alternatives with multiple attributes (Yu and Hu, 2010; Malekly et al., 2010; Chou, 2010; Tzeng et al., 2009; Yu and Tzeng, 2006; Wang et al., 2005) and MCDM techniques support the decision makers in evaluating a set of alternatives (Keskin et al., 2010; Wang et al., 2005). MCDM techniques can help identify desired measures among a variety of alternatives through analyzing multiple criteria by which the strengths and weaknesses of various adaptation options could be evaluated. Thus, they could be adopted as evaluation tools to help identify the priorities of sustainable goals and to rank the desirability of adaptation options (Qin et al., 2008). Traditional MCDM models are based on the additive concept along with the independence assumption, but individual criterion is not always completely independent (Tseng, 2009a). Multiple attribute decision-making (MADM), like MCDM, deals with the problem of helping the decision maker to choose the best alternative, according to several criteria (Tzeng et al., 2009). Alternatively, MCDM or MADM is the approach dealing with the ranking and selection of one or more vendors from a pool of providers. The MCDM provides an effective framework for vendor comparison based on the evaluation of multiple conflict criteria (Shyur and Shih, 2006).

However, in many cases, the judgments of decision making are often given as crisp values, but crisp values are an inadequate reflection of the vagueness of the real world. The fact that human judgment about preferences are often unclear and hard to estimate by exact numerical values so that fuzzy logic is necessary for handling problems characterized by vagueness and imprecision. Hence, there has a need to extend the DEMATEL method with fuzzy logic for making better decisions in fuzzy environments (Wu and Lee, 2007). The DEMATEL method is used to construct the interrelations between criteria to build an impact-relation map (Yang et al., 2008). FAHP or FMCDM analysis has been widely used to deal with decision-making (DM) problems involving multiple criteria evaluation or selection of alternatives (Hsieh et al., 2004).

1.3 Decision Making Trial and Evaluation Laboratory (DEMATEL)

Complex evaluation environment can be divided into many criteria or subsystems to judge differences or measure scores of the divided criteria groups or subsystems more easily. The factor analysis method is commonly used to divide criteria into groups (Tzeng et al., 2007). The foundation of the DEMATEL method is graph theory. It allows decision-makers to analyze as well as solve visible problems (Chen and Chen, 2010).

The DEMATEL method has been successfully applied in many fields. Recently, there have been a lot of studies on fuzzy DEMATEL applications in different fields (Tzeng et al., 2007). DEMATEL method was developed by the Battelle Memorial Institute in Geneva. Those days, the DEMATEL method was used to study the world's complicated problems, such as: Race, hunger, environmental protection and energy, etc. In the recent years, many scholars have broadly applied the DEMATEL method to solve problem in different fields (Chen and Yu, 2009; Hu et al., 2009; Fekri et al., 2008; Wu et al., 2010). The DEMATEL method is an analytic technique of relationship structure. It can find the critical aspect or criteria of the complex structure system (Lin and Tzeng, 2009). The applicability of the DEMATEL method is widespread, ranging from analyzing world problematic decision-making to industrial planning (Wei and Hshiung, 2009; Li and Tzeng, 2009). The original DEMATEL was aimed at the fragmented and antagonistic phenomena of world societies and searched for integrated solutions. Digraphs are more useful than directionless graphs because digraphs can demonstrate the directed relationships of sub-systems. Moreover, digraph portrays a basic concept of contextual relations among the elements of the system, in which the numeral represents the strength of influence. The DEMATEL is based on digraphs, which can separate the involved factors into cause group and effect group (Kim, 2006; Chang and Cheng, 2009; Wu, 2008; Yang et al., 2008). DEMATEL has been widely used to extract a problem structure of a complex problematic. By using DEMATEL, we could quantitatively extract interrelationship among multiple factors contained in the problematic .In this case, not only the direct influences but also the indirect influences among multiple factors are taken into account (Tamura and Akazawa, 2005; Wang et al., 2005; Wu, 2008).

2. Fuzzy Decision Making Trial and Evaluation Laboratory (DEMATEL)

DEMATEL method is presented in 1973 as a kind of structural modeling approach about a problem. It can clearly see the cause-effect relationship of criteria when measuring a problem (Chen-Yi and Gwo-Hshiung, 2007). The decision-making involved in selecting appropriate management systems to create sustainable competitive advantages is a very important topic, which can be formulated as a MCDM problem (Tsai and Chou, 2009). Applying the DEMATEL illustrates the interrelations among criteria, finds the central criteria to represent the effectiveness of factors or aspects and avoids the "over fitting" for evaluation. Thus, non-additive methods, fuzzy measure and fuzzy integral are used to calculate the dependent criteria weights and the satisfaction value of each factor or aspect for fitting with the patterns of human perception (Chen-Yi and Gwo-Hshiung, 2007).

The although, this DEMATEL method is a good technique for evaluating problems and making decisions, we decide the relationships of systems to be usually given by crisp values in establishing a structural model (Liou et al., 2007; Chiu et al., 2006). However, it is generally understood that human perceptions on decision factors are usually judged subjectively. The judgment in social science is always represented as exact numbers. In many practical cases, the human preference model is uncertain and might be reluctant or unable to assign exact numerical values to describe the preferences (Tseng and Lin, 2008). The matrices or digraph portrays a contextual relation between the elements of the system, in which a numeral represents the strength of influence. Hence, the fuzzy DEMATEL method can convert the relationship between the causes and effects of criteria into an intelligible structural model of the system (Chen-Yi and Gwo-Hshiung, 2007; Kim, 2006; Lee et al., 2008) The fuzzy DEMATEL method has been successfully applied in many fields (Lee et al., 2008).

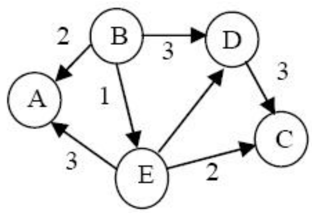

Figure 1. The digraph of the fuzzy DEMATEL example (Lee et al., 2008)

STEP1: Defining the evaluation criteria and designing the fuzzy linguistic scale

However, evaluation criteria have the nature of causal relationships and usually comprise many complicated aspects (Wu and Lee, 2007). To gain a structural model dividing involved criteria into cause and effect groups, the Fuzzy DEMATEL method is an appropriate technique. To deal with the ambiguities of human assessments, the research discard the comparison scale used in crisp DEMATEL method but adopt the fuzzy linguistic scale used in the group decision-making proposed [21-14-78-34]. **(**Wu and Lee, 2007; Kim, 2006; Coussement and Poel, 2008b; Chen-Yi and Gwo-Hshiung, 2007).

Different degrees of "influence" are expressed with five linguistic terms as "Strong", "High", "Low", "No" and their corresponding positive triangular fuzzy numbers are shown in Table 1 (Shieh et al., 2010).

Table 1. The correspondence of linguistic terms and linguistic values (example)

Linguistic terms	*Linguistic values*
No influence (No)	(0, 0, 0.25)
Low influence(L)	(0, 0.25, 0.5)
High influence(H)	(0.25, 0.5, 0.75)
Stronglyinfluence(VH)	(0.5, 0.75, 1.0)

STEP 2: Organizing the directed-relation matrix

Acquire the assessments of decision makers to measure the relationships between the critical success factors which are demonstrated by C ={C_i|i =1, 2 . . .n} (1). The groups of the chosen experts were asked to make sets of pair wise comparisons in terms of linguistic terms. Hence fuzzy matrices $\tilde{N}^1, \tilde{N}^2, \ldots, \tilde{N}^p$, each corresponding to an expert and with triangular fuzzy numbers are obtained. Fuzzy matrix Ñis called the initial direct relation fuzzy matrix of expert.

STEP 3: Establishing the structural model

The linear scale transformation is used here as a normalization formula to transform the criteria scales into comparable scales.

Then, the normalized direct-relation fuzzy matrix, denoted by Ẽ:

As that in crisp DEMATEL method, we assume at least one i suchthat $\sum_{j=1}^{n} \tilde{N}_{ij} < r$ and $\lim_{k\to\infty} \tilde{E}^{k} = [0]_{n\times n}$ (2). This assumption is well satisfied in practical cases (Lee et al., 2008; Wu and Lee, 2007).

STEP 4: The total-relation matrix

The total-relation matrix T can be acquired by using the following equation, in which the **I** is denoted as the identity matrix (Hu et al., 2009).

STEP 5: The sum of rows and columns

Produce a causal diagram. The sum of rows and the sum of columns are separately denoted as vector d'' and vector r'' through formulas 5. In these equations, vector d'' and vector r'' denote the sum of rows and the sum of columns from the total-relation matrix T respectively. (Chen and Chen, 2010; Tseng, 2009b).

***STEP 6:* As that of most fuzzy model, we had to covert the final fuzzy data into a crisp value.**

Here, we suggest the CFCS (Converting Fuzzy data into crisp scores) method proposed by Opricovic and Tzeng (2003) for defuzzification. This method has the advantages of giving a greater crisp value with greater membership function and distinguishing two symmetrical triangular fuzzy numbers with the same mean (Lin, 2010). Let $\tilde{N} = (l_{ij}, m_{ij}, u_{ij})$; k=1, 2,…, n (3) be the positive triangular fuzzy number, and $\tilde{N}_{k}^{jdef}$ denote its respresenting crisp value. Computing L=min (l_k); R=max(u_k); k=1, 2,…, n, and $\Delta = R - L$ (4), then

$$\tilde{N}_{k}^{jdef} = L + \Delta \times \frac{(m-L)(\Delta+u-m)^2(R-l)+(u-L)^2(\Delta+m-l)^2}{(\Delta+m-l)(\Delta+u-m)^2(R-l)+(u-L)(\Delta+m-l)^2(\Delta+u-m)} \quad (5)$$

STEP 7: We draw the causal diagram based on the calculations in step 6

STEP 8: Analyzing the results

Assume that d''_i denotes the row sum of *i-th* row of matrix *T*; then, d''_i shows the sum of influence dispatched from factor *i* to the other factors both directly and indirectly. Supposed r''_j denotes the column sum of *j-th* column of matrix *T*. Then, r''_j shows the sum of influence that factor *j* is receiving from the other factors (Chen-Yi and Gwo-Hshiung, 2007; Tseng, 2009b; Wu and Lee, 2007).

The order of elements from column d''_i indicates hierarchy from influencing elements and the order of elements from column r''_j indicates hierarchy from influenced elements. The actual place of each element in the final hierarchy is determined by columns $(d''_i + r''_j)$ and $(d''_i - r''_j)$. If $(d''_i - r''_j)$is a positive number, it is influencing and if it is negative, certainly, it is an influenced element. $(d''_i + r''_j)$ indicates the sum of density of an element along (longitude axis) regarding being either influencing or influenced. Final hierarchy is gained from the direct and indirect relations of $(d''_i + r''_j)$ and $(d''_i - r''_j)$ in the diagram.

3. Fuzzy Analytic Hierarchical Process (AHP)

The AHP was first proposed by Thomas Saaty in 1980. The AHP weighting is mainly determined by the decision makers who conduct the pair wise comparisons, so as to reveal the comparative importance between two criteria. If there are evaluation criteria, then to decide the decision making, the decision makers have to conduces C(n,2)=n(n-1)/2 pair wise comparisons (Li and Huang, 2009; Lin, 2010; Lee et al., 2008).

The goal of MCDM method is to aid decision makers in integrating objective measurements with value judgments that are based not on individual opinions but on collective group ideas. Further, there are situations in which information is incomplete or imprecise or views that are subjective or endowed with linguistic characteristics creating a ‘‘fuzzy’’ decision making environment. The FMCDM approach is designed to minimize such adverse conditions and strengthen the partnership selection process (Chou, 2007; Ding and Liang, 2005; Vaidya and Kumar, 2006).

Traditional evaluation methods usually take the minimum cost or the maximum benefit as their single index of measurement criteria, although, these approaches may not be sufficient for the increasingly complex and diversified decision making environment. Thus, we utilize a FAHP to assess the sustainable development strategies for industry (Chiou et al., 2005). Fuzzy method weighs levels of criteria importance and the determination of weights is the key point in comprehensive evaluation. The propriety of weights subsets will influence the results of the comprehensive evaluation (Hung et al., 2010).

AHP is a powerful method to solve complex decision problems. Any complex problem can be decomposed into several sub-problems using AHP in terms of hierarchical levels where each level represents a set of criteria or attributes relative to each sub-problem (Cheng et al., 2005; Sun et al., 2009). The AHP method is a multi-criteria method of analysis based on an additive weighting process, in which several relevant attributes are represented through the relative importance (Sun et al., 2009**;** Hung et al., 2010).

In fuzzy MCDM problems, criteria or attribute values and the relative weights are usually characterized by fuzzy numbers. A fuzzy number is a convex fuzzy set, characterized by a given interval of real numbers, each with a grade of membership between 0 and 1.The most commonly used fuzzy numbers are triangular and trapezoidal fuzzy numbers, whose membership functions are respectively defined as For brevity, triangular and trapezoidal fuzzy numbers are often denoted as (a, b, d) and (a, b, c, d) (Wang and Elhag, 2006; Zammori et al., 2009). Human judgment of events may be significantly different based on individuals' subjective perceptivity or personality, even when using the same words (Chiou et al., 2005). Fuzzy linguistic variables are extensions of numerical variables in the sense that they are able to represent the condition of an attribute at a given interval byTaking fuzzy sets as their values (Emre and Ugur, 2009). Triangular fuzzy numbers have been developed to appropriately express linguistic variables (Chiou et al., 2005).

AHP is widely used for multi-criteria decision making and has successfully been applied to many practical problems (Tiryaki and Ahlatcioglu, 2009; Wang et al., 2008). If uncertainty (fuzziness) of human decision making is not taken into account, the results can be misleading. A commonality among terms of expression, such as "very likely", "probably so", "not very clear", "rather dangerous" that are often heard in daily life, is that they all contain some degree of uncertainty (Lee et al., 2008). The concept of fuzziness in traditional AHP directly and without using fuzzy series has been taken into account. In fact, in this method, by using linguistic terms in table 3.1, the concept of fuzziness is applied to determine pair comparison matrices. In this regard, we can refer to models offered by Buckley (1985), Laarhoven & Pedrych (1983), Chang (1992), Lin, 2010, Kahraman et al., 2006).

A wide study in regard to these techniques can be observed in works of Kahraman (2004).Some papers published used the fuzzy AHP procedure based on extent analysis method and showed how it can be applied to selection problems (Önüt et al., 2010). In this study, fuzzy AHP is described based on extent analysis method by Chang because this method has been simpler than other fuzzy AHP and similar to the methodof classicAHP method.

3.1 Extent Analysis Method of Chang

If $X = \{x_1, x_2, \ldots, x_n\}$ is the set of objects and $U = \{u_1, u_2, \ldots, u_m\}$ is wishes, then based on the extent analysis method by Chang, by considering one object, the extent analysis can be considered for every Wish (g_i). Therefore, there is the sum of "m" extent analysis for each object:

$M_{g_i}^1, M_{g_i}^2, \ldots, M_{g_i}^m$ where i=1,2,…,n

$$
\begin{array}{c} \\ o_1 \\ o_2 \\ \vdots \\ o_n \end{array}
\begin{array}{c}
\begin{array}{cccc} w_1 & w_2 & \cdots & w_m \end{array} \\
\begin{bmatrix}
M_{g_1}^1 & M_{g_1}^2 & \ldots & M_{g_1}^m \\
M_{g_2}^1 & M_{g_2}^1 & \ldots & M_{g_2}^m \\
\vdots & \vdots & \vdots & \vdots \\
M_{g_n}^1 & M_{g_n}^2 & \ldots & M_{g_n}^m
\end{bmatrix}
\end{array}
$$

Figure 2. Matrices of wish (W) and object(O)

Where g_i is the goal set (i =1, 2, 3, 4, 5, ..., n) and all the $M_{g_i}^j$ (j =1, 2, 3, 4, 5,..…, m) are Triangular Fuzzy Numbers (TFNs).

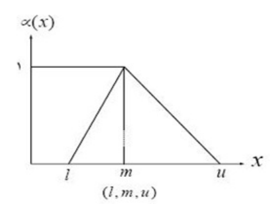

Figure 3. Triangular fuzzy number (Yu and Hu, 2010; Celik et al., 2009)

The steps of Chang's analysis can be given as in the following:

Step 1: To obtain a fuzzy compound equation for each object:

If $M_{g_i}^1, M_{g_i}^2, \dots, M_{g_i}^m$ is the sums of i^{th} object with respect to *m* wishes, then the fuzzy compound equation of *m* Wishes for i^{th} Objects is defined as below:

If $M_{g_i}^j = (l_{ij}, m_{ij}, u_{ij})$, then $\sum_{j=1}^{m} M_{g_i}^j$ is defined by the fuzzy addition operation of *m* extent analysis as below:

Also to obtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j\right]^{-1}$ by the fuzzy addition operation, we will have:

And then compute the inverse of the vector in the equation (3) is then obtained equation 4:

There for:

Step 2: Assessment of degree of priority:

The degree of priority S_i to S_k is $S_i = (l_i, m_i, u_i)$and $S_k = (l_k, m_k, u_k)$ then the priority of S_i to S_k which is indicated by $V(S_i \geq S_k)$ is described as equation 6:

$$V(S_i \geq S_k) = \underset{x \geq y}{SUP}\left(min\{\alpha_{S_i}(x), \alpha_{S_k}(y)\}\right) \tag{6}$$

And the equation is true for triangular fuzzy number:

Where *d* is the highest intersection point $\alpha_{S_i}$and sees Figure 4.

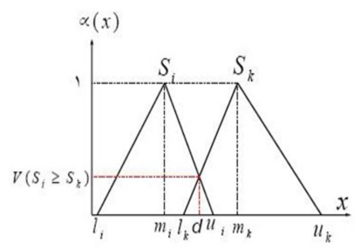

Figure 4. Intersection point of α_{S_k} and α_{S_i}

To compare and S_k; we need both the values of $V(S_i \geq S_k)$ and

Step 3: The degree possibility for a convex fuzzy number to be greater than *k* convex fuzzy numbers S_i (*i =1, 2, 3, 4, 5, ……, k*)can be defined by (Wang et al., 2008)

If $d'(A_1) = minV(S_i \geq S_k)$ for $(k = 1,2, \dots, n \quad k \neq i)$ then the weight vector is given in equation 9 (It is note worthy that the obtained weights are fuzzy):

Where A_i *(i =1, 2, 3, 4, 5, 6, …., n)* are *n* elements.

Step 4: Normalization of vector $\hat{W}$ and obtaining weight vector of normalized weight of W.

$$W = \left(d(A_1), d(A_2), \dots, d(A_n)\right)$$

3.2 Algorithm of Fuzzy Analytic Hierarchical Process (AHP) in the Method of Extent Analysis of Chang

The general process of algorithm of fuzzy AHP in the method of extent analysis of change is as below:

Step 1. Building up a hierarchy for the problem

Step 2. Determining pair comparison matrices and judgment operations, in traditional state (absolute)

Table 2 is used for judgment operations; that is, the corresponding number is entered the pair comparison matrices by linguistic preferences.

Table 2. Numerical sum for preferences in pair comparisons

Linguistic Terms	Numerical Sum
Preference with full and Absolute Importance	9
Preference with very strong importance	7
preference with strong importance	5
Preference with little importance	3
Preference with equal importance	1
For preferences between above linguistic terms	2,4,6,8

But in the fuzzy state, we enter the sum of corresponding number with linguistic preferences in pair comparison matricesby triangular fuzzy numbers (Anagnostopoulos et al., 2007). Table 3 can be used in this regard. The fuzzy numbers given here are not equal to regular linguistic comparisons 1 to 9 but they are suitable for Fuzzy AHP and are used.

Table 3. Corresponding fuzzy numbers with pair comparisons preferences

Linguistic Terms to Determine Preferences	Triangular Fuzzy Number
Preference or full and absolute importance	$(\frac{5}{2},3,\frac{7}{2})$
Preference or very stronger importance	$\left(2,\frac{5}{2},3\right)$
Preference or stronger importance	$\left(\frac{3}{2},2,\frac{5}{2}\right)$
Preference or little importance	$\left(1,\frac{3}{2},2\right)$
Preference or nearly equal importance	$\left(\frac{1}{2},1,\frac{3}{2}\right)$
Preference or equal importance	$(1,1,1)$

It is to be mentioned that all elements on the main diameter of pair comparison matrices are equal to (1, 1, 1) and if the element of row *i* and column *j* of pair comparison matrix is equal to $\mathrm{M}_{\mathrm{g_i}}^{\mathrm{j}} = (\mathrm{l_{ij}}, \mathrm{m_{ij}}, \mathrm{u_{ij}})$, then element of row *j* and column *i* of this matrix is equal to:

$$M_{g_i}^{j} = (M_{g_i}^{j})^{-1} = (l_{ij}, m_{ij}, u_{ij})^{-1} = (\frac{1}{u_{ij}}, \frac{1}{m_{ij}}, \frac{1}{l_{ij}})$$

Step 3. Computing relative weights of criteria and options

To compute the relative weight of the options with respect to each criterion and the relative weight of criteria with respect to object, we use the extent analysis method of Chang for each of pair comparison matrices. Therefore, a relative weight vector corresponding to that matrix is obtained for each matrix.

Step 4. Computing the final weight of the options

The final weight of the options is obtained by modulation of relative weights.The key criteria as mentioned before are C_1 (price), C_2 (Colprossesor), C_3 (capacity of customers (quantity)), C_4 (special features of telecommunications), C_5 (flexibility of the equipment in future), C_6 (the number of customers supported by each rack).

$$\sum_{j=1}^{6} M_{g_1}^{j} = (1,1,1) \oplus \left(1,\frac{3}{2},2\right) \oplus \left(\frac{1}{3},\frac{2}{5},\frac{1}{2}\right) \oplus \left(2,\frac{5}{2},3\right) \oplus \left(\frac{2}{7},\frac{1}{3},\frac{2}{5}\right) \oplus \left(\frac{5}{2},3,\frac{7}{2}\right) = (7/116,8/733,10/4)$$

$$\sum_{j=1}^{6} M_{g_2}^{j} = (3/086,3/667,4/733);\ \sum_{j=1}^{6} M_{g_3}^{j} = (9,11/5,14)$$

$$\sum_{j=1}^{6} M_{g_4}^{j} = (5/883,7/567,9/5);\ \sum_{j=1}^{6} M_{g_5}^{j} = (6/4,7/883,9/667)$$

$$\sum_{j=1}^{6} M_{g_6}^{j} = (4/286,5/5,7/067);\ \sum_{i=1}^{6}\sum_{j=1}^{6} M_{g_i}^{j} = (35/721,44/8,55/367)$$

$$(\sum_{i=1}^{6}\sum_{j=1}^{6} M_{g_i}^{j})^{-1} = (\frac{1}{55/367},\frac{1}{44/8},\frac{1}{35/721}) = (0/018,0/022,0/028)$$

$$S_1 = (7/116,8/773,10/4)\otimes(0/018,0/022,0/028) = (0/128,0/192,0/291)$$
$$S_2 = (0/055,0/081,0/133);\ S_3 = (0/162,0/253,0/392)$$
$$S_4 = (0/105,0/166,0/266);\ S_5 = (0/115,0/172,0/271)$$
$$S_6 = (0/077,0/121,0/198)$$

$$V(S_i \geq S_k) = \begin{cases} 1 & m_i \geq m_k \\ 1 & l_k \geq u_i \\ \dfrac{l_k - u_i}{(m_i - u_i) - (m_k - l_k)} & \end{cases}$$

$$V(S_1 \geq S_2) = 1, V(S_1 \geq S_3) = \frac{(0/162 - 0/291)}{(0/192 - 0/291) - (0/253 - 0/162)} = 0/153$$
$$V(S_1 \geq S_4) = 1, V(S_1 \geq S_5) = 1, V(S_2 \geq S_6) = 1$$
$$V(S_2 \geq S_1) = 0/043, V(S_2 \geq S_3) = 1, V(S_2 \geq S_4) = 0/248; V(S_2 \geq S_5) = 0/165$$
$$V(S_2 \geq S_6) = 0/583, V(S_3 \geq S_1) = 1, V(S_3 \geq S_1, S_2, S_4, S_5, S_6) = 1$$
$$V(S_4 \geq S_1) = 0/841, V(S_4 \geq S_3) = 0/545, V(S_4 \geq S_2) = 1, \quad V(S_4 \geq S_6) = 1$$
$$V(S_4 \geq S_5) = 0/962, V(S_5 \geq S_1) = 0/485, V(S_5 \geq S_2) = 1, \quad V(S_5 \geq S_6) = 1$$
$$V(S_5 \geq S_4) = 1, V(S_5 \geq S_3) = 0/574, V(S_6 \geq S_1) = 0/496, \quad V(S_6 \geq S_2) = 1$$
$$V(S_6 \geq S_3) = 0/214, V(S_6 \geq S_4) = 0/674, V(S_6 \geq S_5) = 0/619$$

Now we obtain preferences of S_i:

$$V(S_1 \geq S_2, S_3, S_4, S_5, S_6) = min\ (V(S_1 \geq S_2), V(S_1 \geq S_3), V(S_1 \geq S_4), V(S_1 \geq S_5), V(S_1 \geq S_6)$$
$$= min\ (1,0/153,1,1,1) = 0/153$$
$$V(S_2 \geq S_1, S_3, S_4, S_5, S_6) = min\ (0/043,0/248,0/145,0/583) = 0/043$$
$$V(S_3 \geq S_1, S_2, S_4, S_5, S_6) = 1$$
$$V(S_4 \geq S_1, S_2, S_3, S_5, S_6) = min\ (0/841,1,0/545,0/962,1) = 0/545$$
$$V(S_5 \geq S_1, S_2, S_3, S_4, S_6) = min\ (0/485,1,0/574,1,1) = 0/485$$
$$V(S_6 \geq S_1, S_2, S_3, S_4, S_5) = min\ (0/496,1,0/214,0/674,0/619) = 0/214$$
$$W' = (0/153,0/043,1,0/545,0/214)$$

We calculate normalization of fuzzy numbers:

$$W = (0/0627,0/0176,0/4098,0/223,0/1988,0/0877)$$

Table 4. Computing the final weight

Object	C1	C2	C3	C4	C5	C6
C1	$(1,1,1)$	$\left(1,\frac{3}{2},2\right)$	$\left(\frac{1}{3},\frac{2}{5},\frac{1}{2}\right)$	$\left(2,\frac{5}{2},3\right)$	$\left(\frac{2}{7},\frac{1}{3},\frac{2}{5}\right)$	$\left(\frac{5}{2},3,\frac{7}{2}\right)$
C2	$\left(\frac{1}{2},\frac{2}{3},1\right)$	$(1,1,1)$	$\left(\frac{2}{7},\frac{1}{3},\frac{2}{5}\right)$	$\left(\frac{5}{2},\frac{1}{2},\frac{2}{3}\right)$	$\left(\frac{5}{2},\frac{1}{2},\frac{2}{3}\right)$	$\left(\frac{1}{2},\frac{2}{3},1\right)$
C3	$\left(2,\frac{5}{2},3\right)$	$\left(\frac{5}{2},3,\frac{7}{2}\right)$	$(1,1,1)$	$\left(1,\frac{3}{2},2\right)$	$\left(1,\frac{3}{2},2\right)$	$\left(\frac{3}{2},2,\frac{5}{2}\right)$
C4	$\left(\frac{1}{3},\frac{2}{5},\frac{1}{2}\right)$	$\left(\frac{3}{2},2,\frac{5}{2}\right)$	$\left(\frac{1}{2},\frac{2}{3},1\right)$	$(1,1,1)$	$\left(\frac{3}{2},2,\frac{5}{2}\right)$	$\left(1,\frac{3}{2},2\right)$
C5	$\left(\frac{5}{2},3,\frac{7}{2}\right)$	$\left(\frac{3}{2},2,\frac{5}{2}\right)$	$\left(\frac{1}{2},\frac{2}{3},1\right)$	$\left(\frac{2}{5},\frac{1}{2},\frac{2}{3}\right)$	$(1,1,1)$	$\left(\frac{1}{2},\frac{2}{3},1\right)$
C6	$\left(\frac{2}{7},\frac{1}{3},\frac{2}{5}\right)$	$\left(1,\frac{3}{2},2\right)$	$\left(\frac{2}{5},\frac{1}{2},\frac{2}{3}\right)$	$\left(\frac{1}{2},\frac{2}{3},1\right)$	$\left(1,\frac{3}{2},2\right)$	$(1,1,1)$

4. Empirical Studies of Voice of Customers (VOC)

The telecommunications industry is undergoing dramatic changes fueled by rapid technical development and regulatory changes (Oh et al., 2009). Tam and Tummala (2001) proposed an AHP-based model and applied to a telecommunications company to examine its feasibility in selecting a vendor for a telecommunications system (Önüt et al., 2009). The MCDM approach is suitable for evaluating service quality expectation. Based on the various points of view or the suitable measuring method, the criteria can be categorized into distinct aspects (Tseng, 2009).

The first and largest manufacturing center of fixed and mobile phones in Iran was put into operation in partnership with Siemens Company of Germany in the form of a private joint stock company in Shiraz in 2004 to manufacture required equipment of the telecommunication network. The products of the company currently include software and hardware of full capacity switching centers of fixed and mobile phones of systems such as IRMC/S12, ITMC/NEAX, ITMC/EWSD, ITMC/MSC, switching supplies, emergency mobile phone centers with potable telescopic posts (BTS), different types of table phones, etc. By renewing fundamental structure, the research center of the manufacturing companies closely cooperate with universities and accredited research centers of the country based on strategic policy of industrial self-dependency. Customer-oriented, constant improvement of production and quality of products have always been taken into consideration by the companies and therefore, in the recent years, by employing modern machinery and mechanism and constant improvement of manufacturing processes, the companies have taken effective steps in promoting quality of products and attracting satisfaction of customers by acquiring the management standard certificate of ISO9001/2000. Demands of customers and satisfaction of customer with one of the products of the company is ranked in two methods of Fuzzy AHP and Fuzzy DEMATEL.

4.1 Applications of Proposed Method

Now we use the steps of the procedure to identify the relationshipbetween the critical success factors of agile voice of customers (VOCs) process as follows:

Step 1: Selecting a committee of VOCs experts including 12 managers.

Step 2: Developing the evaluation criteria and designing thefuzzy linguistic scale.

In our case the criteria are the critical success factorsof agile VOCs, which were extracted by explanatory factor analysis. In this step also the different degrees of influenceof a factor on the other factor are expressed in five linguistic term: Very High, High, Low, Very Low, and No influence and the corresponding positive triangular fuzzy numbers asmentioned before are shown in Table 5.

Table 5. Linguistic evaluation of criteria of voice of customer (example)

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	--	VL	H	L	H	VH
C_2	NO	--	H	VL	NO	NO
C_3	H	VH	--	NO	L	L
C_4	L	L	VL	--	L	VL
C_5	VH	VL	VL	VL	--	VL
C_6	H	NO	NO	VL	VL	--

Step 3: Acquiring the assessments of decisionmakers.To measure the relationships between the critical success factors;$C=\{C_i|i\ =1, 2. . .6\}$ the group of the chosen experts (*17* people mentioned in step *1*)was asked to make sets ofpairwise comparisons in terms of linguistic terms. Hence *17* fuzzy matrices each is corresponding to anexpert and with triangular fuzzy numbers as its elements areobtained.For example matrix $\tilde{N}$ is as follows:

$$\tilde{N}=\begin{bmatrix} (0,0,0) & (0,.25,.5) & (.5,.75,1) & (.25,.5,.75) & (.5,.75,1) & (.75,1,1) \\ (0,0,.25) & (0,0,0) & (.5,.75,1) & (0,.25,.5) & (0,0,.25) & (0,0,.25) \\ (.5,.75,1) & (.75,1,1) & (0,0,0) & (0,0,.25) & (.25,.5,.75) & (.25,.5,.75) \\ (.25,.5,.75) & (.25,.5,.75) & (0,.25,.5) & (0,0,0) & (.25,.5,.75) & (0,.25,.5) \\ (.75,1,1) & (0,.25,.5) & (0,.25,.5) & (0,.25,.5) & (0,0,0) & (0,.25,.5) \\ (.5,.75,1) & (0,0,.25) & (0,0,.25) & (0,.25,.5) & (0,.25,.5) & (0,0,0) \end{bmatrix}$$

Step 4: Acquiring the normalized direct-relation fuzzymatrix. Consider a triangular fuzzy number ($\tilde{a}_{ij}$) according to equations *2* and *3* to calculate eachdirect–relation fuzzy matrix $\tilde{E}$ for each matrix. For example for matrix$\tilde{N}$, the normalizeddirect relation fuzzy matrix $\tilde{E}$can be calculatedby equations *2* and 3 as follows:

$$\tilde{E}=\begin{bmatrix} (0,0,0) & (0,.059,.118) & (.118,.176,.235) & (.059,.118,.176) & (.118,.176,.235) & (.176,.235,.235) \\ (0,0,.059) & (0,0,0) & (.118,.176,.235) & (0,.059,.118) & (0,0,.059) & (0,0,.059) \\ (.118,.176,.235) & (.176,.235,.235) & (0,0,0) & (0,0,.059) & (.059,.118,.176) & (.059,.118,.176) \\ (.059,.118,.176) & (.059,.118,.176) & (0,.059,.118) & (0,0,0) & (.059,.118,.176) & (0,.059,.118) \\ (.176,.235,.235) & (0,.059,.118) & (0,.059,.118) & (0,.059,.118) & (0,0,0) & (0,.059,.118) \\ (.118,.176,.235) & (0,0,.059) & (0,0,.059) & (0,.059,.118) & (0,.059,.118) & (0,0,0) \end{bmatrix}$$

Step 5: The procedure of calculation matrix *T* (The total-relation matrix) according to the Equations 4 is as follows:

$$[T_{IJ}]=\begin{bmatrix} (.066,.196,.64) & (.026,.173,.59) & (.129,.269,.719) & (.063,.188,.569) & (.137,.285,.729) & (.195,.341,.7) \\ (.017,.065,.424) & (.022,.064,.293) & (.123,.206,.508) & (.001,.076,.342) & (.009,.047,.367) & (.01,.047,.349) \\ (.147,.293,.748) & (.183,.302,.622) & (.039,.122,.482) & (.009,.077,.436) & (.079,.206,.621) & (.087,.218,.598) \\ (.075,.219,.642) & (.062,.183,.531) & (.016,.144,.53) & (.004,.056,.333) & (.069,.189,.569) & (.014,.142,.5) \\ (.188,.33,.671) & (.005,.135,.471) & (.023,.154,.514) & (.011,.122,.429) & (.024,.1,.41) & (.034,.168,.493) \\ (.126,.243,.609) & (.003,.049,.37) & (.015,.065,.409) & (.007,.103,\&388) & (.016,.126,.463) & (.023,.078,.338) \end{bmatrix}$$

Step 6: After computing the matrix *T*, the amounts of $d''+r''$and $d''-r''$are calculated by Equations 5. d"\ and r"are sumof the rows and the sum of the columns of matrix *T* respectively .Table 6 illustrates the amounts of d", r", $d''+r''$ and d" −r".

Table 6. Computing sums of "Voc"

	d"	$\boldsymbol{r''}$	$\boldsymbol{d''+r''}$	$\boldsymbol{d''-r''}$
C1	*(0.6166, 1.4518, 3.9463)*	*(0.6193, 1.346, 3.7338)*	*(1.2359, 2.7978, 7.6801)*	*(-0.0027, 0.1058, 0.2125)*
C2	*(0.1822, 0.5045, 2.2814)*	*(0.3012, 0.9056, 2.8769)*	*(0.4834, 1.4101,5.1583)*	*(-0.119, -0.4011,-0.5955)*
C3	*(0.5449, 1.2184, 3.507)*	*(0.3446, 0.9592, 3.1613)*	*(0.8895, 2.1776, 6.6683)*	*(0.2003, 0.2592,0.3457)*
C4	*(0.241, 0.9329, 3.1037)*	*(0.0955, 0.6221, 2.4959)*	*(0.3365, 1.555, 5.5996)*	*(0.1455, 0.3108, 0.6078)*

C5	*(0.2845, 1.008, 2.9877)*	*(0.335, 0.9531, 3.1581)*	*(0.6195, 1.9611, 6.1458)*	*(-0.0505, 0.0549, -0.1704)*
C6	*(0.1907, 0.6639,2.5768)*	*(0.3643, 0.9935, 2.9769)*	*(0.555, 1.6574, 5.5537)*	*(-0.1736,-0.3296 , -0.4001)*

Step 7: Now we use the equation 6 for diffuzification of the amount of ($d"$) and ($r"$), ($d" + r"$)and ($d" - r"$) and convert to $d"^{def}$, $r"^{def}$, $(d" + r")^{def}$ and $(d" - r")^{def}$ respectively .These amounts are illustrated in the Table 7.

Table 7. Computing sums of $d"^{def}$ and fuzzy AHP

	$d"$	$r"$	$d"+r"$	$d" - r"$	Fuzzy AHP
C1	1.777	1.667	3.446	0.108	0.063
C2	0.808	1.212	2.036	-0.329	0.018
C3	1.557	1.299	2.859	0.265	0.41
C4	1.27	0.93	2.204	0.326	0.223
C5	1.304	1.294	2.601	0.026	0.199
C6	0.984	1.294	2.287	-0.35	0.088

STEP 8: Then we draw the causal 4.1 Analysis of resultsdiagram based on these calculation. Figure 5 illustrates the causal diagram of the criteria.

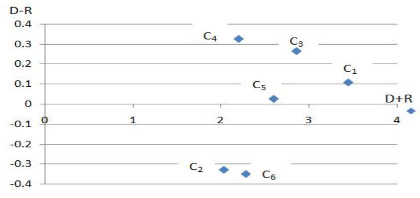

Figure 5. Diagram $d"_i + r"_j$ on axis x and $d"_i - r"_j$ on axis y

5. Discussions

In column d'', elements C_1, C_2 and C_3accordingly indicate the most influence and in column r'', elements C_1 and C_3 are accordingly influenced more than other elements of this column. We know that every element in the hierarchy is determined b$(d"_i + r"_j)$y columns and $(d"_i - r"_j)$. In column $(d"_i + r"_j)$ where the total strength of an element either influencingor influenced are indicated, element C_1 has the highest priority and C_3, C_5, C_6, C_4 and $C_2$are accordingly placed from the second to the sixth rank. In column $(d"_i - r"_j)$, C_4‹C_3‹C_1 and C_5 are influencing elements but C_6 and C_2 are influenced elements because they are negative. In table – the ranking of elements are calculated in the method of Fuzzy AHP where C_3, C_4, C_5, C_6, C_1 and C_2 are accordingly ranked from *1* to *6*. C_3 in $(d"_i + r"_j)$ ranking is the second but in $(d"_i - r"_j)$ ranking and the method of Fuzzy AHP, this element is placed the first rank. But C_2 is the last in both methods and elements C_5 and C_6 are the third and the forth in both ranking methods.

6. Conclusions

If a company tends to be successful and plan to reach high share of markets, surely it must be custom oriented. In twenty first century, the knowledge oriented society will develop if it's economical sources provided by knowledge rather than material, man power and capital.Fuzzy DEMATEL method as a very useful group decision making tool has been used to transform the complex interactions between the criteria of the problems of practical life into a visible structured model. In this paper this method is proposed and applied to find the cause and effect critical success factors of voice of customer, which have been extracted by the explanatory factor analysis method.

Hence the DEMATEL method can convert the relationshipbetween the causes and effects of criteria into anintelligible structural model of the system. The DEMATELmethod has been successfully applied inmany fields.

Using multiple fuzzy decisionmaking in ranking key factors of voice of customer is also effective in Telecommunication Company. Fuzzy AHP is one of the fuzzy ranking methods pairwise comparison criteria but Fuzzy DEMATEL was developed to solve very complicated issues of the world and it is used to structuralize the hypothetical information. With this method, it is possible to estimate the quantity of the effects of direct and indirect relations of elements with each other and promote the quality of relations and interrelations of the group. It is also used in group decision making. Fuzzy DEMATEL can be used together with models such as fuzzy QFD. In this model, the calculation can be easily performed by software such as MATLAB, EXCEL, MINITAB and SPSS. In group decision making, this model is preferred to other fuzzy models such as fuzzy AHP.

References

Anagnostopoulos, K. P., Gratziou, M., & Vavatsikos, A. P. (2007). Using the Fuzzy Analytic Hierarchy Process for selecting wastewater facilities at Prefecture Level. *European Water*, 15-24.

Celik, M., Kandakoglu, A., & Er, I. D. (2009). Structuring fuzzy integrated multi-stages evaluation model on academic personnel recruitment in MET institutions. *Expert Systems with Applications, 36*.

Chang, K. H., & Cheng, C. H. (2009). Evaluating the risk of failure using the fuzzy OWA and DEMATEL method. *J Intell Manuf, 22*(2).

Chen, C. H., & Yan, W. (2008). An in-process customer utility prediction system for product conceptualization. *Expert Systems with Applications.*

Chen, H. C., & Yu, Y. W. (2009). Using a strategic approach to analysis the location selection for high-tech firms in Taiwan. *Management Research News*.

Chen, J. K., & Chen, S. (2010). Using a novel conjunctive MCDM approach based on DEMATEL, fuzzy ANP, and TOPSIS as an innovation support system for Taiwanese higher education. *Expert Systems with Applications, 37*(3), 1981-1990.

Chen, Y. C., Lien, H. P., & Tzeng, G. H. (2009). Measures and evaluation for environment watershed plan using a novel hybrid MCDM model. *Expert Systems with Applications.*

Chen-Yi, H., & Gwo-Hshiung, T. (2007). FMCDM with Fuzzy DEMATEL Approach for Customers' Choice Behavior Model. I*nternational Journal of Fuzzy Systems, 9*(4), 236-246.

Chiou, H. K., Tzeng, G. H., & Cheng, D. C. (2005). Evaluating sustainable fishing development strategies using Fuzzy MCDM approach*. Omega, 33*, 223-234. http://dx.doi.org/10.1016/j.omega.2004.04.011

Chou, C. C. (2007). A fuzzy MCDM method for solving marine transshipment container port selection problems. *Applied Mathematics and Computation*, *186*, 435-444. http://dx.doi.org/10.1016/j.amc.2006.07.125

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.

Chua, T. C., & Lin, Y. (2009). An extension to Fuzzy MCDM. *Computers and Mathematics with Applications, 57*(12), 445-454. http://dx.doi.org/10.1016/j.camwa.2008.10.076

Coussement, K., & Poel, D. V. D. (2008a). Improving customer complaint management by automatic email classification using linguistic style features as predictors. *Decision Support Systems, 44*, 870–882. http://dx.doi.org/10.1016/j.dss.2007.10.010

Coussement, K., & Poel, D. V. D. (2008b).Integrating the voice of customers through call center emails into a decision support system for churn prediction. *Information & Management, 45*, 164–174. http://dx.doi.org/10.1016/j.im.2008.01.005

Emre, G., & Ugur, N. (2009). An occupational safety risk analysis method at construction sites using Fuzzy sets. *International Journal of Industrial Ergonomic, 39*(10)s, 371-387.

Fekri, R., Aliahmadi, A., & Fathian, M. (2008). Identifying the cause and effect factors of agile NPD process with fuzzy DEMATEL method: the case of Iranian companies. *J Intell Manuf, 20*, 637–648. http://dx.doi.org/10.1007/s10845-008-0153-x

Hsieh, T. Y., Lu, S. T., & Tzeng, G. H. (2004). Fuzzy MCDM approach for planning and design tenders selection in public office buildings. *International Journal of Project Management, 22*, 573–584. http://dx.doi.org/10.1016/j.ijproman.2004.01.002

Hu, H. Y., Lee, Y. C., & Yen, T. M. (2009). Amend Importance–Analysis Method with Kano's Model and DEMATEL. *Journal of Applied Sciences, 9*(10), 1833-1846.

Hu, H. Y., Lee, Y. C., Yen, T. M., & Tsai, C. H. (2009). Using BPNN and DEMATEL to modify importance–performance analysis model – A study of the computer industry. *Expert Systems with Applications, 36*, 9969–9979. http://dx.doi.org/10.1016/j.eswa.2009.01.062

Hung, K. C., Julian, P., Chien, T., & Jin, W. T. (2010). A decision support system for engineering design based on an enhanced fuzzy MCDM approach. *Expert Systems with Applications.*

Kahraman, C., Gülbay, M., & Kabak, Ö. (2006). Applications of Fuzzy Sets in Industrial Engineering: A Topical Classification. *StudFuzz, 201*, 1–55.

Kahraman, C. (2007). Editorial Fuzzy set applications in industrial engineering. *Information Sciences, 177*(7). http://dx.doi.org/10.1016/j.ins.2006.09.010

Keskin, G. A., Ilhan, S., & Ozkan, C. (2010). The Fuzzy ART algorithm: A categorization method for supplier evaluation and selection. *Expert Systems with Applications, 37*, 1235–1240. http://dx.doi.org/10.1016/j.eswa.2009.06.004

Lai, X., Xie, M., Tan, K. C., & Yang, B. (2008). Ranking of customer requirements in a competitive environment. *Computers and Industrial Engineering, 54*, 202–214. http://dx.doi.org/10.1016/j.cie.2007.06.042

Lee, A. H. I., Chen, W. C., & Chang, C. J. (2008). A fuzzy AHP and BSC approach for evaluating performance of IT department in the manufacturing industry in Taiwan. *Expert Systems with Applications, 34*(1), 96–107. http://dx.doi.org/10.1016/j.eswa.2006.08.022

Lee, Y. C., Hu, H. Y., Yen, T. M., & Tsai, C. H. (2008). Kano's and Decision Making Trial and Evaluation Laboratory Applied to Order Winners and Qualifiers Improvement: A Study of the Computer Industry. *Information Technology Journal, 7*(5), 702-714. http://dx.doi.org/10.1016/j.eswa.2006.08.022

Li, C. W., & Tzeng, G. H. (2009). Identification of a threshold value for the DEMATEL method using the maximum mean de-entropy algorithm to find critical services provided by a semiconductor. *Intellectual property mall, 36*, 9891–9898.

Li, S. T., & Huang, H. H. (2009). Applying TRIZ and Fuzzy AHP to develop innovative design for automated manufacturing systems. *Expert Systems with Applications, 36*, 8302–8312. http://dx.doi.org/10.1016/j.eswa.2008.10.025

Lin, C. J., & Wu, W. W. (2008). A causal analytical method for group decision-making under fuzzy environment. *Expert Systems with Applications, 34*, 205-213. http://dx.doi.org/10.1016/j.eswa.2006.08.012

Lin, C. L., & Tzeng, G. H. (2009). A value-created system of science (technology) park by using DEMATEL. *Expert Systems with Applications, 36*, 9683–9697. http://dx.doi.org/10.1016/j.eswa.2008.11.040

Lin, H. F. (2010). An application of fuzzy AHP for evaluating course website quality. *Computers & Education, 54*, 877–888. http://dx.doi.org/10.1016/j.compedu.2009.09.017

Lin, Z. P., Wang, R., & Tseng, M. L. (2009). Determination of a Cause and Effect Decision Making Model for Leisure Farm's Service Quality in Taiwan. *Wseas transactions on business and economic, 2*(6).

Liu, H. T. (2009). The Extension of Fuzzy QFD: From Product Planning to Part Deployment. Department of Industrial Engineering and Management. *Expert Systems with Applications, 1*(1), 1-57.

Malekly, H., Mousavi, S. M., & Hashemi, H. (2010). A fuzzy integrated methodology for evaluating conceptual bridge design. *Expert Systems with Applications, 37*, 4910–4920. http://dx.doi.org/10.1016/j.eswa.2009.12.024

Önüt, S., Efendigil, T., & Kara, S. S. (2010). A combined fuzzy MCDM approach for selecting shopping center site: An example from Istanbul, Turkey. *Expert Systems with Applications, 37*, 1973–1980. http://dx.doi.org/10.1016/j.eswa.2009.06.080

Önüt, S., Kara, S. S., & Isik, E. (2009). Long term supplier selection using a combined fuzzy MCDM approach: A case study for a telecommunication company. *Expert Systems with Applications, 36*, 3887–3895. http://dx.doi.org/10.1016/j.eswa.2008.02.045

Özdağoğlu, A., & Özdağoğlu, G. (2007).Comparison of AHP and FUZZY AHP for the multi-criteria decision making processes with linguistic evaluations. *İstanbul Ticaret Üniversitesi Fen Bilimleri Dergisi, 6*(11), 65-85.

Qin, X. S., Huang, G. H., Chakma, A., Nie, X. H., & Lin, O. G. (2008). A MCDM-based expert system for climate-change impact assessment and adaptation planning – A case study. *Expert Systems with*

Applications.

Roos, I., Friman, M., & Edvardsson, B. (2009). Emotions and stability in telecom-customer relationships. *Journal of Service Management, 20*(2). http://dx.doi.org/10.1108/09564230910952771

Sevastjanov, P., & Figat, P. (2007). Aggregation of aggregating modes in MCDM: Synthesis of Type 2 and Level 2 fuzzy sets. *Omega, 35*, 505-523. http://dx.doi.org/10.1016/j.omega.2005.09.005

Shieh, J. I., Wub, H. H., & Huang, K. K. (2010). A DEMATEL method in identifying key success factors of hospital service quality. *Knowledge-Based Systems, 23*, 277–282. http://dx.doi.org/10.1016/j.knosys.2010.01.013

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

Tiryaki, F., & Ahlatcioglu, B. (2009). Fuzzy portfolio selection using fuzzy analytic hierarchy process. *Information Sciences, 179*, 53–69. http://dx.doi.org/10.1016/j.ins.2008.07.023

Tseng, M. (2009). A causal and effect decision making model of service quality expectation using grey-Fuzzy DEMATEL approach. *Expert Systems with Applications.*

Tseng, M. L. (2009a). Application of ANP and DEMATEL to evaluate the decision-making of municipal solid waste management in Metro Manila .Environmental Monitoring and Assessment. *Environ Monit Assess, 156*, 181–197. http://dx.doi.org/10.1007/s10661-008-0477-1

Tseng, M. L. (2009b). Using the extension of DEMATEL to integrate hotel service quality perceptions into a cause– effect model in uncertainty. *Expert Systems with Applications, 36*, 9015–9023. http://dx.doi.org/10.1016/j.eswa.2008.12.052

Tseng, M. L., & Lin, Y.H. (2008). Application of Fuzzy DEMATEL to develop a cause and effect model of municipal solid waste management in Metro Manila. *Environmental Monitoring and Assessment, 158*, 519–533. http://dx.doi.org/10.1007/s10661-008-0601-2

Vaidya, O. S., & Kumar, S. (2006).Analytic hierarchy process: An overview of applications. *European Journal of Operational Research, 169*, 1–29. http://dx.doi.org/10.1016/j.ejor.2004.04.028

Vukmir, R. B. (2006). Customer satisfaction. *International Journal of Health Care Quality Assurance*.

Wang, Y. M., Luo, Y., & Hua, Z. (2008). Decision Support On the extent analysis method for fuzzy AHP and its applications. *European Journal of Operational Research, 186*, 735–747. http://dx.doi.org/10.1016/j.ejor.2007.01.050

Wei, C. L., & Hshiung, G. T. (2009). Identification of a Threshold Value for the DEMATEL Method: Using the Maximum Mean De-Entropy Algorithm. *Communications in Computer and Information Science, 35*, 789–796. http://dx.doi.org/10.1007/978-3-642-02298-2_115

Wu, H. H., Chen, H. K., & Shieh, J. I. (2010). Evaluating performance criteria of Employment Service Outreach Program personnel by DEMATEL method. *Expert Systems with Applications, 37*, 5219–5223. http://dx.doi.org/10.1016/j.eswa.2009.12.068

Wu, H. Y., Tzeng, G. H., & Chen, Y. H. (2009). A fuzzy MCDM approach for evaluating banking performance based on Balanced Scorecard. *Expert Systems with Applications, 36*, 10135–10147. http://dx.doi.org/10.1016/j.eswa.2009.01.005

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

Yang,Y. P. O., Shieh, H. M., Leu, J. D., & Tzeng, G. H. (2008). A Novel Hybrid MCDM Model Combined with DEMATEL and ANP with Applications. *International Journal of Operations Research, 5*(3), 160-168.

Yu, V. F., & Hu, K. J. (2010). An integrated fuzzy multi-criteria approach for the performance evaluation of multiple manufacturing plants. *Computers & Industrial Engineering, 58*, 269–277. http://dx.doi.org/10.1016/j.cie.2009.10.005