COMPARISON OF AHP AND FUZZY AHP FOR THE MULTI-CRITERIA DECISION MAKING PROCESSES WITH LINGUISTIC EVALUATIONS

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ABSTRACT

An analytical way to reach the best decision is more preferable in many business platforms. When variables are quantitative and number of criteria is not high, then one can use several analysis tools and make his/her decision and solve the problem. However, many times beside the measurable variables, there exist qualitative variables, or people are supposed to prefer the best among the many choices, thus, an analytical way to make a successful decision is needed. Analytical Hierarchy Process (AHP) is one of the best ways for deciding among the complex criteria structure in different levels. Fuzzy AHP is a synthetic extension of classical AHP method when the fuzziness of the decision makers is considered. In this paper, the comparison of classical AHP and fuzzy AHP on a case study that is constructed for the same hierarchy structure and criteria set.

Keywords: Analytic Hierarchy Process, Selection Criteria, Fuzzy Sets

SÖZEL DEĞERLENDİRMELİ ÇOK KRİTERLİ KARAR VERME SÜREÇLERİ İÇİN AHS VE BULANIK AHS YÖNTEMLERİNİN KARŞILAŞTIRILMASI

ÖZET

Birçok iş ortamında analitik yöntemler, en iyi kararı vermek adına daha çok tercih görmektedir. Sayısal olarak ölçülebilen değişkenlerin ve kriterlerin varlığında kullanılabilecek birçok analiz ve problem çözme tekniği bulunabilirken, kalitatif değişkenlerle seçim ya da karar verme zorunluluğu olduğunda farklı yaklaşımlara gerek duyulmaktadır. Böyle durumlarda en çok tercih edilen tekniklerden biri de Analitik Hiyerarşi Süreci (AHS)dir. Karmaşık kriter set ve çoklu düzey yapısında seçenekler içerisinde en iyi seçimi yapma konusunda başarılı kararlar alınmasında sık kullanıma sahiptir. Bulanık AHS ise karar vericilerin yaptıkları yorum ve değerlendirmelerde belli bir bulanıklık olduğu düşünüldüğünde ortaya çıkan ve AHS'nin bir uzantısı olarak geliştirilen sentetik bir yaklaşımdır. Bu çalışmada, klasik AHS yöntemi ile bulanık AHS' nin ayrıntılarındaki farklar örnek bir olay üzerinde gösterilmekte olup, bu karşılaştırma için aynı kriterler ve hiyerarşi yapısı kurulmuştur.

Anahtar Kelimeler: Analitik Hiyerarşi Süreci, Seçim Kriterleri, Bulanık Kümeler

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1. INTRODUCTION

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 important as "*what* decided". Everyday life and history are full of lessons that can help people recognize that critical moment. People learn by trying and by example. Deciding too quickly can be hazardous; delaying too long can mean missed opportunities. In the end, it is crucial that people make up their mind. What people need is a systematic and comprehensive approach to decision making (Saaty, 2001).

In evaluating *n* competing alternatives A_1, ... , A_n under a given criterion, it is natural to use the framework of pairwise comparisons represented by a *n x n* square matrix from which a set of preference values for the alternatives is derived. Many methods for estimating the preference values from the pairwise comparison matrix have been proposed and their effectiveness comparatively evaluated. Some of the proposed estimating methods presume interval-scaled preference values. But most of the estimating methods proposed and studied are within the paradigm of the analytic hierarchy process that presumes ratio-scaled preference values. Analytical Hierarchy Process (AHP) is one of the best ways for deciding among the complex criteria structure in different levels. Fuzzy AHP is a synthetic extension of classical AHP method when the fuzziness of the decision maker is considered.

This paper aims at comparing the classical AHP and fuzzy AHP, to show the differences of the results and the decisions made after that. To perform the operations according to see difference on the calculations, a case study is handled from food industry in which the management should decide about the selection criteria for its employees working in the shop floor. To see the distinctions of these two approaches the same hierarchy structure and criteria set are carried out. In the flow of the paper, first the classical AHP and Fuzzy AHP methods are introduced including the past studied from literature, then the summary of calculations are presented as the next section. Finally, the paper ends with comparison results, findings, and comments about these methods.

2. AHP AND FUZZY - AHP

2.1. Classical AHP

AHP is a method for ranking decision alternatives and selecting the best one when the decision maker has multiple criteria (Taylor, 2004). It answers the question, "Which one?". With AHP, the decision maker selects the alternative that best meets his or her decision criteria developing a numerical score to rank each decision alternative based on how well each alternative meets them.

In AHP, preferences between alternatives are determined by making pairwise comparisons. In a pairwise comparison, the decision maker examines two alternatives by considering one criterion and indicates a preference. These comparisons are made using a preference scale, which assigns numerical values to different levels of preference (Taha, 2003). The standard preference scale used for AHP is 1-9 scale which lies between “equal importances” to “extreme importance” where sometimes different evaluation scales can be used such as 1 to 5. In the pairwise comparison matrix, the value 9 indicates that one factor is extremely more important than the other, and the value 1/9 indicates that one factor is extremely less important than the other, and the value 1 indicates equal importance (Sarkis ve Talluri, 2004). Therefore, if the importance of one factor with respect to a second is given, then the importance of the second factor with respect to the first is the reciprocal. Ratio scale and the use of verbal comparisons are used for weighting of quantifiable and non-quantifiable elements (Pohekar ve Ramachandran, 2004).

Since 1977, Saaty (1980) proposed AHP as a decision aid to help solve unstructured problems in economics, social and management sciences. AHP has been applied in a variety of contexts: from the simple everyday problem of selecting a school to the complex problems of designing alternative future outcomes of a developing country, evaluating political candidacy, allocating energy resources, and so on. The AHP enables the decision-makers to structure a complex problem in the form of a simple hierarchy and to evaluate a large number of quantitative and qualitative factors in a systematic manner under multiple criteria environment in confliction (Cheng, et al, 1999).

The application of the AHP to the complex problem usually involves four major steps (Cheng, et al, 1999):

1. Break down the complex problem into a number of small constituent elements and then structure the elements in a hierarchical form.
2. Make a series of pair wise comparisons among the elements according to a ratio scale.
3. Use the eigenvalue method to estimate the relative weights of the elements.
4. Aggregate these relative weights and synthesize them for the final measurement of given decision alternatives.

The AHP is a powerful and flexible multi-criteria decision-making tool for dealing with complex problems where both qualitative and quantitative aspects need to be considered. The AHP helps analysts to organize the critical aspects of a problem into a hierarchy rather like a family tree (Bevilacqua et al, 2004).

The essence of the process is decomposition of a complex problem into a hierarchy with goal (criterion) at the top of the hierarchy, criteria and sub-criteria at levels and sub-levels of the hierarchy, and decision alternatives at the bottom of the hierarchy. Elements at given hierarchy levels are compared in pairs to assess their relative preference with respect to each of the elements at the next higher level. The method computes and aggregates their eigenvectors until the composite final vector of weight coefficients for alternatives is obtained. The entries of final weight coefficients vector reflect the relative importance (value) of each alternative with respect to the goal stated at the top of the hierarchy (Pohekar ve Ramachandran, 2004). A decision maker may use this vector according to his particular needs and interests. To elicit pairwise comparisons performed at a given level, a matrix A is created in turn by putting the result of pairwise comparison of element i with element j into the position a_{ji} as below.

$$A = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ C_6 \\ . \\ C_n \end{array} \begin{array}{c} \begin{array}{cccccccc} C_1 & C_2 & C_3 & C_4 & C_5 & C_6 & . & C_n \end{array} \\ \begin{bmatrix} 1 & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} & . & a_{1n} \\ a_{21} & 1 & a_{23} & a_{24} & a_{25} & a_{26} & . & a_{2n} \\ a_{31} & a_{32} & 1 & a_{34} & a_{35} & a_{36} & . & a_{3n} \\ a_{41} & a_{42} & a_{43} & 1 & a_{45} & a_{46} & . & a_{4n} \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & a_{56} & . & a_{5n} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 & . & a_{6n} \\ . & . & . & . & . & . & 1 & . \\ a_{n1} & a_{n2} & a_{n3} & a_{n4} & a_{21} & a_{21} & . & 1 \end{bmatrix} \end{array}$$

Where
n = criteria number to be evaluated
C_i = i. criteria,
A_{ij} = importance of i. criteria according to j^{th} criteria

After obtaining the weight vector, it is then multiplied with the weight coefficient of the element at a higher level (that was used as criterion for pairwise comparisons). The procedure is repeated upward for each level, until the top of the hierarchy is reached (Saaty, 1994). The overall weight coefficient, with respect to the goal for each decision alternative is then obtained. The alternative with the highest weight coefficient value should be taken as the best alternative. Saaty's AHP, is a well-known decision-making analytical tool used for modeling unstructured problems in various areas, e.g., social, economic, and management sciences (Bard ve Sousk, 1990; Triantaphyllou ve Mann, 1995; Wabalickis, 1988).

2.2. Fuzzy AHP

There is an extensive literature that addresses the situation where the comparison ratios are imprecise judgments (Leung ve Chao, 2000). In most of the real-world problems, some of the decision data can be precisely assessed while others cannot. Humans are unsuccessful in making quantitative predictions, whereas they are comparatively efficient in qualitative forecasting (Kulak ve Kahraman, 2005). Essentially, the uncertainty in the preference judgments give rise to uncertainty in the ranking of alternatives as well as difficulty in determining consistency of preferences (Leung ve Chao, 2000). These applications are performed with many different perspectives and proposed methods for fuzzy AHP. In this study, Chang's (1992) extent analysis on fuzzy AHP is formulated for a selection problem.

The fuzzy AHP technique can be viewed as an advanced analytical method developed from the traditional AHP. Despite the convenience of AHP in handling both quantitative and qualitative criteria of multi-criteria decision making problems based on decision makers judgments, fuzziness and vagueness existing in many decision-making problems may contribute to the imprecise judgments of decision makers in conventional AHP approaches (Bouyssou et al., 2000). So, many researchers (Boender et al., 1989; Buckley, 1985/a, 1985/b, Chang, 1996; Laarhoven and Pedrycz, 1983; Lootsma, 1997; Ribeiro, 1996) who have studied the fuzzy AHP which is the extension of Saaty's theory, have provided evidence that fuzzy AHP shows relatively more sufficient description of these kind of decision making processes compared to the traditional AHP methods. Yu (2002) employed the property of goal programming to solve group decision making fuzzy AHP problem. Weck et al. (1997) evaluated alternative production cycles using fuzzy AHP. Sheu (2004) presented fuzzy-based approach to identify global logistics strategies. Kulak and Kahraman (2005) used fuzzy AHP for multi-criteria selection among transportation companies. Kuo et al. (2002) integrated fuzzy AHP and artificial neural network for selecting convenience store location. Cheng (1996) proposed a new algorithm for evaluating naval tactical missile systems by the fuzzy AHP based on grade value of membership function. Zhu et al. (1999) made a discussion on the extent analysis method and applications of fuzzy AHP.

In complex systems, the experiences and judgments of humans are represented by linguistic and vague patterns. Therefore, a much better representation of these linguistics can be developed as quantitative data, this type of data set is then refined by the evaluation methods of fuzzy set theory. On the other hand, the AHP method is mainly used in nearly crisp (non-fuzzy) decision applications and creates and deals with a very unbalanced scale of judgment. Therefore, the AHP method does not take into account the uncertainty associated with the mapping (Cheng, et al, 1999). The AHP's subjective judgment, selection and preference of decision-makers have great influence on the success of the method. The conventional AHP still cannot reflect the human thinking style. Avoiding these risks on performance, the fuzzy AHP, a fuzzy extension of AHP, was developed to solve the hierarchical fuzzy problems.

Chang's extent analysis on fuzzy AHP depends on the degree of possibilities of each criterion. According to the responses on the question form, the corresponding triangular fuzzy values for the linguistic variables are placed and for a particular level on the hierarchy the pairwise comparison matrix is constructed. Sub totals are calculated for each row of the matrix and new (l, m, u) set is obtained, then in order to find the overall triangular fuzzy values for each criterion, $l_i/\Sigma l_i$, $m_i/\Sigma m_i$, $u_i/\Sigma u_i$, $(i=1,2,..., n)$ values are found and used as the latest $M_i(l_i, m_i, u_i)$ set for criterion M_i in the rest of the process. In the next step, membership functions are constructed for the each criterion and intersections are determined by comparing each couple. In fuzzy logic approach, for each comparison the intersection point is found, and then the membership values of the point correspond to the weight of that point. This membership value can also be defined as the degree of possibility of the value. For a particular criterion, the minimum degree of possibility of the situations, where the value is greater than the others, is also the weight of this criterion before normalization. After obtaining the weights for each criterion, they are normalized and called the final importance degrees or weights for the hierarchy level.

To apply the process depending on this hierarchy, according to the method of Chang's (1992) extent analysis, each criterion is taken and extent analysis for each criterion, g_i; is performed on, respectively. Therefore, *m extent* analysis values for each criterion can be obtained by using following notation (Kahraman, et al, 2004):

$$M_{g_i}^1, M_{g_i}^2, M_{g_i}^3, M_{g_i}^4, M_{g_i}^5, \ldots\ldots\ldots\ldots, M_{g_i}^m$$

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

Step 1*:* The fuzzy synthetic extent value *(S_i)* with respect to the i^{th} criterion is defined as equation 1 .

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

To obtain equation 2;

$$\sum_{j=i}^{m} M_{g_i}^j \qquad (2)$$

perform the "fuzzy addition operation" of *m* extent analysis values for a particular matrix given in equation 3 below, at the end step of calculation, new *(l, m, u)* set is obtained and used for the next:

$$\sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \qquad (3)$$

Where *l* is the lower limit value, *m* is the most promising value and *u* is the upper limit value.

and to obtain equation 4;

$$[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}]^{-1} \qquad (4)$$

perform the "fuzzy addition operation" of $M_{g_i}^{j}$ *(j = 1, 2, 3, 4, 5, ..., m)* values give as equation 5:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j} = (\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i) \qquad (5)$$

and then compute the inverse of the vector in the equation (5) equation (6) is then obtained such that

$$[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right) \qquad (6)$$

Step 2: The degree of possibility of

$M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ *is* defined as equation 7:

$$V(M_2 \geq M_1) = \sup_{y \geq x} [\min(\mu_{M_1}(x), \mu_{M_2}(y))] \qquad (7)$$

and x and y are the values on the axis of membership function of each criterion. This expression can be equivalently written as given in equation 8 below:

$$V(M_2 \geq M_1) = \begin{cases} 1, & \text{if } m_2 \geq m_1, \\ 0, & \text{if } l_1 \geq u_2, \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \text{otherwise} \end{cases} \qquad (8)$$

where d is the highest intersection point μ_{M_1} and μ_{M_2} (see Figure 1) (Zhu, et al, 1999).

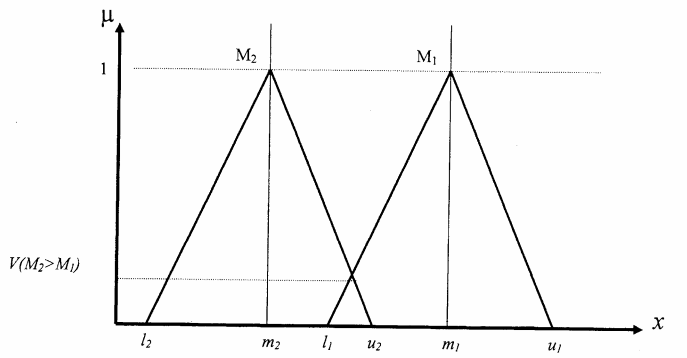

Figure 1. The Intersection Between M_1 and M_2 (Zhu et. al., 1999)

To compare M_1 and M_2; we need both the values of $V(M_2 \geq M_1)$ and $V(M_1 \geq M_2)$:

Step 3. The degree possibility for a convex fuzzy number to be greater than *k* convex fuzzy numbers

M_i $(i = 1, 2, 3, 4, 5, \ldots\ldots, k)$ can be defined by

$V(M \geq M_1, M_2, M_3, M_4, M_5, M_6, \ldots\ldots\ldots\ldots\ldots\ldots, M_k) =$
$V[(M \geq M_1)$ and $(M \geq M_2)$ and $(M \geq M_3)$ and $(M \geq M_4)$ and ..... and $(M \geq M_k)] =$
$\min V(M \geq M_i),\ i = 1, 2, 3, 4, 5, \ldots\ldots, k.$

Assume that equation 9 is

$$d'(A_i) = \min V(S_i \geq S_k) \tag{9}$$

For $k = 1, 2, 3, 4, 5, \ldots\ldots, n;\ k \neq i$. Then the weight vector is given by equation 10:

$$W' = (d'(A_1), d'(A_2), d'(A_3), d'(A_4), d'(A_5), \ldots\ldots\ldots, d'(A_n))^T \tag{10}$$

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

Step 4. Via normalization, the normalized weight vectors are given in equation 11:

$$W = (d(A_1), d(A_2), d(A_3), d(A_4), d(A_5), d(A_6), \ldots\ldots\ldots, d(A_n))^T \tag{11}$$

Where *W* is non-fuzzy numbers.

After the criteria have been determined as given in Figure 2, a question form has been prepared to determine the importance levels of these criteria. To evaluate the questions, people only select the related linguistic variable, then for calculations they are converted into the following scale including triangular fuzzy numbers developed by (Chang, 1996) and generalized for such analysis as given in Table 1 below:

Table 1. TFN Values (Tolga et. al., 2005)

Statement	TFN
Absolute	(7/2, 4, 9/2)
Very strong	(5/2, 3, 7/2)
Fairly strong	(3/2, 2, 5/2)
Weak	(2/3, 1, 3/2)
Equal	(1, 1, 1)

5. COMPARATIVE CASE STUDY

In this paper, a decision making process is handled in Sanek Food Product Co., providing the product and services with respect to the food industry in Izmir and Manisa, about analyzing the selection criteria for shop floor workers. In this part, firstly the outlines of employee selection and the extent analysis with fuzzy AHP and classical AHP are given and then the method is applied to determine the importance level of the employee selection criteria handled as a decision making process in a company. In appropriate with the AHP method, employee selection criteria have been determined and compared the sub criteria according to these criteria and then importance levels for each criteria have been found with the calculation of the process according to the given hierarchy structure. A decision making process arises to select the employees. According to the management board of the company the following criteria set is constructed as given in Figure 2. As an evaluation scale, 1 to 5 ratio scale is applied for both AHP and fuzzy AHP.

The question form developed for this study includes all questions for each level of hierarchy, i.e., the questions with respect to the overall goal "selecting the most appropriate employee for the company" are given as follows:

Question 1: How important is "technical attributes" when it is compared with "behavioral attributes"?

Question 2: How important is "technical attributes" when it is compared with "other factors"?

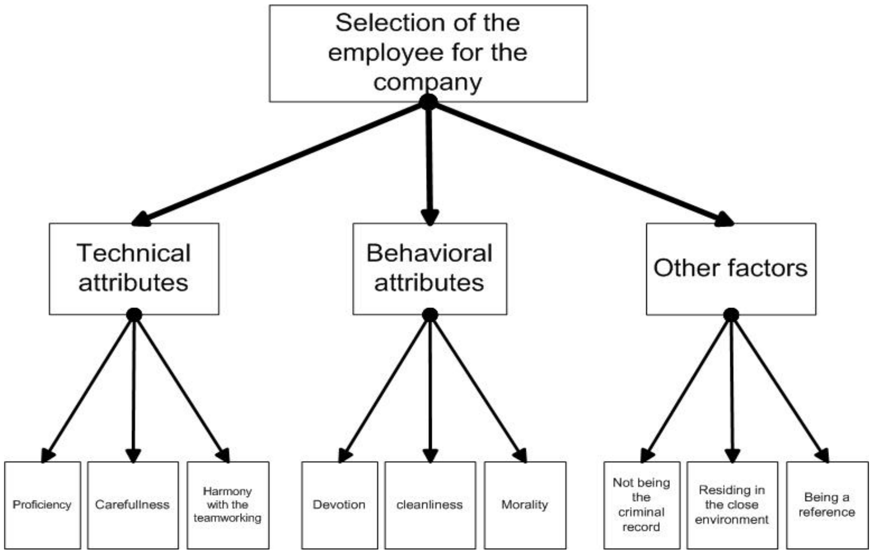

Figure 2. Hierarchy of The Criteria Set

Question 3: How important is “behavioral attributes” when it is compared with “other factors”?

The remaining questions are arranged in a form and represented in *Appendix A.* By starting with the first hierarchy level comparisons are performed to determine the local and global importance levels. These questions are asked for both classical and fuzzy AHP methods, but the calculation of the importance weights are handled according to the methodology given for each process.

Firstly, it can be assumed that the decision makers are deterministic people, and their exact evaluations can be used as they are, so classical AHP method can be applied under these conditions. Comparisons of the three main criteria and sub criteria according to the all criteria will be done by using AHP methodology. The pairwise comparison matrix according to the goal has been shown below to show the flow of the process.

Table 2. The Pair Wise Comparison Matrix According to The Goal

	Technical attributes	Behavioral attributes	Other factors
Technical attributes	1,000000	4,000000	3,000000
Behavioral attributes	0,250000	1,000000	2,000000
Other factors	0,333333	0,500000	1,000000

As seen in Table 2, first of all, the comparison for the criteria is made; the steps of AHP are then applied through the Tables 3 to 5:

Table 3. Summation of The Values in Each Column

	Technical attributes	Behavioral attributes	Other factors
Technical attributes	1,000000	4,000000	3,000000
Behavioral attributes	0,250000	1,000000	2,000000
Other factors	0,333333	0,500000	1,000000
Column total	1,583333	5,500000	6,000000

Table 4. Division of Each Value to The Column Total

	Technical attributes	Behavioral attributes	Other factors
Technical attributes	0,631579	0,727273	0,500000
Behavioral attributes	0,157895	0,181818	0,333333
Other factors	0,210526	0,090909	0,166667

Note: Sum of all columns must be 1.

Table 5. The Average Values

	Technical attributes	Behavioral attributes	Other factors	Importance level
Technical attributes	0,631579	0,727273	0,500000	0,619617225
Behavioral attributes	0,157895	0,181818	0,333333	0,224348751
Other factors	0,210526	0,090909	0,166667	0,156034024

Row averages given in the last column of Table 5 are the importance levels for all criteria. According to these values, technical attributes is the most preferable criterion. Relative priority values of these criteria can be written as a vector below.

$$\begin{bmatrix} W_{11} \\ W_{21} \\ W_{31} \end{bmatrix} = \begin{bmatrix} 0{,}620 \\ 0{,}224 \\ 0{,}156 \end{bmatrix}$$

The consistency index of a matrix of comparisons is given by CI=(λ_{max}-n)/(n-1). The consistency ratio (CR) is obtained by comparing the CI with the appropriate one of the following set of numbers in Table 6 each of which is an average random consistency index derived from a sample of randomly generated reciprocal matrices.

Table 6. Average Random Consistency Index

n	3	4	5	6	7	8
RI	0,58	0,90	1,12	1,24	1,32	1,41

If it is not less than 0.10, study the problem and revise the judgments. Pairwise comparison matrix procedure which was done for criteria should be made for the alternatives in the systematic approach. The remaining steps are performed with the same procedure and obtained consistent judgments. Finally, importance levels are obtained locally in Table 7 and after distributing major criteria weights on this local importance, the global importance are obtained as give in Table 8.

Table 8 shows the global importance levels for the sub criteria in order to select employee. According to these results, proficiency is the most preferred criterion with %25.47 in terms of all criteria. Harmony with the team working has %20.31 importance level. As a result, the company (Sanek Co.) prefers proficiency and harmony with the team working in the production process.

Table 7. Importance Levels of The Sub Criteria

Criterion	Importance level	Criterion	Importance level	Criterion	Importance level
Proficiency	0,411111	Devotion	0,58889	Not being a criminal record	0,119939
Carefulness	0,26111	Cleanliness	0,159259	Residing in a close environment	0,607962
Harmony with the team working	0,32777	Morality	0,251852	Being a reference	0,2720986

Table 8. Global Importance Levels of The Sub Criteria

Criterion	Importance level	Criterion	Importance level	Criterion	Importance level
Proficiency	0,254732	Devotion	0,13211	Not being a criminal record	0,018714
Carefulness	0,161789	Cleanliness	0,03573	Residing in a close environment	0,094863
Harmony with the team working	0,203097	Morality	0,05650	Being a reference	0,042457

As mentioned before, these classical AHP results are compared with the fuzzy AHP results. Therefore, the evaluations are recalculated according to the fuzzy AHP on the same hierarchy structure. From the fuzzy numbers in Table 9, following calculations are performed to reach the importance values of the first level as a sample fuzzy evaluation matrix is obtained in the Table 9 below:

Table 9. Fuzzy Evaluation Matrix With Respect to The Goal

	Technical attributes (t)			Behavioral attributes (b)			Other factors (o)		
Technical attributes (t)	1	1	1	5/2	3	7/2	3/2	2	5/2
Behavioral attributes (b)	2/7	1/3	2/5	1	1	1	2/3	1	3/2
Other factors (o)	2/5	1/2	2/3	2/3	1	3/2	1	1	1

$S_t = (5; 6; 7) \otimes (1/13.07; 1/10.83; 1/9.02)$
$S_b = (1.95; 2.33; 2.90) \otimes (1/13.07; 1/10.83; 1/9.02)$
$S_o = (2.07; 2.50; 3.17) \otimes (1/13.07; 1/10.83; 1/9.02)$
are obtained.

Using these vectors,
$V(S_t \geq S_b) = 1$
$V(S_t \geq S_o) = 1$
$V(S_b \geq S_t) = 0$
$V(S_b \geq S_o) = 0.91394$
$V(S_o \geq S_t) = 0$
$V(S_o \geq S_b) = 0$

Thus, the weight vector from Table 9 is found as

$W_{Goal} = (1; 0; 0)^T$.

This means, according to this person, the one and only main criterion in the first level is “technical attributes” with 1 importance value. The next step consists of operations to calculate the local importance values or weight vector of the second level in hierarchy. For each branch, each criteria group in the second level is subject to a pairwise comparison in itself. The criteria sets are calculated with the same approach and procedure is ended when global and local importance levels are obtained.

Chang’s fuzzy AHP uses intersection operation while evaluating comparison results. The result of the fuzzy intersection can be obtained as zero which means that the corresponding criterion has no importance. This finding rises a question “if this criterion is a concern for the decision, then how can it have a zero importance?”. In fact, it is an ordinary consequence of fuzzy logic. Fuzzy pair wise comparisons provide that if a criterion is less important than all of the others, then relatively this criterion has no importance and weight is zero. Even if it is declared that a criterion is handled for the decision making process, it has no importance when compared with the others. In the classic AHP method, deterministic values and operations do not permits such a situation "having zero weight", but if a criterion is evaluated as "less than all of the others", then the numerical result of this situation, the weight of this criterion would be near to zero, furthermore the weight can descend to 0,01 which means that this criterion is not so important on the final decision. Fuzzy AHP totally neglects the criterion which is less important than the others whereas classical AHP uses this criterion with so small weight. This can also be an advantage for fuzzy-AHP presenting additional information for decision maker that there is no difference between the existence or nonexistence of such a criterion. Therefore, the decision maker can focus on the more important criteria.

Here, this is the point that should not be missed, classical and fuzzy methods are not the competitors with each other at same conditions. The important point is that if the information / evaluations are certain, classical method should be preferred; if the information / evaluations are not certain, fuzzy method should be preferred. In recent years, because of the characteristics of information and decision makers, probable deviation should be integrated to the decision making processes, and because of that for each decision making method, a fuzzy version is developed. Fuzzy AHP method is a natural result of this necessity.

Linguistic and subjective evaluations take place in questionnaire form. Each linguistic variable has its own numerical value in the predefined scale. In classical AHP these numerical values are exact numbers whereas in fuzzy AHP method they are intervals between two numbers with most likely value. As the nature of the human being, linguistic values can change from person to person. In these circumstances, taking the fuzziness into account will provide less risky decisions.

Table 10 shows overall or global importance levels for this decision making problem.

The quantitative values explain that there are three criteria "proficiency", "carefulness" and "harmony with the team working", with the same priorities: 0.333, thus, the employee who has a proficiency, carefulness and harmony with the team working would have a higher chance of being selected where proficiency is the most preferred criterion with %25.47 in terms of all criteria. Harmony with the team working has %20.31 importance level.

Table 10. Importance Weightings of All Main and Sub Criteria for Decision Makers in The Management Level

Sub criterion	Importance weighting	Sub criterion	Importance weighting	Sub criterion	Importance weighting
Proficiency	0.333	Devotion	0	Not being the criminal record	0
Carefulness	0.333	Cleanliness	0	Residing in the close environment	0
Harmony with the team working	0.333	Morality	0	Being a reference	0

As a result, the company (Sanek Co.) prefers proficiency and harmony with the team working in the production process according to both classical AHP and fuzzy AHP with the differences in details. The sequence of the first three criteria are evaluated same in both of the methods with different weights. In the classical method each of the criteria has different weight whereas in the fuzzy method they are equal to the each other. Another distinction point between the methods is about the zero weights of fuzzy AHP. However, classical AHP does not allow such a situation, fuzzy AHP executives find it very natural when a criterion is absolutely not important than all the criteria in its level.

6. FINDINGS AND CONCLUSION

AHP is an effective problem solving methodology. Decision problem may contain social, economic, technical and politic factors that need to be evaluated by linguistic variables. Then AHP is one of the most commonly used techniques for such situations. The Criteria set is determined at the beginning in many multi criteria decision making methods and modeled depending upon to these criteria. Multi criteria decision making techniques based on the linguistic evaluations like AHP helps to make a best selection decision by using a weighting process within the current alternatives via pair wise comparisons.

Prior to the evaluation of the alternatives, evaluation of criteria is handled and weighted. In classical AHP, ANP, and similar methods, directly the numerical values of linguistic variables are used for evaluation of these criteria. If the environment where the decision making process takes place is fuzzy, then fuzzy numbers are used for evaluation concerning some deviations of decision makers. Nowadays, especially in complex economic conditions, many of the decisions are made in such an environment. Thus, fuzzy version of AHP or similar method should be used in spite of its complexity during the calculations. In addition to that, a simple software or procedure can be developed to simplify the calculations.

In this study AHP and fuzzy AHP method are evaluated and compared on a case study including the decision making about employee selection for shop floor of manufacturing platform applied in a company from food industry. When classical AHP is applied to the given case of selection, then Proficiency, Harmony with the team working, and Carefulness are the most three important criteria as obtained in the fuzzy AHP Method. However, for fuzzy AHP method these important levels are found as equally weighted when the fuzziness is considered. Furthermore, the remaining criteria are calculated as zero which is an interesting result, because, at the beginning of the study the given criteria set is assumed to be evaluated. This is not an extraordinary situation and a gap for the Fuzzy-AHP approach, and the situation in the case that the decision makers may not consider one or more of the criteria for the evaluation of the employees even if these criteria are placed in the hierarchy. Therefore, the Fuzzy-AHP approach provides to eliminate the unnecessary criterion or criteria if all of the decision makers assign “absolutely not important” value when compared with the other criteria and expresses the more important criteria. Some expertise does not accept this result whereas some think it is natural. Due to the fact that European culture is affected by the Aristo logic based on existence – nonexistence, which is called 0-1 logic, some European researchers deny the fuzzy set theory. But, Japan scientists adapt to the fuzzy set theory and they use fuzzy logic in many different areas such as the production of the washing machines, microwave oven, refrigerator, scanner, and photograph machine. Consequently, fuzzy set and related methods are still conflictions in the literature so fuzzy AHP applications have some risk about it, but the conventional AHP still cannot reflect the human thinking style. Avoiding these risks on performance, the fuzzy AHP, a fuzzy extension of AHP, was developed to solve the hierarchical fuzzy problems.

In the methodology, one can not find a consistency process for fuzzy inputs and crisp weights and the consistency index method is not appropriate because of the fuzziness. In fact, Chang’s fuzzy AHP comprises such a mechanism during the pairwise calculations when the membership values or possibilities are compared and the intersections are obtained. Furthermore the fuzziness concept has some bias including decision maker’s inconsistency. Because of that the publications applying Chang’s fuzzy AHP did not require any consistency mechanism as seen in many applications in the literature.

Here, this is the point that should not be missed, classical and fuzzy methods are not the competitors with each other at same conditions. The important point is that if the information / evaluations are certain, classical method should be preferred; if the information / evaluations are not certain, fuzzy method should be preferred. In recent years, because of the characteristics of information and decision makers, probable deviation should be integrated to the decision making processes, and because of that for each decision making method, a fuzzy version is developed. Fuzzy AHP method is a natural result of this necessity.

Linguistic and subjective evaluations take place in questionnaire form. Each linguistic variable has its own numerical value in the predefined scale. In classical AHP these numerical values are exact numbers whereas in fuzzy AHP method they are intervals between two numbers with most likely value. As the nature of the human being, linguistic values can change from person to person. In these circumstances, taking the fuzziness into account will provide less risky decisions.

Determination and evaluation of the criteria for employee selection can be affected by the characteristics of the people and the conditions of the decision making platform. The perfection and the position of the authority with which decision is made, and personal characteristics affect the linguistic variable which will be chosen during evaluation. Thus, deterministic scale can produce misleading consequences. For example, some pessimistic people may not give any point more than four, or very optimistic people may easily give 5 even if it does not deserve it. These situations generate fuzziness within the decision making process, so fuzzy AHP method can handle these deviations concerning this fuzziness. Therefore, for the employee selection problems, if a multi-criteria decision making method with linguistic evaluations is selected, this method can be fuzzy AHP or similar methods concerning fuzzy conditions.

APPENDIX: Question Form for Evaluation

Read the following questions and put check marks on the pair wise comparison matrices. If a criterion on the left is more important than the matching one on the right, put your check mark to the left of the importance ‘‘Equal’’ under the importance level you prefer. If a criterion on the left is less important than the matching one on the right, put your check mark to the right of the importance ‘Equal’ under the importance level you.

With respect to the main criterion “technical attributes”

Question 1: How important is “proficiency” when it is compared with “carefulness”?

Question 2: How important is “proficiency” when it is compared with Harmony with the team working”?

Question 3: How important is “carefulness” when it is compared with Harmony with the team working”?

With respect to: "technical attributes"	Importance (or preference) of one sub-criterion over another										
Questions	Criteria	Absolute	Very strong	Fairly strong	Weak	Equal	Weak	Fairly strong	Very strong	Absolute	Criteria
1	Proficiency										Carefulness
2	Proficiency										Harmony with the team working
3	Carefulness										Harmony with the team working

With respect to the main criterion "behavioral attributes"

Question 1: How important is "devotion" when it is compared with "cleanliness"?

Question 2: How important is "devotion" when it is compared with "morality"?

Question 3: How important is "cleanliness" when it is compared with "morality"?

With respect to: "behavioral attributes"	Importance (or preference) of one sub-criterion over another										
Questions	Criteria	Absolute	Very strong	Fairly strong	Weak	Equal	Weak	Fairly strong	Very strong	Absolute	Criteria
1	Devotion										Cleanliness
2	Devotion										Morality
3	Cleanliness										Morality

With respect to the main criterion "other factors"

Question 1: How important is "not being a criminal record" when it is compared with "residing in a close environment"?

Question 2: How important is "not being a criminal record" when it is compared with "being a reference"?

Question 3: How important is "residing in a close environment" when it is compared with "being a reference"?

With respect to: "other factors"	Importance (or preference) of one sub-criterion over another										
Questions	Criteria	Absolute	Very strong	Fairly strong	Weak	Equal	Weak	Fairly strong	Very strong	Absolute	Criteria
1	Not being a criminal record										Residing in a close environment
2	Not being a criminal record										Being a reference
3	Residing in a close environment										Being a reference

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